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Divergent thinking, aesthetic preferences, and orientations towards arts and science

by

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Thesis submitted for the Degree of
Doctor of Philosophy

in the

Department of Psychology
The University of Adelaide

1979

Awarded November 1979

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SUMMARY

This thesis integrates three somewhat separate areas of previous research which are associated with the notion of "creativity". These areas focus on the concepts of
(a) divergent thinking, (b) visual aesthetic preferences, and
(c) orientation towards the arts and humanities contrasted with orientation towards the sciences.

Part A of the thesis describes general features of visual aesthetic preferences, particularly in relation to stimulus complexity. In Part B, the nature of divergent thinking and its assessment are discussed. The heart of the thesis is presented in Part C, which considers the relationships between individual and group differences in aesthetic preferences and divergent thinking, together with other relevant aspects of personality such as independence and emotionality. Because of the nature of the initial findings, subsequent studies considered in detail the role of orientation towards arts or sciences.

It is argued that a "trait" approach to personality is viable, in terms of the consistency and generality of behaviour. Nevertheless, limitations of the present studies are acknowledged; in particular, they involved "normal" persons rather than highly creative groups; and psychological tests rather than observations of ongoing behaviour.

General theoretical approaches which have been applied to understanding aesthetic preferences and divergent thinking are outlined. Broad approaches applying to both areas include: analogies based on energy systems, such as the concepts of libido and arousal; theories based on informational systems; theories concerned with learning and the development of competence; and approaches which emphasize cognitive styles and personal choice. These are not mutually exclusive, and are too "loosely" formulated to be subjected to any definitive test. The present studies nevertheless provided evidence relevant to aspects of these approaches.

Studies of the dependence of visual preferences and exploration on aspects of stimulus complexity are described, including experiments by the author. Two aspects of stimulus complexity should be distinguished, multiplicity of elements and symmetry/asymmetry, since they have distinct effects on response measures. In general, the results supported informational and experiential interpretations of visual preferences; and disconfirmed hypotheses involving such concepts as "arousal" and "adaptation-level".

Studies of divergent thinking tests, and particularly divergent fluency, are reviewed, and a factor analysis of eight such tests is described. Experiments which relate divergency to aesthetic preferences and orientation towards the arts are then considered.

A correlational study disconfirmed Barron's theory concerned with openness to various forms of divergent stimulation. An alternative view is proposed, that orientation towards the arts is a central concept related to both divergency and preference for complexity in visual designs. A follow-up study found that scores on the Graves Design Judgement Test were positively correlated with fine-arts education, interest in the arts, artistic achievement, and creative independence; whilst the Barron-Welsh Revised Art Scale was significantly correlated with only fine-arts education.

Because of the central relevance of artistic interest, a further study involving Holland's Vocational Preference Inventory was used to test aspects of his personality theory. It was found that the artistic interest scale gave significant, predicted positive correlations with the Barron-Welsh Scale, arts-faculty membership, fluency and originality on the Torrance Tests of Creative Thinking, and with creative independence and emotional activation scales; and a significant negative correlation with Holland's Masculinity Scale.

Three studies further explored differences between arts and science students. The main findings were:

(a) the arts-science distinction in educational achievement and subject-choice at secondary-school level was confirmed;

(b) arts faculty students scored higher than science or engineering students on divergent fluency (supporting Hudson's research), on interest and education in fine arts, and on preference for asymmetry; and

(c) the arts-science dimension in some cases affected differential examination performance with regard to "objective" and "essay" questions.

It was found that adult-education courses designed to "broaden" thinking increased divergent fluency, independence and preference for complexity. A final case-study investigated the development of a "convergent science specialist". The predicted associations of early scientific interest with convergent intelligence, conscientiousness, self-control and social conformity were found, but Hudson's suggestions concerning debilitating inhibition were not confirmed.

In relation to broad theoretical systems, explanations of these findings in terms of information processing, educational effects, and cognitive styles each play a part. The results do not support the notion of immutable abilities or highly consistent personality types. Rather, they indicate that activities and interests become progressively channelled, particularly during the years of formal education. People's modes of action, competencies and preferences tend to develop in line with their specialisations.

Further research should improve the rather crude "empirical" measures used in personality investigations, and should investigate the development of specialisations within subgroups of similar persons. Attempts have been made to "liberalise" science teaching, and their effectiveness should be investigated.

Statement

This thesis contains no material which has been accepted for the award of any other degree or diploma in any University, and to the best of my knowledge and belief contains no material previously published or written by another person, except when due reference is made in the text.

Signed _

Eric Edward Rump

ACKNOWLEDGEMENTS OF ASSISTANCE

I am grateful to the University of Adelaide for providing the facilities for my research, to my colleagues for stimulation and advice, and in particular to my supervisors, Professor A.T. Welford and Dr. A.H. Winefield for their encouragement. Thanks are extended to the many hundres of persons, mainly students, who have helped in the research by working as "subjects" for no reward other than the pleasure of assisting in the pursuit of knowledge (including self-knowledge).

The final draft of the thesis was typed with skill by Mrs. M. Bruce, whilst many of the tables were typed by Mrs. J. Fallon, who also assisted with the preparation of figures. Ms. Len Van Ruth assisted with photographic work, and Mr. R. Willson helped with computer programming over several years. Mrs. M. Blaber assisted with much secretarial advice and Ms. Ivana Scapinello and Mrs. Arlene Shaw typed various drafts.

In the studies reported in chapter 2, John Buxton designed the stimulus patterns and Ms. Leonie Ryder helped to transfer data for card punching. The single-frame film projector and timer was loaned by Dr. D. Vickers.

The second judge for categorising types of figures in chapter 4 was Jeanne Roberts, whilst the very time-consuming task of acting as second judge for the assessment of figure complexity in verbal units was undertaken by David Caudrey. Dr. R.S. Roger, University of Sydney, made a valuable suggestion as to the analysis of the Welsh data, although in the event a different method was employed. For the study reported in chapter 5, I am grateful to Margaret Dunn for undertaking most of the test sessions.

For the study reported in chapter 7, Dr. A.H. Winefield acted as an initial judge in relation to items on the Graves Test. D. Caudrey, J. Fraser and J. Beare were scoring assistants. Ms. I. Proske was the

initial judge for checking Self-description Checklist items. W. Gould advised in the preparation of a Fortran programme to score and calculate reliabilities for the Checklist scales. Ms. J. Fallon and Mr. P. Smith gave scoring and card-punching assistance for the study reported in chapter 9.

For the studies reported in chapter 10, some scoring assistance was provided by Ms. Julie Beare and Ms. Maxine Shephard. Several colleagues cooperated in the arrangements for testing various groups in Study b, including at the University of Adelaide, Peter van Rood (Department of Physics), Devon Doble (Mechanical Engineering), Brian Smith (Electrical Engineering), Drs. R. Prager and H. Rodda (Organic Chemistry); at the South Australian Institute of Technology, Dr. R. Culver (Applied Sciences Division); at Flinders University, Dr. R. Smith (Fine Arts); and at the South Australian College of Arts, Mr. G.S. Samstag. I am grateful to the Public Examinations Board of South Australia for supplying statistical information used as the basis for Study a, and to the Chairman of the Board (Professor E.W. Mills) for granting approval of its use in this thesis.

With respect to the training courses studied in chapter 11, every assistance was provided by the lecturers concerned: M. Hutton, Margaret MacNamara, N. Peard and Maxine Shephard.

I am grateful to Frank's parents (chapter 12) for their cooperation, and for permitting the case-study to be described in this thesis. The photographs of Frank's art work were taken for me by Malcolm Hutton.

During the final stages of writing the thesis I received considerable encouragement and support from my University of Adelaide colleagues and particularly Ms. Maxine Shephard. To them and to each of the above I express my thanks.

PREFACE

The purpose of this preface is to explain the personal background to the research described herein, and the organisation of the thesis. In addition, relevant methodological issues are discussed, and certain limitations of the research are acknowledged.

The research grew from the writer's interest in the stimulus determinants of aesthetic preferences, beginning several years ago. This led to studies of the development of visual aesthetic preferences, and subsequently to a search for explanations of individual differences, particularly in relation to preference for complexity. In turn, theories and findings led to the fields of individual differences in "creativity", and in artistic and scientific interests.

The studies reported in this thesis were spread over several years. They were interrupted by other university duties and by research in unrelated areas. As a consequence, much of the reviewed material postdates the actual conduct of the research.

General theoretical approaches to creativity, and more particularly to divergent thinking, are outlined in chapter 1, and shown to be parallel to theoretical approaches applied to visual preferences and exploration. These theories are "full-range" general theories (Merton, 1967), whilst "middle-range" theories which are used to derive empirical hypotheses are discussed in later chapters.

Part A of the thesis is concerned with analyses of visual preferences and exploration, particularly in relation to aspects of stimulus complexity. Part B considers the nature of divergent thinking. Part C is the main section of the thesis in which relationships amongst divergent thinking, aesthetic preference and arts-orientation variables are discussed. In most chapters, previous research is reviewed as well as the writer's own investigations. Rather more review material has been included than is

usual, and the writer views his own findings as adding to a considerable body of relevant evidence in most cases. The final chapter considers general implications of some of the main findings.

In relation to individual and subgroup differences, a conventional "trait" approach has generally been adopted in this thesis. Such an approach has been criticised in recent years, since people's social and physical situations may account for some of the variability in their behaviour (particularly their social actions). Empirical studies, summarised by Bavelas (1978, chapter 24), have suggested the importance of person-trait interaction effects. Nevertheless, this thesis emphasizes main effects of stimuli and persons rather than interactions, as first-order approximations to an understanding of the data. At the same time, differential preference of individuals for visual stimuli of varying degrees of complexity, investigated in this thesis, could itself be considered an example of interaction between "persons" and one aspect of the physical "situation".

Allport (1978) has defended the trait approach, particularly in relation to educational and vocational preferences and interests. These have been found to show some degree of consistency, and stability over the life-span. Competencies and abilities also demonstrate a reasonable degree of generality across situations and over time, as shown in the case of divergent thinking measures in chapters 5 and 6. Since the thesis is largely concerned with individual preferences, competencies and interests, rather than more ephemeral phenomena, a trait approach seems reasonable. This may be thought particularly justified if it is accepted that persons "choose the situations in which they appear, and select those aspects of the situations to which they will respond (Sheehan, 1978, p.171). The same point is made by Ball (1976, p.62) when writing of "The Definition of Situation". It follows that "situations" and "social roles" may not

provide any simpler account of activity systems than "personality" concepts: Goffman (1972, p.112) nicely illustrates the possible complexity of the "perceived situation".

The writer's view is that a trait approach is tenable in some areas, and that the generality of personality measures over time and over situations is a matter of empirical investigation. It would be expected that the longer the time-interval between observations, and the greater the contrast between situations, the lower the generality would be. This approach to personality assessment leads to a consideration of test theory in general.

Since research dexcribed in the thesis involves a variety of personality "tests", it is appropriate to give preliminary consideration to the assumed "model of measurement". The traditional model of personality test measurement assumes that a test score is composed of two independent, additive components, "true score" and "random error". Both these concepts and the assumption of their independence may be criticised, particularly when applied to tests composed of a few unsystematically selected items scored dichotomously (Lumsden, 1976). In any case, the notion of a "true" measure is difficult to accept when applied to personality attributes which are often indications of behavioural probability, evaluating dispositions: for instance, we may attempt to assess the probability that a particular person would choose complex rather than simple visual patterns. It is equally difficult to apply the concept of "random" error to personality assessment. Scoring errors may occur, but they are unlikely to be "random". Lumsden (1977) has argued that it makes more sense to consider the person's characteristics as fluctuating somewhat, rather than considering unreliability to be inherent in test scores themselves.

The traditional measurement model is not much assisted when the two postulated components of scores are subdivided into numerous subcomponents, as in Cattell and Warburton's detailed model (1967, p.45, Equation 4.5).

The main benefit of such a specification is that it reminds test users of the numerous artefacts and possible alternative interpretations of score variations which should be borne in mind.

Some conceptual difficulties are avoided by replacing the notion of "true score" (and its mythical brother, the "perfect objective criterion") with the notion of an item or test score as a sampled statistic deriving from a universe of relevant observations. Definition of the sampled universe depends on a clear description of the personality trait of interest, and subsequent refinement of its range of relevance by investigations of correlates both within and outside the boundaries initially set for the universe. This conception of personality measurement has been mathematically described by Cronbach, Gleser, Nanda, and Rajaratnam (1972). It seems to be an elaboration of "heuristic realism" as advocated by Allport (1978). If behavioural universes are envisaged as partially overlapping sets, with different degrees of overlap at different levels of generality, the model is clearly compatible with the hierarchical conception of personality structure, when applied to the individual person (*e.g.* Guilford, 1959, pp.99 - 100).

Accepting the generalisation model as a reasonable approach for the purpose of this thesis, it is nevertheless admitted that the measures used have not been subjected to any complete investigation of their generality. Rather, the nature and scope of test attributes become clearer as a part of the process of testing substantive hypotheses concerning those attributes. An example will assist this discussion. A 16-item test of preference for multiplicity of elements in visual patterns was devised for the research described in chapter 7. Individual variation in preference for multiplicity was found to generalise across asymmetrical and symmetrical items, so that both types were properly included within the sampled universe. However, scores on the test were not related to preference measures involving other aspects of stimulus complexity, so that it is inadvisable to think in terms

of any general attribute of preference for complexity. Even less is the postulated dimension of "personality complexity" empirically justified, since it implies a very broad universe of attributes which have been shown to have little coherence.

A number of codicils are consistent with the generalisation approach. The use of "rationally" defined measures, rather than *ad hoc* "empirical" scales is preferred. "Reliability" is not a certificate of good performance attached to a test: rather, investigations relevant to this topic are seen as defining the generality of measurement across items, across similar tests or across occasions. Investigations of validity are not concerned with the search for a criterion measure, since if such existed it should replace the test measure. Rather, validation involves the empirical determination of the nature and scope of the measured trait, in terms of generalisation across different methods of assessment, across systems of theoretically related constructs, and again across occasions (in the case of predictive validity). It may be relevant to consider the degree of generality of one's measures in other respects also. In particular, generalisation across different conditions of measurement (for examples, over different testers or scorers, or "examination" compared with "relaxed" conditions) may be relevant. The degree of generality of test score interpretation for varied samples of different cultures, sex, age, and so on, is similarly a matter of empirical determination.

In the case of ability or attitude measures, rather precise interval-scaling with consistency of scores across both item and subject samples is possible, using precise mathematical models of test scores, such as the Rasch model (Andrich, 1975). The measures used in this thesis do not have this precision, nor is it likely that the requirement of "dimensional singularity" could be met by most personality measures in current use. Nevertheless, it is possible to gain understanding of aspects of personality even with imperfect measuring devices. Clarification of the nature of

attributes being measured may be more important than achieving psychometric perfection: for example, it would seem from findings presented in chapter 7 that scores on "neuroticism" may reflect (in the reverse direction) a general tendency to give "socially desirable" responses. Thus the nature and consistency of personality and preference scales are explored in the thesis at the same time as the scales are used to examine relevant theories.

As well as some ambiguity and limited precision pertaining to scales used, the thesis has two other admitted restrictions of importance. The thesis is concerned with aspects of creativity and artistic interest, but investigations did not include highly selected samples of the very creative or artistically talented. It is considered that the hypotheses tested are such that they may be applied to people generally, rather than to special groups.

The second restriction arises from the cultural milieu of the persons tested. Both hypotheses and measures assume a modern "Western" cultural background, and almost all the reviewed research has been within Australia, Britain or the United States. In noting this cultural limitation of the thesis, I am partly thinking of the difficulty of applying intellectual tests like divergent thinking tasks to other cultures (*e.g.* Jones and Shea, 1974). With regard to aesthetic judgements, cross-cultural agreement is not always found (Child, 1969, pp.882-893), although several studies have indicated consistency, at least with people who have an active interest in art (*e.g.* Child and Siroto, 1965; Ford, Prothro and Child, 1966; Iwao and Child, 1966; Child and Iwao, 1968; Soueif and Eysenck, 1971).

More fundamental problems are involved in relation to cultural background. In particular, the purpose and form which creative, artistic or intellectual activities take are dependent on value systems within particular cultures. Mar'i (1976), in presenting the basis for a cross-cultural theory of creativity, postulates: "*Society provides a framework*

or a number of fields into which the creativity of individuals can and should be channeled". It is evident that "creative" activities valued in modern Western societies usually involve material products which have utilitarian or monetary value, whether these be of an artistic or scientific nature. On the other hand, in India a work of art such as an image or dance is traditionally evaluated in spiritual terms, in relation to its religious significance; artistic creativity "seeks to reveal metaphysical, infinite and transcendent values", involving ritual rather than personal expression or problem solving (Mukerjee, 1964). Similarly in tribal Australian Aboriginal culture, painting, engraving and dancing ceremonies communicate the traditions and religious myths of the group (Kupka, 1965).

In modern Western cultures, pervaded by the advantages of scientific progress, novelty and originality are valued to such an extent that in the visual arts a "cult of spontaneity" has arisen (Kelley, 1976). In more slowly changing, traditional cultures there is no such value placed on divergency. "In all of Polynesia there is almost no artistic inventiveness. Rather there is a simple repetition of old designs" (Burdick, 1963, p.290). In contrast with such ways, the theme of this thesis is firmly embedded within the context of modern Western cultures, and is limited thereto in its implications.

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CHAPTER 1

THEORETICAL INTRODUCTION

The purpose of this chapter is to introduce four main theoretical approaches which have been suggested for the explanation of creative activities, or more particularly divergent thinking; and for the explanation of aesthetic preferences, particularly in relation to stimulus complexity. Similar types of explanation may be found in both areas, and theoretical links may be established between them. Specific theories which utilise one approach or another are described and tested in subsequent chapters, so that only a broad outline of the four different approaches is given here. They are concerned with (a) motivational theories, (b) cognitive theories, (c) personal style and choice, and (d) learning.

Many of the theoretical propositions examined in this thesis are speculative, and only partially supported by empirical evidence. The writer feels some sympathy for the viewpoint of Thomas Reid writing in 1785: "The world has been so long befooled by hypotheses in all parts of philosophy that it is of the utmost consequence to every man ... to treat them with just contempt, as the reveries of vain and fanciful men" (Woozley, 1941, p.34). Nevertheless, theories are needed to stimulate enquiry, and to impose some order on data.

(a) Motivational theories

A number of theories are motivational, and based on analogies with physical energy systems. There are two relevant types: (a) those based on the psychoanalytic concept of "libido" and the associated notion of psychosexual stages of development; and (b) those based on the psycho-physiological construct of "arousal", which is often conceptualized as having an optimal level. These two types are discussed in turn.

Freud considered that many creative activities, including art, were due to the sublimation of libidinal impulses. In Strachey's translation of Freud's 1916-1917 Introductory Lectures he stated: "For there is a path that leads back from phantasy to reality - the path, that is, of art" (Freud, 1973 reprint, p.375). Chagall is one painter whose work has been analysed from the Freudian viewpoint. Schneider (1950, ch.9) discussed the symbols used by Chagall, such as the winged fish in a picture entitled "Time is a river without banks". He concluded that "we tap and transform our unconscious. This is what the true artist - and the truly creative scientist - has always done". A similar approach has been applied to creative writing. "A strong experience in the present awakens in the creative writer a memory of an earlier experience (usually belonging to his childhood) from which there now proceeds a wish which finds its fulfilment in the creative work" (Freud, 1908, reprinted 1976, p.53).

Many writers have expanded on this theme, and it has led to various kinds of empirical studies. For instance, in discussing the use of projective techniques for the study of creative persons, Burchard (1952) outlined psychoanalytic views of the relationship between creativity and other aspects of personality, derived from the basic idea that artistic activities are motivated by unfulfilled erotic wishes. Libidinal energy is "dammed up", but may be given controlled release in dreams, phantasies, and art work. Wild (1965) specifically explored the use of "regression" in thinking creatively. She found that art students, particularly the most creative ones, "seem able to engage in unregulated thinking with more pleasure and facility" compared with either school teachers or schizophrenic patients. Gamble and Kellner (1968) reported that high scorers on a divergent thinking test were capable of "cognitive regression", as shown by relative speed of colour-naming on the Stroop Color-Word Test.

Much of the research said to support this approach is with individual cases. This may be illustrated by Pickford's (1967) account of pictures "of considerable artistic merit" by a schizoid patient. One series of pictures illustrated the theme "Mother and Infant" and showed "first the most intense oral wishes for the mother's breasts". Usually, however, the underlying phantasies are disguised by transforming art-work, although in this case Pickford considered that "some of the pictures which are more close to the latent content of the underlying phantasies are more artistically forceful and expressive". Unfortunately, in evaluating such accounts it is impossible to determine whether findings illustrate general principles or only individual psychopathology; and whether a patient's products are influenced by his therapist's preconceptions. It is difficult to separate the patient's art work from the direct influence of ongoing clinical events, although this has been attempted (*e.g.* Fink, 1973).

Psychoanalytic theory has also been applied to aesthetic preferences. A clear example is provided by the "sex symbol" hypothesis, which proposes that designs symbolising male or female characteristics tend to be preferred by the opposite sex. Evidence concerning this very indirect form of wish fulfilment is briefly mentioned in chapter 4. Psychoanalytic character traits have been proposed as partially accounting for aesthetic sensitivity. For example, Cooperman and Child (1968) reported that students whose visual art preferences agreed with those of experts tended to have an "orally active" character as assessed by food preferences, and also tended to show the "anal" characteristics of tolerating dirtying activities. Such observations are interesting, but unequivocal hypotheses are not derivable directly from psychoanalytic theory.

It has been remarked that an original thinker must face the "fear of one's own unconscious processes"(Crutchfield, 1961). Indeed, the

creative person has generally been described as "prepared to take risks" (*e.g.* Taft and Gilchrist, 1970). Conversely it has been argued that the person who lacks originality, who is highly constrained by convention, is constricted in his curiosity by fears of his own internal impulses. Hudson (1966a, p.103) advocated this view: the convergent thinker, who scores lower on divergent thinking tests than expected from his IQ, "uses some sort of mental barrier against thoughts and feelings which unsettle him". Hudson's evidence for such "defensive inhibition" is rather indirect. If feelings are generally repressed, Hudson argued that occasional strong outbursts might occur. He cited a convergent boy who gave very few responses to the Unusual Uses Test, but amongst them as a use for a brick was the morbid suggestion "Smash sister's head in" (*op. cit.*, p.74). Such a response would seem to indicate lack of inhibition rather than providing evidence of its operation. The notion of defensive inhibition is examined further in chapter 12.

The convoluted nature of psychoanalytic explanation is conveyed by a report of Bahnson (1970). He found that emotionally disturbed patients felt elated during periods when they were creative in their art work, but nevertheless they showed signs of "latent" guilt. He concluded: "Thus, when unpleasant affect is projected onto the environment and denied in the self, the subject releases creative potentials." Without this explanation, one would have accepted the parsimonious idea that both elation and creative art are signs of well-being.

Barron, in discussing both creative persons and those who prefer complex visual stimuli, has frequently sought explanations in Freudian terms. The particular stage of infantile sexuality presented as a unifying principle has, however, varied in these explanations. For example, in a study of graduate students, those who preferred more complex

figures were found to be original, emotional and poorly adjusted. Such a combination of characteristics was considered to represent a "complex personality", and was linked with infantile "oral deprivation" (Barron, 1953, p.166). In a further study of pilots, those who were more original were also found to prefer complex patterns and to be more impulsive than a low-originality subgroup. Their freedom from impulsive-suppression was considered to demonstrate "positive rebellion against the prohibition of unregulated anal production" (Barron, 1963, p.212).

To complete the trio of erotic stages, Barron suggested in the same book that a very unconventional student, "Paul", was rebellious towards legitimate authorities because of intense Oedipal feelings (Barron, 1963, p.33). It is interesting that McClelland (1962) gave a related but contrary account of creative physical scientists in general: "the future scientist is simply a boy who resolves his guilt over love of his mother and hatred of his father by early and complete identification with his father" (p.153). It would seem therefore that the Oedipal complex may lead either to rebellion against authorities and convention or to identification with them, which makes prediction problematic. Fascinating as these conjectures are, it is difficult to devise adequate scientific tests of their validity. However, the "surface" personality structure proposed by Barron is testable, and relevant evidence is presented in chapter 7.

The other major motivational concept relevant to parts of this thesis is that of arousal. The concept is a broad, loose one. It may refer to the current level of central nervous system activation, possibly mediated through the reticular formation; to a persisting state such as anxiety level; or to the "arousal" characteristics of stimulus conditions. Hunt (1971) reviewed the history of the concept in relation to intrinsic motivation. It has been postulated that an optimal level of arousal is

required for efficient performance, and this may apply to creative production. Perhaps creative persons are "by constitution more vigorous and have avilable to them an exceptional fund of psychic and physical energy" (Barron, 1958). Perhaps also too high a level of arousal may lead to inefficient proliferation of ideas, bizarre and unfruitful, as in the case of schizophrenic thought disorder (such as a scientist's phantasies described in the account of "the jet-propelled couch" by Lindner, 1956).

There have been some attempts to connect arousal measures more directly with divergent thinking ability. Martindale (1975) suggested that those who scored high on divergent thinking tests found it easy to relax, and had *low* arousal level, contrary to evidence suggesting their emotionality. Martindale provided some support for his theory, in that high scorers on divergent tasks gave distinct alpha-wave activity, which has often been taken to indicate deep relaxation. The prominent alpha-wave activity was present both following instructions to relax and during the divergent tasks. Martindale's theory must be regarded as speculative, since the interpretation of alpha activity is uncertain, and in any case the results may indicate merely that people who find intellectual tasks easy are less tense during test sessions than those who find them difficult. (A variety of convergent and divergent tasks could be used to investigate this possibility.)

Eysenck (1967c, ch.V) has discussed activation and arousal, and their physiological bases, especially in relation to the personality dimensions of extraversion and neuroticism. Similarly, Welford (1966) discussed the use of arousal as a concept to explain characteristic modes of behaviour, and particularly the two dimensions emphasized by Eysenck. These were included in the correlational study described in chapter 7 of this thesis.

Much effort has been expended in developing arousal theory in relation to aesthetic preferences and visual exploration, particularly through the work of Berlyne and his associates. Explanation of preferences by means of such energy concepts may be traced to early empirical psychologists. Birkhoff (1933) wrote of "the feeling of effort or tension" which he considered to derive from the complexity level of aesthetic stimuli. Rashevsky (1938) and Eysenck (1942) explained increasing preference for more complex stimuli in terms of central nervous system "energy" levels. It was Berlyne's (1960) work which popularised the notion of "arousal-jag" to explain why some complex stimuli are pleasing.

Berlyne's thesis is that an increase in arousal is generally pleasurable, unless it is so great as to become aversive. He discussed both arousal-increasing devices (Berlyne, 1971a, chapter 11) and arousal-decreasing devices (*op. cit.*, chapter 12). He also argued that individuals with a high prevailing level of arousal will consistently tend to be averse to complex, novel or otherwise arousing aesthetic stimuli (*op. cit.*, p.258).

Whilst the theory has a broad range of application, conflicting evidence has been neglected or glossed over. For example, Berlyne and Peckham (1966) predicted that individual differences in interest for more complex visual patterns and fixation on those patterns would be positively correlated; and that preference for more complex patterns would similarly correlate with choice of more complex patterns for further viewing. These predictions follow from the notion that people differ consistently in their arousal level, and that the observed behaviours or ratings reflect those differences. However, the two relevant correlations were not reported; instead, another unpublished study was cited to "provide some measure of corroboration for our speculations".

One crucial test of the arousal theory involves the use of the galvanic skin response as a physiological indication of arousal. It is

known to be a sensitive measure; for example, a change in a stimulus sequence evokes large responses (Berlyne, 1961). Now, more complex stimuli are regarded as more arousing and should therefore give greater responses, according to the theory. Indeed, Berlyne and Lewis (1963) regarded the evidence as clear, since they wrote of "the complexity and incongruity variables that have been shown by several previous studies to affect ... the galvanic skin response". However, with five experimental groups, a small significant difference between Berlyne's more-complex and less-complex patterns occurred for one group only (see Appendix 1.1). This hardly demonstrates convincingly that more complex patterns are usually more arousing than simple patterns. Indeed, according to Davis's (1957) research "It looks as though any stimulus would produce an increase in sweat gland and muscular activity". Further disconfirming evidence of a more general kind has been produced by Apter (1976). He found that some highly pleasant stimulus situations may be considered highly "arousing", but others may be low in felt arousal, while some are average. This appears to contradict any simple explanation of hedonic tone in terms of arousal.

A fundamental difficulty with arousal theory is that it provides "double-headed" explanations (of the kind illustrated above with the Oedipal concept). That is, the theory may accommodate opposite findings, at least in some areas. An illustration of this "flexibility" is provided within the report of Berlyne and Lewis (1963). They predicted correctly that "high-arousal" groups would give longer total viewing time for visual patterns, measured by the length of time that subjects continued to press a response button. But suppose the opposite result had been obtained. It might then have been argued that the patterns were too disturbing for the already aroused groups. In fact this form of explanation was offered in Berlyne and Lewis's report to account for the choice of *less* complex patterns for further viewing in another part of

the study. Thus whatever the results obtained, the arousal concept may be used, since arousal may be either too high or too low in a largely unspecified manner.

The theory becomes more ambiguous with the introduction of the concept of "diversive exploration", which "occurs in conditions that are not conducive to perceptual curiosity" (Berlyne and Peckham, 1966). The concept was used to explain the greater preference for low-complexity patterns after long exposure than after short exposure. However, in another study (Berlyne and Lewis, 1963) the control group *less often* preferred low-complexity patterns for further viewing after previous exposure to similar patterns. This too could be explained, since in this case specific exploration of the more complex patterns "will be reinforced more strongly" because of their greater arousal characteristics. Thus either result could be explained within the ambit of arousal theory.

A more detailed account of work with Berlyne's patterns is given in chapter 3 of this thesis. The work is important because of the large body of empirical data which has been collected. Enough has been presented here to show that arousal theory as applied to divergent thinking and aesthetic preferences is appealing in its scope, but lacks precision in its application.

(b) Cognitive theories

Several theories have as a common theme the notion that people differ in the skills and strategies whereby they process incoming sensory information and their own ideational information, whether this be for the purpose of solving an intellectual task or making an aesthetic judgement. An example of such a theory would be Guilford's model of intellect, in which divergent production and evaluation are two modes of operation within the framework of intellectual processes. The model is intended to account for relationships amongst individual differences in performance on various

tests of ability and expression. Guilford's theory stresses the separation between different facets of intellectual performance (see chapter 5); but the point emphasised here is that the model is concerned with tests involving various kinds of information processing, including both divergent production and evaluation which are the facets most involved in creativity (Guilford, 1957).

Several theoretical accounts of divergent thinking treat the topic broadly in cognitive terms, not necessarily using the mathematical tools associated with information theory. A well-known example is the work of Koestler in "The Act of Creation" (1964). Koestler considered that original thoughts, whether in the realms of art, science or humour, occur as an act of "bisociation" between two previously separate matrices of thought. One of Koestler's examples will clarify the notion of matrices (informational systems) and their bisociation or novel integration. Gutenberg, who invented printing with movable type, was familiar with three distinct ideas deriving from different aspects of his experience: block-engraving, used then for printing playing cards; metal castings, then used for seals; and presses, used to crush grapes for wine. The combination of these separate matrices of thought led to the idea of using movable lead in a printing press for the mass production of books.

A modern example of the fruitful combination of information from different "matrices" is provided by Watson's (1968) account of the discovery of the double-helix structure of the DNA molecule. Watson realised that finding the chemical basis of heredity was the challenging problem of the period: "I daydreamed about discovering the secret of the gene" (p.30). He and Crick brought together the required knowledge of chemical analyses, the X-ray chrystallographical data of Franklin, and the model-building techniques used successfully by Pauling to deduce the molecular structure of protein: "All we had to do was to construct a set of molecular models and begin to play ..." (p.50). The story illustrates

common features of creative activities, as listed by Newell, Shaw and Simon (1962): recognition of a problem ripe for solution; the novel combination of previously discrete information systems; the value of the outcome to current or future society; and persistence of thought and effort despite setbacks and despite initial false "solutions".

For Koestler, the person best able to think divergently yet within the bounds of potentially useful ideas, is one who is flexible, with matrices not too fixed and clearly bounded. A preconceived, dogmatic approach, with each matrix firmly controlled by its own code of "rules", is antithetical to humour, art and scientific discovery. Koestler particularly criticised the boredom, the static concept of the world, presented by many scientific texts, so that for the science student "the mysteries of nature are drummed into his head as if they were paragraphs in the penal code" (1964, p.295). The possibility that many science students tend to "match" the textbooks described by Koestler, having poor divergent thinking ability and being highly conventional, is explored in chapter 9 of this thesis.

Kelly (1955) in his theory of personal constructs put forward a view somewhat similar to Koestler's. Kelly considered that creative thinking depends on some initial loosening of normal constraints on the free flow of ideas, although convergent, rational thought is required to bring ideas to fruition and to evaluate them. He remarked (1955, p.528) "The Creativity Cycle is one which starts with loosened construction and terminates with tightened and validated construction" (original italicized). Another description of original thinking similar to Koestler's is that of Hebb (1958, p.214). "A new idea, a new insight, is the adventitious occurrence of a certain combination of mediating processes". Spearman (1930) considered that the "eduction of relationships" is the essential ability underlying creativity, as for other forms of reasoning. These conceptions all imply that divergent thinking involves the "playful"

manipulation of existing informational systems to evolve a novel and fruitful conjunction.

The notion of "playing" with exact scientific information may seem fanciful, and there is an apparent contradiction between the creative research scientist's reliance on existing knowledge and techniques and the postulated independence and freedom from convention which allows a restructuring of that knowledge. Nevertheless, the appropriateness of this double-sided view of scientific discovery may be illustrated by the formulation of the periodic table of chemical elements by Mendeleef, as described by Kedrov (1966). Much of the basic information about elements, such as their atomic weights, was already familiar in Mendeleef's time. However, he had the particular problem of organising elements into groups, so as to organise the chapters of a textbook he was hurrying to complete. He happened to be fond of playing patience, and found it helpful to write out the properties of each element onto cards, in order that they might be ordered and re-arranged. After some months, these attempts at systematic arrangement finally allowed him to realise and formulate the "periodic law" of atomic weights. Thus both the importance of basic knowledge and the importance of "playfully" re-structuring that knowledge, are illustrated by Kedrov's account.

The informational approach has led several writers to postulate testable hypotheses as to the nature of individual differences in divergent thinking. Rogers (1959) proposed that divergent thinking ability was related to openness to experience. "This means that instead of perceiving in predetermined categories (trees are green; college education is good; modern art is silly) the individual is aware of this existential moment as it is ... It means the ability to receive much conflicting information without forcing closure upon the situation". The theory of openness to experience, which is supported by Barron's research (*e.g.* 1969), is further specified in terms of testable hypotheses and investigated in chapter 7.

The notion that divergent thinkers delay "closure", that they delay critical assessment of novel ideas and behaviour, is similar to Cropley's view that divergers learn less rigid adherence to "stop-rules", and thus retain some "willingness to express impulses" (Cropley, 1967a, pp.46-51). The converger, by contrast, "cannot proceed, especially into areas of emotional expression, without clear and authoritative route signs" (Hudson, 1968, p.67). Another hypothesis related to the theory that divergers are willing to accommodate more diverse informational possibilities, is presented by Wallach and Kogan (1965b). They considered that American school-children who scored high on divergent tests would tend to show tolerance of "deviant" information, and thus have a large "band-width" in categorising instances. To test the hypothesis, an adaptation of the Pettigrew "Category-Width" test was used. The test asks factual questions such as: "Most birds fly at about 17 mph. How fast does the fastest bird fly?". Items are scored according to the degree of acceptance of wide-range possibilities filling the category. Wallach and Kogan confirmed that divergers, both boys and girls, did obtain higher scores on the Category-Width test than convergers. Data obtained by Cropley (1967a, p.40) with Canadian children supported this result.

Similar cognitive accounts have been put forward as approaches to the understanding of visual art and aesthetic preferences. In some cases, theorists have suggested that processes in visual perception may closely parallel those involved in creative thinking. Arnheim (1966, p.297) noted that creativity involves the restructuring of experience, and that a limited instance of such restructuring occurs during the prolonged inspection of geometrical figures. He commented that "Art educators use their ingenuity to find effective methods of breaking down the familiar norms of perception and representation".

Historical analyses of the art of painting show that it may be used to convey information, to communicate between painter (and perhaps

his employer) and the "audience". Irvin Child (1969, pp.866-870) discussed the ways in which meaning is conveyed in visual art. Gombrich (1966) gave various examples. Thus medieval art was used largely "for telling the sacred story". Court portraiture was used to convey the superiority of the aristocracy: for instance, Vandyke "helped to crystallize the ideals of blue-blooded nobility" (Gombrich, 1966, p.305) as in his portrait of Charles I of England. The writer has admired tapestries commissioned by the first Duke of Marlborough hanging in Blenheim Palace, which represent with meticulous care each of his victories over the armies of Louis XIV. With nice irony, the tapestries were made in France to further underline the message of victory and defeat.

Moles (1966) has particularly emphasized the communicational function of art, and has made the strong assumption that "esthetic information obeys the same general laws that govern all informative messages" (p.132). Even so, he distinguished between semantic and aesthetic information, mainly on the ground that the former may be described in a general "meta language", whereas aesthetic information is personal to the source-receiver diad (p.131). The transmission of aesthetic information varies according to the recipient's "repertoire of knowledge, symbols, and *a priori* structures" (p.132). This variation in transmitted information would seem to apply to many semantic messages also (Harre, 1976).

An informational approach has been adopted by several writers specifically in relation to preference for complexity in works of art, both in terms of group trends and in terms of individual and subgroup differences. Writing about musical composition on a chapter on information theory and art, Pierce (1961, ch.13) considered that only when the composer "doles his variety out at a rate of a very few bits per second can be expect an audience to recognise and appreciate it".

With regard to visual pattern preferences, the "inverted-U" hypothesis suggests that if the degree of preference for each of a set

of visual patterns is plotted against some measure of pattern complexity, there will be a maximum preference for some intermediate level of complexity. Munsinger and Kessen (1964) argued that such a relationship is to be expected if there is an intermediate level of stimulus uncertainty which is most preferred, corresponding with the observer's limited capacity for processing information. Walker (1973) has proposed the inverted-U relationship between psychological complexity and preferences as part of his general theory. However, he considered that arousal, rather than information value, is the "organismic state which serves to modulate the psychological complexity of a psychological event" (p.72).

A precursor for the inverted-U hypothesis was provided by Moore (1914, p.19) writing about the appreciation of music: "It is the barely successful synthesis, in which the individual accomplishes with difficulty the unification of a manifold, that he finds the keenest pleasure". In other words, the most pleasant stimulus arrangement is that which is complex but not too difficult to comprehend. Modern research on group trends of reactions to visual stimuli plotted against measures of complexity is presented in chapter 2.

Subgroup differences in the complexity of the most preferred stimulus are predicted by an information approach. Subgroups which have less experience with relevant stimuli or which have less ability to process such information, would be predicted to have greater preference for simple stimuli; whilst experienced subgroups would be predicted to have greater preference for complex stimuli. Thus art students would be expected to show an increasing preference for more complex patterns (Munsinger and Kessen, 1964). Young or inexperienced observers might prefer stimuli which are less complex, as shown for pictures (Rump and Southgate, 1967), scientific films (Rump, 1967b and guessing-games (Eckblad, 1963). Further subgroup differences, between arts and science oriented students, are described in chapters 4 and 10.

Individual differences in preference for complexity in visual patterns may also be described in informational terms. In particular, one would expect that preference for complexity would be positively correlated across individuals with amount of fine-arts education and with interest in fine-arts, as suggested by Welsh (1959). This matter is discussed briefly in chapter 2, while Part C of the thesis includes several experiments concerned with variables correlating with measures of preference for aspects of stimulus complexity.

(c) Personal style and choice

One of the themes espoused by "humanistic" theorists is that of personal choice and growth. For instance, Rogers (1955) wrote about the client undertaking psychotherapy: "Involved in this process of becoming himself is a profound experience of personal choice". To some extent this point of view might seem to express an abnegation of scientific determinism, a denial that aspects of creativity, for instance, might be explained by any general theoretical system (Bergson, 1946, reprinted 1976). However, to the extent that the approach emphasizes personal "styles", the nature, consistency and development of these styles may be investigated empirically.

Little (1972b) has advocated an approach of this kind as the basis for personality research. Persons, including psychologists themselves, are seen as "specialists". This conception applies to professional skills but also to interests, competencies and modes of social interaction. As a model of man, this is clearly vague, but the metaphor has interesting implications. It suggests that specialised education may lead to specialised personality profiles, including competencies, activities, preferences, and dispositions. It suggests also that such specialisation may increase with age and education, so that consistent personality styles may be more apparent in, say, senior secondary-school classes than in junior classes. Consistent styles may revolve around important areas

of specialisation such as those associated with tertiary education and career choice. Finally, it suggests that personal styles develop not merely as a passive acceptance of one's abilities and traits, but as an active seeking for "channelized competence". As Taylor (1976, p.198) expresses this last point: "the essential nature of the organism is to shape or design its environment rather than to be shaped or designed by it".

Holland's theory of careers (1973) provides a further development of this approach. He argued that there are six major areas of career specialisation, and that a person's profile of interest in those six areas indicates wide-ranging personality characteristics as well as fields of competence. This theory is examined in relation to artistic and scientific specialisation in chapter 9 of the thesis. The theory readily encompasses the view that both characteristic modes of thinking and aesthetic preferences are related to areas of interest, and particularly to level of artistic interest.

Several writers have suggested that scores on divergent thinking tests indicate a preferred mode of operation or cognitive style, rather than a fixed ability akin to convergent reasoning. "Differences between highly divergent and highly convergent individuals would, in this conception, be understood not in terms of how much they possess of one or other ability, but in terms of the style or bias of their way of utilizing whatever intellectual capacities they possess" (Cropley, 1969, p.5). Thus "some able people may prefer to function one way, some the other" (Cropley, 1967a, p.6). Similarly, Vernon (1964) considered that creative persons are mainly distinguished by interests and attitudes rather than by abilities.

Hudson (1968) emphasized the role of personal choice even more strongly. He considered that an adolescent when choosing a career, is "involved in a choice among selves that already exist inside him" (p.72). This proposition implies some flexibility in response styles,

when required. It was supported by "anecdotal" evidence, in that Hudson found when he was ill-tempered, a class of fifth-form pupils were flexible enough to give an unusually high number of responses on divergent thinking tasks. Hargreaves (1977) gave a more systematic illustration of flexibility, in the sense that young children may choose between possible response styles. He found when giving a divergent task to children of about ten years, that boys gave more "mechanical-scientific" and fewer "domestic" responses than girls. These sex differences were reversed when the children were asked to pretend to be the other sex.

Despite this evidence of flexibility in divergent style, it is clearly the case that the more specialised people become, the more alternative pathways close behind them. For instance, Eiduson (1962) wrote of the restrictions consequential upon a specialised scientific education: "... men who were interested in literature and music and art, in culture and humanities, have had so little opportunity to capitalize upon these interests once they become scientists, that essentially they have cut off the strings that have made them one with the larger intellectual community" (p.259). This theme is explored in investigations described in chapters 9, 10 and 12 of the thesis.

The idea of personal style implies wide variations between persons but consistency within persons, over a range of chosen behaviours or preferences. In its application to visual preferences, the work of Child (1965) may be cited. He considered various "cognitive style" variables in relation to his measure of aesthetic judgement such as "tolerance of ambiguity". As Hogg (1969, p.72-76) has pointed out, hypotheses relating such styles to aesthetic preferences are usually "ad hoc" rather than systematically deduced within a theoretical system. Nevertheless, Child's research showed that the approach is useful in providing interesting data to encourage more detailed theoretical specification.

There is a particular difficulty with the personal-style approach to aesthetic preferences, which has methodological implications. Suppose that symmetrical and asymmetrical patterns were presented, and all observers preferred symmetrical patterns, to an equal extent. In such a case, with a highly consistent group effect, there would be no subgroup "styles" to differentiate. Application of the approach requires the selection of stimuli which do give rise to diverse preferences. On the other hand, if each individual's "personal aesthetic theory" is completely idiosyncratic, if "styles" are completely personal, then no theory based on a limited set of hypothetical styles could accommodate the data with precision. (Examples of such idiosyncratic choices in response to a pattern preference test are given in chapter 7). A theory of response style may therefore be applied most readily when persons differ systematically along a measurable dimension, rather than idiosyncratically. This condition would appear to apply to preference for complex and for asymmetrical visual patterns, to a large degree (*cf.* chapters 7 and 8).

(d) Learning

Some theorists argue that divergency is learned in ways similar to those applying to other forms of behaviour. For instance, Skinner (1968, ch.8) considered that originality is aided by avoiding too much over-learning that produces rigidity; by teaching alternative responses to questions like "we drink coffee from a tube called a ...?"; and by rewarding over-production of varied responses. Skinner concluded that there is "nothing relevant to freedom, individuality, or creativity which cannot be taught effectively and to large number of students". Newell, Shaw and Simon (1962, p.65) considered that "creative thinking is simply a special kind of problem-solving behaviour". There is an obvious difficulty in this approach, in that the forms of behaviour usually

studied by learning theorists, such as running mazes or solving anagrams, may be defined *a priori*. This is by definition not the case with original, divergent responses. Nevertheless, it has been argued that the conditions for encouraging the development of divergency may be empirically determined, and that a divergent mode of responding may be learned. This conception of a learned style of responding, rather than a specific habit, is perhaps similar to the idea of a "learning set" as generalised learning derived from experiencing many related but differing tasks (Postman, 1971, pp.1033-1045).

Three areas of experience have been investigated as relevant to the development of divergency: within the family, within the classroom, and within specific training programmes. It is sufficient here to give examples from each area. In general, conditions which allow independence, provide wide experiences and a number of alternative "models", and which encourage diverse activities by the restraint of criticism or punishment, seem to be associated with the development of divergent abilities.

The family backgrounds of highly creative architects were reported by MacKinnon (1962a). He noted that their parents had shown "an extraordinary respect for the child". Independence was expected, and "emphasis was placed upon the development of one's own ethical code". Families often moved home, and adults other than the parents were available as models for the child. Helson (1961, p.iv-12) noted that creative mathematicians have strong "cross-sex parent ties", making more cognitive resources available. Dewing (1969) reported that the family's practice of "unusual" religious beliefs, associated with not conforming to the majority view, was related to high divergent thinking scores in school-children. She also reported that the fathers of high-scoring boys tended to describe themselves as independent, inventive, imaginative and original, suggesting some familial resemblance in creative traits. Watson (1957) reported that loving, permissive parents had more creative

and independent children than loving, strictly-disciplining parents. (Watson's results might be interpreted as showing that creative children are able to devise means to encourage permissiveness in their parents.) Cropley (1967a, p.60) has summarised such evidence concerning family conditions: "the kind of parents who tend to foster divergent thinking in their children are those who permit the child to function independently and treat him as a worthwhile person".

Torrance (1970) has elaborated school-conditions which foster creative thinking abilities, in some detail. His basic proposal is that "man fundamentally prefers to learn in creative ways through creative and problem-solving activities" (p.1). In a chapter entitled "Awakening Unrecognised Potential", Torrance described schooling projects in which disadvantaged children flourished with a diversity of activities, when carefully organised opportunities for creative work and play were provided.

Within a normal school system, Haddon and Lytton (1968) hypothesized that more informal, progressive teaching would promote divergent thinking more than formal, subject-centred teaching. Children in "informal" primary schools did in fact gain higher scores on six divergent thinking tests, the differences being significant in five cases, with schools matched for mean verbal reasoning quotient and socioeconomic background. Haddon and Lytton (1971) followed up the majority of these pupils about four years after, and confirmed the original differences, irrespective of the type of secondary school attended.

A description of the stifling effects of a formal primary school, as it used to exist in rural England, is provided by Laurie Lee (1978) in his autobiography. His teacher was called "Crabby" by the pupils, whose schooling "seemed to be designed simply to keep us out of the air and from following the normal pursuits of the fields. Crabby's science of dates and sums and writing seemed a typical invention of her own,

a sour form of fiddling or prison-labour like picking oakum or sewing sacks" (p.50).

Lytton and Cotton (1969) hypothesized that the differential influence of formal and informal schools would be found at secondary school level also. However, they did not obtain a consistent difference in divergent thinking scores between two schools of each types. This may reflect the fact that in secondary schools, teaching styles depend more on the particular subject of study, teachers and teaching methods, rather than being common throughout the school. Thus, within secondary schools, pupils given "modern methods" of mathematics teaching tended to score higher on divergent tests than those given "traditional methods" (GopalRao, Penfold, and Penfold, 1970).

Care must be exercised in comparing "formal" and "informal" teaching methods. In the first place, these notions are complex; an informal school may encourage pupil participation, have less punitive discipline, use a wider range of methods, and so on, and it is not clear which aspects of the regime are responsible for encouraging divergency. Secondly, it is likely that not all pupils would respond well to the less restrained, unstructured setting of the informal class: for example, a student under my supervision (Parham, 1978, p.35) found that extraverted children tended to have higher achievement than introverted children in informal classes; but with formal classes, introverted children tended to obtain higher achievement scores. Joyce and Hudson (1968) also noted teacher-student interaction effects on medical students' examination performance.

The evidence that divergent thinking may be encouraged by variations in teaching method is sufficiently strong to have gained common acceptance. For example, even in the "conservative" area of education for professional engineering, some writers have argued strongly for the development of technological creativity at universities and have

suggested techniques to encourage engineering innovation (Gregory, 1972).

This leads to the topic of specific training for creativity. Several techniques have been suggested, requiring from few minutes training to many months. Two related issues with such training courses are: (a) How specific should the content of such courses be?; and (b) How specific are the observed effects of such courses? In particular, for the purpose of the present thesis, it is of interest to ascertain whether "creativity training" affects aesthetic preferences as well as divergent thinking, as would be expected if there is some affinity between the two. The topic is investigated in chapter 11 of the thesis, in which evidence of the effectiveness of specific training courses relevant to creativity is reviewed.

Various kinds of enquiry clearly show that artistic work and preferences may be modified by different experiences, particularly art-education courses. Whilst this thesis is not concerned with such courses, it is relevant to mention some of this research to show how learning theory has been applied to this field. For Burkhart (1964), creative learning in visual art may be seen as an increase in complexity of the product (such as a still-life drawing), or by a change in strategies of working. He considered that "self-reflective" learning was important. Thus "Students made much greater gains under self-discovered criteria than Authority Designated ones" (p.28). Moreover, photographs used for feed-back evaluation during the courses, which were taken during a drawing's development, "proved superior for learning in art to providing the student with the photographs of the two or three End Products".

Of course art education courses may be designed to encourage students to modify their aesthetic preferences so as to approximate the aesthetic judgements of contemporary art experts. There is the possibility of a paradox here. For the judgements of experts may favour diverse, complex forms of art, and indeed be divergent from the layman's

point of view; yet if the student learns to adopt the expert's view as his own, he is thinking convergently, he is attempting to adduce the single "correct" answer. Learning aesthetic judgement in this sense, then, cannot be considered a divergent activity.

Nevertheless, studies of this kind illustrate the application of learning theories in the field of artistic preferences. Child and Schwartz (1966) hypothesized that providing immediate informational reinforcement during a training session would increase scores on an aesthetic-sensitivity test. Reproductions of art-works were shown by slide-projection in pairs of an aesthetically better item and a poorer item, as previously assessed by art experts. College students selected which they preferred from each pair of slides, and were told whether they were right or wrong. High scorers on the initial test of aesthetic sensitivity as well as low scorers generally "improved" their scores on the training task itself, and on the subsequent sensitivity test. It was similarly found that as early as the fourth grade, school pupils "can readily learn some discrimination between what experts consider better and poorer works of art" (p.53). The authors emphasized, however, that the effects of learning during their experimental sessions were not as striking as the individual differences which existed initially.

Conclusions

A number of theoretical approaches to the understanding of divergency and aesthetic preferences have been outlined, rather than any single point of view. The relationships between these approaches and specific theories which are examined in subsequent chapters have been noted.

It has been shown that the four types of theory outlined can be applied to both divergency and aesthetic preferences, and that various arguments suggest that individual and subgroup differences in the two areas could be associated. Both divergency and aesthetic preferences

might be affected by a common motivational disposition, by the informational load of tasks and stimuli, by coordinated cognitive styles, or by learning experiences affecting both areas. Part C of the thesis explores some of these possibilities using a variety of methodologies.

Although the four different approaches outlined above appear to provide alternative, competing explanations, they are not necessarily incompatible. Each theoretical approach embodies some truths, and it is therefore appropriate not to limit the investigations to any particular theoretical position in advance. For instance, cognitive styles may well be characterised by differential preference for structured information, acquired by specifiable learning processes, and motivated in part by their functioning as "ego defenses". In this way it is possible to regard the four approaches as complementary, rather than as alternative accounts. It remains for the empirical studies of specific hypotheses in the following chapters to determine which approach does have the most heuristic value when faced with the grinding mills of data analyses.

Finally, the possibility is acknowledged that the selection of stimuli and measures in the empirical studies can have unintentionally biased results in favour of one theoretical approach rather than another. In particular, abstract visual patterns, usually in black and white, have mainly been used in the writer's studies of aesthetic preferences. These lend themselves to informational interpretations, whereas colourful realistic pictures might have led to interpretations in terms of arousal or motivation. Similarly, divergent thinking tests known to be reasonably reliable were used rather than projective techniques or "free-response" methods. Perhaps this biased the studies in the direction of "cold creativity" (Taft, 1971b), and that other measures of "hot creativity" might have led to a greater emphasis on emotionality, impulse expression and imagination. The reader should allow for such

selection of methods in interpreting the studies to follow: "all experimental reports are deceptive, because they give a false impression of sureness of interpretation" (Crowle, 1976, p.170).

PART A

THE NATURE OF VISUAL PREFERENCES AND RELATED RESPONSES

Chapter 2. Responses to visual patterns in relation to complexity

Chapter 3. Experiments using Berlyne's figures and similar material

Chapter 4. Figure preference in relation to complexity and regularity of stimuli, and in relation to age of observers, using Welsh's data

CHAPTER 2

RESPONSES TO VISUAL PATTERNS IN RELATION TO COMPLEXITY

Perceptual and aesthetic responses to aspects of complexity in visual patterns are discussed in this chapter. Studies by the writer in this area are then described, and findings discussed in relation to an informational model, and in relation to Terwilliger's (1963) adaptation-level hypothesis. However, experiments using Berlyne's (1960) patterns are separately described in chapter 3; Welsh's (1959) data, and children's preferences, are also discussed separately, in chapter 4. These accounts attempt to explicate the nature of some of the main effects found in the study of visual pattern preferences, using an information approach as described in chapter 1. The material described in the present Part of the thesis serves as background to the use of aesthetic preference tests in studies of individual and subgroup differences described in Part C of the thesis.

One approach to the understanding of perceptual processes generally is to elucidate the relationships between the informational properties of stimulus patterns and corresponding perceptual responses (Lindsay and Norman, 1972). As an example of the historical development of the informational approach, Marshall (1977) has described the work of Gibson in the areas of object and space perception. The approach received a boost with attempts to apply mathematical information-theory analyses to stimulus complexity (*e.g.* Attneave, 1954 and 1959). Thus in a visual matrix of independent dichotomous elements, such as a square matrix with random black or white cells, the amount of information in the pattern is specified in bits by the number of elements. ("Information" is used mainly in this technical sense, rather than referring to "messages" in the form of words or representational drawings.)

The mathematical application of information-theory has been criticised (*e.g.* Green and Courtis, 1966), on the ground that observers' perceptual strategies may not correspond with the optimal sequential processing of pattern elements implied by the "objective" informational analysis. People may not perceive patterns in a manner analogous to an electronic optical-scanning device. Nevertheless, the general application of the informational approach has been very fruitful. It clearly suggests the importance of complexity in stimulus patterns as a determinant of perceptual responses; and suggests three main dimensions of such complexity, the number of elements, their heterogeneity (that is, the number of types of element), and their redundancy (that is, any symmetry or other regularity in the pattern).

If various perceptual responses to visual patterns can be shown to have systematic relationships with aspects of stimulus complexity, understandable in terms of the information which the observer has to process to achieve the responses concerned, then the informational approach is thereby vindicated. The approach does not depend on the appropriateness of a strict mathematical application of information theory measures, but only on the usefulness of its general concepts.

Some psychologists have advocated the use of multidimensional scaling analysis to elucidate relevant stimulus dimensions in visual patterns, and the way these may be used by different subgroups of observers in categorising or distinguishing the patterns. For example, Silver, Landis and Messick (1966) studied the categories which art students formed from sets of random or geometrical black/white figures. Five distinct "viewpoints" were found for different subgroups, although in all cases complexity (the number of sides to each figure) was a prominent determinant of categories. It is almost inevitable that multidimensional scaling techniques will provide a detailed and

complicated specification of the nature of responses to visual stimuli. It is the writer's opinion that other, less sophisticated, analyses of the kind discussed in this chapter provide a more parsimonious account of at least first-order effects of importance.

Dimensions of stimulus complexity

The concept of "complexity" is itself semantically complex (Day, 1967a). One of the problems when one attempts to interpret the literature on the effects of visual stimulus "complexity" is that various aspects, and particularly multiplicity of elements and asymmetry, are not clearly distinguished. This may be because in certain theoretical systems various kinds of complexity are supposed to have common effects on responses. Thus complexity may be seen as leading to "arousal" or as representing "informational load", and differences between the various forms of complexity may be neglected or confused. Hutt (1970, p.126) has criticised Berlyne's "vernacular use" of the term "complexity" as liable to lead to confusion.

An example of the confusion which results, is provided by the work of Berlyne, Ogilvie and Parham (1968). They applied multidimensional scaling to judgements of complexity (*inter alia*) with visual patterns as stimuli, and concluded that "judged complexity is a major determinant of judged interestingness and judged pleasingness". This clearly suggests a unitary concept. Indeed they considered that "On the whole, all these (complexity) variables have been found to have similar effects". However, two distinct factors involving complexity were found in their study. Inspection of the factor plot and the nature of the stimuli (Berlyne *et al.*'s Figs. 1 and 2) shows that factor I largely represented the number of elements in patterns. Factor II represented symmetry/asymmetry in that of those eight patterns with below-the-median loadings on factor II, six were symmetrical; while of those eight patterns

with above-the-median loadings, seven were asymmetrical. Despite this clear identification of factor II with symmetry/asymmetry, the authors considered it hard to identify and referred to an unsupported interpretation in terms of "unitariness *vs*. articulation into easily recognizable parts".

As will be shown further in the next chapter, the confusion between simplicity in the form of symmetry and simplicity in the form of paucity of elements in a pattern has led to quite false conclusions being drawn by eminent writers in this field. For example, Irvin Child (1969, p.898) discussed Berlyne's work and referred to "a tendency for subjects to judge especially pleasing the stimuli whose complexity is either very low or else fairly high but not the highest." Such a hypothetical trend is contrary to the evidence presented below, in studies where only the number of elements is varied. The supposed pleasing quality of "low complexity" patterns in fact stems from a general preference for symmetrical patterns, and this is a distinct effect from the trend over multiplicity of elements.

Similar confusion has occurred in Eysenck's interpretations of data, stemming from his attempts to combine both multiplicity of elements (Eysenck refers to "complexity"), and symmetry (part of Eysenck's concept of "order") into one "factor". Consider the interpretation of preference ratings for 90 polygons in a study by Eysenck (1968). A third-order factor was extracted from the correlations across subjects, between stimuli; and polygons with high positive and negative loadings were found. It should be noted that the results were obviously dependent on the stimulus sample, and the factor did not indicate shapes with high or low preferences. Inspection of the two contrasting sets with positive or negative loadings shows that one consisted of familiar shapes with mainly right-angled turns, whereas the other consisted of less familiar shapes with mainly acute-angled turns. (The shapes are shown in Appendix 2.1).

Eysenck (*op. cit.*, p.11) interpreted the factor as "order *vs.* complexity", so that both symmetry and multiplicity were supposed to be combined in what Eysenck called "this all-embracing super-factor" (p.12). Yet the so-called complex polygons have *fewer* turns on average (a mean of 6.4) than the so-called simple polygons (9.4). Moreover, *both* sets are characterised by "order" in the sense that all polygons in one set show mirror symmetry about a vertical axis, and all polygons in the other set show either this form of symmetry or rotational symmetry (see Appendix 2.1). Thus Eysenck's linking of "order" and "complexity" in one factor is quite unjustified by this evidence, since the factor represents neither symmetry or multiplicity.

In a follow-up study, Eysenck and Castle (1970b, p.77) referred to the third-order factor found earlier as the "simplicity factor". Because the factor was positively correlated (r = .28 across items) with mean preferences given by a group of artists, Eysenck and Castle concluded that "artists value simplicity". The conclusion was contrary to much evidence concerning the preferences of artists and non-artists, and was not justified by the nature of the factor described above. The confusion stems from the original misconception (Eysenck, 1968) as to the identification of the factor. (Chapter 8 provides further elaboration of this issue.)

It is clear from the foregoing discussion that major stimulus dimensions should be distinguished in the analysis of preferences. The writer agrees with Eisenman and Rappaport (1967) that "the symmetry-asymmetry dimension deserved investigation in its own right, and cannot necessarily be equated with complexity-simplicity". Similarly Leeuwenberg (1973) commented that "before the dimensions and descriptive categories (logons) of patterns have been specified, the application of information theory is pointless".

If is therefore unfortunate that various aspects of figural complexity are confounded in one of the most frequently used tests of individual differences in aesthetic preferences, the Barron-Welsh Revised Art Scale. In an attempt to face this problem in the present research, other preference tests were also used in some of the investigations reported in Part C of the thesis (chapters 7, 8 and 10). At the same time it is convenient in the thesis to use the expression "preference for complexity" when several dimensions relevant to complexity are involved, or when the particular stimulus variable is clear from the context.

Most studies have involved objective measures of stimulus complexity, but subjective complexity may also be assessed. The question therefore arises as to whether consistent judgements of complexity are possible, and whether subjective complexity is linearly related to objective complexity measures. It has been found that fairly reliable judgements of the subjective complexity of visual patterns or shapes may be obtained, at least when they vary in relatively few dimensions. Judgements also tend to be consistent across different methods of assessment (*e.g.*Elliott, 1958).

Attneave (1957) found that the subjective complexity of random polygons was determined almost entirely by the number of sides (or turns). The correlation between judged complexity and "log. turns" was .93. Others have since reported similar findings. For instance, Day (1967b) found that mean subjective complexity rose steadily with increasing number of sides for polygons. A fairly linear relationship was found in four separate studies, and mean subjective complexity continued to increase with number of sides at least over the range of 10 to 130 sides.

Preferences in relation to multiplicity of elements

This section is concerned with preferences expressed in terms of various evaluative responses, such as ratings of liking, pleasingness, or aesthetic preference. It is believed that such ratings are broadly

similar, and probably represent a "general evaluative factor" (*e.g.* Hardiman and Zernich, 1977, p.455). Therefore, various measures of evaluation are included in this section.

McClelland (1955) noted that "a moderate increase in stimulus intensity in any sense modality may lead to pleasure and a further increase to pain". This implied an inverted-U shaped relationship if a measure of pleasantness or preference were to be plotted against stimulus intensity. It has similarly been postulated that there is typically an inverted-U relationship between preference and complexity of visual patterns, when complexity is varied in terms of the number of component elements in the patterns. Most research of interest here has been with abstract patterns, but the interpretation has been applied widely, in such fields as environmental planning (Rapoport and Kantor, 1967).

Such a relationship has been explained in informational terms, as described in the previous chapter. A very simple stimulus pattern provides so little information as to be boring, whilst a very complex pattern overloads the observer's capacity to process information. As Gombrich (1963) remarked: "There is a clear limit to the visual information we can assimilate in any given glance". Phrasing this in a more positive fashion, "humans should prefer stimulus material with complexity values at or close to their maximum processing ability" (Vitz, 1966).

Ad additional point needs to be made when unlimited viewing time is available, since additional information from a very complex pattern could obviously be processed by the observer taking more time. Presumably, then, when an observer assesses his own pleasure at viewing a complex stimulus, he may be unwilling to take the required time to appreciate all the information available, or if he does spend a long time this may itself be somewhat aversive. Thus the dislike of very complex patterns may not be due to any absolute limit of "processing capacity", but rather to an observer's view as to the appropriateness of the information load, given the role of the stimulus (as say an artistic picture or as a technical

drawing) and the time he is willing to spend on its appreciation. Day (1968b, Fig. 1) found that observers looked at a random polygon, particularly a more complex one, for less time if asked to look as long as it was "pleasing", compared with instructions to look long enough for recognition later.

Other theoretical views as to the effects of stimulus complexity on preferences or hedonic tone are not compatible with an inverted-U shaped relationship. In particular, Birkhoff (1933) considered that aesthetic pleasure is inversely proportional to figural complexity, whilst Eysenck (1941a) found the opposite, that aesthetic pleasure is positively associated with having six or more sides to a figure. Eysenck reviewed research using Birkhoff's set of polygonal figures (*e.g.* Davis, 1936), and showed that Birkhoff's formula was grossly inadequate in relation to preference ratings. However, Eysenck's own formulation, whilst in some cases more accurate, is nevertheless misleading in that the possibility of a curvilinear trend with multiplicity of elements is neglected (*e.g.* 1968).

There have been several studies which have found evidence in favour of the hypothesized inverted-U curve for preferences plotted against the number of elements in visual patterns. One of the first studies of this kind was by Munsinger and Kessen (1964), using random polygons with up to 40 sides. The predicted relationship occurred with two student groups, but with three other groups more complicated functions were obtained. In addition, monotonic increasing functions were obtained with art students as subjects, and when symmetrical polygons were used as stimuli. The results were interpreted as broadly consistent with the informational approach, if subsidiary effects were allowed for. With regard to the latter, it was argued that the visual experience of art students allowed them to process readily even the most complex shapes; and the redundancy of very complex

symmetrical patterns ensured that their information value was not too high for assimilation.

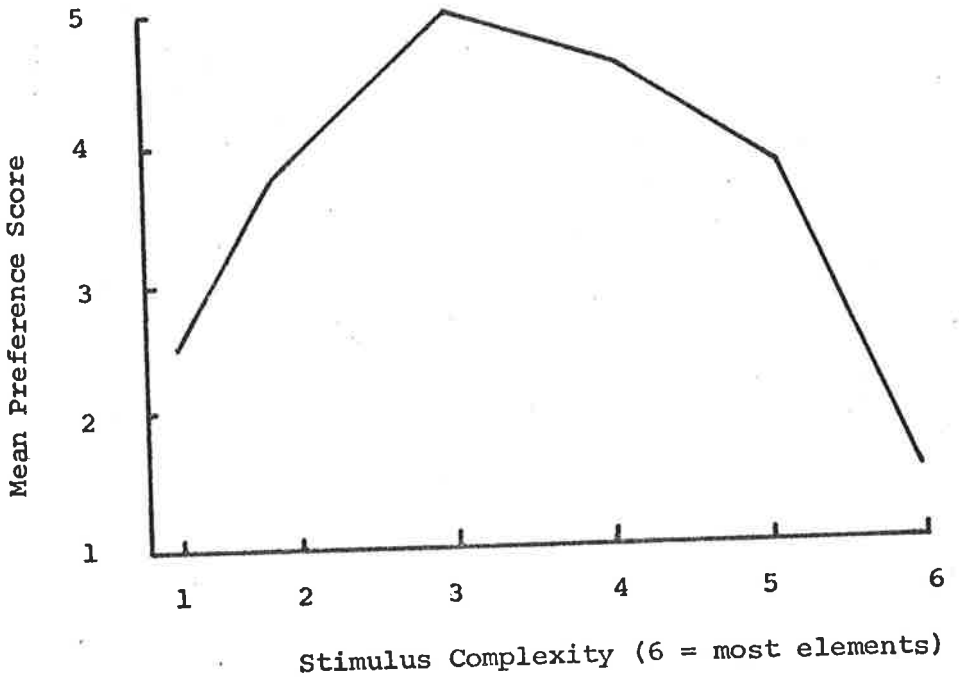
Although polygons have been used in several studies, they are not ideal stimuli in aesthetic preference investigations for two reasons. First, they are perceived as "shapes" rather than aesthetic "designs". Secondly, they confound other dimensions with multiplicity of elements, in that some random polygons are more meaningful, more verbally codable or have higher association values than others (Munsinger and Kessen, 1964; Eisenman, 1966b; Kelly and Martin, 1974), and these features affect the preference complexity curve.

Vitz (1966) reported two studies with two different varieties of random figures, and confirmed the inverted-U shaped curve for average preference against number of elements, using both a ranking method and a paired-comparison method. Moreover, in the first study "approximately 60% of the subjects had preference curves which substantiated, or closely substantiated, the prediction of a preferred amount of complexity"; the majority of subjects in the second study similarly gave the predicted form of relationship, although there were large subgroup variations in the most-preferred complexity level.

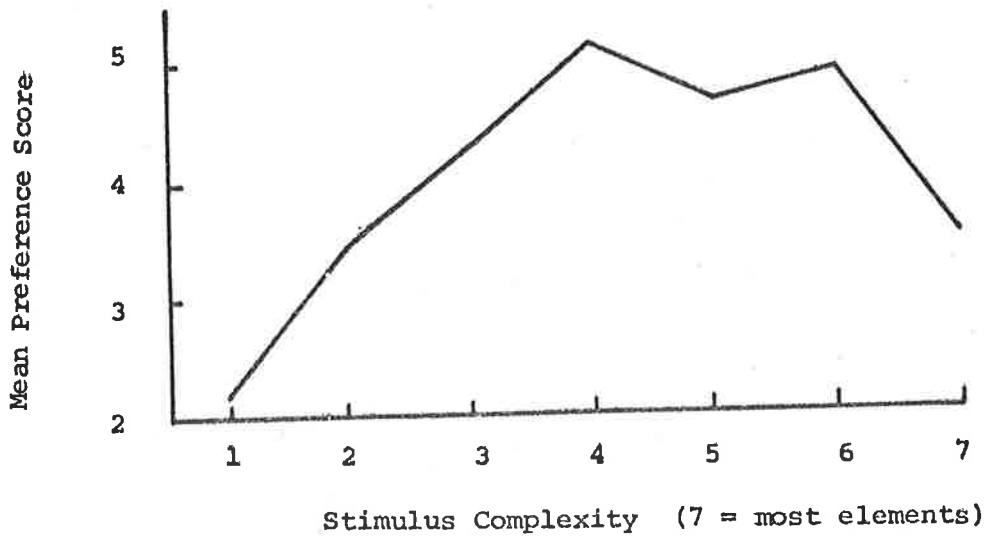
The writer (Rump, 1968b) reported five studies of aesthetic preference for abstract designs, and obtained the predicted inverted-U relationship in most cases. Two examples are reproduced in Figure 2.1 for paintings by Mondrian and for random black/white designs composed with quadrilaterals. The writer concluded: "These results are largely compatible with the 'information-processing' approach to preferences." Another study in which reproductions of abstract paintings by well-known modern artists were used included five pictures at each of low, medium and high complexity levels, as categorised by graduate students (Osborne and Farley, 1970). Both graduate art students and graduate educational psychology students

Figure 2.1. Mean preference scores plotted against stimulus complexity (extracted from Rump, 1968, Figs 1 and 3)

(a) Six reproductions of Mondrian paintings



(b) Seven random black/white designs composed with quadrilaterals



showed increasing mean preference scores for more complex pictures. There was no decrease in mean preference for the most complex pictures, but it is impossible to determine the precise form of the relationship with only three levels of complexity being discriminated.

Day (1967b) investigated the pleasingness of random polygons with differing numbers of sides, using different ranges of stimuli in four different studies. Pleasingness scores in three studies "peaked" for polygons with about 28 sides, although in Day's Study 2 only small unsystematic fluctuations in pleasingness were found. It may be noted that Day (1968a) described his earlier results as showing that "pleasingness decreases with increasing complexity", but this description is inaccurate.

Using slides of abstract art as stimuli, Wohlwill (1968, Fig. 2) obtained increasing preference ratings as subjective complexity increased, with a down-turn for the highest complexity level, giving the typical inverted-U shape. For slides of environmental scenes, however, no such regular trend was obtained, possibly due to unpleasant associations attached to particular environments in the series.

It would be incorrect to imply that all studies using abstract stimuli have found systematic relationships between measures of stimulus complexity and preferences. Lindauer (1970, Study III) used nine abstract paintings as stimuli, and found that subjects were consistent in their rankings of complexity, but "the preference ranks showed a relatively low degree of consensus". Unfortunately no analysis of within-subgroup relationships between complexity and preference rankings was undertaken of the kind used by the writer (Rump, 1968b).

Another experiment with an unexpected outcome was by Boykin as described by Walker (1973, pp.88-91). Pleasantness ratings for anagram-solving problems showed a monotonic decrease with complexity. Possibly

even the shorter anagrams were above the subjects' preferred level of difficulty, but in any case the ratings given were not akin to the aesthetic preference judgements which are of primary concern here. In another study described by Walker (*op. cit.*, p.80), using musical compositions varying in complexity, it was stated: "The mean liking rating shows the classical inverted U-shaped function".

Berlyne (1973, Table 3) found significant complex "trends" for symmetrical and for asymmetrical polygons varying in number of sides; but since only four polygons of each type were used, it is impossible to draw firm conclusions as to the nature of the relationship from that study.

Preferences in relation to symmetry/asymmetry

It has generally been found with observers not selected as particularly interested in art, that symmetrical patterns are preferred to asymmetrical patterns which are otherwise of similar type. Amongst studies which have found a general preference for symmetrical shapes or patterns are those by Harsh, Beebe-Centre and Beebe-Centre (1939), Eysenck (1941a), Eisenman (1967), Eisenman and Rappaport (1967), Eysenck (1968, p.13), and Eisenman and Gellens (1968). Morris (1966, p.159-161), in summarising his own research and that of Rensch, stated that many species share with man a preference for regular or symmetrical patterns. Species tested included the chimpanzee, the Capuchin monkey, the Guenon monkey, the jackdaw and the crow.

In a study of items from the Welsh Figure Preference Test, Moyles, Tuddenham and Block (1965) found that 36 of 51 students showed a greater preference for symmetrical figures, with both sexes combined, which is statistically significant using the Sign test ($p < .05$). Less direct evidence was also provided by Tucker (1955) who used semantic-differential scales with non-artist students rating representational paintings. It was found that "good", "clear", "ordered" and "controlled" had high

loadings on the evaluative factor, and these last two adjectives might be thought to apply to symmetrical designs. Various forms of redundancy other than overall symmetry may lead to positive evaluation of a pattern. Local contingency introduced into a computer-generated random pattern "alters and improves its appearance profoundly" (Pierce, 1961, ch. 13).

Symmetrical patterns of pink and blue lights gained higher scores on a "hedonic value" factor in a study by Berlyne (1973, Table 3). Symmetrical polygons also received higher scores than asymmetrical ones, but to a nonsignificant extent.

Frith and Nias (1974) reported that "symmetry played a relatively minor role" in their study of preference ratings, but their interpretation would appear to be incorrect. It was based on unfolding and factor analyses. However, the more appropriate way of assessing the effect of symmetry from their data is to examine the mean preference ratings. Three types of black/white computer-generated, square checkerboard matrices were used: (A) matrices with double mirror symmetry; (B) matrices with a single axis of mirror symmetry; and (C) no symmetry. Within each type, there were different levels of "information" varied in terms of the degree of contingency (local clusterings) within the matrix. Mean preference ratings, re-arranged in order of "information value" are given for each type in Table 2.1. It may be seen that there was a clear increase in preference with more symmetry, contrary to the interpretation offered by Frith and Nias. Indeed, the consistency of the ordinal trend was high, with a Mean Tau of 0.83 ($p < .01$) using Jonckheere's (1954) method.

Gestalt theorists have argued that the general preference for symmetrical patterns is because a well-organised form "produces in the visual cortex a correspondingly balanced organisation" (Arnheim, 1947). However, there are large individual differences, with some observers liking asymmetrical designs, so that an explanation in terms of a common neurological representation of "balance" is insufficient.

Modern writers who are connoisseurs in the aesthetics of visual designs stress "balance", but rarely do they illustrate this concept by simple mirror symmetry (*e.g.*, de Sausmarez, 1975). It has also been suggested (*e.g.*, Berlyne, 1971, p.162) that such organisational features as pattern symmetry are liked because they reduce arousal and have a serene effect, but there is little supporting evidence for this, as remarked in the previous chapter.

Perhaps most observers without advanced education in art consider it appropriate that "designs" should have some regularity if they are to be considered to have aesthetic or decorative value. Garner (1977) described the relationship between symmetry, informational redundancy and pattern "goodness". He considered that these concepts could be accounted for in terms of an implied subset of similar patterns: symmetrical patterns and other "good *Gestalts*" are members of small subsets of equivalent form, whereas asymmetrical and "poor" patterns have many like equivalents in their implied subsets.

However, it does not appear that the informational approach alone is sufficient to account for preference data, even though the concept of "redundancy" may be apt. Symmetrical patterns are widely preferred by most observers at all levels of overall complexity, which would not be expected if redundancy merely served to reduce unpleasant "excess" information. Moreover, symmetrical patterns are preferred by subjects who show relative dislike for other forms of simple stimuli. Whatever the reason for the majority preference for symmetrical patterns, it is clear that such stimuli should be considered separately from asymmetrical patterns in the analysis of preferences.

There has been little emphasis in the literature on different degrees of symmetry, and it may be that this is less important than its presence or absence. However, a recent investigation has included the quantification of degree of symmetry in designs produced by placing small squares or cubes

Table 2.1. Relative preference ratings for different degrees of symmetry in computer-generated, black/white square matrices

(Data were extracted from Frith and Nias, 1974, Table 1, and re-arranged in order of "information value" of matrices within each set)

Order of information value, within sets		Degree of Symmetry: None (Set C)	1 reflection (Set B)	2 reflections (Set A)
			Preference Ratings	
1	(lowest value)	3.1	4.2	5.5
2		3.5	4.6	4.7
3		3.5	4.3	5.0
4		3.6	3.6	4.8
5		2.8	3.8 *	3.3
6	(highest value)	2.8	3.1 *	4.4
	Overall mean	3.2	3.9	4.6

*These two stimuli were equal in "information value".

Note: The ordinal trend, for the patterns matched in terms of relative "information value", was calculated for the above data using Jonckheere's (1954) method. The increasing preference with greater symmetry gave a Mean Tau = 0.83 ($z = 2.98$, $p < .01$, one-tail test).

into one, two or three dimensional matrices (Szilagyi and Baird, 1977). It was found that most undergraduates asked to produce designs attempted to create at least one type of symmetry. Over 70% stated this intention, and 65% succeeded in producing designs with perfect symmetry: "Perfect symmetry was the most common condition for all three dimensions".

Subgroup and individual differences in preference for complexity

Although clear group trends have been described above, several studies have shown marked differences between individuals or subgroups, with respect to preference for multiplicity of elements, preference for asymmetry, and preference for complexity in general. Some of these studies are reviewed here. Others more directly related to scales intended to discriminate individual preferences, and in particular the Barron-Welsh Art Scale and the Graves Design Judgment Test, are discussed in chapter 8. Part C of the thesis is *inter alia* concerned with personality variables associated with these individual differences in preference.

In a study using inverse factor analysis, Lane (1970) found that different subgroups gave different preference-for-complexity functions with random polygon which had perceived complexity mainly determined by their "jaggedness". The largest subgroup of subjects gave increasing preference with increasing complexity. However, a small subgroup preferred simple polygons. Thus, Lane concluded: "It is no longer feasible to make the general statement that all individuals prefer a moderate level of complexity" (pp.161-162). Moyles, Tuddenham and Block (1965) obtained preference rankings for 24 figures from the Welsh Figure Preference Test, which were also rated for complexity and for asymmetry. Whilst some of their conclusions may be disputed (see chapter 4), they undoubtedly demonstrated large individual variation. For example, individual subjects gave correlations between "disliking" and "asymmetry" ranging from 0.39 to +.58.

In a well-analysed study of preferences for random, square green-and-white checkerboard matrices of different "grain", Dorfman and McKenna (1966) confirmed the general U-shaped trend with preferences plotted against the number of elements in the matrix, and went on to analyse trends for particular subgroups. One subgroup of 15 students preferred the simplest matrix with only 4 elements, whilst another subgroup of fourteen students preferred the most complex matrix with 144 elements.

In two studies similar to Dorfman and McKenna's, Vitz (1966) used black straight-line drawings of "random walks" in Study I, and outline squares subdivided by random straight-lines in Study II. In Study I it was found that subjects with a strong interest in art and more than one year's formal art training selected the more complex stimulus in paired-comparisons on 75% of presentations, whereas subjects with little interest in art did so on only 56% of presentations. However, this greater preference for complexity amongst art-oriented subjects was not replicated in Study II.

From those studies in which fine-arts students prefer more complex visual patterns than others, it is commonly argued that this is due to their greater experience with such stimuli. If this argument is generalised, it may be hypothesized that familiarity with a set of stimuli of one type will lead to increasing preference for more complex stimuli within that set. This hypothesis was indeed proposed in an earlier report on the effects of stimulus complexity, on maze-running rats (Dember, Earl and Paradise, 1957). It was hypothesized that "Any change in preference will be from the less to the more complex path", and some confirmatory evidence was obtained.

Several studies have reported consistency of individual or subgroup differences in preferences, without isolating the stimulus dimensions concerned. An early study of this kind was that of Eysenck (1940). He used 18 varied sets of pictures to extract a general factor of aesthetic

judgement which "accounts for what we call 'beauty' in pictures, and 'good taste' in persons", according to Eysenck. In fact, the factor represented individual differences in concordance with the majority view, amongst the 18 persons studied: it was obtained from data using each person's judgement correlated with the group's average order.

Eysenck and Castle (1970b) found some differences between artists and non-artists in preference judgements for regular polygons, although the stimulus dimensions involved in their contrast is debatable (the point is discussed further in chapter 8). Aitken (1974) used random polygons varying in number of sides, and obtained "unimodal" preference curves for individual observers consistent with the inverted-U hypothesis. However, the complexity levels corresponding to the most preferred polygon varied greatly from individual to individual, so that as well as individuals who gave inverted-U curves, a few gave generally increasing preference ranks with increasing complexity, whilst others gave generally decreasing preferences with increasing complexity.

An experiment by Steck and Machotka (1975) is important in this context, even though it dealt with musical rather than visual complexity. Complexity was varied in terms of the number of notes in ten-second compositions. (This necessarily meant that "complex" sequences were also faster.) Four different ranges of complexity level were presented, with eight levels in each range, as well as the full range of stimuli. Each subject rated each composition on a scale of "like-don't like", for all five possible ranges, with a short interval between each set. The experiment confirmed the generality of the inverted-U curve of preference against complexity but showed marked subgroup differences in the most-liked level of complexity similar to those reported by Dorfman and McKenna (*op. cit.*). For example, one extreme subgroup had preference curves with marked "positive skew" and with the most-liked composition consistently near the simple end of the range; whilst for another

subgroup the preference curves had a marked "negative skew", with the most-liked composition consistently near the complex end of the range (Steck and Machotka's Figure 1). In addition, it was found that individual preferences for different levels of complexity were highly consistent for different ranges of complexity, but were almost entirely relative to that range. The experimenters concluded that "there is no 'natural' degree of complexity toward which a given subject will tend; there is, instead, a relative degree toward which the subject will repeatedly be attracted".

Now, Steck and Machotka (*op. cit.*, p.173) correctly pointed out that their findings are difficult to reconcile with a simple informational account of preferences for complexity. The difficulty, in the writer's view, rests not only with the contextual relativity of the ratings, but also with the extreme variations between subjects in the "optimal" information content. Steck and Machotka's explanation in terms of a central control mechanism, using feedback to regulate the flow of information from sensory receptors, is speculative. A more direct interpretation is that preferences for complexity (or information) are a matter of cognitive style as well as information-processing ability, and that personal levels of preference are expressed in relative terms.

Interest, visual exploration and attentional responses

A pattern with a moderate number of elements is usually preferred and evaluated more highly compared to a very simple pattern, and it would be expected that the former would also be more interesting. For example, Gale, Bramley, Lucas and Christie (1972, Table 2) found that with patterns of random black dots varying from 2 to 16 in number, ratings of beauty, pleasantness and interestingness all increased significantly as the number of dots increased. Very highly complex figures are disliked, but are they also seen as uninteresting? Several studies suggest little decline in interest ratings moving from moderately complex patterns to

very complex patterns, although an asymptotic level of interest is often reached when interest is plotted against the number of elements in a pattern.

Eisenman (1966a) used as stimuli nine random polygons and found that the more complex shapes were ranked higher on "interestingness". Day (1967b) in four studies of a more elaborate kind also used random polygons varying in number of sides, and found that mean "interestingness" increased with complexity of shape for polygons with up to about 28 sides. There was only a very slight reduction, if any, in interestingness for more complex shapes than this. An example of the trend is shown in Figure 2.2. Evans and Day (1968, Figure 2) reported that interest in more complex polygons was particularly marked when viewing stimuli for the second time, which would be expected from an informational viewpoint.

Berlyne and Boudewijns (1971) varied complexity in terms of the heterogeneity of elements rather than their number. Patterns consisted of pairs of elements which might be circles or squares, red or green, large or small, and solid or pierced. They were presented side-by-side, or in quick succession. The greater the number of differences between elements of a pattern, the more interesting they were rated, but the curves were negatively accelerating as shown in Figure 2.3.

Interest in visual stimuli may be assessed not only by rating methods but also by observing the amount of time subjects wish to view each item with no extrinsic task. Viewing time may be measured in terms of a period of continuous observation terminated by the subject's response, or in terms of the number of short-period stimulus exposures which are presented so long as the subject continues responding (by pressing a key, for example). Other studies have assessed the period of fixation by recording eye-movements.

When students were shown pictures tachistoscopically for .14 seconds for as many exposures as they wished, the number of exposures gained was consistently greater for more complex stimuli; complexity was varied

in several ways, including number of elements (Minton, 1963). Students were asked to look at colour slides of objects and places for as long as they wished by Leckart and Bakan (1965). The slides were separately rated for complexity and divided into three sets of low, medium and high complexity levels: the mean looking times were 7, 11, and 13 seconds respectively, so that a monotonic increase with complexity was evident. Similar results were obtained by Gaschk, Kintz and Thompson (1968), who also found that the increase in inspection time with complex stimuli was much greater if actual objects were used which subjects could handle as well as visually examine. Presumably "the several tactual components would contribute to the total configuration of complexity" and thereby increase the time required to appreciate the sensory information provided.

With a series of 32 abstract patterns designed to represent five contrasts in physical characteristics, it was found that viewing times were significantly longer for patterns with 18 components than for patterns with 3 components (Brown and Lucas, 1966; Brown and O'Donnell, 1966). Similarly, when viewing patterns with an "interestingness" set, observers looked longer at 9-sided shapes than at 3-sided shapes (Brown and Farha, 1966).

Wohlwill (1968) studied the number of voluntary half-second exposures to slides which displayed (a) environmental scenes or (b) abstract paintings. The slides varied in their subjective complexity, as rated by five "judges". It was found that viewing time increased with increasing complexity, with a significant linear trend for both sets of stimuli. The trend for abstract paintings is shown in Figure 2.4.

Day (1968b) investigated viewing time under four instructional sets, using random polygons. Observers were instructed to look at each projected slide as long as they cared to, or until they could recognize the slide later, or so long as it was interesting, and with these

Figure 2.2. Mean "interest" score (using paired comparisons) plotted against stimulus complexity of polygons (extracted from Day, 1967b, Fig. 6)

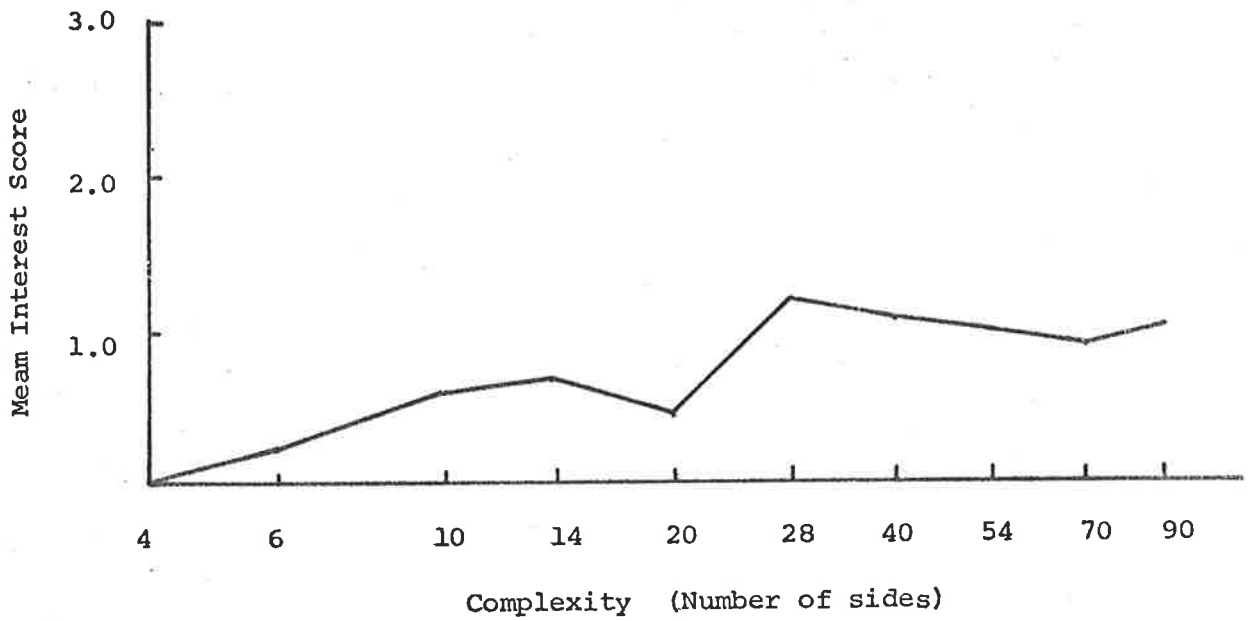
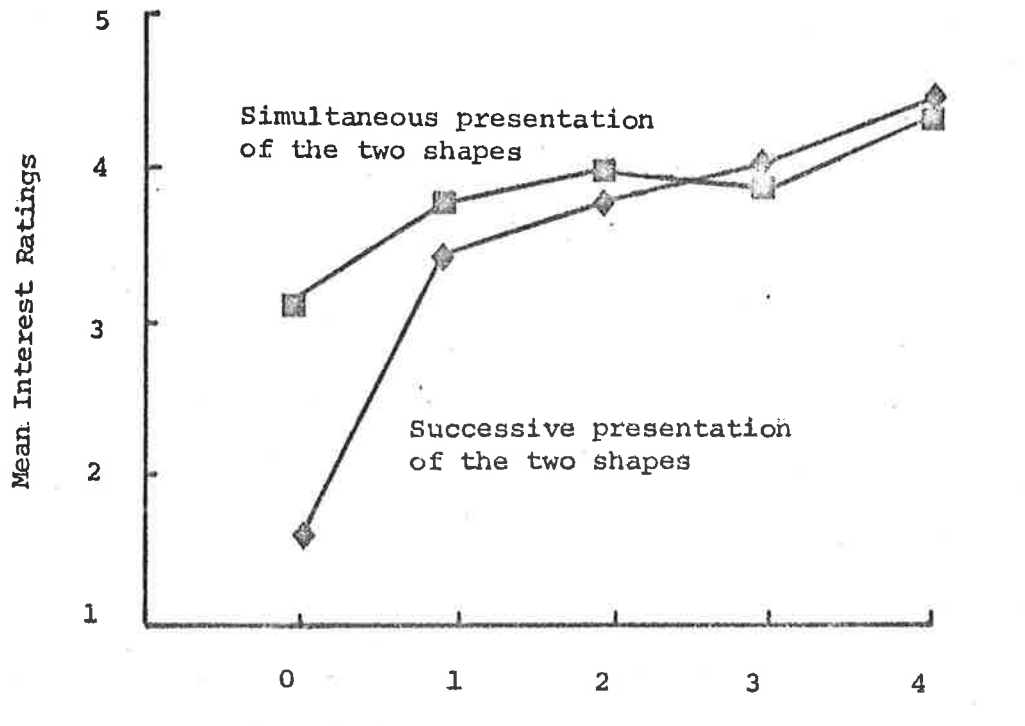


Figure 2.3. Mean "interesting" rating plotted against stimulus complexity for pairs of shapes (extracted from Berlyne and Boudewijns, 1971, Figures 1 and 3)



instructions looking time increased as the number of sides in the polygon increased. The relationship was rather irregular, as shown in Figure 2.5 for the "look as long as the slide is interesting" condition. Moreover, interpretation is not straightforward because the number of sides was plotted on a logarithmic scale, and in addition viewing times were converted to logarithms before averaging. Nevertheless, two main features of the trend are apparent: a marked increase in looking time with increasing complexity within the range of 10 to 40 sides; and little further increase in looking time for polygons with 40 or more sides. When observers were instructed in Day's experiment to view each slide for as long as it was pleasing, viewing time showed some significant increase with stimulus complexity, but not to the same extent as with other instructions.

Representational pictures have been used in several studies of inspection time in relation to stimulus information. For example, Loftus and Mackworth (1978) reported that observers fixate earlier, more often and longer on depicted objects that have low probability (and hence greater informational value) in the portrayed scene.

Jones, Wilkinson and Braden (1961) hypothesized that sensory deprivation would increase responding to view stimuli. During 12-hour periods of sensory deprivation, subjects gave more button-presses to view sequences of red and green lights after 3 hours of deprivation than within the first 3 hours. In a follow-up study of viewing choice, following a ten-hour period of sensory deprivation (Jones *et al.*, *op. cit.*, Experiment 2), the proportion of choices increased approximately in proportion to the information value in the stimulus patterns. The authors suggested that their findings confirmed that information seeking was a form of intrinsic motivation.

Using eye-movement recording with stimuli presented in pairs, Faw and Nunnally (1967) found that students looked longer at the more complex and also at the more pleasant stimulus. The sets of slides used in this

Figure 2.4. Mean number of exposures for slides of modern art of different levels of subjective complexity (extracted from Wohlwill, 1968, Fig. 2)

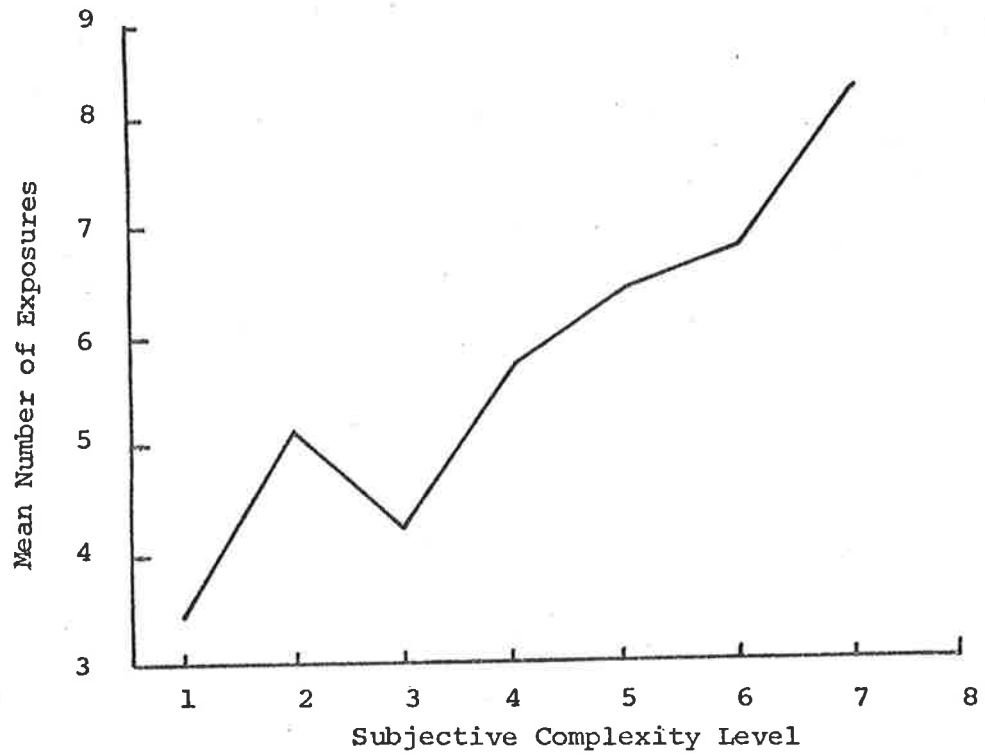
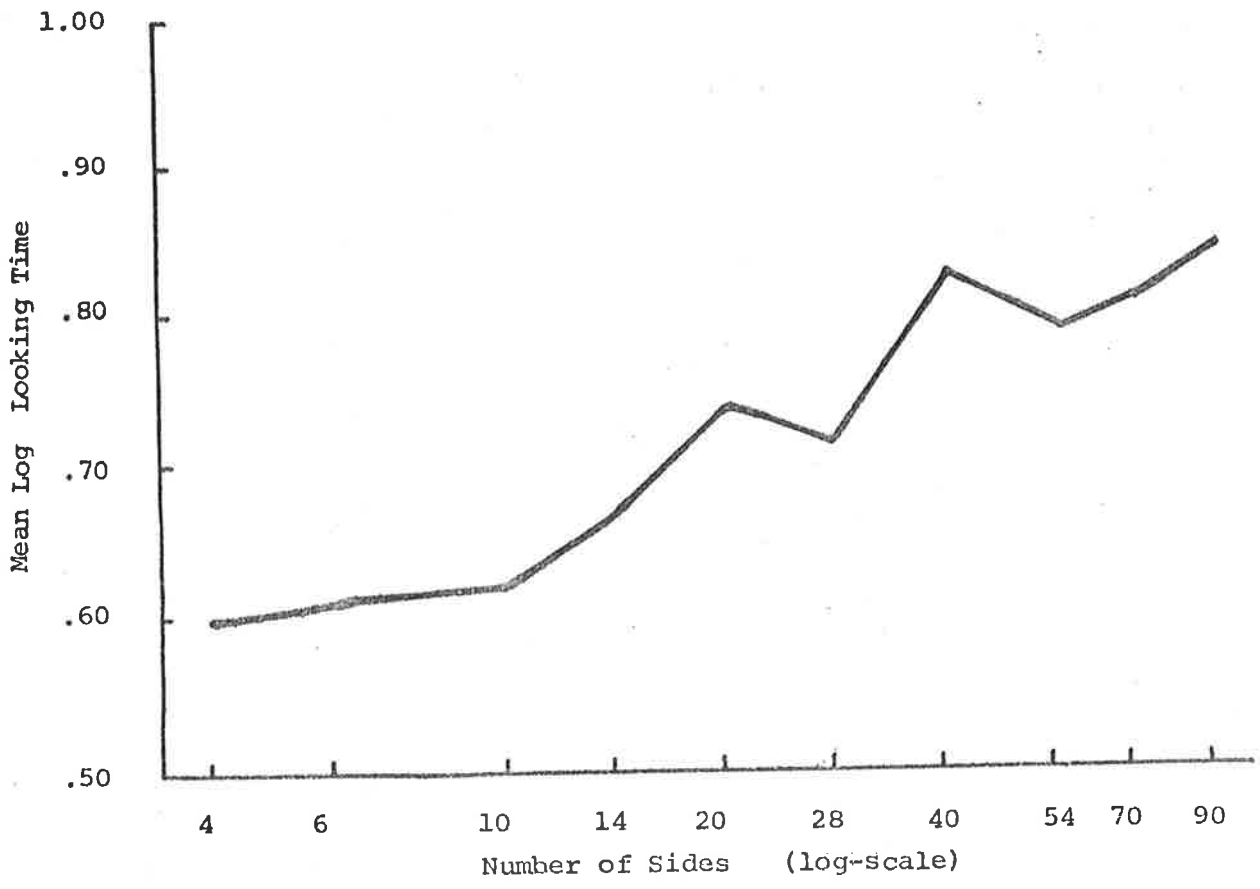


Figure 2.5. Looking time for polygons of varying number of slides (extracted from Day, 1968b, Fig.1)



experiment included words, pictures of faces, clothes, cars, and so on. Day (1966) reported similar results using looking-time recorded from the subject's activation of a slide projector. Day's materials included patterns selected from Berlyne's figures (see chapter 3) and from the Barron-Welsh Art Scale.

Berlyne (1973) also used a wide variety of visual stimuli, including both abstract and representational pictures. He reported that both mean interest ratings and mean looking time were highly correlated with subjective complexity, correlating across the stimulus items. For interest and complexity, the correlation was .76; and for looking time and complexity, the correlation was .89. However, when twenty *representational* paintings depicting people were used, the simple-complex ratings "did not figure very prominently". For example these ratings did not correlate significantly with looking time, which was affected by the paintings' style and meaning.

Although Nicki and Moss (1975) described their response measures as reflecting "preference", they did in fact measure interest ratings and viewing time (number of exposures), for nonrepresentational works of art. These measures were positively related to picture complexity, in the main. Finally, Faw and Wingard (1977) presented stimuli having three levels of heterogeneity of elements, from "banal objects" to a combination of animate and inanimate objects. Viewing time using eye-movement records generally increased for the more complex pictures, with three age-groups of children (Faw and Wingard's Figure 1).

Although preference and interest should be distinguished, they are not unrelated responses. For instance, Aitken (1974) found the complexity levels corresponding with the most "pleasing" item from sets of random polygons, and the complexity levels corresponding with the most "interesting" item, for each subject. The two values correlated .616 over thirty subjects.

This result implies some consistency in individual differences in preference and interest reactions to complexity. On the other hand, if

one looks at group mean ratings for "interesting" and for "pleasing", clear differences in these measures are evident in some cases. Day (1968a, Fig. 1) showed that simple symmetrical figures from the Barron-Welsh Art Scale were pleasing but not very interesting.

If interest and viewing time (and not preferences) are considered, it is often found that they are closely inter-related. Russell (1975) measured subjective complexity, looking time, frequency of brief voluntary exposures to stimuli and rated interest for a varied set of 21 pictorial slides. The correlations across slides between these variables were all high (> .7). For instance, subjective complexity correlated .75 with looking time and .85 with rated interest in the same group (Russell's Table 2). The detailed forms of the relationships were not presented in Russell's report.

Responses involving encoding and transmitting stimulus information

Previous sections were concerned with the observer's evaluation of stimuli when task requirements are minimal. In this section, responses involving more clearly specified processing of stimulus information are discussed. When the observer has to make a straightforward decision on the basis of a visual display, such as giving an appropriate discriminative response to a light-signal from a set of "n" possible signal positions, the choice reaction time is usually a linear function of log.(base2)"n", or log.(base2)"n + 1" to allow for the "no signal" possibility (Welford, 1960). This relationship is named Hick's law from his pioneer studies reported in 1952, and Welford demonstrated that such a relationship applies to many decision-time tasks. It may be interpreted as showing that the subject gains information from the stimulus display at a constant rate, so that the time required is proportional to the stimulus information which has to be processed for successful completion of the response.

When the observer has to encode, recall, transform or otherwise

respond in a complex fashion to information in a visual display, task difficulty increases with the complexity of the display. As the complexity increases to very high levels, measures of task difficulty increase with positive acceleration. That is, for fairly simple stimulus displays, difficulty increases roughly in proportion to increasing complexity; but with further increases in complexity, a disproportionate increase in difficulty results.

An example of this accelerating form of curve is provided by an experiment of Cohen and Meudell (1968), with children in different age groups. They were shown pages of circles varying in number, and asked the experimenter questions (to be answered "yes" or "no") in order to identify the "correct" circle on each page. The number of questions required was plotted against the amount of information required for solution of the problem. In information-theory terms, the latter is equal to "log.(base2) number of circles" *bits*, which also represents a measure of the complexity of the display. An example of the findings is shown in Figure 2.6, for the 9-year age group. The Figure clearly shows the accelerating trend obtained.

Similar trends have been found with a variety of materials and tasks. For instance, Naylor (1968) used geometrical shapes in four different colours (Naylor's Series D). The subject pressed a key to illuminate the display for long enough for him to report subsequently the nature of the items in the display. The number of units in the stimulus display was varied, each unit having five *bits* of information. Inspection time was recorded. An example of Naylor's results is given in Figure 2.7, which confirms that when difficult cognitive processing of visual information is required, high complexity in the display "overloads" the observer's capacity and increases the time required by a disproportionate amount.

Figure 2.6. Median estimated number of questions required to find a circle, plotted against $\log_2$ the number of circles (extracted from Cohen and Meudell, 1968, Fig.1a)

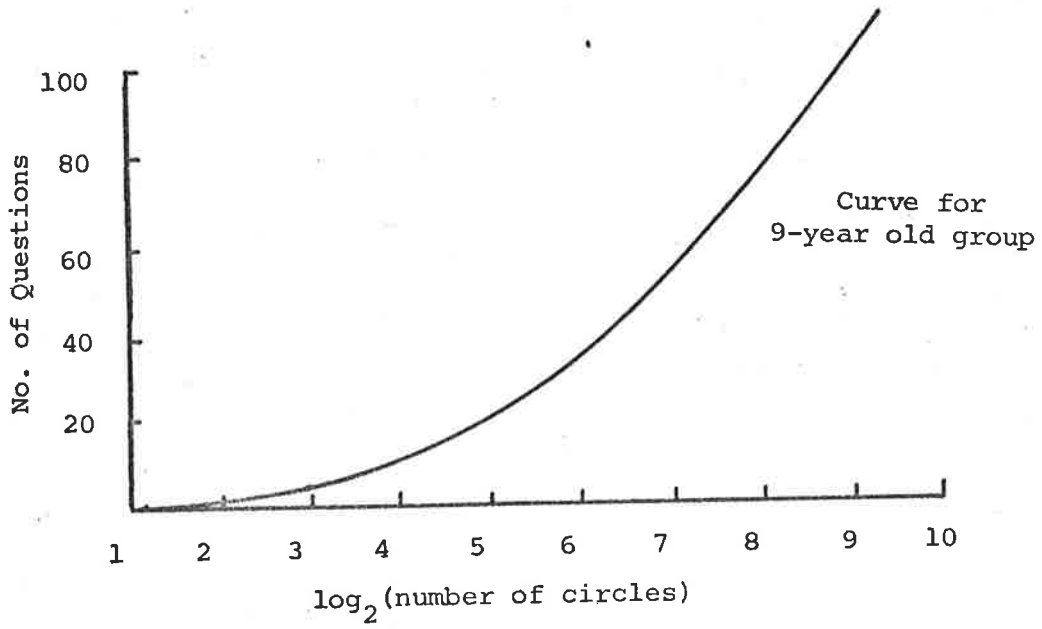
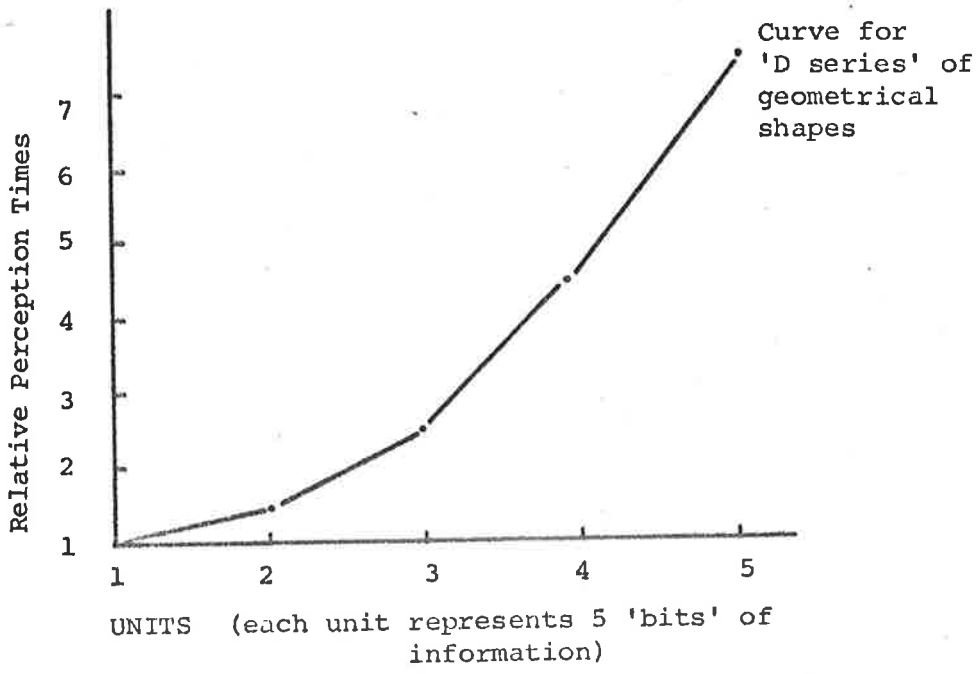


Figure 2.7. Relative perception times in relation to number of geometrical shapes displayed (extracted from Naylor, 1968, Fig.1)



Conclusions from the review, and Hypotheses

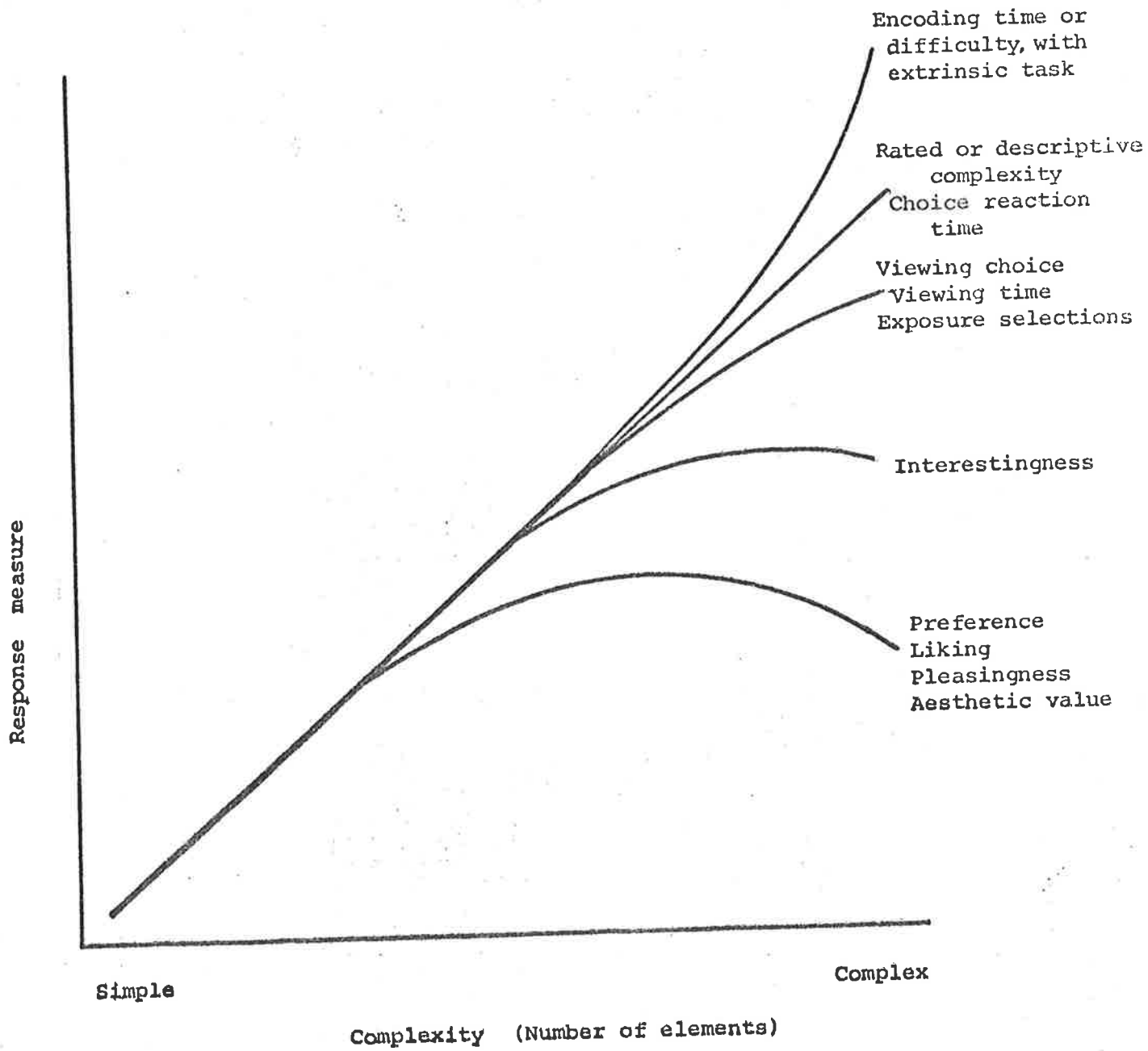
It is possible to summarize the main features of the many experiments reviewed above by a fairly simple model, so long as an "idealised" picture is allowed. Clearly, several types of response, both verbal and nonverbal and quantified using various methods, are strongly dependent on stimulus complexity. If this is measured in terms of the number of elements in visual patterns, fairly consistent trends emerge, supporting the informational approach.

The precise nature of the trend depends on the observer's set and his task, which in the laboratory situation are normally determined by the experimental instructions. For many response measures, there is a general increase with increasing complexity, until a medium level of complexity is reached. For more complex stimuli, however, the trends for different response measures diverge, as shown in the model drawn in Figure 2.8.

In certain cases, response measures increase in an approximately linear fashion even at high stimulus complexity levels. This is the case for judgements of subjective complexity, or when the response requires a straightforward translation of stimulus information, with no memory or transformation load, such as choice reaction times with familiar stimulus-response connections.

For evaluative responses such as preference ratings, the response curve shows a marked decline for very complex stimuli, provided the range of complexity extends to high values. This decline has been interpreted as avoidance of informational overload. Measures of interest increase with complexity and show little decline with very high complexity; but curves have some negative acceleration and tend to reach an asymptotic value. Very complex patterns arouse attention and interest, even though they are not considered pleasing.

Figure 2.8. Hypothetical relationships between stimulus complexity (multiplicity of elements) and various response variables



Visual exploration of high complexity patterns increases almost linearly with the number of elements presented in the patterns (as shown in Figure 2.8). The lower preference for very high-complexity patterns therefore does not imply a "defensive" rejection of sensory input. When the observer has to perform a task such that all stimulus information (as defined by the experimenter) must be processed or stored in memory, response time or measures of task difficulty increase disproportionately as complexity becomes very high.

The idealised curves in Figure 2.8 represent the following generalisation. The more information processing that is involved in the observer making his response, the greater is the positive effect of increasing stimulus complexity. This is what may be expected from an informational approach. Aesthetic preferences need involve as little information processing as the observer wishes, and the most complex stimuli are disliked by many observers. With an imposed task requiring full information processing, increasing complexity demands additional response time and effort. It may be noted that if no stimulus in an experimental set is very complex, the various response curves in Figure 2.8 are similar. In this circumstance different response variables may correlate highly. For instance Dornič and Kuric (1969) found a correlation of .84 between preference and looking time for eight art prints.

Hypotheses consistent with Figure 2.8 were tested in studies reported in the next section of this chapter, to provide further empirical support. However, there are three further aspects of the reviewed data which should not be neglected, since together they mitigate the efficacy of the informational approach to aesthetic preferences. The preference for symmetry shown by the majority of people in unsophisticated groups even with very simple designs, suggests the influence of design principles which are matters of personal choice or social convention rather than informational imperatives. Similarly, the lack of evidence that preferences

are related to absolute levels of complexity, consistent across different types of stimuli, is a critical lacuna in the evidence for strict application of information theory. Finally, the large individual and subgroup differences in preference for multiplicity of elements in patterns do not seem explicable in terms of ability to handle visual information; even in college student samples, small subgroups prefer the most simple shapes or designs.

These features favour a cognitive style, rather than a purely informational approach to the explanation of individual differences in preferences. Thus the greater preference for complex and asymmetrical patterns shown by fine-arts students (discussed further in chapter 8) may not be due to increased visual processing capacity, but rather because they choose to appreciate aesthetic value in a wide variety of patterns and works of art. An implication of this argument is that when correlates of preference for complexity are examined in Part C of the thesis, interests and cognitive styles are likely to be relevant, rather than general intellectual ability.

Experimental studies of responses to stimulus complexity using Terwilliger patterns

As a further test of the accuracy of the generalizations stated above, three groups of university students were tested using patterns of the type devised by Terwilliger (1963) as stimuli. These were chosen because they have the appearance of abstract two-dimensional designs, and the number of component parts may be quantified and varied over a wide range. It was also planned that the results should bear on Terwilliger's adaptation-level hypothesis; the nature of that hypothesis will be described after presentation of the experimental results. These data have been presented in part as an ANZAAS Congress paper (Rump, 1969).

Subject groups

Group I consisted of 60 University of Adelaide Arts faculty students studying a second-year psychology course. These subjects were asked to assess the pleasantness of each pattern.

Group II consisted of 66 students similar to Group I, in the following year's class. These subjects were asked to assess the interestingness of each pattern.

Group III consisted of 12 students in the University's Science faculty studying a second-year course in psychology (but which was taken in their third-year of university studies). These subjects were tested for viewing time and for preference ratings for each pattern. When the study was undertaken, it was not anticipated that science and arts students might give different response curves. The literature indicated that *fine-arts* students tend to give different aesthetic preferences from others but none of the students in the groups tested was currently studying fine-arts. In the event, the assumption of equivalence between Arts and Science faculty students proved to be incorrect, and the findings in this respect led to several further investigations described in Part C of the thesis. This account is given here to explain why Group I rated "pleasantness" but Group III rated "preference". It was envisaged that the two response curves would be similar but no direct comparison between groups was intended in the original design of this experiment.

Stimulus patterns

Patterns similar to those used by Terwilliger (1963) were designed. They were drawn as 6 inch by 6 inch (152 by 152 mm) outline squares, subdivided into straight-edge component shapes. The fourteen asymmetrical and ten symmetrical patterns are shown in Figures 2.9 and 2.10 respectively; the pattern code number and Terwilliger's "complexity score" are also shown for each pattern.

Figure 2.9. Terwilliger-type asymmetrical patterns ("A" Series)

(The code number for each pattern indicated the number of component parts; and the Terwilliger "complexity score", C', is given in brackets)

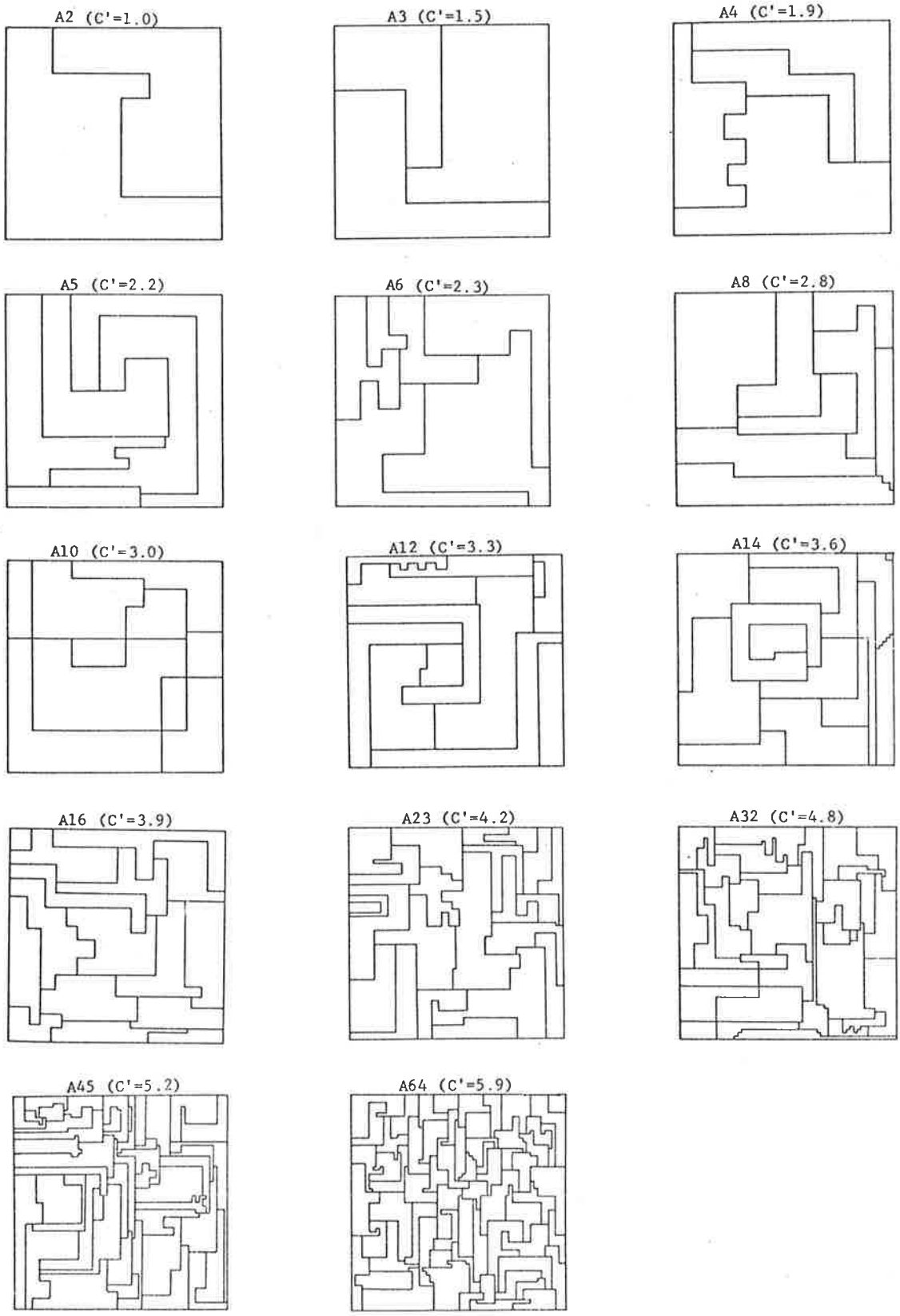
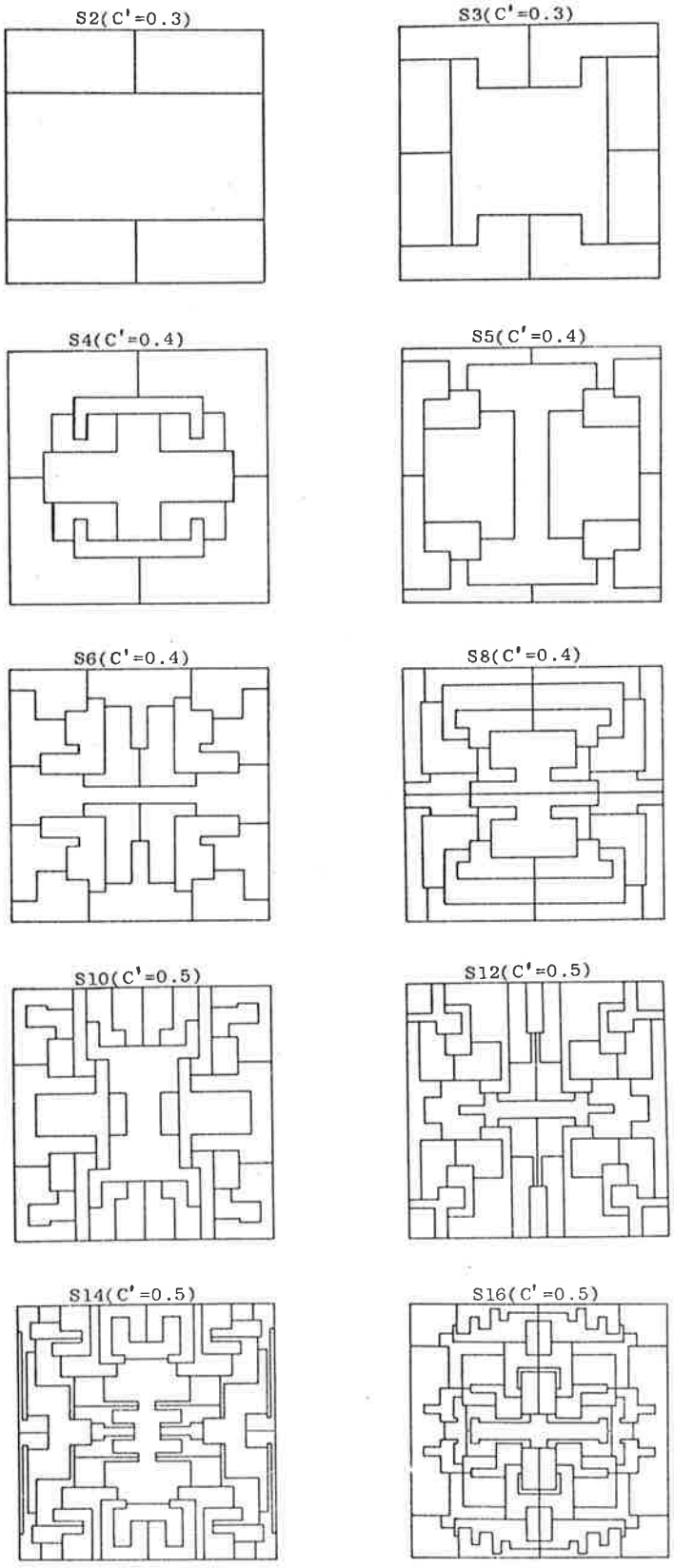


Figure 2.10. Terwilliger-type symmetrical patterns ("S" series)

(The code number for each pattern indicated the number of independent component parts; and the Terwilliger "complexity score", C', is given in brackets).



The designs were constructed to the following specifications using graph paper with a 0.1 inch (2.5 mm) square matrix. For asymmetrical patterns, a predetermined number of component areas was set (as indicated by the pattern's code number), and the outline square was subdivided by horizontal and vertical lines to form closed areas for the required number of rectilinear polygons. The areas were to be mostly non-congruent and not symmetrical about horizontal or vertical mid-lines. In addition, two independent judges confirmed that the patterns did not have three-dimensional or figure-ground characteristics, and did not appear to represent a familiar object. In order that the designs should not be influenced by the experimental hypotheses, an assistant was asked to construct the draft outlines to the foregoing specifications. The number of component areas varied from 2 to 64, and the values for the fourteen patterns were chosen to approximate a logarithmic scale.

The symmetrical patterns were constructed in a similar fashion, except that the required number of "independent" component areas (as indicated by the pattern's code number) were first constructed within one quadrant of the square outline, and then reflected about both the vertical and horizontal axes of symmetry. The axes were not drawn, except for segments which formed parts of component outlines. The total number of outlined areas was up to four times the set number of "independent" areas, because of the reflections. (The actual total number was somewhat less, since the midlines were not drawn in, and reflected areas could extend across the axes of symmetry). Because of the greater total number of areas in the symmetrical patterns, their "independent components" were restricted to the range 2 to 16. There were ten symmetrical patterns chosen within that range corresponding to the first ten asymmetrical patterns. One symmetrical pattern with two independent components was replaced by that given in Figure 2.10, since the former was judged to resemble a familiar object. None of the patterns used in the experiment was

considered to be "representational".

Procedures

Separate subgroups were given different random orders of stimulus presentation; the numbers of subjects in each subgroup were always equal. The random orders had the restriction that no pattern appeared in any given position in more than one order. The orders are given in Appendix 2.2.

Patterns were presented by means of slide projection, using a Kodak Carousel with Kodak timing device for Groups I and II. For Group I, two sizes of the projected pattern image were used, of 146 cm square and 47 cm square for equal sized subgroups. The size of the pattern on the screen made no significant difference to pleasantness judgements, and only combined data are presented. Subjects were seated in a classroom in their subgroups, between 3.5 m and 5.0 m from the screen. Each of six subgroups (for 3 random orders by 2 sizes of image) contained ten students, giving a total of 60 subjects. Patterns were pre-viewed for about one second each through the series and then viewed again for 10 seconds for ratings to be made, with about 2 seconds between slides. Instructions included the following: "Your task is to write on this form an assessment of how pleasant each pattern is. Give a mark of 0 to a pattern which you consider extremely unpleasant, and a mark of 100 to one which you consider extremely pleasant. . . Try to spread your marks out over the range. . . You need not use the extreme marks of 0 and 100 unless you wish to".

For Group II, a similar procedure was used, except that only one screen size (approximately 75 cm square) was used since this factor was unimportant in Group I's results. In this case students were instructed: "I am going to ask you to rate the 24 slides for interest. . . Write your rating on the form, from 0 to 100". For this group, the task was interpolated between two learning tasks in practical-work sessions.

Twenty-two students were in each slide-order subgroup, giving a total of 66 subjects.

For Group III, a different method of presentation was employed in order to measure viewing time as well as preference. Subjects were tested individually by means of back-projection onto a translucent screen about 30 cm square and placed about 60 cm in front of the subject, using a single-frame film projector linked to a timer. Both projector and timer could be controlled by two morse-keys operated by experimenter and subject. The projector occasionally "jammed", and subjects with incomplete data were discarded. The 24 patterns were shown twice. During the first run subjects were instructed *inter alia:* "You simply have to press your button to change the pattern. Each time you press your button, the pattern will go and for a few seconds the number of the next pattern (1 to 24) will come on. Just wait during these intervals for the next pattern. When you have looked at that pattern long enough, press your button again, and so on." The timer displayed the interval between contiguous button-presses in .01 seconds, and the experimenter recorded this. Because of a mechanical delay between the button-press and the next slide appearing on the screen, the recorded "viewing time" is over-stated by a small constant delay-time.

Because it was considered that order might have a systematic effect on viewing time, with subjects possibly decreasing their viewing time over the series as the type of pattern became familiar, random orders (i) and (ii) in Appendix 2.2 were used together with their reverse orders. There were thus four orders used with four subgroups, each composed of three subjects to give a total of 12.

During the second run through the sequence, each pattern was shown for ten seconds under the control of the experimenter, and the subject was instructed as follows: "Your task is to write down on this form your personal preference for each pattern. Give a pattern which you dislike intensely a minimum mark of zero, and one which you like very much give a maximum mark of one hundred.

Give each pattern an appropriate mark between 0 and 100."

Results: trend analyses for multiplicity of components

Data were re-ordered systematically from the random sequences, and transferred to punched cards for computer analyses. Trends were examined for symmetrical and asymmetrical series separately.

Both nonparametric and parametric analyses were employed. Parametric analyses allowed the extraction of curvilinear components and the calculation of curves of best fit. On the other hand, ordinal statistics were also appropriate in that the complexity measure, the subjects' responses, and their hypothesized relationships were essentially relative in nature. Both kinds of technique were used, therefore, for different aspects of the analyses.

Kendall's W was calculated to determine the degree of inter-subject consistency in their responses across patterns. Where a near-monotonic relationship between number of components and the mean response scores was found, the degree of relationship was assessed by Spearman's Rho.

In all cases the linear and quadratic trends were tested for significance, using parametric analysis and allowing for the "repeated measures" over patterns in the following way. For each subject, the degree of positive or negative trend was assessed by applying the appropriate orthogonal polynomial weights (Hays, 1963, Appendix C, Table VI) to his scores, and summing. Each subject thereby had a linear-trend coefficient and a quadratic-trend coefficient for symmetrical and for asymmetrical sets. The average trend coefficient over all subjects was calculated, and tested for significance using a single-sample t test, against the null hypothesis value of zero. In addition, a line of best fit was calculated for the mean response scores. A straight line of best fit was obtained and Pearson's r calculated if the linear trend only was significant, and a second-order curve if the quadratic component was significant. For the purpose of calculating these least-square fits and plotting empirical trends, the complexity measure used was $\log_2$ "number of independent components"; the

latter is defined above in describing the design of the patterns.

Interest ratings and viewing times

The mean interest ratings and viewing times for Groups II and III respectively are presented in Table 2.2, which also gives the Kendall's W and Spearman's Rho values. With interest ratings, there was a moderate degree of consistency between subjects for both asymmetrical and symmetrical patterns. This was due to a fairly consistent tendency for subjects to be more interested in more complex patterns, as expected. The rank correlations between complexity and mean interest were .83 and .95 for symmetrical and asymmetrical patterns respectively.

Inter-subject consistency for viewing times was low, and indeed W was not significant in the case of symmetrical patterns. However, inspection of the ranked data for symmetrical patterns showed that most subjects (10 out of 12: $p < .01$ using a Binomial test) looked longer at the four most complex patterns compared with the other six, although otherwise subjects showed little consistency with one another. Despite this low consistency the *mean* viewing times displayed a fairly clear tendency to increase with increasing complexity: significant Spearman's Rho values were obtained, of .92 and .75 for symmetrical and asymmetrical patterns respectively. Although a clear group trend was thus apparent (and the null hypothesis may certainly be rejected), it should be borne in mind that there was nevertheless little consistency between subjects.

The detailed trends for mean interest ratings are shown in Figure 2.11, together with significance tests and lines of best fit. For asymmetrical patterns, a very marked linear trend with no significant quadratic component was found. On the other hand, a significant linear trend for symmetrical patterns was modified somewhat by a significant quadratic component in the form of a negatively accelerating curve for the highest complexity values (see Figure 2.11). Thus the interest ratings for both sets of patterns conformed approximately to the informational model presented above (Figure 2.8), although only the symmetrical patterns showed a flattening of the interest

curve for very complex patterns as envisaged in the model.

The detailed trends for mean viewing times are shown in Figure 2.12, together with significance tests and lines of best fit. Marked linear trends were obtained for both sets of patterns, with the increase in viewing time as complexity increased being more prominent for symmetrical patterns. The values for the slopes of the lines of best fit were 1.26 and 0.77 for symmetrical and asymmetrical patterns respectively, but these were not significantly different (t = 1.46, df = 20, $p > .05$, using Equation 52 given by Bailey, 1959, p.99). There was no significant quadratic component but inspection of the mean values showed that over the four most complex asymmetrical patterns there was no further increase in viewing time. These trends for viewing time were roughly consistent with the model presented in Figure 2.8, both in that there was a predominant linear trend, and also in that there was some indication of a decrease in slope for very complex asymmetrical patterns. Nevertheless, there were very marked deviations from the line of best fit for asymmetrical patterns (see Figure 2.12), representing variations in viewing time probably due to the small group size and to particular features of individual patterns.

Because both interest and viewing time were highly correlated with complexity, the two mean response measures themselves were highly correlated across patterns: Pearson's r values were .79 and .81 for symmetrical and asymmetrical patterns respectively ($p < .01$ in each case).

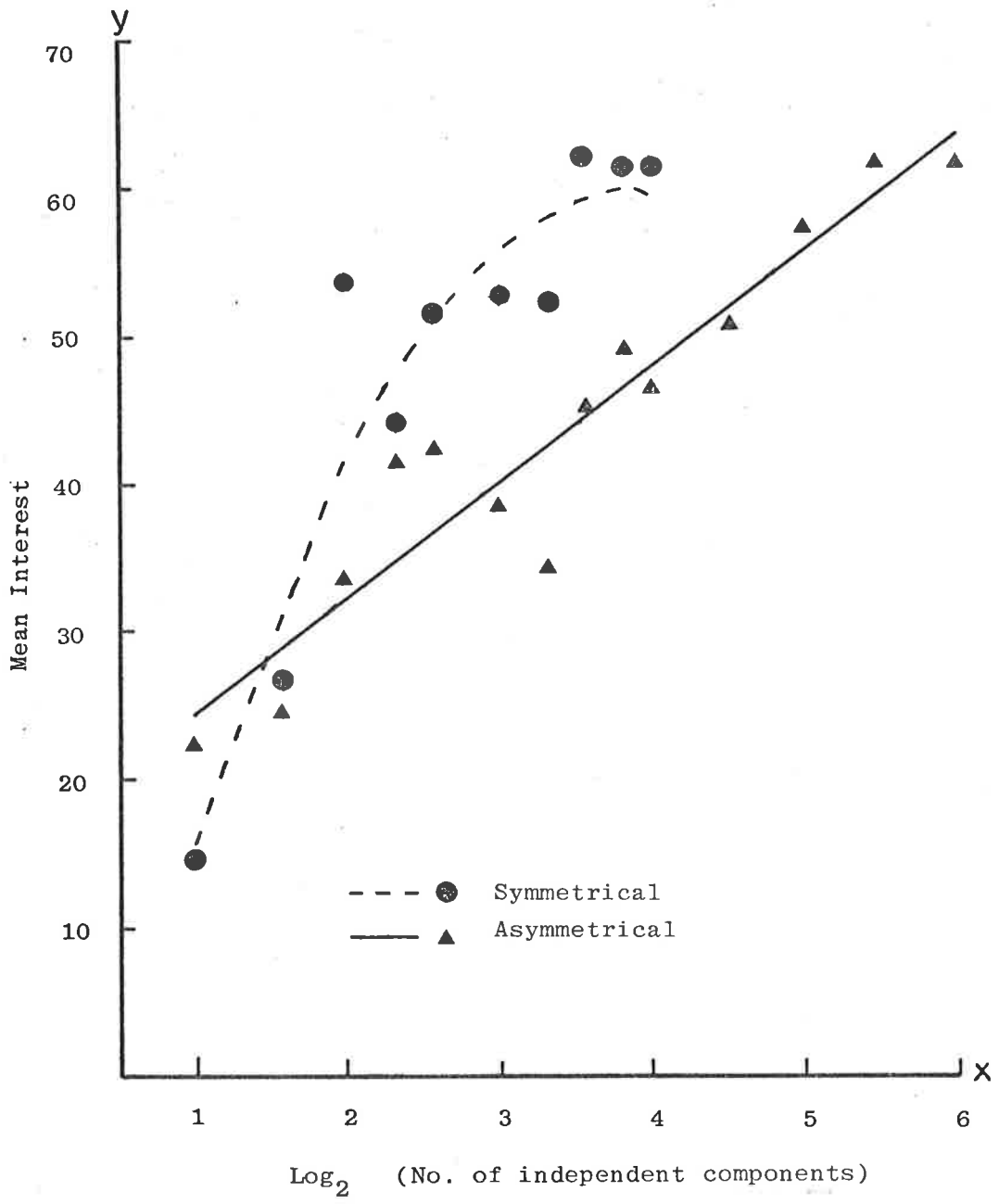
Preference and Pleasantness ratings

The mean pleasantness and preference ratings for Groups I and III respectively are presented in Table 2.3, which also gives the Kendall's W values. Spearman's Rho and Pearson's r were not calculated in these cases since non-monotonic relationships were expected and obtained. Table 2.3 shows maximum values toward the complex end of the series in the case of Group I, and near the "simple" end of the series for Group III. Despite the

Table 2.2. Mean interest ratings and viewing times for 10 symmetrical and 14 asymmetrical Terwilliger-type patterns, with inter-subject consistency (Kendall's W) and rank correlations

No. of "independent components"	Group II (N=66) Interest ratings (0-100 scale) Symmet.	Asymmet.	Group III (N=12) Viewing time (seconds) Symmet.	Asymmet.
2	14.7	22.3	7.20	7.17
3	26.8	24.5	8.40	5.78
4	53.8	33.7	8.72	7.60
5	44.4	41.2	9.76	10.18
6	51.4	42.1	8.53	8.03
8	52.8	38.2	8.93	9.32
10	52.4	34.1	10.30	7.98
12	62.0	45.0	10.22	8.56
14	61.2	49.0	11.49	8.73
16	61.3	46.2	11.38	9.83
23	-	50.6	-	11.21
32	-	57.2	-	10.60
45	-	61.6	-	9.97
64	-	61.3	-	10.08
Consistency (Kendall's W)	.41	.28	.11	.25
p <	.001	.001	N.S.	.001
Monotonic trend (Spearman's Rho)	.83	.95	.92	.75
p <	.01	.01	.01	.01

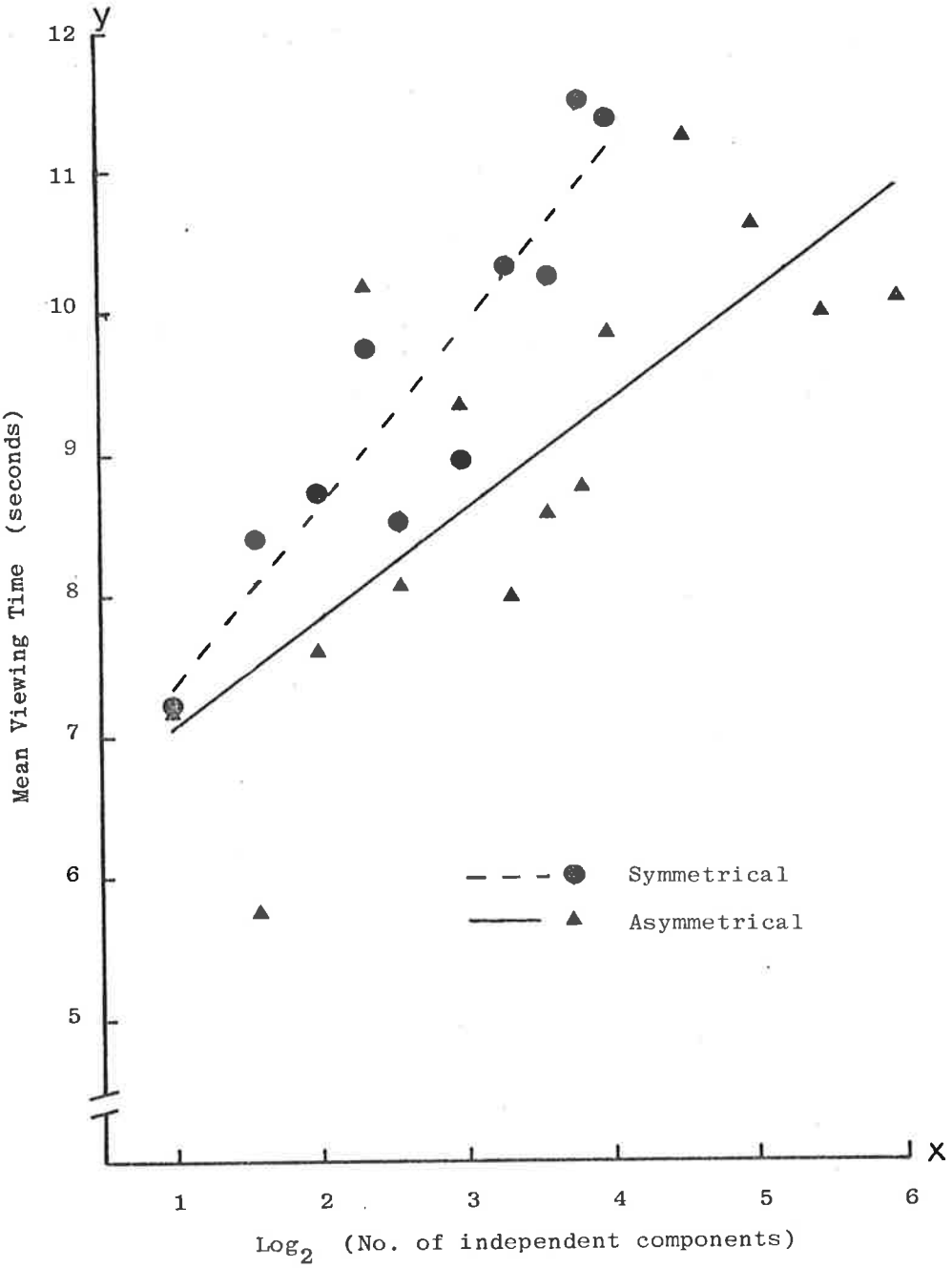
Figure 2.11. Mean interest ratings for symmetrical and asymmetrical patterns for Group II, with tests of significance for linear and quadratic trend and lines of best fit



Parametric tests of significance for trend components					
Type	Trend Component	Mean coefficient	t(1-tail)	df	p<
Symmetrical	Linear	726.45	10.47	65	.001
Symmetrical	Quadratic	-191.35	7.65	65	.001
Asymmetrical	Linear	1257.20	7.84	65	.001
Asymmetrical	Quadratic	2.14	0.03	65	NS

Least-squares lines of best fit	
Symmetrical patterns	Asymmetrical patterns
$y'=-5.44x^2 + 41.97x - 20.92$ (Pearson's r = 0.89)	$y'=7.86x + 16.31$ (Pearson's r = 0.95)

Figure 2.12. Mean viewing time for symmetrical and asymmetrical patterns for Group III, with tests of significance for linear and quadratic trend and lines of best fit



Parametric tests of significance for trend components					
Type	Trend Component	Mean Coefficient	t(1-tail)	df	p<
Symmetrical	Linear	68.73	2.40	11	.05
Symmetrical	Quadratic	2.29	0.24	11	N.S.
Asymmetrical	Linear	125.87	2.58	11	.05
Asymmetrical	Quadratic	-19.78	0.75	11	N.S.

Least-squares line of best fit	
Symmetrical patterns	Asymmetrical patterns
y'=1.26x + 6.06 (Pearson's r = 0.91)	y'=0.77x + 6.29 (Pearson's r = 0.75)

marked variations between patterns in their group means, the consistency amongst subjects was very low, with Kendall's W between .05 and .28. The four W values were significantly greater than zero, but the low degree of consistency strongly suggested that individual differences in aesthetic preferences for complexity were marked.

The detailed trends for preference ratings (Group III) are shown in Figure 2.13, together with significance tests and second-order curves of best fit. As predicted from the informational model, a significant quadratic component was obtained with both symmetrical and asymmetrical patterns. As may be seen from inspection of the lines of best fit, the curves were of inverted-U form. The statistical indicators of this form were the negative mean polynomial coefficients for quadratic trend, and the negative parameters for the square coefficient (x^2), shown with Figure 2.13. These results confirm the model proposed in Figure 2.8.

The maximum preference was for patterns near the simple end of the series, with Group III. This feature was responsible for giving a significant, negative linear component of trend in the case of asymmetrical patterns, which may be seen as a negative slope for a major segment of the curve (see Figure 2.13).

The detailed trends for pleasantness ratings (Group I) are shown in Figure 2.14, together with significance tests and second-order curves of best fit. The quadratic component was pronounced and significant only in the case of symmetrical patterns, which gave a line of best fit of inverted-U form, consistent with the prediction. The quadratic polynomial coefficient and the parameter for "x^2" for asymmetrical patterns were negative as predicted, but to a nonsignificant degree. The asymmetrical patterns also gave a very low consistency value (W = .05), and therefore the data for that set suggested the importance of individual-observer variation in judgements of pleasantness.

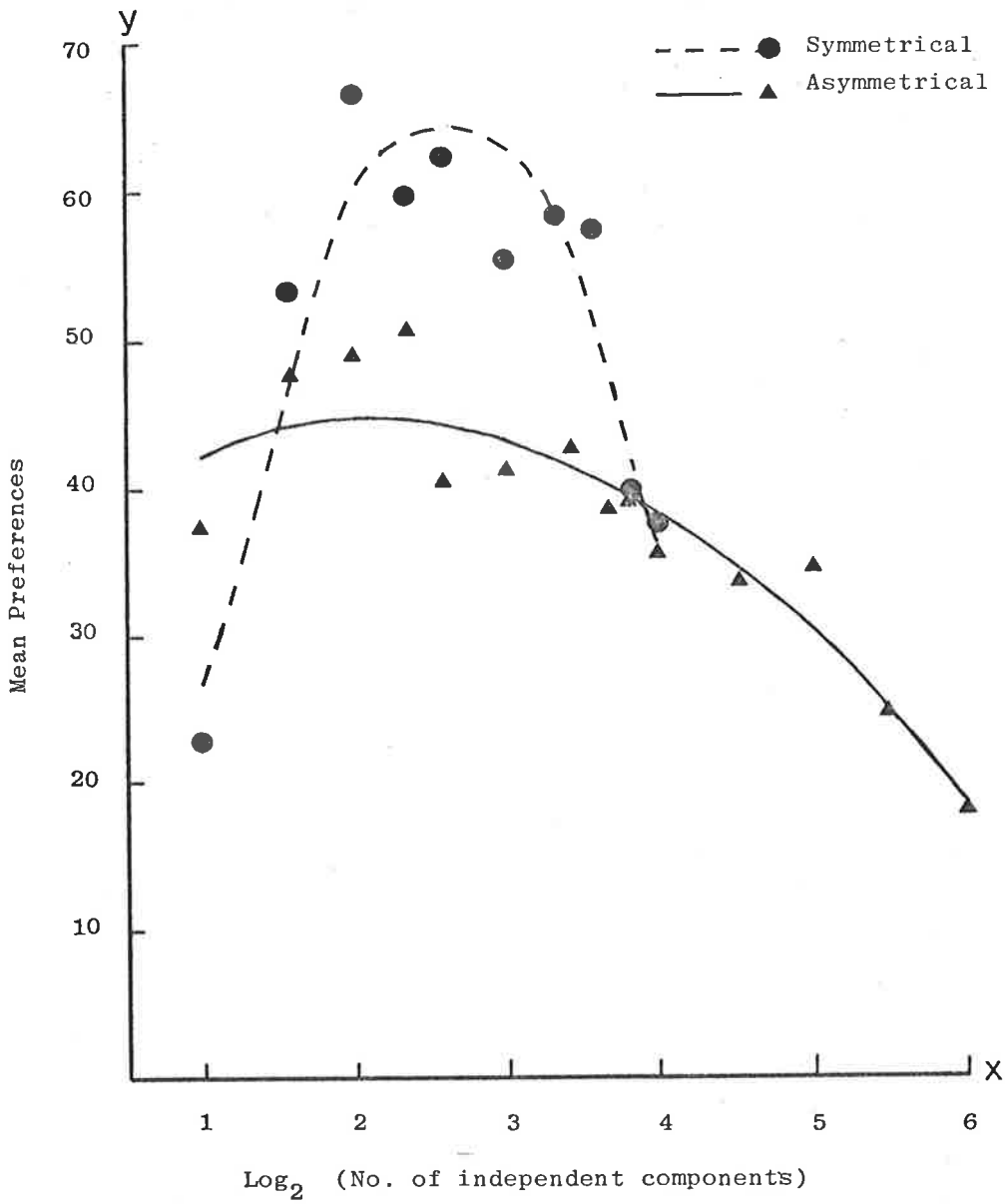
For both sets of patterns, there was a positive linear trend for pleasantness ratings, which was significant in the case of the symmetrical patterns. This trend component derived from the position of the peak of

Table 2.3. Mean pleasantness and preference ratings for 10 symmetrical and 14 asymmetrical Terwilliger-type patterns, with inter-subject consistency (Kendall's W)

No. of "independent components"	Group I (N=60) Pleasantness ratings (0 - 100 scale) Symmet.	Asymmet.	Group III (N=12) Preference ratings (0-100 scale) Symmet.	Asymmet.
2	26.9	31.5	22.9	37.5
3	40.7	34.1	53.1	47.4
4	56.5	38.1	66.3*	49.0
5	49.4	36.6	59.8	50.6*
6	59.7	39.1	62.1	40.1
8	57.7	35.4	55.2	41.0
10	56.9	36.5	58.2	42.6
12	61.5*	40.6	57.2	38.2
14	55.7	40.2	39.6	39.0
16	50.7	46.3*	37.3	35.7
23		41.8		33.5
32		41.4		34.2
45		42.2		24.5
64		38.8		18.0
Consistency (Kendall's W)	.16	.05	.28	.15
$p <$	.001	.001	.001	.05

* Maximum mean rating for the set

Figure 2.13. Mean preference ratings for symmetrical and asymmetrical patterns for Group III, with tests of significance for linear and quadratic trend and lines of best fit

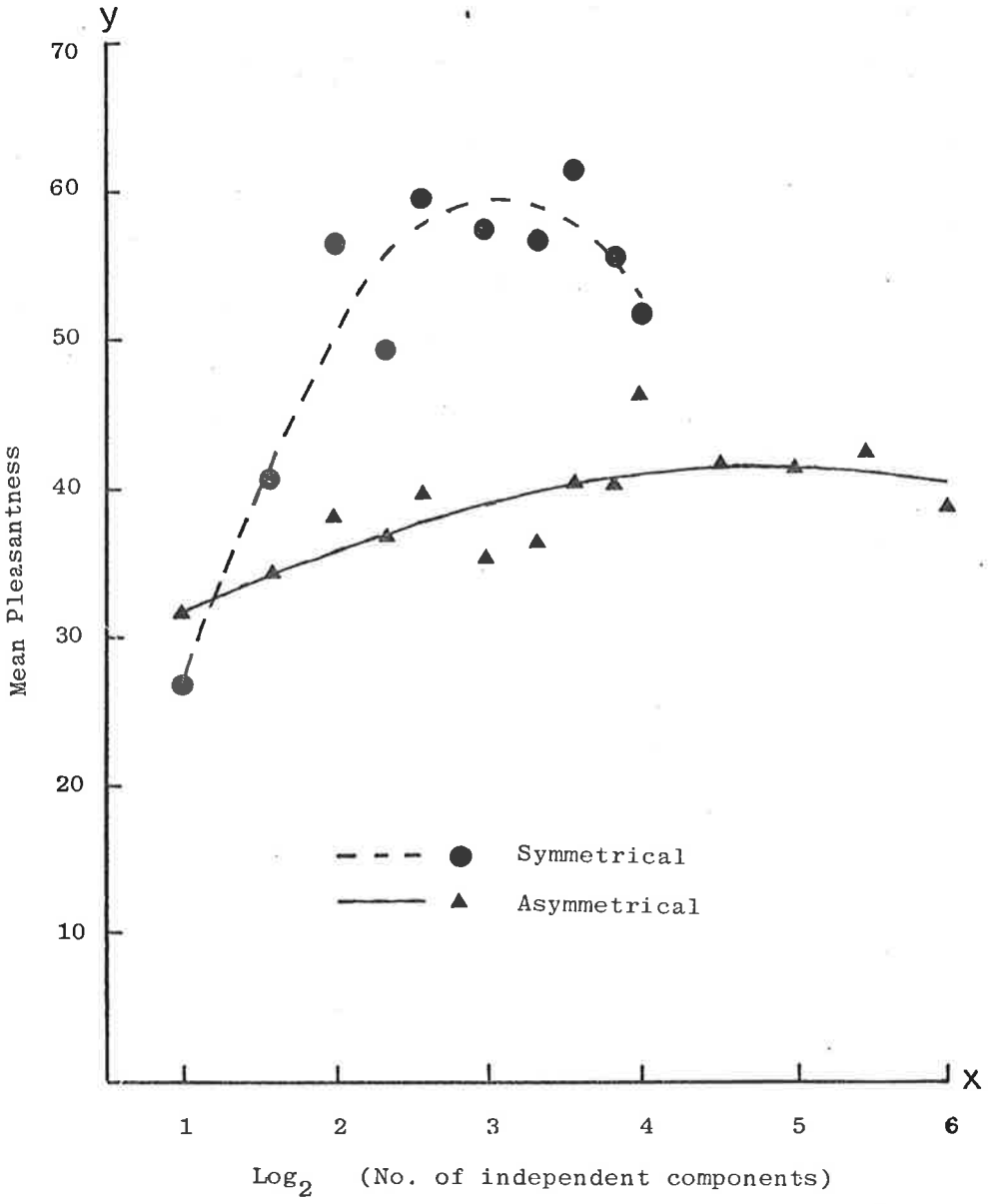


Parametric tests of significance for trend components					
Type	Trend Component	Mean coefficient	t*	df	p<
Symmetrical	Linear	-21.83	0.13	11	NS
Symmetrical	Quadratic	-400.00	3.94	11	.01
Asymmetrical	Linear	-790.42	3.04	11	.05
Asymmetrical	Quadratic	-361.50	2.10	11	.05

Least-squares lines of best fit	
Symmetrical patterns	Asymmetrical patterns
$y'=-14.67x^2 + 76.52x - 35.28$	$y'=-1.72x^2 + 7.19x + 37.09$

*Tests were one-tailed for quadratic trends since a clear prediction was made that the quadratic component would be negative (inverted-U shape). Two-tailed tests were used for the linear components, since it was not predicted whether the peak of preferences would be for low or high complexity values.

Figure 2.14. Mean pleasantness ratings for symmetrical and asymmetrical patterns for Group I, with tests of significance for linear and quadratic trend and lines of best fit



Parametric tests of significance for trend components					
Type	Trend components	Mean coefficient	t*	df	p<
Symmetrical	Linear	364.83	3.61	59	.01
Symmetrical	Quadratic	-248.47	9.66	59	.01
Asymmetrical	Linear	303.25	1.66	59	NS
Asymmetrical	Quadratic	-123.15	1.43	59	NS

Least-squares lines of best fit	
Symmetrical patterns	Asymmetrical patterns
$y'=-7.65x^2 + 46.88x - 12.44$	$y'=-0.71x^2 + 6.75x + 25.35$

*Tests were one-tailed for quadratic trends since a clear prediction was made that the quadratic component would be negative (inverted-U shape). Two-tailed tests were used for the linear component since it was not predicted whether the peak of preferences would be for high or low complexity values.

maximum preference toward the complex end of the series for Group I (as evident in Figure 2.14). The position of the maximum evaluation was thus different from that obtained for Group III, as may be observed by comparing Figures 2.13 and 2.14.

The difference could have been due to either of two factors: (a) a difference between preference and pleasantness responses, or (b) a difference between students from the two faculties, Group I being Arts and Group III Science students. The ambiguity of interpretation was resolved by considering data gathered by Tiffany Frayne under the writer's supervision. The same stimuli and procedures were used as for Group III except that pleasantness rather than preference ratings were obtained. The data obtained were similar to those described for Group III, with peaks of pleasantness near the "simple" end of the scale. Mean ratings compared across patterns were very similar for Group III and Frayne's group, with product-moment correlations of .88 for symmetrical and .74 for asymmetrical sets. It was therefore concluded that the original contrast between Group I and Group III was not due to their different rating scales, but to their differing composition, of Arts and Science faculty students respectively.

The tendency for Arts students to find complex patterns pleasant, and for Science students to prefer simple patterns, was an unexpected finding. This apparent faculty effect must be regarded as tentative, since no comparison between faculties was intended in the design of the experiment. The finding was nevertheless important, since it suggested one line of enquiry into the nature of individual differences in aesthetic preferences which was taken further in studies described in Part C of the thesis.

In summary, preference and pleasantness ratings gave trends against stimulus complexity broadly in line with the informational model. However, the precise form of the trends differed for symmetrical and asymmetrical patterns, and this required their separate analyses. Moreover, consistency

between subjects was low, despite fairly clear group trends. The importance of subgroup differences was confirmed by the unexpected finding of a difference between Arts and Science faculty students in their evaluation of pattern complexity. Very complex asymmetrical patterns were not preferred or regarded as particularly pleasant, even though they were given high interest ratings.

Results: comparisons between symmetrical and asymmetrical patterns

Whilst differences between the two sets of patterns have been mentioned in the above account, direct comparisons between mean responses for the two sets are undertaken in the present section. For this purpose, analyses of variance were undertaken on each dependent variable. Each analysis was for a three-way, balanced design: Symmetry (2 levels) by Pattern (10 levels) by Subjects (dependent on group size). "Subjects" was treated as a random factor, so giving a mixed model, and error terms for the experimental factors were selected accordingly. Computations were executed using the MANOVA subprogramme of SPSS (Cohen and Burns, 1976).

The four most complex asymmetrical patterns were excluded from these analyses, leaving symmetrical/asymmetrical pairs matched for number of independent components. It is admitted that control of this number meant that the total number of all components in a pattern was inevitably greater for the symmetrical set. The symmetrical patterns may therefore have had a "subjective complexity" value somewhat greater than their asymmetrical counterparts (Attneave, 1957). Nevertheless, it was considered more satisfactory to match "independent components" than "subjective complexity" or "total components".

The detailed analyses of variance are given in Appendix 2.3. For all response variables the main Pattern effects were significant; they do not require further discussion since they reflect the trends analyzed in greater detail above. The main effects of interest here are for Symmetry, and these are presented in Table 2.4. Symmetrical patterns, on average,

were regarded as more pleasant and more interesting; they were also preferred and looked at for a longer time compared with asymmetrical patterns. Very consistently, then, symmetrical patterns were more highly regarded than asymmetrical patterns. This finding was well supported by previous research (reviewed above) in the case of preference and pleasantness ratings. The finding that symmetrical patterns were also more interesting and viewed longer must be regarded as somewhat tentative, since there has been little previous work published on these aspects. Experiments using Berlyne's figures are relevant, and are discussed in the following chapter.

One minor exception to this consistent picture is worth noting. In the case of preference, pleasantness and interest ratings, the very simplest symmetrical pattern having only two independent components was rated lower than its corresponding asymmetrical pattern. This feature of the data is illustrated in each of Figures 2.11, 2.13 and 2.14 as a "cross-over" effect; it is also represented by the significant Symmetry by Pattern interactions shown in Table 2.5. It may be concluded that a pattern with very few component parts which is simplified yet further by symmetry, is a most "boring" stimulus for many people. For all but this exceptional case, however, symmetry was positively evaluated by the majority, as expected from previous research.

Eysenck's (1942, p.348) formula, which defined aesthetic pleasure as a function of the product of order and complexity, has some support from these data, if order is taken to involve symmetry and if complexity refers to multiplicity of elements. Nevertheless, Eysenck's formula is misleading in that it neglects the curvilinear relationship with multiplicity, and suggests a specific multiplicative combination for which there is no justification.

The results in relation to Terwilliger's adaptation-level hypothesis

Terwilliger (1963) described two studies which involved 37 and 61 patterns respectively of the type illustrated in Figures 2.9 and 2.10.

Table 2.4. Mean responses to ten symmetrical and ten asymmetrical patterns, with tests of significance

(The complete analysis of variance tables from which the significance tests derive, are given in Appendix 2.3)

Group	Response	Mean scores		Significance test		
		Symmet.	Asymmet.	F	df	p≤
I	Pleasantness	51.58	37.86	24.45	1,59	.01
II	Interest	48.09	37.64	17.55	1,65	.01
III	Preference	51.18	42.10	16.12	1,11	.01
III	Viewing time (in seconds)	9.49	8.32	6.59	1,11	.05

Table 2.5. Significant Symmetry x Pattern interactions, shown as cross-over effects in Figures 2.11, 2.13 and 2.14

(The complete analysis of variance tables from which the significance tests derive, are given in Appendix 2.3)

Group	Response	Significance of Symmetry x Pattern Interaction Effect		
		F	df	p≤
I	Pleasantness	5.09	9,590	.01
II	Interest	5.78	9,650	.01
III	Preference	2.00	9, 99	.05

He obtained median pleasantness ratings for groups of psychology students, like those comprising Group I in the present inquiry. Terwilliger interpreted his results in terms of a hypothetical "adaptation-level", a concept proposed by Helson (1959) to account for effects observed when a series of stimuli varying in intensity is presented to an observer. Terwilliger's hypothesis was thus an attempt to apply a notion derived from consideration of stimulus "energy" to the realm of stimulus complexity or information. Before discussing the present results in terms of the hypothesis, it is necessary to describe Terwilliger's analysis.

Terwilliger devised a complex formula for an index of pattern complexity which attempted to take into account the number of component parts, their heterogeneity and symmetry. The mean value for this Index was calculated for the set of patterns used, and this value was specified as the "adaptation-level". Complexity values were then taken as deviations from the adaptation-level.

Terwilliger hypothesized that "pleasantness increases and then decreases as complexity becomes increasingly different from the adaptation level complexity" (*op. cit.*, p.387). If pleasantness is plotted against Terwilliger's Complexity Index, the curve predicted from his hypothesis has two maxima, with a minimum between the maxima coinciding with the adaptation level.

This conception is similar to an earlier proposal by Haber (1958), that a moderate discrepancy in either direction from an adaptation-level is pleasant, but that larger discrepancies are less so. There has been little investigation of the hypothesis in relation to visual complexity, although Hunt (1971, p.18) noted that unpublished research by a postgraduate student, Unikel, in 1966 did not support the adaptation-level hypothesis.

Terwilliger fitted a "butterfly-shaped" curve to his data, using arbitrary parameters, and considered that he obtained "a rather accurate prediction". His plot is shown in Figure 2.15. Rather than having the form suggested by Terwilliger's hypothesis, examination of the data points shows two separate

Figure 2.15. Terwilliger's (1963) plot of median judged pleasantness against pattern complexity (as deviation from average complexity level)

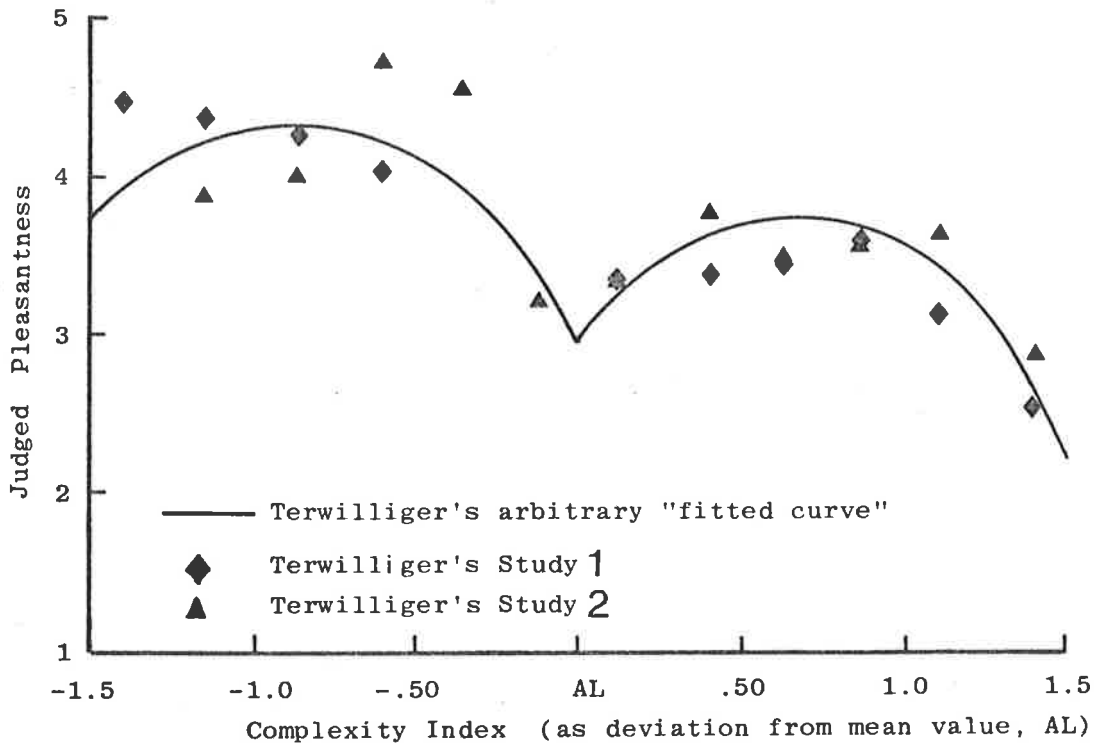
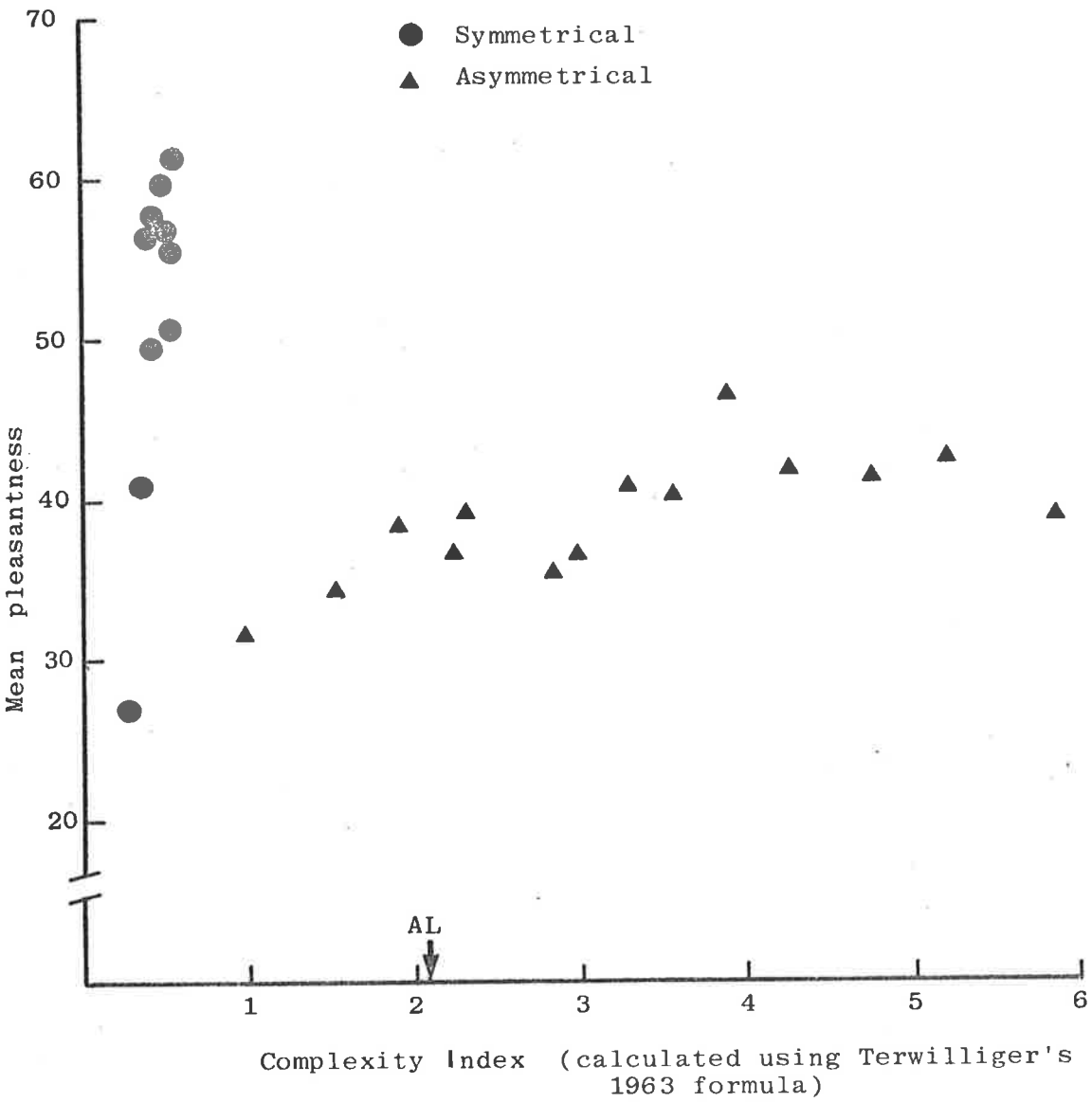


Figure 2.16. Mean pleasantness ratings for Group I plotted against Terwilliger's (1963) complexity-index values



Notes: All symmetrical patterns had similar complexity index values in the present study, partly because all had two axes of symmetry. In Terwilliger's (1963) study, patterns had from one to four axes of symmetry.

The position marked AL represents the "adaptation-level" in Terwilliger's terms, and is the mean Complexity Index value for all patterns included in the study.

features: (a) patterns with high Complexity Index values gave an inverted-U curve of the kind predicted from the information model presented earlier; (b) patterns with low (negative) complexity values gave no systematic trend, but received generally high pleasantness ratings. How may these two features be explained? Consideration of Terwilliger's complexity formula shows that asymmetrical patterns obtain Index values of about 1 or more, whilst most symmetrical patterns obtain Index values of less than 1. The right-hand inverted-U trend in Terwilliger's plot (Figure 2.15) was therefore derived from asymmetrical patterns. The left-hand part of Terwilliger's plot, with high pleasantness scores, was derived mainly from symmetrical patterns. Both features of Terwilliger's data were therefore consistent with generalisations stated above, rather than consistent with his hypothesized "butterfly-shaped" adaptation-level curve.

Day (1967b) correctly commented that "The bimodal function may possibly be due to the effect of symmetry", although he did not elaborate. Why did the "left-hand" half of Terwilliger's plot (derived mostly from symmetrical patterns) not show an inverted-U form? The data showed no regular trend; it may be supposed that this was because the Complexity Index for these patterns did not adequately reflect the number of component parts, but that it varied according to the differing numbers of axes of symmetry in the patterns used by Terwilliger.

To check these suppositions, Terwilliger's Complexity Index was calculated for each pattern used in the present investigation. Values are given in Figures 2.9 and 2.10. The data for pleasantness ratings provided by Group I are plotted against the Complexity Index in Figure 2.16. The Figure illustrates the division between asymmetrical and symmetrical patterns deduced from the complexity formula, and confirms that the right-hand inverted-U shape stems from asymmetrical patterns only.

Figure 2.16 also shows that Terwilliger's Complexity Index does not

discriminate well between symmetrical patterns all having two axes of symmetry. Presumably the distinct complexity values obtained by Terwilliger (see Figure 2.15) resulted from the use of patterns with one, two, three or four axes of symmetry (including diagonal axes). It may be noted incidentally that different axes are not identical in their perceptual effects as assumed by Terwilliger's formula (Palmer and Hemenway, 1978).

Clearly the results shown in Figure 2.16 are explicable only when separate consideration is given to the symmetrical and asymmetrical sets, as in Figure 2.14. The relationship is not one best represented as a "butterfly-shaped" curve, but rather as separate inverted-U relationships for symmetrical and asymmetrical sets. Whereas Terwilliger's hypothesis predicts that a minimum occurs at the "adaptation-level" (the mean complexity index value of 2.07 in the present case), inspection of Figure 2.16 shows that this did not occur. Rather, the lowest pleasantness ratings were given for the simplest symmetrical and asymmetrical patterns.

It is concluded that Terwilliger's adaptation level theory is arbitrary and disconfirmed by the data; and that his Complexity Index serves to confound rather than elucidate relationships.

Chapter Summary

From previous research and from studies using Terwilliger-type patterns, an informational model of the relationships between aesthetic and perceptual responses and the multiplicity of elements in visual patterns was proposed. In particular, it was found that aesthetic preference or pleasantness tended to give an inverted-U relationship with multiplicity, whereas such responses as interest ratings and viewing time generally gave a monotonic increasing trend. Terwilliger's adaptation-level theory was not supported. In addition, there was consistent evidence that symmetrical patterns (other than the very simplest) are evaluated more highly by the majority of observers than

asymmetrical patterns, with the number of independent elements controlled.

Whilst the group trends were broadly in favour of an informational interpretation, the low degree of consistency between subjects in evaluation of pattern-complexity suggested the need to investigate individual differences in this respect. In particular, the difference between Arts faculty students in Group I and Science faculty students in Group III in their evaluation of complex patterns, suggested that Arts-Science orientation would be one relevant aspect to consider. This possibility is extensively explored in Part C of the thesis.

CHAPTER 3

EXPERIMENTS USING BERLYNE'S FIGURES AND SIMILAR MATERIAL

In this chapter, experiments by Berlyne and others using his patterns, as reproduced for instance by Berlyne and Peckham (1966, Figure 1), are discussed in relation to informational, arousal, and adaptation-level models. They are separately considered in this chapter since they have been used in a large number of studies, and because the patterns are organised as "more complex" and "less complex" pairs, which makes them unsuitable for the detailed investigation of general trends as described in chapter 2.

Berlyne interpreted responses to visual complexity in terms of curiosity drive and arousal theory. "There are evidently vital links between arousal and exploratory behaviour" (Berlyne, 1968). For instance, the inverted-U relationship described in informational terms in chapter 2 was related by Berlyne to Wundt's curve of pleasantness against stimulus intensity (Berlyne, 1967, p.52), which he considered could be generalised to the dimension of stimulus complexity and explained in terms of arousal (1967, p.87-88). Although the "butterfly-shaped" curve derived from adaptation-level theory is clearly incompatible with the U-shaped curve, Berlyne (1967, p.88-89) considered that the former represented merely a "mirror-image" extension of the latter.

It seemed to the writer that the nature of findings with Berlyne's patterns needed to be clarified first, before attempting any theoretical interpretation. One of the causes of confusion in this area has been the neglect of differences between various aspects of complexity, including asymmetry and multiplicity of elements, which are represented in Berlyne's patterns. In this connection, attempts have been made to describe previous results for the pairs of patterns in terms of a single continuum of complexity, and this has led to several misinterpretations.

In this chapter, a summary of findings with Berlyne's patterns is presented, for different responses to pairs of patterns representing "asymmetry/symmetry" and "multiplicity of elements". Heckhausen's (1964) criticism of Berlyne's work is considered, and shown to be a "red herring". Then Berlyne's support for Terwilliger's adaptation-level hypothesis will be criticised and shown to be based on misinterpretation due to confounding of stimulus variables. Finally, physiological responses to Berlyne's patterns are considered.

Relevant patterns

The stimulus material used by Berlyne and others consisted of pairs of patterns in subsets denoted by a letter code. The types of pattern have been fairly consistent over several studies, although the exact number of pairs within subsets has varied, and not all subsets have been used in all experiments. Subsets relevant to the concepts of "symmetry" and "multiplicity of elements" are described in Table 3.1.

The idea of the pattern-pairs was that they should represent various "collative" variables whilst holding other variables constant. Despite their wide use, the patterns are not ideal, and their labelling is confused. Thus Table 3.1 shows that five subsets involve a contrast between symmetrical and asymmetrical patterns, and yet only one of these (XB) is stated to represent "Asymmetry". Within some subsets, more than one aspect of complexity is varied: in subset C heterogeneity of elements as well as symmetry differentiates the less and more complex items, and in subset D items differ in both symmetry and multiplicity in the form of number of independent turns in outline shapes. Despite these difficulties, it was considered that evidence concerning the two "multiplicity of elements" subsets and the five "symmetry/asymmetry" subsets was adequate to examine hypotheses derived from the informational model presented in Figure 2.8.

Hypotheses derived from the informational model

Multiplicity of elements. From the model, it was expected that those patterns with more elements (in subsets B and XA) would be viewed longer and be more interesting than the corresponding patterns with fewer elements. With regard to evaluative responses, "predictions" were differentiated for the two subsets, because within subset B both patterns in each pair have few or a moderate number of elements, whilst subset XA consists of relatively complex patterns with many elements. (The nature of the subsets is clarified by the descriptions in Table 3.1). The B patterns were likely to be on the rising segment of the hypothesized inverted-U preference curve, so that the patterns with a moderate number of elements within the B subset would be more highly evaluated than the very simple members of the pairs. On the other hand, the XA patterns were likely to be on the declining segment of the inverted-U curve, so that in this case the patterns with very many elements would be less highly evaluated. The predictions are summarised in Table 3.2(i).

Symmetry/asymmetry. With regard to symmetry/asymmetry subsets, it was expected that symmetrical patterns would be given higher evaluative and interest ratings than asymmetrical patterns. Generally speaking, the data for Berlyne's patterns have not been reported in the literature in a manner conducive to testing these hypotheses, since subsets relevant to symmetry have not been considered separately. Rather, authors seem to have expected that all more complex items, whether asymmetrical or with more elements, would be similarly arousing and thereby have similar effects on response variables. Indeed, Berlyne and McDonnell (1965) considered that all aspects of complexity "have been shown to have significant and, on the whole, similar effects on the duration of exploratory inspection and on the direction of exploratory choice... on ratings of 'pleasingness' and 'interestingness'. This assertion is contrary to the predictions expressed

Table 3.1. Subsets of Berlyne's patterns (in less complex and more complex pairs) relevant to (i) multiplicity of elements and (ii) symmetry

(The patterns are given in several reports, such as Berlyne and Peckham, 1966, Figure 1 and Berlyne, 1958a, Figure 1. The subsets are similar in different reports, although some subsets may be excluded. Within subsets, the particular pattern-pairs have varied somewhat.)

(i) Pairs relevant to multiplicity of elements

Berlyne's identification		Description of pattern-pairs	
Code	Label	Less Complex	More complex
B	"Amount of material"	Few lines, shapes or curves	More elements added in a symmetrical pattern
XA	"Number of independent units"	Many lines, or sides to polygons, etc. in asymmetrical arrangement	Even more lines, or sides etc., in an asymmetrical arrangement

(ii) Pairs relevant to symmetry/asymmetry

Berlyne's identification		Description of pattern-pairs	
Code	Label	Less Complex	More Complex
A	"Irregularity of arrangement"	Vertical symmetry, plus additional symmetry in some items	No symmetry, by rearrangement of elements
C	"Heterogeneity of elements"	Vertical and horizontal symmetry, with homogeneous elements	No symmetry, and heterogeneous elements
D	"Irregularity of shape"	Vertical and horizontal symmetry with geometrical outline shapes	No symmetry, with irregular shapes having more turns
XB	"Asymmetry"	Vertical and horizontal symmetry in complex patterns	No symmetry, by rearrangement of elements
XC	"Random redistribution"	Vertical and horizontal symmetry in complex patterns	No symmetry, by rearrangement of elements

Table 3.2. Predictions based on the informational model presented in chapter 2, applied to Berlyne's patterns

(i) Predictions relevant to multiplicity of elements

"+" Indicates the prediction that patterns with more elements receive the greater mean response.

"-" Indicates the prediction that patterns with fewer elements receive the greater mean response.

Response	Subset	
	B	XA
Preference or other evaluative response	+	-
Interest rating	+	+
Viewing time and viewing choice	+	+

(ii) Predictions relevant to symmetry

"+" Indicates the prediction that patterns with asymmetry receive the greater mean response.

"-" Indicates the prediction that patterns with symmetry receive the greater mean response.

"?" Indicates that the outcome depends on experimental conditions, and no unequivocal prediction is made.

Response	Subset				
	A	C	D	XB	XC
Preference or other evaluative response	-	-	-	-	-
Interest rating	-	-	-	-	-
Viewing time	+	+	+	+	+
Choice for further viewing	?	?	?	?	?

in Table 3.2, which show quite different effects for multiplicity and for asymmetry, on the basis of the evidence presented in chapter 2.

With regard to the effect of asymmetry on viewing time, it was found in the experiment with Terwilliger patterns reported in chapter 2 that asymmetrical patterns were viewed for a slightly shorter time than symmetrical patterns. However, the latter had a greater total number of components than the corresponding asymmetrical patterns (since the number of *independent* components was controlled). In the case of Berlyne's patterns, asymmetrical patterns have the same or more elements compared with the corresponding symmetrical patterns. In this case, the symmetrical patterns have lower informational content as a result of their redundancy compared with the asymmetrical items, which should therefore require a longer viewing time for their assimilation, as was indeed found with symmetrical and asymmetrical polygons (Day, 1968b, Figure 2). Positive difference-scores were thus predicted for the Berlyne patterns, as shown in Table 3.2(ii).

It was not possible to predict the effect of asymmetry on choice for further viewing, since there was little evidence other than that with Berlyne's patterns under consideration. Theoretical considerations from the informational point of view suggested the importance of the initial period of "pre-exposure". If observers are given but a brief period to glimpse the patterns, they may well choose to see again the pattern with more information (the asymmetrical item of the pair). However, after a longer pre-exposure period, observers may have assimilated most of the stimulus information and therefore select for further viewing preferred patterns; they may thus favour symmetrical items. If these suppositions are correct, differences between symmetrical and asymmetrical patterns with respect to choice for further viewing might depend on the period of pre-exposure, and be somewhat unpredictable. This is indicated by "?" in Table 3.2(ii).

Difficulties in assessing published evidence

Inadequacies and errors in some of the studies reviewed in this chapter hinder evaluation of the evidence. For instance, Berlyne and Lewis (1963) gave inconsistent mean viewing times in their Figure I and Table II. It appears that for all but the "C" group, data for more and less complex patterns were reversed in the Figure's histogram. In other cases, difficulty arises from misleading interpretations. For instance, Berlyne and Lawrence (1964) concluded from their Experiment II that there was "some indication of a negative correlation between verbally expressed preference and exploration time". However, the ordinal correlation (Tau) calculated by the writer across the twenty figures used in their experiment was -.13, which was not significantly different from zero.

One particular source of difficulty is the generalization across all forms of complexity, including asymmetry and multiplicity. Interpretations may thus be confused and even inconsistent. Examples were given in the previous chapter in the section on "Dimensions of stimulus complexity". A further example of confused interpretation was provided by Berlyne, McDonnell, Nicki and Parham (1967), who wrote that "there is a tendency for the more complex pattern of a pair to be judged more interesting", but also wrote of "inverted U-shaped curves that connect interestingness with visual complexity". Clearly both statements cannot simultaneously be accurate. The confusion arose, the writer believes, because of the failure to recognise that patterns which are more complex by having many elements are interesting, but that patterns which are "simple" by being symmetrical also arouse interest.

In some cases data have not been given separately for each subset, so that findings for different aspects of complexity cannot be distinguished. For example, Berlyne (1963, Table IV) gave only combined results for subset XA (number of independent units) and subset XB (asymmetry). Berlyne is not alone in confounding variables in this way. Day (1966)

reported that less complex patterns "of the Berlyne slides were generally preferred"; since the subsets were not individually identified it is not known whether this finding represented greater preference for the symmetrical patterns. In a subsequent report on viewing times, Day (1968b) noted that data for Berlyne's patterns "showed more internal variability, probably due to the confounding of the complexity and asymmetry factors". Even so, no attempt to separate these factors within Berlyne's patterns was made in that report.

Evidence concerning multiplicity of elements

For Berlyne's subsets B and XA, mean difference-scores were obtained or calculated from published data, taking the response measure for the more complex patterns minus the measure for the less complex patterns. Difference-scores for evaluative and interest ratings are given in Table 3.3. Differences were small, but significant and in the predicted direction for three cases from the available seven instances. For subset B, more complex patterns tended to be more preferred and more interesting; whilst for subset XA, the patterns with a median number of elements were judged more beautiful than those with very many elements. Whilst not extensive, the evidence on the effects of multiplicity using Berlyne's patterns was fairly consistent with the informational model with regard to evaluation and interest.

Data for viewing time and choice for further viewing following a short pre-exposure are shown in Table 3.4. As predicted from the informational model, all difference-scores for both B and XA subsets were positive, and in several cases significant. Thus items which contained more elements were consistently looked at for longer and were selected for further viewing after short exposure, compared with their paired control patterns with fewer elements. The findings supported the monotonic relationships described in chapter 2 for these response variables.

In addition to the data tabulated, other reports on similar patterns have given findings in a form not suited to such presentation. Greenberger,

Table 3.3. Summary of effects of multiplicity of elements on evaluative or interestingness judgements with Berlyne's patterns

(A positive mean difference-score indicated that patterns with more elements obtained higher preferences, etc.)

Author/s	Date	Study	Response	N	Mean Difference Score	
					B pairs	XA pairs
Berlyne	1963	Expt. II	Pleasingness	16	0.0	
Berlyne	1963	Expt. II	Interest	16	+0.2*	
Berlyne & Lawrence	1964	Expt. II	Preference	60	+1.3*	
Berlyne & Peckham	1966		"Ugly-Beautiful"	38	+0.1	-0.9*
			"Weak-Strong"	38	-0.1	-0.4

* $p < .05$

Table 3.4. Summary of effects of multiplicity of elements on viewing time and choice, with Berlyne's patterns

(A positive mean difference-score indicated that patterns with more elements were viewed longer or received more selections for viewing)

Author/s	Date	Study (or footnote)	Response measure	N	Mean difference B subsets	Mean difference XA subsets
Viewing Time (VT)						
Berlyne	1958a	Expt. I	% of 10 sec VT	20	+ 9#	
Berlyne	1958b		% of 10 sec VT	16	+19*	
Berlyne	1958b		% of 2 min VT	16	+16*	
Berlyne & Lewis	1963		VT in sec	64	+ 0.4	
Berlyne & Lawrence	1964	Expt. I	VT in sec	80	+ 0.4#	+ 0.2
		Expt. II (i)	VT in sec	30	0.0	
		Expt. II (ii)	VT in sec	30	+ 0.2	
Percentage Viewing Choice (VC) (iii)						
Berlyne	1963	Expt. I	VC after ½ or 1 sec pre-exp.	40	+57#	+27*
Berlyne	1963	Expt. II	VC after 3 or 4 sec pre-exp.	40	+25	+20
Berlyne & Lewis	1963	(iv)	VC after ½ or 3 sec pre-exp.	64	+20*	+20*
Hoats, Miller & Spitz	1963	Expt. I (iv) (16 yr normals)	VC after 3 sec pre-exp.	30	+21*	

Footnotes: * $p < .05$ # $p < .01$

(i) With 0.6 sec pre-exposure condition.

(ii) With variable pre-exposure condition.

(iii) Subjects viewed pairs of patterns for the stated pre-exposure time, and then choose whether to see the more complex or less complex item of the pair. The difference, precentage-choice for more complex patterns minus that for less complex patterns, is given.

(iv) Two-tail significance levels were estimated by the writer using the Binomial test on the total observations for each subset.

Woldman and Yourshaw (1967) reported longer viewing time for "high-information" visual stimuli (varied in terms of complexity, incongruity, and ambiguity). Their report did not distinguish between these various stimulus facets.

Berlyne (1971b) reported that most subjects tended to select more complex patterns for viewing after various types of prior auditory stimulation. Berlyne and Crozier (1971, Experiments 1 - 4) also found that subjects tended to select complex patterns after various forms of prior visual stimuli; an exception, such that no significant choice of complex patterns occurred, was when coloured pictures were shown before each of the Berlyne pattern-pairs (Experiment 3, Condition C). The stimulus pairs in these particular experiments were not the "standard" pairs used previously, but in two of three cases were "mixed pairs" such that the more complex and less complex items differed both in number of elements and in symmetry (Berlyne, 1971b, Figure 1). The same "mixed" stimulus pairs were used in a further experiment (Berlyne 1972c), when again it was found that the "more complex" patterns were selected for more exposures and were rated more interesting than the "less complex" patterns.

Data in the form of factor loadings from Berlyne, Ogilvie and Parham's (1968) study have not been included in Tables 3.3 and 3.5, because the values were derived from judgements of *differences* in pleasingness (and interestingness), regardless of direction. The factor values for Berlyne's pattern-pairs cannot therefore be interpreted as reflecting pleasingness and interestingness levels directly.

Evidence concerning symmetry/asymmetry

Results with the Berlyne subsets, when symmetrical and asymmetrical patterns were evaluated, are shown in Table 3.5. The mean difference-scores were generally negative, as predicted (*cf.* Table 3.2). Several significant differences were reported, all in the negative direction, as expected from the preference for symmetrical patterns described in chapter 2. Whilst

these results are clear and consistent, they have not usually been reported in this fashion. Indeed, the particular findings for symmetry/asymmetry comparisons have been neglected, in the sense that they have been contaminated with other features under the general notions of complexity or incongruity.

It may be noted that the symmetrical patterns in the XC subset were interesting as well as pleasing (Table 3.5), just as the patterns with more elements in the B subset were both interesting and preferred. This pattern of relationships is inconsistent with Berlyne's (1963) suggestion that "*arousal-raising* stimulus properties" are reflected in interest ratings, whilst "*arousal-restraining* stimulus properties" are reflected in pleasingness judgements. Clearly the same stimuli cannot be both arousal-raising and arousal-restraining. Berlyne's suggestion has also been contradicted by the positive correlations between interest and pleasingness (or preference) for patterns varying from simple to moderate complexity levels (Beittel, 1963; Berlyne, Ogilvie and Parham, 1968, Table 2; and the data reported in chapter 2). Berlyne, McDonnell, Nicki and Parham (1967, Experiment V) similarly obtained a positive correlation of .38 between interest and pleasingness for 14 sound stimuli. All of this evidence demonstrates how misleading was Berlyne's (1972a) statement that the two scales (pleasing and interesting) "are representative of mutually orthogonal factors".

The comparisons between Berlyne's symmetrical and asymmetrical patterns in viewing time are shown in Table 3.6. As predicted (Table 3.2), the asymmetrical patterns were inspected for a longer time in most cases, resulting in positive difference-scores which were statistically significant in several instances. Thus asymmetrical patterns were viewed longer than symmetrical patterns having the same total number of elements, even though the former were generally liked less and in the case of subset XC were less interesting (compare Tables 3.5 and 3.6). This result was expected

Table 3.5. Summary of effects of symmetry on evaluation or interestingness judgements with Berlyne's patterns

(A positive mean difference-score indicated that asymmetrical patterns obtained higher preferences etc. compared with symmetrical patterns. A negative mean difference-score indicated that symmetrical patterns were more preferred, etc.).

Author/s	Date	Study	Response	N	Mean difference-score				
					A pairs	C pairs	D pairs	XB pairs	XC pairs
Berlyne	1963	Expt. II	Pleasingness	16	-0.8#	-1.1#	-1.3#		-1.7#
Berlyne	1963	Expt. II	Interest	16	0.0	+0.5	+0.3		-0.7#
Berlyne & Lawrence	1964	Expt. II	Preference	60	-2.6#	-0.5	-0.7		
Berlyne & Peckham	1966		"Ugly-Beautiful"	38	+0.3	-0.1	-1.2#	-0.7#	-0.5*
			"Weak-Strong"	38	-0.1	-0.7#	-1.9#	-0.6#	-0.3

* $p < .05$ # $p < .01$

Table 3.6. Summary of effects of symmetry on viewing time (VT) with Berlyne's patterns

(A positive mean difference-score indicated that asymmetrical patterns were viewed longer. A negative mean difference-score indicated that symmetrical patterns were viewed longer.)

Author/s	Date	Study (or footnote)	Response measure	N	Mean difference-score				
					A pairs	C pairs	D pairs	XB pairs	XC pairs
Berlyne	1957	(i)	No. of .14 sec exp.	16	+ 1.6*	+ 1.6#	+ 1.4#		
Berlyne	1958a	Expt. I	% of 10 sec VT	20	+ 12#	+ 18#	+ 16#		
Berlyne	1958b		% of 10 sec VT	16	+ 16	+ 26*	+ 15		
Berlyne	1958b		% of 2 min VT	16	0	+ 20*	+ 19*		
Berlyne & Lewis	1963		VT in sec	64	+ 0.2	+ 0.5	+ 0.3		- 0.5
Berlyne & Lawrence	1964	Expt. I	VT in sec	80	+ 0.2	+ 1.3#	+ 1.0#	0.0	+ 0.9#
		Expt. II (ii)	VT in sec	30	+ 1.3*	+ 0.5*	+ 1.2#		
		Expt. II (iii)	VT in sec	30	+ 0.3	+ 0.9*	0.0		

* $p < .05$ # $p < .01$

Footnotes:

(i) In the report by Berlyne (1957) stimulus-pairs were named somewhat differently from later studies. The A subset consisted of the two "Series A" cards; the C subset consisted of cards 1 and 4 from "Series C"; and the D subset consisted of cards 3 and 4 from "Series B". The significance levels are those for the complete Series, since only these were available.

(ii) With 0.6 sec pre-exposure condition

(iii) With variable pre-exposure condition.

Table 3.7. Summary of effects of symmetry on choice for further viewing (VC) after various pre-exposure times, with Berlyne's patterns

(Subjects viewed pairs of patterns for the stated pre-exposure time, and then chose whether to see the symmetrical or asymmetrical item of the pair. The difference in percentage-choice for asymmetrical minus that for symmetrical patterns is given. A positive mean difference-score indicated that asymmetrical patterns were chosen more often for further viewing. A negative difference-score indicated that symmetrical patterns were chosen more often.)

Author/s	Date	Study (or footnote)	Response measure	N	Mean difference-score				
					A pairs	C pairs	D pairs	XB pairs	XC pairs
Berlyne	1963	Expt. I	VC after ½ or 1 sec pre-exp.	40	+10	+45#	+45#	-15	+ 5
Berlyne	1963	Expt. I	VC after 3 or 4 sec pre-exp.	40	-32#	+25	- 5	-50#	-35#
Berlyne & Lewis	1963	(i)	VC after ½ or 3 sec pre-exp.	64	0	+10	+10	-30#	-30#
Hoats, Miller & Spitz	1963	Expt. I (i)	VC after 3 sec pre-exp.	30	-32#	- 4	-29#		

# $p < .01$

Footnote: (i) Two-tail significance tests were applied by the writer using the Binomial distribution on the total observations for each subset.

from the analysis given in chapter 2; but it was contrary to Berlyne's (1950, 1954a and 1954b) theory of curiosity, in which both interest and stimulus exploration were regarded as similar effects of curiosity drive.

The findings of experiments on viewing choice following an initial pre-exposure period, were not entirely consistent (Table 3.7). As envisaged above, there was some indication in the case of very short pre-exposure durations (½ or 1 sec), that asymmetrical patterns were chosen for further viewing more often than symmetrical ones (Berlyne, 1963, Expt. I). In the case of longer pre-exposures used in the other studies summarised in Table 3.7, the symmetrical patterns tended to be chosen more often. It is unfortunate that Berlyne and Lewis (1963) did not give their data separately for the ½ sec and 3 sec pre-exposure condition; they reported that there was no significant effect of different pre-exposure times over all subsets, but some difference may have occurred for the symmetry/asymmetry subsets.

In interpreting these viewing-choice results, it seems likely that with very short pre-exposure times the observer chooses to have more time to assimilate the non-redundant patterns, as in the case of direct viewing-time measures. However, when he has already been given (say) three seconds to view the pair of patterns, he tends to select for further viewing that pattern which he prefers. For the subsets under consideration, this tends to be the symmetrical item of the pair. Berlyne and Peckham (1966) came to somewhat similar conclusions, by distinguishing "specific exploration" directed towards the satisfaction of curiosity, from "diversive exploration" directed towards stimuli which "possess collative properties... to the right degree". However, these authors did not identify the distinction specifically in terms of the interaction between pre-exposure time and symmetry/asymmetry, as indicated here. Since experiments have not been undertaken to further explore this interaction, its reliability and meaning remain in some doubt.

What is clear from the foregoing analysis is that the effects of asymmetry are different from the effects of multiplicity of elements, in systematic ways. Berlyne's (1966a) contention that "We have regularly found that the subject spends more time looking at the 'more complex' than at the 'less complex' pattern of a pair" is misleading in its failure to distinguish between different aspects of complexity.

Berlyne (1966a) also claimed that "Experiments incorporating categories *XA* through *XC* have indicated that exploration time reaches a peak and declines as complexity becomes extreme". This implied that symmetrical patterns and those with fewer elements in subsets XA, XB and XC had longer viewing times. The claim is contrary to the findings discussed in chapter 2 for viewing time, and is also contrary to Berlyne's own evidence summarised in Tables 3.4 and 3.6. Again, Berlyne's confusion stemmed from the confounding of two quite different effects: the monotonic increase in viewing time with increasing multiplicity of elements (as shown in Table 3.4); and the choice of symmetrical ("less complex") patterns for further viewing after pre-exposure for a few seconds (as shown in Table 3.7).

Evidence concerning the so-called "bimodal" trend

In the previous chapter, Terwilliger's (1963) hypothesis that preference/complexity curves display two maxima (the "bimodal", "butterfly-shaped", or "inverted-W" curve) was described and criticised. However, Terwiller's hypothesis has received apparent support from research using Berlyne's patterns. For example, Berlyne and Peckham (1966) stated: "All these measures show two peaks in the function relating evaluation to complexity." In a review of relevant studies, Berlyne (1966b, p.15) concluded that the evidence favoured Terwilliger's hypothesis of "*une fonction bimodale*". Again, Berlyne, McDonnell, Nicki and Parham (1967) wrote that "preference has repeatedly been found to have two modes" when plotted against stimulus complexity.

How was it that Berlyne's pattern-*pairs* were regarded as providing

evidence of a complex *trend* over a range of levels of complexity? As well as each pair providing a more complex ("MC") and a less complex ("LC") item, the pairs were also divided into more complex subsets ("X") and less complex subsets (NonX). There were thus four types of patterns distinguished in the relevant literature and labelled there as follows: LC-NonX (or NX-); MC-NonX (or NX+); LC-X (or X-); and MC-X (or X+). These types differed in subjective complexity, with LC-NonX patterns given the lowest average complexity ratings through to MC-X patterns given the highest complexity ratings, according to Day's results presented by Berlyne and Peckham (1966,Figure 2). The so-called "bimodal function" in terms of Berlyne's patterns is illustrated in Figure 3.1, which shows Berlyne and Peckham's own results for Pleasingness ratings. Similar results were obtained by Berlyne (1973, Table 3,"line drawings") with respect to "hedonic value" scores: "we find the multimodal relation with complexity that former investigations found" (p.182). This interpretation was still propounded, despite the earlier realisation that "A large number of experiments have produced inverted U-shaped curves" (Berlyne, 1972b).

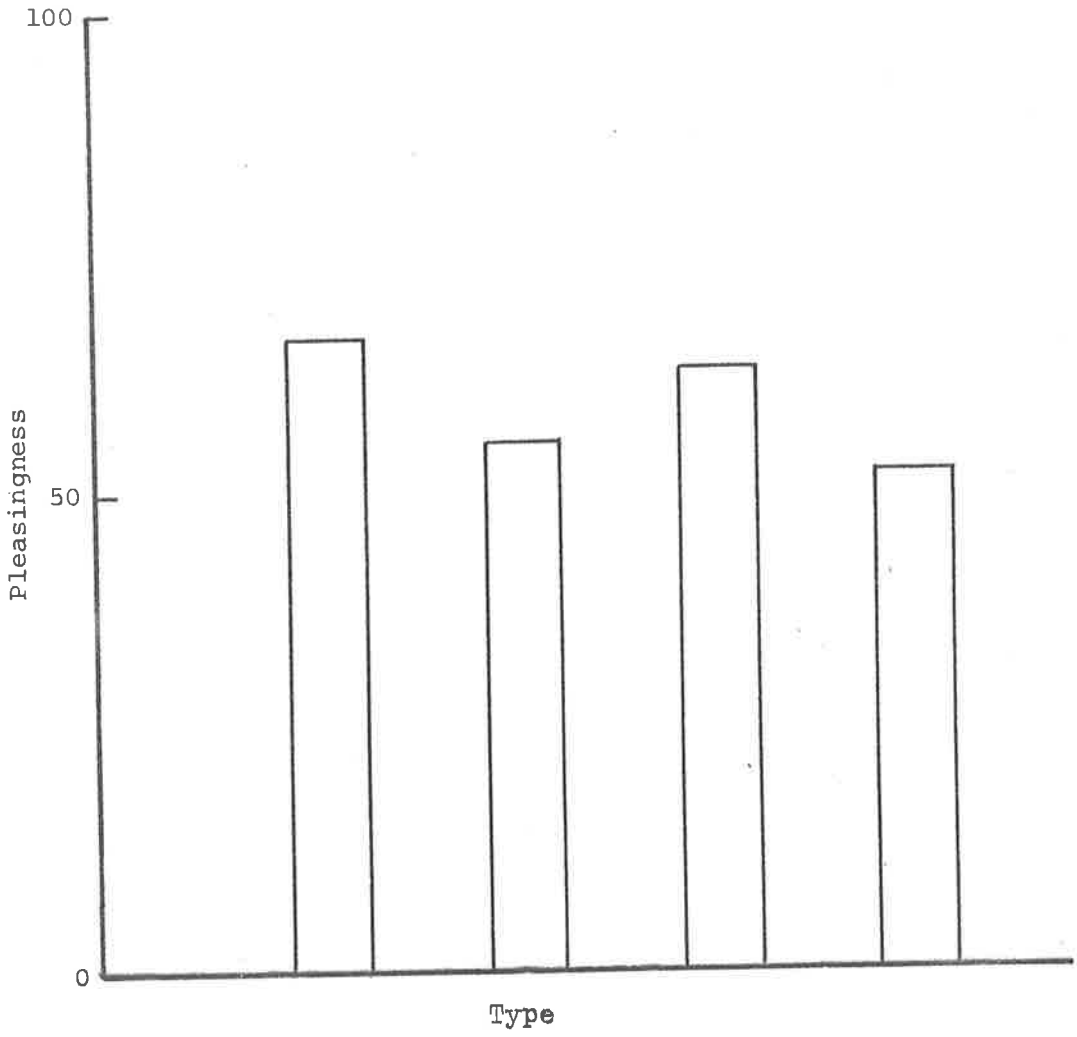
Figure 3.1 shows that the so-called "bimodal function" can be described more accurately as a histogram which represents LC patterns as more pleasing than MC patterns. How should that finding be interpreted? In the writer's view, the data demonstrated a general preference for symmetrical patterns, since the more pleasing types of pattern (LC-NonX and LC-X) were mostly symmetrical (as shown below Figure 3.1). The "bimodal function" was merely an artefact arising from the inclusion of symmetry/asymmetry with other aspects of stimulus complexity, as in the case of Terwilliger's (1963) analysis.

Heckhausen's interpretation of Berlyne's results, and an empirical test of his hypothesis

Heckhausen (1964) attempted to explain "contradictions" in Berlyne

Figure 3.1. Example of the "bimodal function" obtained for evaluative ratings with Berlyne's patterns

(Histogram from Berlyne and Peckham, 1966, Figure 2.)



Type of Pattern:	LC-Non X	MC-Non X	LC-X	MC-X
Order of subjective complexity (1 = least complex)	1	2	3	4
Proportion of symmetrical patterns in the set	100%	25%	67%	0%

et al.'s research when predictions from Berlyne's curiosity-drive (and arousal) theory were compared with empirical findings. Discrepancies were noted for the A, XB and XC subsets, in that the less complex (*i.e.* symmetrical) patterns tended to gain more interest, higher evaluative ratings and viewing choices. These findings become consistent and understandable when it is recognised that symmetry/asymmetry must be distinguished from an overall conception of complexity. Both Heckhausen and Berlyne failed to do this.

Berlyne (1964) responded to Heckhausen by arguing that the "anomalous" results for the subsets concerned were "not statistically significant" or were "more equivocal". He reaffirmed his belief in a unified dimension underlying his stimulus pairs: "The presumption is that they all reflect some psychologically important dimension, which we may, if we choose, call 'complexity'."

What of Heckhausen's own solution for the contradictions he observed? He argued that subjective complexity was not monotonically related to objective measures of complexity. In particular, he hypothesized that completely random patterns were perceived as more homogeneous and subjectively regular than patterns with some redundancy, and that therefore random patterns are *less* complex subjectively despite their greater informational value.

Day (1965) disputed Heckhausen's suggestion, since he found using 28 of Berlyne's patterns that "material labelled more complex on information theoretical terms was also judged phenomenologically as more complex". Day gave no correlation value or mean subjective complexity rankings to support his assertion.

It seemed to the writer that Heckhausen's hypothesis should be tested directly by using patterns specifically selected for the purpose, and by asking questions specifically relating to the hypothesis. Two black-and-white checkerboard square patterns were used with a 100 x 100 matrix of cells (Pierce, 1961, chapter 13). One was completely random, with black and white having an equal probability for each cell; the other pattern had partial redundancy, by the introduction of local contingencies as described by Pierce. (Neither pattern had overall symmetry.)

The two patterns were shown by slide projection to 24 students, tested in two equal groups to control for pattern position. The students were asked: "Which appears to you to be more homogeneous; that is, the same all over, and constant as you look at it?" and "Which is the more ordered or regular pattern?". According to Heckhausen's hypothesis, most students should have considered that the random pattern looked more homogeneous and regular than the pattern with some redundancy. In fact, a majority of subjects (87.5%, $p < .01$ using the Sign test) considered that the partially redundant pattern looked both more homogeneous and more regular.

Heckhausen's suggestion that patterns with some informational redundancy are less regular and therefore subjectively more complex than random patterns was therefore disconfirmed. The "discrepancies" which Heckhausen noted in Berlyne's findings are due to the confusion of multiplicity and asymmetry dimensions in Berlyne's patterns, in the writer's view, and are not due to any hypothetical anomalies in perceived complexity.

Evidence concerning individual differences in viewing choice and preferences

There have been a few investigations of individual differences in the research under review. Berlyne (1963) presented the frequency distribution of subjects who choose different numbers of more complex patterns, which was compared with the chance expected distribution. Berlyne concluded that there were clear individual differences in the tendency to choose the complex or the simple patterns for further viewing, since the observed frequencies were above chance at either end of the distribution (see Appendix 3.1).

Whilst the writer does not dispute this conclusion, it must be pointed out that there were errors in both the observed and expected frequencies published by Berlyne. With respect to observed frequencies, the total number of choices for more complex patterns was 791 in Berlyne's (1963) Table 1, but 799 in his Table III. The overall empirical probability of a more complex choice was stated to be 0.56, whereas the correct value is .55, whichever of

the two total frequencies is used. Even allowing for this "approximation", the chance expected distribution was grossly erroneous, and unfortunately the "corrected" values published subsequently (Berlyne, 1963 "erratum", p.411) were also incorrect.

The erroneous published distributions, the expected values using the Normal distribution approximation, and the exact values based on the Binomial distribution, are given in Appendix 3.1. The deviations between observed and chance distributions of observers showing different tendencies to choose simple or complex patterns gave a significant χ^2, as calculated by the writer, of 105.6 ($df = 5$, $p < .001$). Clearly individual differences in choosing many (or few) complex items are marked with Berlyne's patterns.

Apart from the numerical difficulties in interpreting Berlyne's data on individual differences, other difficulties were evident. The frequency distributions did not distinguish between different aspects of complexity, so that it was not known whether individual differences referred to choice of multiple elements, or choice of asymmetry, or both. Furthermore, groups with different pre-exposure times were combined, and this variable affected choices in the case of asymmetrical/symmetrical pairs.

The same difficulties applied to findings by Berlyne and Lewis (1963). They measured each subject's tendency to choose more complex patterns for further viewing, and combined data for different aspects of complexity and pre-exposure durations. The number of "complex" choices gave a significant mean correlation of .32 with subjects' scores on a short version of the Barron-Welsh Art Test (Berlyne and Lewis' Table IV).

There is therefore some evidence from Berlyne's patterns that observers differ systematically in their preference for complexity, although the aspects of stimulus complexity of relevance are not clear. Supporting evidence of systematic individual variation has been provided by Kreitler and Kreitler (1974). They found that both preference and looking-time for complex stimuli like Berlyne's patterns were significantly related to scores on a Cognitive Orientation Questionnaire measuring curiosity.

Evidence of systematic inter-observer differences has not been found in all cases. Berlyne and Lawrence (1964, Table 5) found that the distribution of observers with different degrees of preference for more complex patterns was similar to the chance distribution expected if a common probability of preferring complex patterns applied to all observers.

Evaluation of Berlyne's patterns and the Galvanic Skin Response

It was noted in chapter 1 that Berlyne's arousal theory has been tested directly by the measurement of psychogalvanic skin responses (GSR). The latter are commonly regarded as indicating emotional arousal (Lindsley, 1951, pp.474-475). It was shown in chapter 1 that Berlyne's more complex patterns did not in fact generally give a greater GSR than simple patterns, contrary to Berlyne's (1963, p.287) basic assumption that "collative properties of stimulus patterns affect the level of arousal", and contrary to Berlyne's (1972a) assertion that "more complex items in our collection of visual patterns evoke more GSRs".

In this section, consideration is given to the proposal that evaluative responses to Berlyne's patterns are mediated by arousal: if this were the case, then some systematic relationship between evaluative responses and the GSR during inspection of the patterns should be found. However, the exact nature of the hypothesized relationships is problematic. Berlyne (1963, p.288) at one time suggested that judgements of pleasingness "reflect internal processes dependent on *arousal-reducing* or *arousal-restraining* stimulus properties", which implied a negative relationship between evaluative judgements and the GSR. This suggestion is indeed supported indirectly by evidence that grossly aversive stimulation gives a strong galvanic skin respons Examples of unpleasant stimuli which have been shown to increase the GSR are sudden hard sounds and emotional words (Landis and Hunt, 1935), unpleasant words (Lanier, 1941) and electric shock (Lovibond, 1963).

On the other hand, Berlyne (1960, p.200) argued that "Human beings and

higher animals will normally strive to maintain an intermediate amount of arousal potential", which suggested a curvilinear relationship between evaluative ratings and the GSR. Whatever the precise nature of the relationship, clearly some consistent trend should occur if "arousal" has any utility as a hypothetical construct in this area.

To examine the relationship between evaluative ratings and the GSR, evidence from various studies was collated for eight of Berlyne's subsets (A to E, and XA, XB, XC). Since each subset consisted of more complex and less complex types of pattern, there were 16 types in total for which both evaluative and GSR data have been published. The data from different studies were "standardised" by ranking mean values from 1 to 16 across the patterns. For studies which did not include all pattern-types, rankings were adjusted *pro rata* to give a scale of 1 - 16 in each case. These "standard scores" were averaged across the three studies involved for evaluative ratings (preference, pleasingness or beauty); and across five available GSR measures. The 16 overall mean scores were then re-ranked, and Spearman's correlation (*Rho*) between overall evaluation and GSR was calculated. Details are given in Appendix 3.2.

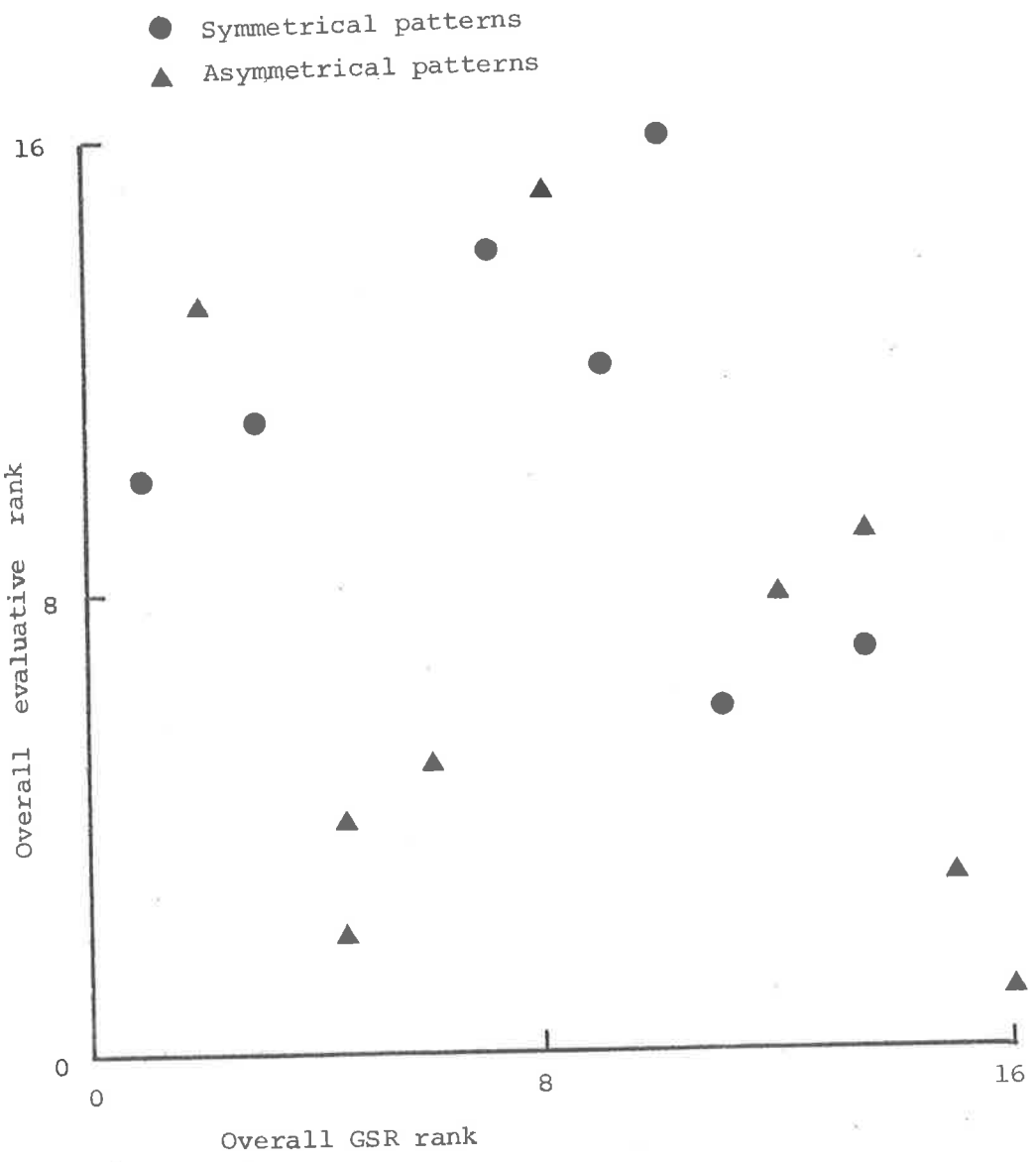
The obtained correlation value was -.307, a nonsignificant value. Figure 3.2 illustrates the point that no systematic relationship was evident between the overall evaluation of Berlyne's patterns and strength of the GSR. It is concluded therefore that the concept of arousal, as indexed by the GSR, contributed little to the explanation of evaluative responses to abstract visual patterns.

Pattern complexity and the EEG

Apart from the GSR, the other physiological measure commonly associated with "arousal" is the EEG. Berlyne and McDonnell (1965) found that the duration of EEG desynchronisation was significantly greater on inspection of patterns with more elements (in subset B) and asymmetrical patterns (in

Figure 3.2. The lack of a systematic relationship between overall evaluative ratings of Berlyne's patterns and Galvanic Skin Response

(The data were collated from several published studies in the manner shown in Appendix 3.2. Each point represents one of Berlyne's 16 pattern types for which evaluative ratings and GSR have been found in several studies).



(Note: Rank 16 was given to the highest evaluative score or GSR).

subsets A and XC). However, no significant difference occurred for pattern-pairs in other relevant subsets XA, C, D, or XB. Even if it is granted that asymmetrical patterns and those with more elements tend to be more "arousing" in terms of EEG desynchronization, this could not explain aesthetic preferences since asymmetrical patterns are *less* liked and those with more elements (in subset B) *more* liked, as shown above.

Later research has confirmed that more complex visual stimuli cause longer EEG desynchronization and reduced Alpha-wave output (Baker and Franken, 1967; Gale, Dunkin and Coles, 1969; Gale, Coles and Boyd, 1971; Gale, Christie and Penfold, 1971; and Christie, Delafield, Lucas, Winwood and Gale, 1972). The research by Christie *et al.* (1972) showed that Alpha-wave activity decreased with a significant linear trend as $\log_2 n$ (the number of elements in visual patterns) increased; but that increasing the variety of elements did not lead to any reliable change in Alpha-wave activity. These authors pointed out that Berlyne's theory of arousal predicted that all aspects of stimulus complexity would similarly affect arousal, and since this was not the case the theory was disconfirmed.

It seems possible that a close relationship between physiological indicators of emotional arousal and aesthetic appeal may be restricted to the extreme case of unpleasant stimuli which irritate the observer, as suggested above in relation to the GSR. Gale, Bramley, Lucas and Christie (1972) found that simple and monotonous auditory stimuli were rated as irritating and unpleasant, and gave "arousing" effects in terms of reduced EEG output. Similarly, Berlyne and Borsa (1968) found that blurred pictures evoked a longer EEG desynchronization than clear pictures. These findings involve a much more specific form of relationship than that implied by Berlyne's (1972b) assertion that "there is plentiful evidence of intimate connections between arousal and hedonic value".

Chapter summary

Experiments using Berlyne's stimulus patterns were examined to determine whether their findings were concordant with the informational model and other generalizations presented in chapter 2. On the whole the "predictions" of the model were confirmed. At the same time, the special status of pattern symmetry, which is valued by the majority of subjects, was confirmed. Recognition of this special status allowed the integration of data, previously considered to be "anomalous", with the general body of aesthetic preference research; it also showed the so-called "bimodal" preference/complexity curve to be an artefact. The concept of "arousal", as indexed by the galvanic skin response, was found not to be useful in explaining visual pattern preferences.

Although group data were explicable in informational terms, large and consistent individual differences were demonstrated in some studies, which again suggested the need for further investigations of their nature in terms of personal cognitive styles.

CHAPTER 4

FIGURE PREFERENCE IN RELATION TO COMPLEXITY AND REGULARITY OF STIMULI, AND IN RELATION TO AGE OF OBSERVERS, USING WELSH'S DATA

The evidence presented in chapters 2 and 3 mainly concerns trends and comparisons within fairly homogeneous sets of patterns. This chapter is concerned with testing hypotheses across diverse kinds of visual patterns, *viz.* the abstract figures within the Welsh Figure Preference Test (Welsh, 1959). Figures varying in regularity and symmetry were distinguished to test the hypothesis that a figure is more liked, the greater its "order". Within each type of figure, it was hypothesized that an inverted-U shaped trend would be found when the probability of "liking" was plotted against complexity.

Because of the heterogeneous nature of the figures, it was not possible to assess complexity simply by counting the number of elements. The measure of complexity devised was related to the "verbal-loop" hypothesis (Glanzer and Clark, 1964), and is described below. Preference for the figures was not empirically assessed by the writer, since Welsh (1959) has provided very adequate data for each figure separately, with which the hypotheses can be tested. An advantage of using available data in this way is that there is very little possibility of experimenter-bias influencing the results, and certainly Welsh's subjects could not have been influenced by any knowledge of the hypotheses presently under investigation.

A further aspect of figure preferences was studied using Welsh's data, the comparison between adults' and children's responses. On the Welsh Test, subjects respond by recording whether they "Like" or "Don't Like" each of 400 figures. Welsh (1959) provided the percentage responding "Don't Like" on each item, for a sample of 150 adults and a sample of 82 children aged 6 to 8 years. The literature on children's aesthetic

preferences is considered below in relation to hypotheses as to their nature.

Background to the analyses

Previous studies using the Welsh Figure Preference Test

The Welsh Test was primarily designed to assess individual differences, and consideration to the literature in that respect is given in chapters 7 and 8. In the present chapter, differences between figures in group preferences are considered. Being a convenient source of varied abstract figures, items from the Test have been used in previous studies for diverse purposes. For example, the writer has used a carefully selected set of figures which might be thought to represent male or female sex "symbols". According to McElroy (1954), subjects tend to prefer drawings considered to be opposite-sex symbols more than same-sex symbols. In an experimental test of this hypothetical sex-difference, the writer found no evidence in support of the hypothesis, although female students were perhaps slightly more discriminating and consistent in their responses than male students (Rump, 1967a).

Variation between figures in their "percentage liking" scores have been fairly consistent when large groups of adults were compared. For example, the correlation across the 400 items between the "percentage liking" scores of Americans and Egyptians was 0.9, using very large total samples (Welsh, 1967). This chapter is concerned with the elucidation of figural characteristics underlying this group consistency. Despite the importance of stimulus determinants of group preferences, there are also large and consistent variations between individuals, and these are considered in Part C of the thesis.

Eysenck and Castle (1970a) carried out a factor analysis of 86 items from the Welsh Test (those used for the Barron-Welsh Art Scale). A second-order general factor corresponded with the assumption underlying

the Scale, of an overall "preference for complexity" dimension. Nevertheless, four nearly independent primary factors emerged, which distinguished between simple geometrical shapes (Factor 1), complex but regular shapes (Factor 2), complex freehand drawings (Factor 3) and representational drawings (Factor 4). These distinctions were not made very clearly by Eysenck and Castle's factors, but they corresponded somewhat with the *a priori* categories found useful in the analysis of the whole Welsh Test, described below.

A different type of analysis of the Welsh figures was undertaken by Moyles, Tuddenham and Block (1965), and one of their conclusions was that both figural complexity and symmetry/asymmetry were "of equivalent and usually small importance in determining figure preferences". Since this conclusion is at variance with the results for other patterns presented in chapters 2 and 3, its evidential basis is examined.

The first point to emphasize is that Moyle *et al.*'s conclusion was based on a very small and nonrepresentative subset of 24 figures from the Test. This very highly selected subset was chosen so as to ensure a near-zero correlation between judgements of symmetry and subjective complexity. In the trend analyses presented below, the effect of complexity was analysed within separate subsets of symmetrical and asymmetrical items, so avoiding the problem of an unrepresentative sampling of items resulting from Moyle *et al.*'s method.

The second point involves Moyle *et al.*'s statistical method of assessing the importance of complexity and symmetry. Rank correlations were determined between each individual's preferences for the 24 figures and their complexity or asymmetry values (assessed from other judges's Q-sorts). This method was limited in some ways: it did not allow for the expected curvilinear relationships; it treated symmetry-asymmetry as a subjective scale with nine (forced) levels, rather than as a simple

dichotomy or according to objective degrees of symmetry; and group means were not examined. To assess the importance of complexity and symmetry, group preferences for subsets of figures with differing complexity and symmetry may be compared, as in the analyses below.

The nature of Moyle *et al.*'s analysis may be understood if it is imagined as applying to a reliable questionnaire scale of twelve items which measure extraversion. Suppose the items were ranked for the degree to which they "displayed" extraversion (although items had not been chosen as scaled for "intensity" in this way). Suppose, then, that each subject ranked items according to the degree to which they applied to himself. The correlation between a subject's ranks and the "extravertedness" of items might be high, in a few cases, but high correlations would not generally be expected. The occurrence of low correlations would not demonstrate that extraversion is unimportant, or that the extraversion scale is unreliable; all that would be suggested by such a finding is that not all subjects are consistently extreme extraverts, and/or that the items do not form a clear Thurstone-type scale. In the same way, Moyle *et al.*'s analysis of figure preferences did not demonstrate that symmetry and complexity are unimportant.

Children's visual preferences

Information-processing theory leads to the expectation that younger children have more difficulty assimilating complex visual information than older persons. It may therefore be supposed that young children demonstrate a negative relationship between preference and complexity; and that preference for complexity has a positive trend with increasing age.

Some of the studies supporting these predictions were mentioned in chapter 1, and further findings may be cited. Vernon (1940) found that when school-children were shown diagrams of the flow of wheat through a flour mill, only a quarter could indicate such features as the point of

entry of the wheat. When children were asked to describe complex pictorial material, the accuracy and completeness of descriptions increased with age. Older children (11 year olds) are more successful in detecting alternative interpretations of complex ambiguous pictures than younger ones (down to 4 year olds), according to Elkind and Scott (1962). Forsman (1967) reported that 4th grade children took longer than tertiary students on tasks involving visual discrimination and search.

With regard to preferences, French (1952) found that most first-grade pupils preferred simple pictures, whereas teachers preferred complex items. Child, Hansen and Hornbeck (1968) considered that the increasing importance of hue rather than chroma as a determinant of colour preference with increasing age, was "a consequence of the greater differentiation of cognitive functions in the adult" (p.246). More recently, Hutt and McGrew (1969) reported that 5 year olds looked longer at simple than at complex patterns; whilst 11 year olds looked longer at complex items. Similarly, Aitken and Hutt (1975) found that 7 year olds showed a preference for complex (incongruous) pictures whilst 3 year olds showed no such preference. From her extensive review of this area, Hutt (1970, p.171) concluded that: "there seems some measure of agreement that immature organisms (young children and retardates) in general show greater fixation of and preference for the more simple and symmetrical figures of a series".

Despite the foregoing evidence, there are many contrary views and findings. Eysenck (1942) wrote that "laymen and even young children tend to agree on the average with the judgments of experts" (p.252-353), with regard to visual appreciation. However, the references cited by Eysenck following his statement do not in fact justify such a claim. There are, of course, a few experiments which have reported no age difference in preference for complexity. For example, Hoats, Miller and Spitz (1963) found no significant difference between 8 year old and 16½ year old normal

children in their overall choice of more complex stimuli (presented in pairs): the percentages of more complex choices were 37% and 39% respectively, over all pairs.

More striking evidence *against* the information-processing view of children's preferences has suggested that children actually prefer or tend to fixate more complex stimuli. Some of this evidence was obtained with young babies. For example, 3-9 month old babies tended to fixate first patterns with a high level of black/white contour (Berlyne, 1958c), and similarly 14 week old babies fixated longest on matrices with a complex grain, although this was not so with 3 week old babies (Brennan, Ames and Moore, 1966). Furthermore, Greenberg and O'Donnell (1972) reported that 11 week olds fixated longer on complex patterns than 6 week olds. It is likely that such apparent "preferences" for complexity in babies reflects a basic tendency to orient towards a more differentiated (and therefore excitatory) source of stimulation. The process involved is presumably very different from those affecting evaluative judgements by children and adults. Hutt (1970, p.134) urged that: "some caution be exercised in the interpretation of results obtained from work on infants, particularly newborn ones".

Nevertheless, other work with school-age children has confirmed that they may choose to view, and may prefer, complex patterns. An early report indicated that 6-8 year olds gave more responses to view complex figures than to view simple figures (for .25 sec periods), for all stimulus-pairs (Smock and Holt, 1962). This was described as motivation by environmental "novelty", but in fact stimuli were varied in terms of such characteristics as multiplicity of elements and asymmetry. Cantor, Cantor and Ditrichs (1963) obtained similar, but less consistent, results with 4-5 year olds using continuous viewing time rather than short exposures to stimuli. Young children aged 2½ to 6 years also viewed complex visual

stimuli and objects longer than a simple standard wood block, and their looking time increased as the trials progressed (Banta, Sciarra and Jett, 1966).

Before undertaking their research, Munsinger, Kessen and Kessen (1964) considered that: "A plausible expectation was that older *Ss* would prefer figures of high variability more than younger *Ss*." However, their (Study I) results demonstrated the opposite. For the "high variability" random polygon with most sides (40), preference and age were *negatively* correlated across seven age groups (Kendall's Tau = -.78, $p < .05$, as calculated by the writer from data given in Munsinger *et al.*'s Figures 3 and 4, including a correction for one tied value). Subsequently, Munsinger (1966) confirmed that whereas tertiary students gave an inverted-U shaped curve of preference against the number of sides of random shapes, children from first to eighth grade showed highest preference for the most complex figure. Thomas (1966) obtained basically the same kind of result, with a total of 787 subjects aged six through nineteen years. Children's preference for complex stimuli is not limited to the visual modality, as Duke and Gullikson (1970) found when children aged about 5 years made selections from various sounds.

Possible explanations of children's preference for complexity

Various explanations have been offered to explain why children often prefer very complex patterns, shapes or objects; and why this tendency is reduced with adolescents and adults. Munsinger *et al.* (1964, p.10) suggested that this reduction was caused "by the inhibiting influence of training in school", but no evidence for this was given.

A more viable suggestion (Munsinger *et al.*, 1964) was that younger children do not assimilate all the available details of complex stimuli, but identify them in some general way, so that they "respond to figures above a certain level of variability as generally equivalent" (p.10).

There is some evidence that young children show little discrimination in their reactions to visual displays. For instance, the 4 and 5 year olds in Clapp and Eichorn's (1965) sample did not distinguish in their viewing responses between symmetrical and asymmetrical figures from Berlyne's Series A and Series B, unlike the adult sample tested by Berlyne (1957). Similarly Aitken and Hutt (1975) found that 3 year olds showed "no indication of a consistent relationship between preference and type of picture" (p.85), unlike older children. This would explain why young children do not always show the strong preference for regular, symmetrical patterns which adults display. However, children's lack of discrimination clearly cannot explain why children sometimes show a pronounced positive preference for shapes or patterns with many elements.

Possibly children like neatly-drawn figures with many elements because they admire the drawing skill involved in their production, relative to their own limited ability in that respect. This was indicated by an unpublished study conducted by one of the writer's senior students, G. Haslam, who investigated the preference order of designs with ten-year old boys. The designs were carefully drawn, and composed of varying numbers of geometrical shapes. The boys almost all liked the most intricate design best, and asked such questions as "Did you draw them, Sir". From later discussion with the children, it became clear that the complex drawings were liked because of the technical skill they represented. Irvin Child (1968) remarked that primary-school pupils tend to prefer a picture which looks more difficult to make, whereas adolescents evaluate pictures in terms of more subtle aesthetic qualities. This notion also fits Garner's (1977) conception of a good *Gestalt*: "Perhaps now we can understand why circles and squares are good patterns, whereas ink blots are not; there are very few ways in which circles and squares can be made, but many ways in which ink blots can be made" (p.193).

Hypotheses

From the findings presented in chapter 2, it was hypothesized that the proportion of respondents liking figures in the Welsh Test would be greater for symmetrical and for smoothly-drawn items. It was further hypothesized that within each type of figure, "liking" would have an inverted-U relationship with complexity measured on a scale of verbal units applicable to all figures.

From the informational point of view, it was hypothesized that a greater proportion of children would like simple figures compared with adults. However, because of the evidence reviewed above it was considered probable that this informational hypothesis would not be supported. Even so, it was hoped that the analyses would throw some light on the nature of children's preferences which would account for some of the inconsistencies in the literature.

Methods of analysis

Types of pattern

It was decided to include in the analysis as many abstract patterns from the Welsh Test as possible. However, twenty items (Nos. 361-380) were repeated items and were therefore excluded, leaving 380 for initial consideration. These were examined by two judges (the writer and Mrs Jeanne Roberts) so as to exclude representational drawings. Agreement between judges in defining figures as abstract or representational was moderate (phi = 0.74, $p < .01$). The 57 figures considered by either or both judges to be representational were exluded from further analysis, since in such cases "liking" might be determined by the pleasantness of the depicted object rather than by figural characteristics.

The remaining 323 figures were then assessed by the two judges in terms of "symmetry", "partial symmetry" or "no symmetry". The judges' decisions disagreed in only six cases, but in addition twenty-nine figures

had "partial symmetry". The total of 35 figures with uncertain or partial symmetry were excluded from further analysis, leaving 288. A further 18 were excluded because of unreliability in assessing their complexity (described in the following section), so that the final sample of figures numbered 270.

The writer categorised these items as smoothly-drawn (or regular) and irregularly-drawn figures. The former were composed of ruled lines or smoothly, carefully drawn curves or outlines, or dots of regular size and distribution (ignoring slight printing flaws). The latter were composed of irregular lines or outlines, or with irregular shading, or were roughly drawn, and included most but not all of the freehand items. This categorisation is similar but not identical to Welsh's distinction between ruled and freehand figures, and was applied to all items in the analysis. There was no difficulty in deciding which category applied, and it was considered unnecessary for a second judge to undertake the task. A subset of the smoothly-drawn figures, of geometrical shapes, was also defined. This subset included such shapes as circle, square, diamond, triangle, star, pentagon, arrow-symbol, and so on. Some figures in this subset included more than one geometrical shape; most were symmetrical, but a few asymmetrical arrangements were included.

Thus, for the analysis of the relative popularity of different types of figures, three factors were defined: symmetrical/asymmetrical, smooth/irregular, and geometrical/nongeometrical nested within the smooth category. The numbers of figures in each category are shown in Table 4.1.

The assessment of complexity in verbal units

Various methods have been used to evaluate figural or pattern complexity with heterogeneous stimuli (*e.g.* Nicki and Moss, 1975). Subjective complexity ratings have frequently been used, but the method has disadvantages: it is difficult to obtain judgements which discriminate more than a few

complexity values; with stimuli varying in several dimensions, subjects may limit their attention to just one or two in making their judgements; and in general the stimulus dimensions underlying the obtained subjective dimension remain uncertain. Associational meaningfulness has also been used as an indication of the conceptual complexity of figures, but this seems inappropriate when abstract patterns are the main concern as in this thesis. Figural redundancy may be assessed using a technique similar to the "cloze" method in the study of linguistic redundancy. However, when applied to patterns, arbitrary segmentation is involved which does not correspond with normal perception.

In order to assess complexity for a diverse set of non-representational visual figures, a method of assessment is required having these characteristics. It should allow a reasonable degree of discrimination. The measure should have a high degree of inter-judge reliability over at least the majority of figures in the defined stimulus sample. The measure should reflect identifiable stimulus characteristics rather than being based on an unspecified subjective reaction. And ideally the measure should have some theoretical basis in terms of the nature of perceptual processing. A method having these characteristics involves the assessment by "judges" of figural complexity in verbal units.

The method stems from two separate notions, computer pattern recognition, and the "verbal-loop" hypothesis. In the last two decades, much progress has been made in the area of computer simulation of pattern recognition. Various computer programmes have been devised, mostly for rather restricted pattern sets such as letters of the alphabet. Other more general programmes of various kinds have been attempted (Uhr, 1966). A recent summary of research on "The Psychology of Computer Vision" at the Massachusetts Institute of Technology gives an indication of the wide range of application of this notion (Winston, 1975). Now, in principle the complexity of a pattern might be defined in terms of the number of

steps required by a computer-recognition "run" to identify the pattern. This would clearly depend on the nature and efficiency of the programme used in relation to that particular type of pattern. The programme would need to be appropriate, in the sense of simulating human perceptual assimilation of the patterns used. This leads to the second notion, that observers (judges) might be asked to specify their own pattern-identification process, so as to assess the number of steps involved.

Specifically, observers may be asked to describe each figure verbally, and thus to define the number of verbal units required, as a measure of the figure's complexity. Such a measure reflects various aspects of complexity, such as number and variety of parts, unfamiliarity, redundancy and so on; and directly reflects the observer's mode of assimilating the figure's information. These points have been formalized as the "verbal-loop" hypothesis by Glanzer and Clark (1964): "The verbal-loop hypothesis states that perceptual processing includes covert verbalization and that the length of verbalization determines the 'complexity' of the stimulus-object" (p.626).

These authors showed that the length of verbal descriptions of 26 outline figures correlated highly with rated complexity and with difficulty of reproducing the figures after brief exposure. A previous study by the same authors (Glanzer and Clark, 1963) showed that for simple sequences of black and white symbols, accuracy of reproduction was highly correlated (negatively) with the number of words used in verbal descriptions of the sequences. Further studies have confirmed that at least in the case of some visual stimuli and when subsequent recognition is desired, figures may be coded verbally and that codability is related to recognition accuracy (Kelly and Martin, 1974).

For the purpose of utilising codability as a measure of complexity, it is not necessary to accept that an observer actually verbalises, whether overtly or covertly. It is sufficient to assume that normal perceptual

Table 4.1. Frequencies for figures of various types included in analyses of Welsh's data

	Asymmetrical	Symmetrical	Totals
	Number of figures		
Irregular	75	35	110
Smoothly drawn:			
Nongeometrical	48	64	112
Geometrical	6	42	48
Total	129	141	270

Table 4.2. Effective range of complexity values, after grouping extreme figures, and mean complexity values, for each type of figure used in the trend analyses

Type of figure	Number of figures	Effective range of complexity values*	Mean Complexity
Irregular, asymmetrical	75	6 - 20	14.28
Irregular, symmetrical	35	3 - 15	7.11
Regular, asymmetrical (nongeometrical)	48	6 - 20	13.33
Regular, symmetrical (nongeometrical)	64	2 - 13	5.39
Regular, geometrical	48	2 - 8	4.48

*Figures with extreme complexity values were grouped to give a minimum of three figures at the end positions on the complexity scale, as explained in the text, so as to define the effective complexity range.

assimilation of a visual figure is largely analogous to acquiring a verbal description of its characteristics. This viewpoint has been expressed by Rock (1974): "Perceived shape is based on a cognitive process in which the characteristics of the figure are *implicitly described* by the perceptual system" (italics added). There was, of course, much research of an earlier date which recognised the relationship between perceptual discriminability and the language codability of a stimulus. For example, Brown and Lenneberg (1954) found that correct identification of colour was positively correlated with inter-subject consistency in its naming.

In order to ascertain the length of verbal description required to specify each of the Welsh figures, two judges (the writer and Dr. David Caudrey) independently wrote a description in coded and standardised form. Details of the instructions to judges are provided in Appendix 4.1. It was decided to count not the number of words required, but rather the number of verbal concepts and their modifiers. That is, the number of verbally expressed ideas rather than words were counted. Descriptions covered "the main features of each figure, in such a way that a reproduction from the description would look essentially similar". Judges were also instructed to describe figures "by listing concepts, together with modifying terms; each piece of information being separated by a stroke (/)". Judges coordinated their descriptive techniques initially by joint practice with a few other figures not included in the analysis. Any figure which was so complex as to require twenty or more verbal units for its description was given a maximum score of 20, since it was difficult to provide any more accurate assessment of such very complex figures.

Of the 288 abstract figures available for analysis, 18 were excluded because the two assessments of their complexity were grossly discrepant (by 7 or more verbal units). This arose when one judge described a figure in more detail than the other judge; and particularly when one

judge saw a figure as a simple organisation (such as a star pattern for Item 62), whilst the other judge saw the same figure as a collection of distinct parts to be described in detail.

Given the difficulties associated with the concept of overall figural complexity pointed out in chapters 2 and 3, it might be thought contradictory to use any measure of overall complexity for analysis of Welsh's data. However, the objection was not to the use of the concept as such, but rather to confounding the effects of complexity (or information) with effects due to type of pattern, and particularly with the general preference for symmetrical patterns. It was noted that preference for an "orderly" design was a marked effect with group data, which could not readily be explained in informational terms. The objection to previous uses of "overall complexity" is largely met if trend analyses are conducted for the different types of patterns separately, according to their symmetry/asymmetry and their degree of regularity.

Variables, subjects, and statistical analyses

The items for analysis were the 270 abstract figures of the Welsh Test, selected and classified in ways described above. The dependent variable was the "percentage liking" score (henceforth called "liking") for each of the Welsh figures used in the analyses. This score was obtained by subtracting the "percentage disliking" (DL) score obtained by Welsh (1959, Appendix, Table 1) for two samples described below.

There were five independent variables: Complexity in verbal units with a possible range from 1 to 20; Age group, having two levels of normal adults and children (Welsh's samples B and C); Regularity of the figure, with two levels of smoothly drawn (scored 2) or irregularly drawn (scored 1); Symmetry with two levels, symmetrical figures (scored 2) and asymmetrical figures (scored 1); and Geometrical figures (scored 2) contrasted with other smoothly drawn figures of a nongeometrical kind (scored 1). This

last factor was nested within level 2 of the Regularity factor. The items, their complexity score, classification, and two liking scores are listed in Appendix 4.2.

The two subject samples involved in Welsh's (1959) investigation were described by him as follows: (B) "150 adults (75 males, 75 females)"; and (C) "82 children aged 6 to 8 years (42 boys, 40 girls)".

In principle, all five independent variables could have been introduced into one analysis. However, computer limitations, and the need to investigate trends for different types of pattern separately, required that trends for the Complexity variable were analysed after consideration of the other variables.

The first analysis, then, was an analysis of variance of liking scores by four factors, Regularity, Symmetry, Geometrical figures and Age group. The factor "Geometrical figures" was nested within level 2 (smoothly drawn items) of Regularity, and this was allowed for in the design. Computations were undertaken using the MANOVA subprogramme of SPSS (Cohen and Burns, 1976).

Because of the small number of asymmetrical, geometrical figures (see Table 4.1), it was not possible to estimate all Geometrical effects independently of other effects potentially represented in the design. Therefore, the two sources of variance "Geometrical by Asymmetrical by Age group" and "Geometrical by Asymmetrical" were combined, and obtained as a residual effect (in the event, nonsignificant). Sources represented in the design are listed in the analysis of variance Table below (Table 4.3). A subsidiary analysis of variance was also undertaken with the complexity measure as a covariate.

Trend analyses of liking on complexity scores were undertaken for each type of figure separately. However, because there were too few asymmetrical geometrical figures to analyse them separately, they were combined with the symmetrical geometrical figures for the trend analysis.

The figures were not well represented at the extremes of the complexity distribution. To overcome this problem, and to avoid undue weight in the analysis being given to "extreme" figures, those at either end of the complexity scale were grouped to give a minimum of three figures in the extreme positions of the scale. Thus, for example, in the category of irregular asymmetrical figures, the lowest complexity scores were 4 and 5 each obtained by one figure only. These two figures were grouped with six figures having the next complexity value of 6, so that the effective range of complexity for this category was 6-20. Within that complexity range, all values were represented, although this was not the case for all types. The effective range of complexity, using this procedure, is given for each type of figure in Table 4.2, together with the mean complexity values.

Regression of liking scores on complexity scores was used to analyse trends, using the SPSS subprogramme REGRESSION (Nie, Hull, Jenkins, Steinbrenner and Bent, 1975). Linear trend was assessed using the complexity score alone, for each type of pattern. The data were examined for any inverted-U relationship by adding complexity-squared to the regression. The complexity score used in these regressions was the integer-part of the mean of two judges' scores, as listed in Appendix 4.2.

Results

Effects of figure type

Mean liking scores for each type of figure are shown in Table 4.3. Significant effects are indicated in Table 4.4. All main effects were significant, and two interactions. As expected, symmetrical, smoothly drawn and particularly geometrical figures were liked by significantly more respondents than asymmetrical, irregular, nongeometrical figures (see Table 4.3). This was the case for both adults and children. Thus the most popular figures were those which combined each of these attributes, the

subset of smoothly drawn, symmetrical, geometrical items, which were liked (on average) by 72.26% and 65.12% of adults and children respectively. These data may be contrasted with those for the subset of irregular, asymmetrical figures, liked by only 31.65% and 47.25% of adults and children respectively.

It is clear that the type of figure had reliable effects on its evaluation. The strength of these effects (treated as dichotomous variables) are indicated by their biserial correlation coefficients with liking, given for the adult and child samples respectively: for Regularity, biserial r was .75 and .35; for Symmetry, .36 and .37; and for the Geometrical variable, .50 and .43. Each of these correlations was calculated over the 270 figures, and was significant ($p < .001$ in each case).

The significant main effect of Age group indicated that children showed a slightly greater tendency overall to like the patterns, but this was of no theoretical importance. However, the significant interaction effects involving Age group were of interest. The significant "R by A" effect (in Table 4.4) indicated that adults showed much less liking for irregular figures, and somewhat more liking for smoothly drawn figures compared with children (indicated by means in the right hand column of Table 4.3). The significant "R by S by A" effect (in Table 4.4) indicated that adults showed about as little liking for irregular figures whether or not they were symmetrical; whereas children showed greater liking for symmetrical figures in the irregular as well as the smoothly-drawn category. These features are shown by the top rows of Table 4.3 (a) and (b).

Taken together, these findings suggest that adults were even more impressed by smoothness or regularity of drawing than the children. It may be supposed that the children had lower "internal standards" for figural designs in this respect, in line with their own less developed drawing skills compared with adults.

Table 4.3. Mean "percentage liking" scores for various types of figures, with (a) adults and (b) children

(The number of figures within each cell is given in Table 4.1)

(a) Adults (Welsh's Sample B)

	Asymmetrical	Symmetrical	Combined
	Mean liking score		
Irregular	31.65	31.57	31.63
Smoothly drawn			
Nongeometrical	55.63	60.63	58.48
Geometrical	66.67	72.26	71.56
Combined	42.20	56.88	49.87

(b) Children (Welsh's Sample C)

	Asymmetrical	Symmetrical	Combined
	Mean liking score		
Irregular	47.23	54.83	49.65
Smoothly drawn			
Nongeometrical	53.29	55.45	54.53
Geometrical	59.00	65.12	64.35
Combined	50.03	58.18	54.29

Table 4.4. Analysis of variance of "percentage liking" scores by four factors: Symmetry, Regularity, Geometrical figures and Age group

(The subset means corresponding with this analysis are given in Table 4.2)

Code	Source	Mean Square	df	F	P
R	Regularity	48583.11	1	388.49	.00001
S	Symmetry	3775.22	1	30.19	.00001
G	Geometrical figures (within Regularity Level 2)	6732.52	1	53.84	.00001
A	Age group	2635.65	1	21.08	.00001
	R by S	0.96	1	0.01	NS.
	R by A	17165.75	1	137.26	.00001
	S by G	45.67	1	0.37	NS.
	S by A	47.25	1	0.38	NS.
	G by A G by A by S	62.55	1	0.50	NS.
	R by S by A	821.10	1	6.57	.01
Error (within cells)		125.06	528		

(Note: Because of the small number of symmetrical, geometrical figures, it was not possible to estimate the "G by A by S" and "G by A" effects independently of other effects. These terms were therefore combined, and the sum of squares for that source was obtained as the residual).

The children's results might also be described as showing generally less discrimination between different types of pattern compared with adults. The category means for adults ranged from 31.65 to 72.26, but for children the range was only from 47.23 to 65.12 (see Table 4.3). This point may be made more explicitly in terms of the overall standard deviations (population estimates) for the liking scores: for adults the value over all figures was 20.31, whilst for children it was only 10.97 (F = 3.43, df = 269,269, $p < .001$).

Moreover, the standard deviation was greater for adults than for children within each type of figure, so that the "within cell" components in the analysis of variance lacked homogeneity (Cochran's C statistic (44,12) = .18, $p < .001$). This violated one of the assumptions required for precise analysis of variance, but it has been found that significance levels are little affected by some degree of heterogeneity of variance within cells (Winer, 1971, p.206). In the present case, the significant effects were so clear (with p < .01 or better) that the decisions to reject the null hypothesis were considered to be unaffected by the approximation due to heterogeneity of variance.

The analysis of variance was repeated with each figure's complexity score included as a covariate. However, the results were very similar to those in the initial analysis, as shown in Appendix 4.3, and require no further discussion.

Effects of complexity

The assessment of figural complexity in verbal units gave an inter-judge reliability of .98 for the 270 figures used in the analysis. However, this reliability is artificially high, in that 18 other figures which had high inter-judge discrepancies were excluded. The inter-judge reliability with these items included was .87 over the 288 figures, which was highly satisfactory.

The trends of liking scores on complexity were examined for the two samples and for each type of figure listed in Table 4.2. The results are summarised in Table 4.5. No significant curvilinear trend was found, contrary to the experimental hypothesis. Three significant, positive linear relationships were found involving symmetrical patterns. The regression equations are given in Table 4.5. Correlation values corresponding with these significant regressions between liking and complexity were as follows: for the adult sample, with irregular, symmetrical figures, $r = .34$ ($p < .05$); for the adult sample, with regular, symmetrical figures, $r = .44$ ($p < .001$); for the child sample, with regular symmetrical figures, $r = .25$ ($p < .05$).

These results were very different from those obtained with the Terwilliger patterns. Although complexity had some influence on liking, there was no reliable indication of any reduction in liking for very high complexity values. Whilst this might have been due to restriction of the complexity range in the case of symmetrical and geometrical figures (see Table 4.2), this did not apply to the asymmetrical subsets. The informational hypothesis was therefore not confirmed under these conditions.

The positive correlations indicated that subjects tended to like the more complex figures amongst the symmetrical subsets. For smoothly-drawn symmetrical figures, this was true of children as well as adults. There was no indication that children liked simpler figures more than adults, so that the informational approach was disconfirmed in this respect also.

Discussion

The hypothesis that symmetrical figures are liked more than asymmetrical figures was confirmed. Moreover, it was similarly shown that "well-constructed" figures in the form of smooth, regular drawings, and particularly geometrical figures, were liked more than irregular figures. The clear differences between types of figure suggested that subjects

Table 4.5. Significant trends for percentage liking scores (L) on figure complexity (C), for five types of figure and two samples

(First and second order regressions were tested)

Type of figure	No.	Trend
Irregular asymmetrical	75	No significant trend
Irregular symmetrical	35	Significant positive linear trend, for adults only Adults: $L = 1.50C + 20.91$ $(F = 4.36, df = 1, 33, p < .05)$
Regular asymmetrical (nongeometrical)	48	No significant trend
Regular Symmetrical (nongeometrical)	64	Significant positive linear trends, for both samples Adults: $L = 1.56C + 52.24$ $(F = 14.97, df = 1, 62, p < .001)$ Children: $L = 0.83C + 50.99$ $(F = 4.16, df = 1, 62, p < .05)$
Regular geometrical	48	No significant trend

evaluated figures first in terms of their type and only secondarily in terms of complexity and other criteria.

Gregson (1963) has discussed such cases of evaluative scaling, involving a hierarchy of criteria. Donovan (1975) reported the results of an experiment on similarity ratings for random polygons in such terms: "When the stimulus sample contains perceptually distinct subsets, individual differences are negligible, and the results suggest that *S*s firstly separate the figures on a typal basis, and then scale the subsets separately on some continuous attribute(s)". It seems possible that subjects adopt a similar procedure in evaluating Welsh's figures. However, unlike Donovan's study, individual differences are wide with respect to the evaluation of at least the subset of Welsh's figures used for the Barron-Welsh Art Scale (see chapters 7 and 8).

The tendency to like symmetrical figures, together with the tendency to like complex figures within the symmetrical subset, provided some support for Eysenck's (1942) formula, aesthetic quality = $O \times C$. The term "O" represents "order" such as symmetry, and "C" represents complexity. However, there was no indication from the present analyses that these variables determine preference as a simple product. Rather, complexity only had a significant effect in the present case within the symmetrical subset. The primary determinant was type of figure, and indeed "simpler" *types* (with respect to their average complexity, as shown in Table 4.2) were preferred. Complexity was a positive effect only within symmetrical types.

There are a number of possible reasons why the inverted-U trend was not replicated in the present analyses. It may be that the very diversity of figures in the Welsh Test introduced so many extraneous, uncontrolled factors that regular trends with complexity were "swamped". Since linear trends and the effects of figure type were detected, this plea is unconvincing. More important features of the data were that they

stemmed from dichotomous judgements by subjects ("like" or "don't like") rather than from more precise ratings or rankings; and the variation in complexity was not immediately evident to the subjects, as was the case when the Terwilliger patterns were presented. Further speculation on this question is unwarranted. It was concluded that the inverted-U relationship could be restricted to situations such that observers evaluate a set of stimuli of similar type; and that many other characteristics of abstract figures, such as their associations, probably affect their evaluation.

The diversity of the Welsh figures, and the nature of the obtained results, allow understanding of how apparently contradictory findings can occur. For example, if different *types* of pattern are compared, an experimenter might well conclude that people generally prefer *simpler* designs, such as the regular geometrical patterns (with a mean complexity value of only 4.48 verbal units) which were liked on average by 71.56% of the adult sample. On the other hand, an experimenter who used only symmetrical designs might conclude that adults tend to prefer *complex* designs, as indicated by the positive correlation of .44 between liking and complexity in the present case.

In the same manner, it is possible to understand the contradictory results reported with respect to children's aesthetic preferences. Children liked *simple* geometrical and other smoothly-drawn designs more than irregular figures. However, it was also found that more children liked relatively *complex* figures within the regular, symmetrical subset; and moreover, children liked the *complex*, irregular figures (49.65%) more than adults (31.63%).

Findings of the latter kind, in isolation, could lead an experimenter to deduce falsely that children generally prefer complexity. The positive trend with complexity occurred for children only within the subset of regular, symmetrical figures having a complexity range of only 2 to 13

(see Table 4.2). Perhaps the children admired the drawing skill involved in producing such figures. The children's apparent "preference" for irregular figures could be described as near the chance level of responding (50%), whereas the adults discriminated firmly against irregular figures.

Chapter summary

Previous analyses of the Welsh Figure Preference Test have not investigated group preferences for different types of pattern, nor the nature of trends over complexity levels, nor the nature of differences between child and adult responses. The analyses of Welsh's (1959) data reported here filled these *lacunae*.

It was found that both adults and children tended to like smoothly drawn and symmetrical figures. Within symmetrical figures the proportion of subjects liking the figures increased with their complexity, assessed in terms of the verbal units required for each figure's description. The sample of 6-8 year old children gave similar results to the adult sample, except that the children did not discriminate between types of figure to the same extent as adults. The data for children did not support the informational hypothesis that children have restricted cognitive capacity which interferes with their aesthetic appreciation of complex figures.

No significant inverted-U relationships were found, suggesting that the informational model supported in chapters 2 and 3 has limited application to stimuli varying in many different ways. The findings helped to explain how apparently conflicting evidence concerning the effects of stimulus complexity can occur.

PART B

THE NATURE OF DIVERGENCE/CONVERGENCE

Chapter 5. Is there a factor of divergent fluency?

Chapter 6. Validity of divergent thinking tests

CHAPTER 5

IS THERE A FACTOR OF DIVERGENT FLUENCY?

This chapter is concerned with three inter-related questions. The first question is whether there is a satisfactory degree of generality amongst purported measures of divergent fluency, sufficient to justify the use of that concept in subsequent studies. The second question is whether divergent fluency should be regarded as a facet of general intellectual ability, rather than being a distinct factor; this question concerns the possible wider generality of divergent thinking tests, particularly in relation to tests of convergent intelligence. The third question is whether divergent thinking measures should be divided into subsets, according to postulated processes or according to the nature of the stimuli or responses involved; in particular, the question of whether verbal and non-verbal tests have little factorial overlap is posed.

The evidence discussed in relation to these questions is a selection which illustrates some of the main findings. The only new evidence presented is in relation to the third and more contentious question. This evidence was derived from the writer's factor analysis of divergent fluency data which were obtained by Margaret Dunn under the writer's supervision.

Ideational and associational fluency are of particular concern, since such tests were used for studies described in Part C. The tests measure the number of different responses given, usually within a time limit, which have a specified semantic relationship to the task stimuli. For example, subjects may be asked to give as many uses of a brick as they can. Such tests have been extensively studied by Guilford and his colleagues, and are sometimes referred to as "Guilford-type" divergent thinking tests.

Consistency amongst tests of divergent fluency

In this section evidence concerning consistency amongst tests of divergent fluency is examined, first in terms of average correlations amongst tests and then in terms of the extraction of factors from correlation matrices. The subsidiary question as to the temporal stability of divergent thinking scores is then examined. Finally in this section reasons why high positive correlations between divergent thinking scores have not always been obtained, are discussed.

Wallach (1970) summarized extensive evidence concerning inter-correlations amongst divergent thinking tests. Typically, correlations amongst divergent thinking tests were found to average about .2 to .4 with young adults. To some degree these low values reflect the fact that tests were diverse in nature, for example including measures of originality as well as fluency, and were often "experimental". For instance, Barron (1963) used eight measures to assess "originality" in U.S.A.F. captains, some involving projective techniques and others divergent fluency tests. The average value of the twenty-eight inter-test correlations was about .2.

The generally positive correlations amongst Guilford-type tests supported, in Wallach's view, the concept of divergent ideational fluency, distinct from convergent intelligence. The concept was defined by Wallach as "the person's ability to generate in plentiful number ideas that are appropriate to a given task constraint" (1970, p.1223). In Wallach and Kogan's (1965b) study the average value of 45 correlations between carefully selected divergent thinking measures was .41.

Further research, particularly later work using tests known to be reliable and sufficiently discriminating, has confirmed that there is a reasonable degree of consistency amongst divergent fluency tests. In many cases quite high average correlations betwen pairs of tests have been reported. For example, Richards (1976) found that the average of correlations

(corrected for attentuation) between several "creativity measures" given to a large sample of naval recruits was as high as .64. Richards concluded: "The present results argue for a relatively simple description of the creative thinking domain, supporting the Wallach-Kogan position of a unitary and independent dimension". Similarly Yčas and Pascal (1974) found correlations of .56 or greater amongst four divergent tests.

The notion of a rather broad divergent thinking domain has been supported by studies using trait ratings by observers. For example, Barron (1965, p.43) described ratings of "originality", "adaptive flexibility" and "fluency of ideas" given by investigators after observing subjects during a living-in assessment period of three days. Fluency correlated .76 with flexibility, and .85 with originality ratings. Of course, this degree of generality is partly indicative of the halo effect commonly found with such rating techniques.

High inter-correlations amongst divergent thinking tests have been found with children as well as with adults. For example, Ward (1968, Study 1) tested 7- and 8-year old boys, and found that "the average correlation among all creativity measures was .55". In three further studies of children by Ward, the average correlation among ideational fluency scores was .32, .51 and .58 (Ward, 1971, Table 2); the lowest value was obtained with very young kindergarten pupils. Ward, Kogan and Pankove (1972) reported that 64 "Control group" children about elevan years old gave an average inter-test correlation as high as .59 for four fluency tests.

The use of the phrase "creativity measures" in the quotation above implies far too wide a generality for the three divergent thinking tests Ward used. "Creativity" became a popular term amongst American writers of that period. As later writers, particularly those concerned with the philosophy of education, have consequently pointed out, creative acts do not indicate one general ability, but may involve any of a range of

diverse skills, special knowledge, and personal dispositions (*e.g.*, Woods and Barrow, 1975). This criticism does not apply to the more cautious "divergent fluency" concept.

When scores on two batteries of divergent fluency tests have been compared (rather than pairs of individual tests), very high correlation values have been obtained. For instance, Torrance (1966) reported that divergent fluency, measured by the Torrance Verbal Tests of Creative Thinking, gave correlations between Form A and Form B of .79, .87 and .93 for three groups. Thus a good method of increasing both reliability and generality of measurement is to use more than one test. Two or three divergent fluency tests were used for the studies reported in Part C of this thesis.

Reports which have been at pains to denote diverse aspects of creative performance may nevertheless offer evidence of some consistency amongst scores, at least within the ideational fluency domain. Taft (1971b) scored nine "unusual uses" items for fluency (that is, number of responses); however, a bonus was added for very unusual responses, and Taft referred to the assessment of "originality". Although Taft emphasized the distinction between these measures of "cold creativity" and other measures derived from projective tests, the inter-item correlations for the nine unusual uses items were sufficient to justify the summation of scores, with correlations from .22 to .50.

It might be considered more satisfactory to determine the consistency of scores within the divergent fluency domain by means of factor analysis, rather than in terms of the raw correlations. In the simplest case when tests are all similar measures of divergent fluency, and reliable, factor analysis may indeed produce a unique single-factor solution, with good estimates of factor loadings. However, in most published studies, more than one factor is involved, either because tests themselves are complex,

or because measures of other factors such as convergent intelligence or personality traits are involved in the analysis. In such cases no unique factorial solution is available; rather, alternative interpretations are possible, depending on the number of factors extracted, the method of estimating communalities, and the nature of the rotation of factor axes.

A detailed example may be used to illustrate this point. If a principal components analysis is applied to a correlation matrix derived from both divergent fluency and convergent intelligence tests, then the first component may not distinguish clearly between the two types of test. The first component, by definition, extracts as much of the communality amongst the tests as possible, which (if interpreted without further analysis) might lead to the conclusion that no distinct divergent fluency factor was evidenced. Shouksmith (1970, Table 6) presented loadings on a first principal component for 47 females. They included, for convergent intelligence tests: A.H.5 part I, .66; A.H.5 part II, .75; Canterbury Reasoning Test version 1, .65; and Canterbury Reasoning Test version 2, .72. Positive loadings were also found for the three divergent fluency tests: Word Association, .30; Uses, .47; and Consequences, .31. However, Shouksmith noted that the third extracted component gained positive loadings on the divergent tests, whilst three of the four convergent tests gained negative loadings. After rotation to simple structure, the third factor was interpreted by Shouksmith as "creative associating"; a similar third factor was found for a group of male subjects. The problem is that multifactorial solutions are equivocal, in the sense that they may be used to support more than one interpretation. In the case of Shouksmith's data, the first component might be used to support the notion that divergent tests are merely impure measures of intelligence; whereas the third rotated factor supports a distinct divergent fluency concept.

In early studies by Guilford, separate factors identified as associational fluency, ideational fluency, word fluency and expressional fluency were obtained (*e.g.*, Guilford and Christensen, 1956; Kettner, Guilford and Christensen, 1959). However, factors were rotated to improve "psychological meaning" as well as to simplify factor structure, and such subjective rotation may have given a bias in favour of expected factors.

This point may be illustrated by a detailed consideration of Guilford and Christensen's results (1956, Tables 5 and 11). They presented two factor analyses, one with rotation using "psychological meaning" as one of the criteria, and the other using only simple structure and positive manifold as the criteria. Since the authors also presented their predictions for loadings on the four hypothesized fluency factors, it is possible to determine the degree to which the loading patterns from the two analyses agree with the predicted patterns. In particular, one may enquire as to whether the hypothesized factors were "confirmed" only following the subjective rotation.

Relevant data are shown in Table 5.1. When rotation to psychological meaning was employed, the obtained loadings for all four fluency factors accorded somewhat with the predicted patterns of loadings, although the degree of agreement between predicted and obtained patterns was low ($\phi < .4$) in the case of ideational and expressional fluency. On the other hand, when rotation involved only the unbiased objective criteria, there was no significant confirmation of the predicted loading patterns for associational fluency or for expressional fluency. Only two of the postulated factors were confirmed by the unbiased form of rotation, ideational fluency and word fluency. The results shown in Table 5.1 thus illustrate the difficulty of drawing unequivocal conclusions from factor analyses which involve the rotation of several factor dimensions.

Analyses involving the extraction of few factors and the use of the

objective Varimax criterion for rotation of factor axes provide more convincing evidence in favour of a single divergent fluency factor. For example, Hargreaves and Bolton (1972) reported such a factor with 10- and 11-year olds. The factor was distinct from the convergent intelligence factor.

The objective Promax oblique rotation also avoids the problem of possible bias in rotated solutions. Nicholls (1971) provided an example of such an analysis. For boys and for girls in each of two groups, divergent and convergent tasks given with normal test instructions produced corresponding factors. However, as often found with oblique rotation, the significant loadings for the divergent tasks were split over two factors which were themselves correlated (Nicholls' Tables E and G). In this case again, the factors offer somewhat ambivalent evidence, in that they may be interpreted as supporting the concept of divergent thinking ability, but may also be taken to support a distinction between different types of divergent thinking tests using verbal or nonverbal stimulus material.

With oblique factor resolutions of correlation matrices, higher order factors may be obtained from the correlations between primary factors. For example, Fee (1968) obtained a second-order "creativity" factor (his term) from an analysis of Wallach and Kogan's data, but nevertheless distinguished between tests using verbal and visual material on the basis of the first-order factors. Ward (1967) analysed the same matrix, also extracting oblique factors but with a somewhat different method of factor estimation, and obtained a primary factor with positive loadings on all ten divergent thinking measures. Ward (1968) considered Fee's two separate creativity factors "somewhat difficult to accept". This controversy clearly illustrates the point that conventional factor analysis may be problematic when used to determine the borders of psychological domains. In a case such as that described, one may either derive narrow factors each

Table 5.1. Analysis of fluency factor loadings for 41 tests reported by Guilford and Christensen (1956), to determine the degree of agreement between predicted factor patterns and obtained patterns: (A) with rotation using both statistical and subjective criteria, and (B) with rotation using only statistical criteria

Derivation of contingency tables

The tables below integrate the information given by Guilford and Christensen in Table 5 (predicted factor patterns) and Table 11 (obtained factor patterns). Their study involved 41 tests, most being relevant to divergent fluency. In each case the tests were classified according to factor loadings. The critical value of .25 was used by Guilford and Christensen. For each factor the predicted loading and the obtained loading classifications were compared for the 41 tests, to give a 2x2 contingency table. This was done both for the obtained factor solution including "psychological meaning" as a criterion (Solution A); and for the obtained factor solution using only statistical criteria (Solution B). The degree of agreement between predicted and obtained patterns was assessed in each case by ϕ, and its significance by χ^2 corrected for continuity.

Factor name (used by Guilford & Christensen)	Distribution of 41 tests	
	Solution A	Solution B
Word fluency	Predicted loading ≥.25 <.25 Obtained ≥.25 6 3 loading <.25 1 31 ϕ = .70 χ^2 = 15.80 (p<.001)	Predicted loading ≥.25 <.25 6 4 1 30 ϕ = .65 χ^2 = 13.44 (p<.001)
Associational fluency	Predicted loading ≥.25 <.25 Obtained ≥.25 9 1 loading <.25 9 22 ϕ = .53 χ^2 = 9.07 (p<.01)	Predicted loading ≥.25 <.25 4 3 14 20 ϕ = .12 χ^2 = 0.13 (N.S.)
Ideational fluency	Predicted loading ≥.25 <.25 Obtained ≥.25 5 3 loading <.25 6 27 ϕ = .40 χ^2 = 4.38 (p<.05)	Predicted loading ≥.25 <.25 9 6 2 24 ϕ = .57 χ^2 = 10.73 (p<.01)
Expressional fluency	Predicted loading ≥.25 <.25 Obtained ≥.25 9 3 loading <.25 10 19 ϕ = .37 χ^2 = 4.09 (p<.05)	Predicted loading ≥.25 <.25 6 4 13 18 ϕ = .16 χ^2 = 0.40 (N.S.)

having a high level of consistency amongst a few high-loading measures, or (with equal propriety) a broad factor with a lower level of generality amongst more numerous measures (*e.g.* Sultan, 1962). This choice has become familiar in the case of convergent thinking tests (Vernon, 1950).

A unique factorial solution may be determined only in the special case when all variables in the analysis represent a single common factor, and when residuals after extraction of that factor are not significant (Spearman, 1957). An empirical example with divergent tests is provided by the study described in the last section of this chapter.

Despite the equivocal nature of the factor analytic evidence, it seems reasonable to conclude that there is sufficient consistency amongst measures of ideational fluency to support its use in the further study of the nature of divergent thinking, and its possible relation to aesthetic preferences.

It is also necessary to demonstrate that divergent thinking scores have a reasonable degree of temporal stability, if they are deemed to represent more than an ephemeral characteristic of persons. A reasonable degree of stability has been demonstrated over both short and long time intervals, for various divergent thinking tests.

Bush (1971) obtained total scores from six such tests given to school children on five successive days, and found test-retest reliabilities ranging between .45 (Day 1 to Day 5) and .85 (Day 2 to Day 3). Goldman and Clarke (1967) reported that scores from an imaginative-stories task, repeated after an interval of one week, gave a test-retest reliability of .95 for both boys and girls, in the case of one scorer; a second scorer gave corresponding reliabilities of .92 for boys but only .48 for girls.

Dewing (1970b) reported average reliabilities for divergent fluency, over a six-week interval using parallel forms for two verbal tests, of .51; and for two nonverbal tests, of .69.

Torrance (1966, pp.20-22) quoted various reliability studies for the Torrance Tests of Creative Thinking. For example, in one study using the alternate Verbal Forms A and B with an interval of eight months, verbal fluency gave a reliability coefficient of .79; whilst in another study (by Sister Dalbec) over a three-year interval the correlation was reduced to .59. Ward (1971) reported test-retest correlations of "around .6 over a six-month interval", for the divergent fluency tests used by him.

Even over a period of four years, Haddon and Lytton (1971) reported a stability coefficient of .62 for their battery. One of the longest time-intervals reported was five years, by Kogan and Pankove (1972). These investigators concluded: "Substantial stability in ideational productivity and uniqueness scores over a 5-year period was observed for males in the setting of group administration and for females in the context of individual testing". Although divergent fluency is by no means a fixed or unvarying attribute, its measurement has shown sufficient stability for it to be regarded as a "trait" rather than a temporary "state" variable.

Finally in this section, it is informative to consider explanations as to why some "divergency" measures have not been significantly correlated with others. One important point is that some research in the two preceding decades used a wide range of novel tasks considered to involve "creativity" in some way, and it is not surprising that low correlations sometimes occurred. As Wallach and Kogan (1965a) noted: "a potpourri of abilities was being assessed in the good name of 'creativity'". The potpourri might include mathematical aptitude, convergent verbal reasoning, vocabulary, and various complex perceptual-cognitive styles reflected by projective tests, embedded figures tests, and so on.

Some of the divergent-fluency tasks used in early studies had little reliability. For instance "Thing Listing III' (Guilford and Christensen, 1956, Table 6) had an estimated alternate-form reliability of only .36;

it is not surprising therefore that it was not significantly loaded on the ideational fluency factor, for its total communality was "a mere .28". Fluency tests of known high reliability were used for studies reported in Part C of this thesis.

A number of studies have shown that when task instructions severely restrict the range of acceptable responses, or when tasks are similar in other ways to convergent intelligence tests, they tend to have low correlations with divergent tests of a more "open" kind. Conversely, as Guilford and Christensen (1956) found, "the tasks that seem to permit the more responses are those with highest loadings" on associational fluency. A good example of a restricted response test is the Remote Associates Test. Although Mednick (1962) considered it to be a measure of creative thinking, each item has only one correct solution, so that in principle convergent thinking is involved as well as associational fluency. Indeed Cropley (1966), Taft and Rossiter (1966) and Worthen and Clark (1971) all reported that the Remote Associates Test correlated more highly with measures of convergent thinking ability than with divergent fluency tests.

Further examples of scores which are ambivalent in nature are provided by word-fluency tasks, such as "list words beginning with the letter w". The number of responses possible on a test of this nature is controlled by the person's vocabulary, and vocabulary tests are known to provide "an excellent measure" of convergent intelligence (Wechsler, 1958, p.84). It is not surprising therefore that "word fluency" is related to convergent thinking as well as to divergent thinking (Thorndike, 1963), and that it is consistent with a general factor of verbal ability (Rogers, 1953).

A similar situation was found with the test called "Multiple Analogies". It was designed to measure divergent associational fluency, but was found to relate primarily to convergent thinking tests owing to its dependence on vocabulary (Guilford, 1967, pp.147-8). In the studies described in

Part C of this thesis, tests of ideational or associational fluency rather than word fluency were used primarily.

It also has to be recognised that a divergent person may not always conform to a test's presuppositions sufficiently to obtain a high score, by dint of his divergent approach. For instance, one individual, asked to construct a mosaic from variously coloured pieces of cardboard, selected only white pieces (Barron, 1969, p.22). Should the resulting "pattern" be considered clever or merely eccentric? Such examples are rare, but undoubtedly do affect the consistency of test scores to some degree.

It has further been suggested that a test may give low correlations if it fails to motivate subjects. Wallach and Kogan (1965b) considered that a game-like atmosphere should be used to encourage an imaginative approach to tasks. However, Nicholls (1971, Table F) found that an oblique factor I, representing game-like divergent scores, correlated significantly with an oblique factor III, representing test-like divergent scores, .42 for boys and .48 for girls. Ward, Kogan and Pankove (1972) investigated motivation by considering the effect of monetary reward on ideational fluency. They concluded that since nonrewarded and rewarded performance correlated .60 and .53 in two experimental groups, "individuals showed a high degree of consistency in their relative ideational production".

Whilst mean scores may be affected by differing motivational states induced by special conditions of testing or instructions, it would appear that such effects may not unduly affect the use of divergent thinking tests for assessing relative differences amongst individuals. After reviewing the evidence (much of it being unsatisfactory or inconsistent), Hattie (1977) concluded that "there is little evidence against using timed test-like conditions as the norm".

Divergent thinking and general intelligence

Given that there is reasonable evidence in favour of a factor of divergent fluency, it remains to be established that the factor is distinguishable from general intelligence. Much research effort has been directed towards the relationship between convergent and divergent thinking tests. Burt (1962) noted some of the early British research on the notion of verbal fluency, as well as the more recent American work. In his critique of the Getzels and Jackson (1962) research, Burt commented that their "new tests for 'creativity' would form very satisfactory additions to any ordinary battery for testing the general factor of intelligence". Indeed, eleven "verbal fluency" items are included in The British Ability Scales (Elliott, Murray and Pearson, 1977), although unfortunately at the time of writing information regarding the correlations between the verbal fluency scale and other scales is not available. This inclusion of divergent fluency tests represents an innovation, since "the divergent-production abilities have historically been outside the domain of intelligence tests" (Guilford, 1967, p.139).

One of the initial contributors to the British emphasis on the general factor "g" was Spearman, who considered that the major process involved in creative activity in fine arts or in sciences was "the educing of a 'correlate'" (1930, p.110). Thus creativity was seen as involving associative thinking of a similar kind to that involved in other intellectual activity. After reviewing a considerable number of recent studies on the issue, Gilchrist (1972, p.57) concluded "that the evidence for an independent creativity factor is by no means conclusive". However, this conclusion seems to the present writer too cautious and too vague, in that there is extensive evidence to support three conclusions. First, the notion of an ideational fluency factor is justified, as argued in the previous section. Second, the correlations between measures of this factor and IQ are generally

positive, significant and low. Third, with very heterogeneous subject samples, moderate positive correlations occasionally occur; and with more homogeneous samples, particularly those above average IQ, correlations may be negligible. As early as 1962, Taylor and Holland reviewed the available research and came to much the same conclusions. Some of the subsequent evidence supporting the second and third conclusions is described below.

Guilford (1967, p.167) tabulated "some representative correlations" between IQ scores and divergent productivity measures of various kinds, and most values were near zero or low positive correlations. In one of these studies, by Ripple and May (1962), three different groups of high, medium and low intelligence were selected from seventh-grade children, as well as a fourth heterogeneous group. The correlations between the Otis Quick Scoring Test and nine varied "creativity" tests were low and mostly non-significant for the relatively homogeneous groups, as would be expected as a consequence of the limited range on the IQ variable. Generally higher correlations, with a median value of .6, were found with the heterogeneous sample, illustrating Shouksmith's (1970, p.132) cautious comment that "Divergent and convergent processes are best regarded as two aspects of thinking".

On the other hand, most studies have reported rather low correlations with IQ even in fairly heterogeneous samples. The average of one-hundred correlations between ten "creativity" measures and ten convergent intelligence measures obtained by Wallach and Kogan (1965b) was only .09 for 10 and 11 year olds. Ward (1968, Study 1) tested 7 and 8 year old boys, with most having an IQ above average (mean of 115) and found that "Each creativity measure had a non-significant correlation with the IQ score". Similar non-significant (or low negative) correlations were obtained by Ward (1968, Study 2) with the "semantic" divergent production measures given to kindergarten children with a mean IQ of 103. Wallach's (1970) review of research to that date led him to support ideational fluency "as a dimension

of individual differences independent from the convergent-thinking domain but also cohesive in its own right" (p.1223). The evidence he reviewed did not justify the term "independent", but rather "considerable separation" between ideational fluency and convergent intelligence (also quoted from p.1223).

Later evidence from several countries has further supported this interpretation. Dacey, Madaus and Allan (1969) reported a mean correlation between divergent and convergent thinking tests of only .08 with 14 and 15 year old Irish pupils. Wallach and Wing (1969, their Table 2.9) found that Scholastic Aptitude Test scores gave uniformly low correlations with verbal and figural measures of divergent fluency and originality, in a group of American undergraduates. Dewing (1970a) obtained a significant but low correlation of only .14 between total "creativity" scores and IQ amongst children aged about 12 years from ten Australian schools. Ward (1971, his Tables 2 and 3) obtained near-zero mean correlations between fluency and IQ scores (-.03, -.12 and -.21) for three samples of young American children, and low mean correlations (.17 and .26) for two samples of older children. Significant and somewhat higher correlations were obtained by Nicholls (1971, his Table 1) between verbal divergent thinking scores (under test-like conditions) and intelligence test scores for four groups of New Zealand pupils aged about 11 years: for boys the correlations were .32 and .47, and for girls .32 and .48.

British undergraduates gave no significant correlation between verbal intelligence and either associational or ideational fluency measures (Innes, 1972, his Table 1). Murphy (1973, p.129) reported a negligible correlation between oblique factors described as "intelligence" and "creativity" for New York high-school students. Similarly, Leith (1972) reported that his "creativity measures were significantly intercorrelated and were not

significantly related to a measure of general intelligence', with nine to thirteen year old children in Germany. Nijsse (1975) obtained a mean correlation between "creativity tests" and "intelligence" of .12 with Dutch fifth-grade pupils, and Richards (1976, her Table 3) similarly obtained a low mean correlation of .21 with American naval recruits. Finally, Renner (1978, p.333) found that "Correlations computed between the average convergent and average divergent scores were generally low" in her study of 493 Australian children with a mean IQ of 115.

The above research, spread over several years and several countries, appears to give firm support to the conclusion that divergent fluency generally has a low or an approximately zero correlation with convergent intelligence. At the same time, it is admitted that "the correlation between the two factors cannot be well determined" (Guilford, 1967, p.60). It is unfortunate that some writers, even in recent papers, use the misleading terms "creativity" and "intelligence" in this context, instead of more precise terms like divergent fluency and convergent intelligence.

The research has been described in detail since some writers have come to a quite different conclusion. For example, Freeman, Butcher and Christie (1971, p.14) wrote: "creativity as assessed by the Guilford-Torrance-Messick tests of divergent thinking overlaps very considerably with intelligence as assessed by conventional tests". (Messick was a misprint for Mednick.) Two studies have been used in particular to justify such a claim. Cropley (1966) found that oblique convergent and divergent thinking factors were correlated (.51); however, even this degree of relationship does not represent a "very considerable" overlap. Hasan and Butcher (1966) obtained a correlation as high as .74 between aggregate "creativity" and the mean of two verbal reasoning test scores, with Scottish secondary-school children. The reasoning tests, used for the purpose of

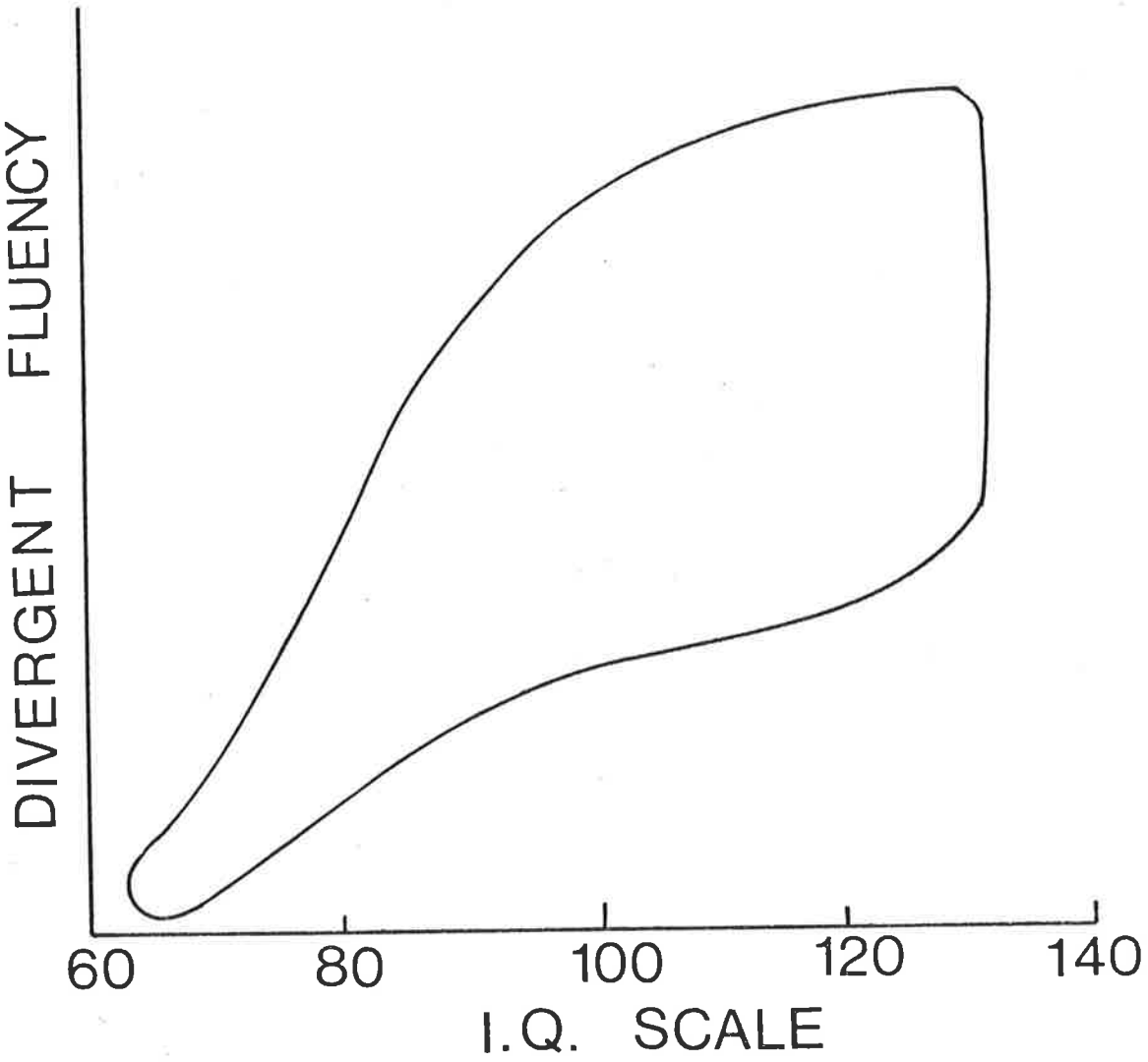
secondary-school placement, may have allowed more divergent responses than usual with such tests. On the whole, it seems appropriate to regard Hasan and Butcher's finding as unusual, and certainly not typical of such research. Torrance (1967b) tabulated 178 such correlation values reported in the literature, and the median value was only .2.

Although the research reviewed above has utilized linear correlation coefficients, there is some evidence that the relationship does not conform to a bivariate normal distribution. Rather than elliptical, it has been suggested that the bivariate distribution resembles a "twisted pear" shape, as illustrated in Figure 5.1. Such a shape is often found in prediction, if IQ is regarded as the "predictor" and divergent fluency as the "criterion" (Fisher, 1959). Guilford (1967, his Figure 6.12) presented a similar hypothetical scatter diagram; possibly actual data are seldom presented in this form since the generally low degree of relationship makes the form of the bivariate distribution difficult to discern.

The evidence in favour of the pear-shaped relationship is mostly indirect, being that the positive linear correlation is supposedly lower for groups of above-average IQ than for groups below average IQ. A good example of such evidence was provided by Haddon and Lytton (1968). They found a correlation between verbal IQ and divergent thinking of only .16 amongst eleven and twelve year olds with above-average IQ, but .51 amongst those with below-average IQ. Examination of the left- and right-hand sections of Figure 5.1 shows that such a difference in correlation values would be expected from the hypothesized relationship.

The study which has often been quoted in this regard is that by Yamamoto (1965), who interpreted his data as showing a consistent decrease in the size of correlation as the IQ level of subgroups became higher. In fact, this statement provided a poor description of his results. The raw correlations between IQ and the divergent thinking score were shown in Yamamoto's Table 2 as nonsignificant for all IQ subgroups. Moreover, in

Figure 5.1. Hypothesized relationship between convergent thinking (IQ) and divergent thinking (fluency) scores



the case of schools from an exclusive suburb ("School System A"), raw correlations for the three IQ subgroups were approximately zero (-.14, .08 and .04). However, even the lowest IQ subgroup from School System A had a mean IQ of 105, so that sample did not allow an adequate examination of the hypothesis. The other sample obtained by Yamamoto ("School System B") was more adequate in this regard, but nevertheless provided evidence which is suggestive rather than convincing.

If the pear-shaped relationship is accepted as a reasonable hypothesis, it has three distinct aspects. First, the trend in grouped-data plots is curvilinear: specifically the trend has a negative acceleration as well as a main positive slope. Second, the standard deviation of divergent fluency scores increases for higher IQ subgroups, reflecting the greater spread of scores at higher IQ levels (see Figure 5.1). Third, the IQ distribution is truncated at the upper bound, since the score is limited by the number of test items (see Figure 5.1). On the other hand, fluency scores are often positively skewed, with no absolute upper limit to the score. The writer suspects that the mismatch in distributions for the two variables is a relevant feature contributing to the lower correlations for above-average IQ subgroups: this suggestion is supported by Richard's (1976, p.160) scatterplot results.

Yamamoto's (1965, his Table 1) subgroup means and standard deviations showed some slight signs of both a negatively accelerating trend of creativity scores on IQ, and increasing standard deviations for creativity scores. However, the subgroup standard deviations for IQ scores were also not equal, so that no firm interpretation can be made. Ginsburg and Whittemore (1968) specifically investigated these points, and found support for the positive trend with some negative acceleration, but no increase in variance in "creativity" scores at higher IQ levels. Unfortunately, the "creativity" test used was the Remote Associates Test, which does not have the open-ended characteristic of other fluency tests, as noted above. A more satisfactory study in this respect was completed by Davis (1966) who used five divergent

fluency tests, given to 109 Australian pupils in their third year of high school. She obtained a correlation of .34 with IQ, for the subgroup with IQ less than 120, and a correlation of only .05 for those with IQ of 120 or more. Moreover, the bivariate distribution scatterplot conformed with the twisted-pear hypothesis.

Should divergent fluency be subdivided?

Guilford in particular appears to have advocated the separation of various fluency factors, although he also acknowledged that there is "a divergent-thinking group" of such factors (Kettner, Guilford and Christensen, 1959, p.30). There seems little doubt that the word-fluency factor should be treated as distinct, since it is more closely related to convergent intelligence, as described above.

The other separate fluency factors identified in the first large-scale factor-analytic study of creative-thinking abilities were associational and ideational fluency (Wilson, Guilford, Christensen and Lewis, 1954). Examples of tests with high loadings on these two factors were Controlled Associations and Brick Uses respectively, similar to tests used for the study described in chapter 11. The raw correlation matrix was provided by Guilford, Wilson and Christensen (1952), and the separation of these two types of tests may be examined more closely. The average within-factor correlation amongst the four tests with highest loadings on ideational fluency was .44. Their average between-factor correlation with the four tests having highest loadings on associational fluency was only .09. (In calculating these values, correlations for "variable 27" were reflected, following Guilford *et al.*, since it was in "error score" terms). Thus the factor separation of the two types of test was quite marked. Nevertheless, more recently Horn and Cattell (1967, their Table 1) reported that ideational and associational fluency have high loadings on a second-order

factor of verbal fluency.

Other recent papers have emphasized possible subdivisions. For example, Nuttall (1973) concluded: Divergent thinking "is better considered as a number of distinct abilities. These abilities seem to depend largely upon the stimulus material". Nuttall reached this conclusion partly from his own investigation using very varied tasks involving a word fluency test and tasks involving semantic, figural and numerical material. The median inter-test correlation was only .14 for secondary school fourth-formers and .10 for fifth-formers.

Discussion of this question has mainly concerned Guilford's "structure of intellect" model, which is illustrated in Figure 5.2. Divergent thinking is one of the basic "operations" incorporated within the model. For each kind of operation like divergent thinking, the model further distinguishes between six types of required responses ("products"), and four types of test materials ("contents"). Each cell within the model defines a particular combination of operation, product and content, so that there are twenty-four divergent thinking cells. The cells specify "unique abilities or classes of abilities" (Guilford and Merrifield, 1960, p.3).

Much of Guilford's subsequent research on divergent thinking has been intended to determine the correspondence between empirical divergency factors and the cells in the model. The nature of this correspondence will be discussed first in relation to tests requiring different types of product, mainly within the semantic content area, since tests of this type were used in Part C of this thesis. Then the relationship between tests of differing content, particularly semantic and figural, will be discussed, leading to the empirical analysis at the end of this chapter.

The "DM" domain

Within the class of semantic divergent thinking tasks, Guilford considered that all six possible factors for different types of product have

been identified by several studies (Guilford, 1967, his Table 6.1). Each factor is represented by a trigram commencing with DM meaning "divergent production, with tasks having semantic content". The third letter in the trigram represents the type of product, as follows: DMU (units), DMC (classes), DMR (relations), DMS (systems), DMT (transformations) and DMI (implications). The previously mentioned factors of associational and ideational fluency were considered by Guilford (1967) to correspond with the DMR and DMU cells of the model of intellect, respectively. A further factor initially called "expressional fluency", and represented mainly by sentence-construction tests, was allocated to the DMS cell (Guilford, 1967, p.150). The three other DM cells were identified with scoring techniques other than fluency: DMC with "spontaneous flexibility" in the production of different classes of response, DMT with "originality" and DMI with "elaboration" of responses.

It seems to the present writer that some "low order" factors have been supported by the research cited by Guilford. Doubt remains, however, as to their independence. Many studies (*e.g.* Wallach and Kogan, 1965b, and others using their battery) have involved divergent thinking tests from two or more of the above categories of DM tests, and have found moderate correlations amongst them, with no clear separation according to Guilford's cells. Moreover, internal evidence within the reports of Guilford and his colleagues indicates the overlap amongst factors within the DM domain. For example, the total score on the Consequences test has been found to have high loadings on both DMU and DMI (Guilford, 1967, p.142). When only remote consequences were counted, the Consequences test was found to load significantly on DMT for some age-groups and on DMC for others (Guilford, 1967, p.155). Similarly, the Unusual Uses test was related to both DMC and DMT (*op. cit.*, p.145); a Simile Interpretation test was related to both DMS and DMT (*op. cit.*, p.151); and different Associations tests have loaded on either DMT or DMR factors (*op. cit.*, p.155).

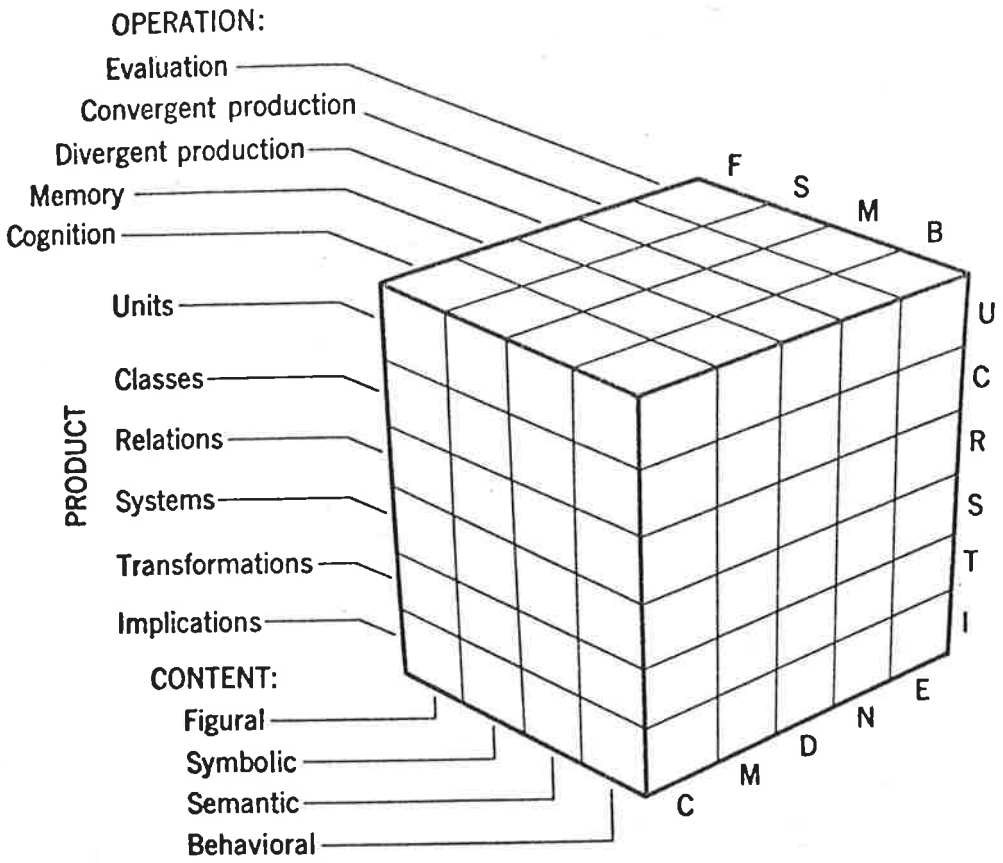
As Vernon (1964) has stated "psychometrists other than Guilford's own followers have not generally confirmed the enormous number of distinct factors that he claims". As a result, Guilford has been widely criticized for neglecting the generally positive correlations within both divergent and convergent thinking domains (*e.g.* Eysenck, 1967b). Indeed, Wallach (1970, p.1215) considered Guilford's claim, that a number of divergent-thinking abilities can be usefully distinguished, to be "extreme".

Guilford (1957) acknowledged that "so many distinctions, and separations of function may be somewhat surprising", and that the actual degree of correlation between the facets of divergent thinking remained to be determined. A hierarchical model (*e.g.* Guilford, 1959, p.100) would allow for both a broad divergent thinking dimension and narrower abilities at a more specific level in the hierarchy, so that there is no necessary conflict between the two levels of analysis. Nevertheless, there is great disagreement as to the most useful level in view of the correlations obtained.

The disagreement may be illustrated by an exchange between Richards and Guilford. Richards (1976) reported that the average of correlations (corrected for attenuation) between several divergent thinking tests of various types (including DMU, DMS, DMT and DMC), was .64. Richards concluded that there was therefore a "unitary" divergent thinking dimension. However, Guilford (1976) considered that this conclusion was "very unjustified", for two reasons: the correlations obtained in his own Aptitudes Research Project were generally lower than those obtained by Richards (with a mean corrected value of .44, in Guilford's Table 1); and in any case a correlation value of .64 accounted for only 41% of the variance.

The present writer finds Guilford's effort to interpret all data as conforming to his model of intellect unconvincing. Low correlations of the order of .2 to .4 have been frequently used as the basis for Guilford's factors. For example, in a matrix from which twelve "Structure of Intellect"

Figure 5.2. Guilford's Structure-of-Intellect Model (from Guilford, 1967, frontispiece)



factors were extracted (Gershon, Guilford and Merrifield, 1963, Table 3), 394 of the 406 correlations in the matrix were less than .4. If Guilford-type factors may be justified by generally low correlations, there is no good reason for rejecting Richard's divergent thinking dimension based on much higher correlation values. It would seem that Guilford's criticism may apply to his own model of intellect: "The goal of simplicity is definitely appealing, but pursuit of it can get in the way of understanding" (Guilford, 1976, p.169).

The semantic, symbolic and figural domains

As in the semantic domain, so also there is considerable overlap across Guilford's cells in the figural domain. Tests measuring divergent production with tasks having figural content are expected to represent various "DF" cells within the model. The overlap between different DF cells, and their corresponding factors, may be illustrated by a finding of Gershon, Guilford and Merrifield (1963, p.15). Seven tests had loadings above .3 on a "DFU" factor for an adult sample, and four of these also had significant loadings on a "DFS" factor.

Perhaps it might be considered that cells which differ only in product are neighbouring, like units (U) and systems (S) in the above example, and so allowed by Guilford's model to overlap somewhat. From the evidence it would seem that such cell "walls" in the model are so pervious as to be almost undetectable. Are the divisions between the model's *content* categories, particularly semantic, figural and symbolic tasks, more distinct?

Consider, for example, the distinction between the DMS (semantic systems) cell and the DSS (symbolic systems) cell. Tasks involving semantic material can clearly be distinguished from those involving symbolic material, according to the model, and corresponding factors should emerge from correlation matrices involving the two types of test. In an empirical test

of this hypothesis, Guilford and Pandey (1974) used five tests intended to represent the DMS cell and five others to represent the DSS cell. Only four of the ten tests had their highest loading on the predicted factor, six having highest loadings on a non-predicted factor in the three-factor solution. It may be noted that this relative failure to fit the model followed an extensive series of unsuccessful attempts to differentiate clearly measures of DSS and DMS (Guilford, 1967, p.150). Despite this, Guilford and Pandey concluded: "The two factors of special interest were demonstrated... It is likely that a DSS factor was correctly identified here for the first time". It would seem that Guilford's model is almost immune from falsification.

Several studies bear on the question of whether semantic and figural divergent thinking tests are factorially distinct, and orthogonal. Again internal evidence within Guilford's own research suggests that such a distinction, whilst rational, may not be concordant with correlational patterns. For example, tests with "exceptionally high loadings" on a semantic factor included instructions "to write in response to a picture", which would seem to imply figural content; similarly, the number of responses to the Rorschach inkblots was related to the DMU factor, despite its obvious "figural" nature (Guilford, 1967, p.143). Results reported in chapter 11 further support the notion that ideational fluency using verbal tests is positively correlated with the number of Rorschach responses. A further example of difficulty in separating semantic and figural tasks on the basis of factor analytic evidence is provided by the DMI cell: one test considered to be relevant, called Possible Jobs, involved the subject responding to a pictorial design (Guilford, 1967, p.161).

Apart from the empirical difficulties for the model, the above examples also demonstrate a conceptual ambiguity. The content categories were intended to refer to the content of test items, as stimuli (Guilford, 1967, p.61), and were selected primarily to accord with evidence concerning

convergent thinking factors. Some divergent thinking tests have involved *pictorial* stimuli but required *verbal* responses. The distinction between stimulus and response content has been made explicit in the design of the new British Ability Scales (Elliott, Murray and Pearson, 1977, Figure 1). Generally, divergent thinking research has not made this distinction: for example, the Torrance Figural Tests of Creative Thinking require both figural responses (drawings) and semantic responses (titles).

Bearing this ambiguity in mind, what degree of correlation has been found between figural and semantic tests? Torrance (1966) denied that creative thinking is a "unitary function" (p.24), but nevertheless reported a moderately high correlation of .52 between figural and verbal fluency for Form A of his battery (p.82). Similarly, Nicholls (1971, his Table 1) found correlations between verbal and non-verbal divergent thinking batteries, under test-like conditions, of .51 and .46 for two groups of boys, and .76 and .45 for two groups of girls. Ward (1968, Study 1) found that "the test which employed figural stimuli did not separate from the nonfigural procedures" with boys about 8 years old; however, this was not so for kindergarten children in his Study 2. Adcock (1968) in a study involving convergent and divergent tests with spatial, verbal and symbolic contents, found a fluency factor and no general spatial/verbal differentiation. Lytton and Cotton (1969) reported a correlation of .43 between verbal and non-verbal divergent tests. Finally, Wallach and Wing (1969, Table 2.8) found that two verbal and two figural fluency measures gave correlations between .57 and .79. This evidence contradicts Guilford's (1966) assertion: "Generally, the correlations between figural tests and symbolic tests, on the one hand, and semantic tests, on the other, are very low."

On the other hand, a number of studies have reported orthogonal figural and verbal divergent thinking factors. Examination of this evidence shows that it is far from convincing. For example, Dacey, Madaus and Allan (1969) interpreted two factors as "verbal" and "non-verbal" divergent thinking.

However, all divergent thinking variables had positive loadings of at least .63 on their first unrotated factor, so that a single divergent thinking factor would be a reasonable interpretation of the data. Even if their rotated solution were preferred, it would be impossible to interpret factors with confidence because the measures within each factor were empirically dependent, being fluency, flexibility, originality and elaboration scores from the same responses.

A study by Rowell (1978b) even more clearly points to the different interpretations possible according to whether rotated or unrotated solutions are reported. He analysed data from two verbal divergent measures, two figural divergent measures and two convergent measures. The four divergent measures all had loadings of .78 or higher on the first unrotated principal component. Nevertheless, after Varimax rotation only the figural divergent measures had high loadings on Component 1, whilst the verbal divergent measures had high loadings on Component 2.

Butcher (1970, p.109) reported a separate factor of "divergent thinking applied to graphic or diagrammatic material" however, there was only one figural test (the Circles test), which is hardly sufficient to justify a "factor". Another unsatisfactory interpretation was provided by Hargreaves and Bolton (1972). They considered that their fourth factor reflected "the differences in content between tests (verbal/pictorial)". This interpretation is controversial, in that loadings for all divergent thinking measures as well as perceptual and verbal IQ were in the same direction (negative).

Few experiments have been undertaken specifically to examine the relationship between various divergent fluency tests in order to test Guilford's model. The experimental analysis described below provides such an examination.

Factor analytic study of divergent fluency

Aim

The aim of the present analysis was to distinguish between three alternative propositions, given the application of various divergent fluency tests representing various cells from Guilford's model. Proposition 1 is incompatible with Guilford's model, whereas Propositions 2 and 3 are consistent with it.

Proposition 1. There is a single divergent fluency factor, on which all tests have high positive loadings, and which accounts for a large proportion of the variance, with no significant residual.

Proposition 2. There is a significant residual after extraction of the first factor, giving a second factor (or further factors) interpretable in terms of the figural/semantic division, or in terms of the type of product required by the tests.

Proposition 3. There is a single major factor corresponding with the cell in Guilford's model which is best represented by the tests; and those tests from other cells have lower or negligible loadings on that factor.

Tests

Eight tests of divergent thinking were used, each scored for fluency, that is, the number of all responses which fitted the requirements of the test. Four tests were primarily concerned with words ("verbal"), and four primarily concerned with shapes and objects ("non-verbal"). Amongst the latter were two figural tests, in the sense that figural stimuli were used, although all tests required written responses. Each test included three items. Tests were similar to those in the ETS kit (French, Ekstrom and Price, 1963) or the Purdue Creativity Test (Lawshe and Harris, 1960), but modified to suit the desired format.

The tests are listed in Table 5.2, with the postulated cell from Guilford's model. The cell was determined partly from the nature of the test *a priori*, and partly from Guilford's description of the cell's representative tests. The cell allocation is tentative because of the problematic nature of Guilford's factors, as described in the previous section. As Table 5.2 shows, the tests were varied over the M, F and S types of content, and over the U, C and R types of product, in Guilford's scheme.

Subjects

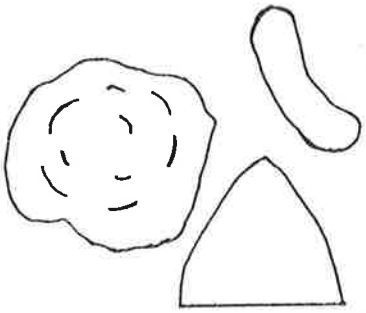
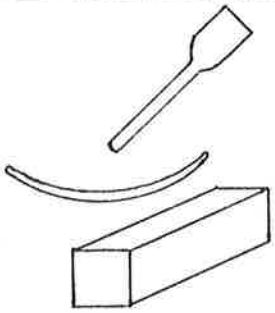
Subjects were first-year male students at the University of Adelaide, taking Psychology I or Engineering I. Three independent groups were given different general instructions as described below. There were 44 men in each group.

Procedure

Subjects were tested in six subgroups and given all tests in one session, with 7½ minutes allowed for each test and a 5-minute break between verbal and non-verbal batteries. Half did the verbal battery first, and half the non-verbal first. The three general types of instruction were as follows: the standard instruction required the subject to give as many responses as he could (Group A); the more permissive instruction added "Please give any response at all that occurs to you" (Group B); and the most permissive instruction had in addition the phrase "no matter how far fetched it may appear to you" (Group C). For the purpose of the present analysis, these additional groups form modified replications, to check whether the factorial structure is affected by the general ambience of the tests as implied by Wallach and Kogan (1965b).

The experiment was conceived jointly by the writer and Margaret Dunn (Rump and Dunn, 1971). Testing was undertaken by the latter after an

Table 5.2. Tests of divergent fluency in the factor-analysis study

TEST	CELL	ITEMS	EXTRACT FROM INSTRUCTIONS
1. Prefixes	DSU	per con trans	"Indicate as many words beginning with each of the prefixes as you can".
2. Questions	DMU	carboard box piece of string piece of paper	"List as many questions as you can about each of the following items".
3. Similies	DMR	dark wild clear	"List as many words of similar meaning as you can".
4. Consequences	DMU	Laws repealed average height rise oceans dropped	"Give as many consequences which you consider would follow such an event as you can".
5. Shapes	DFU		"List as many possibilities as to what these shapes could represent as you can".
6. Materials	DMC	glass wood stone	"List as many different types of objects which are made of the following materials as you can".
7. Purposes	DFU		"Give as many purposes for which objects of the shapes below could be used as you can"
8. Types of Objects	DMC	long and thin rough surface shiny	"List as many different types of objects or things which can be fitted by the following descriptions as you can".

initial practice group had been tested under the writer's supervision. The factor analyses reported here were completed by the writer subsequently, when the data's relevance to the aforementioned Guilford-Richards controversy became apparent.

Statistical Analysis

The twenty-eight correlations between tests were calculated, and the matrix subjected to principal components analysis followed by maximum-likelihood factor analysis (Jöreskog, 1966). The method assumes normally distributed latent traits, and is more precise than the usual least-squares methods of factor estimation. Its main advantage is that a statistic may be calculated which assesses the poorness of fit to the original correlation matrix, after the extraction of each factor. This statistic is distributed approximately as Chi-square. If nonsignificant, the implication is that the fit is good, and that it may be inappropriate to interpret further factors. The computer program used, called FACTAN, was written at the University of Adelaide by Brown, Parfitt and Lewis.

Three factors were extracted to allow for the possibility of a "content" factor and a "product" factor as well as a general divergent fluency factor. As a further check, the initial solution was rotated according to the Varimax criterion, although in the event this proved unnecessary.

Results

The average inter-correlation between pairs of tests, using Fisher's normalising transformation (Diem, 1962, p.179), was .55 for Group A, .59 for Group B and .54 for Group C. These results support the conclusion in terms of a coherent dimension of divergent fluency, reached from the review of previous studies in the first section of this chapter. Is a single factor sufficient to fit the correlational data? The results for the principal components and the Jöreskog factor analysis are shown in Table 5.3.

For each of the three groups the initial principal components analysis

Table 5.3. Jöreskog factor analysis of eight divergent fluency tests, with three factors extracted

(a) Eigenvalues (for initial principal components analysis)

	Components 1	2	3
Group A	4.79	0.97	0.70
Group B	4.73	0.41	0.13
Group C	4.78	0.86	0.68

(b) Percentage variance (for final Jöreskog factors)

	Factor I	II	III
Group A	56.13	7.74	3.49
Group B	59.89	6.06	2.66
Group C	55.68	5.78	3.53

(c) Chi-square tests (for significance of residuals after extraction of factor I)

	χ^2 (27df)	p	Factors required for "good fit"
Group A	35.9	>.10	Factor I only
Group B	30.9	>.20	Factor I only
Group C	25.7	>.50	Factor I only

(d) Loadings on Factor I

	Tests 1	2	3	4	5	6	7	8
Group A	.62	.48	.68	.65	.81	.81	.92	.92
Group B	.49	.79	.69	.79	.88	.79	.84	.85
Group C	.45	.67	.76	.68	.84	.80	.85	.82

gave only one dimension with an Eigenvalue greater than one. Nevertheless, three factors were subsequently extracted so that any significant factors interpretable in terms of Guilford's model might have a chance to appear. In the event, the Jöreskog factor I was sufficient to account for over half of the variance, and to provide a good fit to the original correlation matrix, in all three groups. After the extraction of factor I, the Chi-square statistic testing the residuals was clearly nonsignificant in each case.

The most appropriate factor solution is the single unrotated factor I for each group. The loadings on factor I are shown in Table 5.3(d). All tests had high loadings for each group, ranging from .45 to .92. The "non-verbal" tests (Nos. 5-8) gave somewhat higher loadings than "verbal" tests. The Prefixes test was a measure of "word fluency" and was the only one to have low loadings (below .5) for two of the groups. In an earlier section of this chapter it was pointed out that word fluency tests were less satisfactory as divergent thinking measures, because of their dependence on vocabulary, and hence their convergent intelligence component. The lower loadings for the Prefixes test, and the relatively high loadings for tests involving shapes and objects, contra-indicated an interpretation of factor I in terms of verbal intelligence.

The patterns of loadings for factor I, in ordinal terms, showed a fairly high degree of similarity across the three groups: Kendall's coefficient of concordance was .88 (χ^2 = 18.6, 7df, $p < .01$). However, the relative ordering of tests in relation to factor I loadings was not such as would be expected if Guilford's categories were important. If they were, the well-represented categories, semantic tasks and unit products, would have obtained higher correlations amongst themselves, and thereby higher loadings. This did not occur. In particular, the two figural tests, Shapes and Purposes, did not have lower loadings compared with the semantic tests which were in the majority. Nor did the two tests requiring

"classes" as products, Materials and Objects, have lower loadings than the majority of tests which required "units".

The results clearly supported Proposition 1: there is a single divergent fluency factor, replicated for three groups, on which all eight tests have high positive loadings. There was no indication that the different types of content and product defined by Guilford's model were necessary to account for the data. There was also no clear evidence that the more permissive instructions increased the coherence of the divergent thinking factor, as implied by Wallach and Kogan's (1965b) argument in favour of game-like instructions, even though the overall response rate in the experiments was greater with the permissive instructions (Rump and Dunn, 1971).

The loadings for factors II and III were generally small, and showed little consistency across the three groups (see Table 5.4). From the factor II loadings for Group A, it might be suggested that the factor represents a bipolar dimension distinguishing semantic tests (Questions and Consequences) from figural tests (Shapes and Purposes). Such an interpretation would be dubious, since three other semantic tests (Similies, Materials and Objects) have negligible loadings on factor II. The inconsistent loadings for the other two groups further demonstrate the difficulty of interpreting factor II. For Group C the two highest, negative loadings are for Questions and Similarities; for Group B these two tests again have the two highest loadings, but in this case the loadings are opposite in sign.

It may be concluded that the loadings on factor II for Group A do not provide reliable evidence of a semantic/figural division to confirm Guilford's model. Rather, these results, taken together with those for Group B and C, show that it is inappropriate to rely on a few moderate loadings in a multifactorial analysis unless replication is included in the design. In the present case, it seems clear that the only reliable factor is the first, and that this is reasonably interpreted as a general dimension

Table 5.4. Factor loadings on the minor factors II and III from the Jöreskog factor analysis of eight divergent fluency tests

Loadings on Factor II

	Tests							
	1	2	3	4	5	6	7	8
Group A	-.01	.61	.17	.31	-.31	.01	-.14	.07
Group B	.19	-.34	.40	-.25	.17	-.13	.22	-.15
Group C	-.22	-.43	-.33	.13	.18	.12	.23	-.10

Loadings on Factor III

	Tests							
	1	2	3	4	5	6	7	8
Group A	-.09	-.13	-.34	.26	-.11	.25	.01	.01
Group B	.17	-.01	.20	-.17	-.09	.22	-.20	.15
Group C	-.16	-.16	.17	-.39	-.11	.12	.13	.08

of divergent fluency. The residual variance is not significant, and is not systematically related to Guilford's divisions within the divergent thinking domain. This was the case also for the factors obtained after Varimax rotation, which did not assist interpretation.

Summary and Implications

From a survey of the evidence and from a factor analytic study, it was possible to draw a number of conclusions. The survey was given in detail because of long-standing controversies in the literature, which remain the subject of debate despite the extent of relevant bodies of evidence.

The divergent production of ideas, within controls imposed by an expressed task, forms a fairly coherent factor representing a dimension of divergent fluency. This dimension is distinguishable from convergent intelligence, although measures of the two concepts have generally low positive correlations within heterogeneous subject samples. With groups of above average intelligence, such as university students, the correlation is usually very low or near zero. However, the relationship between convergent intelligence and divergent fluency is not sufficiently described in terms of linear correlation coefficients. The relationship tends to be curvilinear and to have other complex features, as illustrated by Figure 5.1.

The degree of consistency amongst measures of divergent fluency depends on many variables. High consistency may be found when reliable and discriminating tests are applied to sufficiently motivated respondents. On the other hand, divergent tests which have low reliability, which differ greatly in their task requirements, or which depend on specialised areas of knowledge or experience, may have low inter-correlations, despite some degree of communality. Similarly, tests presented under varied conditions, such as test-like or game-like situations, may give lower correlations than those obtained when conditions are constant.

Divergent fluency tests which are strongly dependent on vocabulary may be as closely related to convergent measures of verbal intelligence as to other divergent measures. Word fluency tests are examples of this phenomenon. Similarly, tests which have a very restricted range of possible correct responses, such as the Remote Associates Test, may have a dual allegiance to convergent and divergent intelligence. Nevertheless, it is possible to devise many tasks which have a greater degree of factorial clarity.

Guilford's Structure of intellect model is useful in distinguishing between convergent and divergent thinking, in suggesting new types of tests, and in proposing a system of task descriptors. It does not satisfactorily indicate *distinct* domains of individual differences within the divergent thinking area. In particular, various divergent tasks involving verbal or figural stimulus material, and different categories of response products, may reflect a common dimension of divergent fluency. Guilford's statement (1967, p.139) that "of 16 DP factors that had been investigated, 16 had been demonstrated," grossly exaggerates the distinctiveness of these supposedly separate factors.

Following from these conclusions, divergent fluency was further investigated in relation to other areas of personality, and particularly in relation to visual aesthetic preferences and interest in the arts. Studies of this kind are reported in Part C, in which tests of associational and ideational fluency are discussed. It was considered advisable to use semantic rather than figural tests in these further studies, in order that any association with visual preferences could not be interpreted as merely due to use of a similar "method". Direct and indirect assessments of convergent intelligence were used in some studies, as a further check on its relevance.

CHAPTER 6

VALIDITY OF DIVERGENT THINKING TESTS

Much of the research described in Section C of this thesis makes considerable use of the concept of divergent thinking, and measures thereof. The research assumes that tests of divergent thinking of the Guilford and Torrance "types" have validity beyond the construct and factorial validity discussed in the preceding chapter. It is necessary to describe some of the evidence concerning the relationships between test measures and relevant criteria, since according to Cronbach (1970, p.395) "Most of the tests have been announced to the world prior to any solid validity studies". It is shown below that publication of divergent thinking tests, often in experimental form, has stimulated much research relevant to the question of their validity.

One reason for the frequent use of divergent thinking tests in research is their face validity in relation to real problems requiring creative solutions. For example, the Unusual Uses test is analogous to the reputed unusual use found by forestry department personnel for a certain type of rubber-ware: to collect soil samples and seedlings in the field. An invention by Abdul Quraishi (as reported by Windsor, 1972) may also be cited as a commercially important, unusual use. He had tried for three years to improve the heat-resistance of plastics. He realised that some plastic polymers burnt rather well, and after dreaming of burning pigs, woke with the idea of using burnable plastics for the internal moulding of pig-iron. These are not isolated examples. Wallach and Kogan (1965a, p.351), following consideration of introspective accounts by creative artists and scientists, stated that they "consistently stress the ability to give birth to associative content that is abundant and original, yet relevant to the task at hand," and this ability is the focus of divergent thinking tests.

Of particular relevance to this thesis is the question of whether divergent thinking tests have validity with regard to both artistic and scientific endeavours. Studies involving criteria relevant to fine arts and the humanities are described, followed by consideration of scientific criteria, and then further studies involving general or mixed criteria. These studies imply that "creativeness in the arts and in the sciences has common attributes" (Lowenfeld and Beittel, 1959). This is not to deny that other attributes may distinguish creative workers from these two areas, or indeed that their mean scores on divergent tests may differ. The point made is that despite such differences, the tests are relevant to achievements in both arts and sciences.

There are two main reasons why low or moderate validity coefficients would be expected, rather than high values. First, it has proved difficult to obtain consistent, reliable criteria for divergent fluency and originality. For example, the median correlation amongst "real-life" measures of scientific output and evaluations of the scientists' work by peers and supervisors was only .19 in one study, after partialling out such variables as length of work experience (Andrews, 1965, p.143). Dewing (1970b, Table 2) reported "a moderate amount of generality" amongst creative performance measures used with classes of Grade 7 pupils, but average correlations between these measures were only between .15 and .35. Brogden and Sprecher (1964) discussed the many considerations involved in establishing adequate criteria of creativity. However, Torrance (1966, p.23) wrote of his "despair of finding any kind of overall measure of validity."

The second general reason why low validity coefficients are expected, is that the available criteria are likely to be affected by many factors other than divergent thinking. Criteria like the amount of published scientific research, or the number of art-works accepted by established galleries, are affected by the worker's motivation to achieve, persistence in the face of set-backs, and serendipity. Such factors may play some

part in affecting creative performance and so reduce the apparent relative effect of divergent thinking itself.

Criteria in the arts and humanities

A variety of artistic criteria have been used in validation studies. Duenk (as summarised by Torrance, 1966, p.49) used classroom measures of industrial-arts performance, in relation to a battery of Torrance's tests. Multiple correlations of .40 and .77 were found in two classes between total classroom "creativity" and an optimal combination of the divergent test scores.

More recently, Wallbrown and Huelsman (1975) found that with children about ten years of age, rated originality of their artistic work with clay was related to scores from the Line Meanings and Alternative Uses divergent thinking tests, with 45% of the variance accounted for. However, another aspect of their study illustrated the difficulty of obtaining a reliable criterion in the artistic field: two similar criterion measures (rated originality for two sets of drawings completed by the children) gave a nonsignificant correlation of only .15.

Tertiary students and other adults were studied in the research projects for this thesis described in later chapters, and validity studies with such groups are therefore of more direct relevance than those with children. Beittel and Burkhart (1963, Table 3) found that a "divergent question" test distinguished as predicted between subgroups of art-education students: those who adopted an "academic" strategy in their art-work ("like a technician who concentrates on competency") scored significantly lower than students who adopted a "divergent" or a "spontaneous" strategy in their art-work.

Brittain (1956) reported that tasks such as forming designs and listing ideas on a topic differentiated more creative from less creative art-education students, as judged by members of the faculty. Similarly, Johns (1975) found that divergent thinking scores from the Minnesota Tests of Creative Thinking

predicted arts students' fluency and flexibility displayed in a visual art "abstraction" task. Skager, Klein and Schultz (1967) studied possible predictors of two artistic criteria for students at the Rhode Island School of Design: (a) academic performance; and (b) judges' aesthetic ratings of students' drawings. They found that various measures of divergent thinking ability, both figural and verbal, "did not show *consistent* relationships" to the criteria (p.114). However, their final samples consisted of 357 students in total who remained from over 3000 initial applicants, so that there might well have been a gross restriction of range to more creative persons.

Fairly consistent correlations between verbal scores from the Minnesota Tests of Creative Thinking and two artistic criteria were obtained by Madeja (1967, Table IV). One criterion was the average Art Grade obtained by each of 135 high-school students; this criterion correlated between .318 and .570 with verbal divergent-thinking variables. The other criterion was teacher evaluation of each student's ability in art, which correlated between .396 and .494 with verbal divergent-thinking variables. However, no such consistent correlations were found for figural divergent-thinking variables. This raises the possibility that the students' criterion scores were a reflection of their academic ability rather than artistic creativity: indeed the two criteria correlated .749 and .587 respectively with "overall grade point average".

Several studies have examined divergent thinking tests in relation to performance in the humanities. Haddon and Lytton (1971) obtained a correlation of .29 between composite test scores and ratings of pupils' creativeness by teachers of English. In a similar vein, Bennett (1973, Table I) reported significant positive correlations between fluency scores derived from ten divergent thinking tests and marks on an English test, marks for an imaginative story, and fluency scored from the same story, with ten-year-old pupils. Although a convergent (verbal reasoning) test

was also correlated with these criteria, Bennett concluded from a factor analysis, and from detailed examination of subgroups, that the construct validity of the divergent thinking tests had been demonstrated.

Concurrent validity has been demonstrated by a post-graduate student under the writer's supervision. Kelley (1979), in a study of 15-year-old pupils' religious and moral attitudes, found that divergent thinking ability scored from three divergent thinking tests correlated significantly with the number of words written on two topics "Why I am religious" and "The person I would most like to be", with correlations of .24 and .34 respectively. An Honours student supervised by the writer (Hall, 1975) found that fluency on a "Write a Prayer" test was correlated .50 ($p < .001$) with personal religous commitment. A further study showing wide generality of divergent thinking scores was that of Elliot (1964), who found significant positive correlations between test scores and creativity ratings of advertising and public relations personnel by their supervisors.

Cropley (1972a) obtained a composite creativity criterion reflecting achievement in the humanities (art, drama, literature and music). Seventh grade pupils were given six divergent thinking tests, and their achievements were assessed after five years. First canonical correlations between tests and achievements were .52 for boys and .46 for girls, suggesting medium-range predictive validity. (It should be noted that these canonical correlations are difficult to interpret in detail, since the values and direction of the contributions of each test and achievement variable are not stated.)

These findings clearly demonstrate the relevance of divergent thinking scores to achievements within the humanities. Nevertheless, mere study of the arts and humanities does not of itself always generate high scores on divergent tests. For example, Hare and Gaier (1971) found that mean scores for small groups of students of art, music and writing were not above the median score for the Making Objects test. The authors concluded that their

results "cast serious question" on the validity of the test, which seems an inappropriate conclusion given that subjects were not selected for their divergent achievements. The separate question as to whether students of the humanities generally tend to obtain higher scores than students of other specialities, is considered in a later chapter.

Scientific criteria

Many studies conducted in the 1960s demonstrated the validity of various divergent thinking tests in relation to scientific criteria. Taylor (1963, Table 3) reported a correlation of .24 between a Test of Productive Thinking and ratings of scientific creativity by direct supervisors for electronics engineers and scientists. Datta (1963) reported a correlation (*rho*) as high as .71 between a composite score from three divergent thinking problems and managers' ratings of their staff scientists' creativity in the laboratory, when the scientists were instructed to "be creative" in responding to the problems. Other workers have reported fairly consistent validity of divergent thinking tests with respect to scientific creativity without the use of special test instructions. For example, Hitt and Stock (1965) found that research scientists and engineers who were high on an "originality" factor derived from supervisory ratings, obtained higher mean scores on six out of seven divergent thinking tests, compared with those who were low on the factor.

In most studies which have demonstrated significant validity in terms of positive correlations, obtained r values have been rather low. An early study was that of Cattell and Jones, as reported by Cattell and Butcher (1968, p.297, Table XLVII). A correlation of .33 was found between ideational fluency and a creativity index derived from pooled ratings by observers, for a group of industrial research chemists. This result was probably extracted from the study reported in more detail by Jones (1964). Apart from the correlation with ideational fluency, the creativity index was also reported to have a significant validity correlation of .28 with

originality scored from the Consequences and the Rensselaer tests. (It is clear from Jones' report that although most of the subjects were chemists, 20% of the cases were from miscellaneous other disciplines including literature, psychology and zoology.)

One of the most thorough studies of research scientists was conducted by Shapiro (1968). He obtained a diverse sample of 72 scientists working in many different areas, such as chemical, medical and building research, and applied twelve varied divergent thinking tests. Each scientist was assessed also with respect to four criterion measures of creative work habits and personality, using self-ratings and supervisors' ratings. All divergent thinking scores and criteria gained loadings greater than .30 on the first principal factor extracted from the correlation matrix (Shapiro's Table 16). The four ideational fluency measures gained loadings greater than .60. Shapiro concluded that his data "provide evidence for the validity of the test battery designed to identify creative subjects" (p.145). It was also shown that the subgroup of scientists who obtained high scores on the tests gained significantly higher ratings for the overall *quality* of their scientific products, compared with a "low creativity" subgroup; however, the two subgroups did not differ significantly in supervisors' ratings of the *quantity* of their work products. It may well be that the amount of research successfully completed depends on many variables other than divergent ability, particularly when comparing scientists from very different disciplines.

An interesting study, which included an experimental performance measure of scientific "creativity" as one criterion, was reported by Bass *et al.* (summarised by Guilford, 1967, p.164). High school pupils were asked to design an experiment on transfer of training. Their performance score on this task correlated .41 with a composite divergent thinking score from three tests.

Creativity and achievement criteria in diverse fields

Divergent thinking scores have been found to correlate positively with rated "creativity" or "originality" in diverse groups. It is difficult to interpret some studies since the behaviours rated as "creative" were not clearly specified. For instance, Barron (1956) found a correlation of .55 between composite scores from a battery of eight divergent thinking tests and rated "originality" of U.S.A.F. captains. It is not clear whether "originality" would be a desirable characteristic for an aircraft pilot or not.

More recently, Morris and Fargher (1974) were directly concerned with the question of objectively measurable effectiveness. They showed that an index of unique responses from the Geometric Patterns test was significantly related to business efficiency: Australian businessmen who obtained low scores were associated with a static or declining business, which suggests that a capacity for conceiving novel approaches is relevant to commercial success. Of course other characteristics are also relevant in this field. Morris and Fargher found that achievement motivation was important, whilst Barron (1969) found that business innovators in Ireland were also distinguished by their vision of "conquest, mastery, personal dominance, command".

Harrington (1975) found moderately high positive correlations between scores on the Alernate Uses test and criteria such as self-ratings of performance and questionnaire measures of self-confidence and dominance, provided that students were instructed to produce "creative" uses, and only such responses were scored. Using standard instructions with the Minnesota Tests of Creative Thinking, Haven (1965) obtained correlations of .21 with "creative accomplishment" and of .25 with an "aesthetic values" scale. Given these low values, Haven concluded that the Minnesota measure of divergent thinking "is not strongly identifying those *Ss* who are creative producers". Reasons why low validity coefficients might be expected have already been noted.

Several studies have evaluated the relevance or divergent thinking tests to academic achievement. This criterion is not entirely satisfactory, since the degree of divergent thought required for academic achievement in the examined fields of study remains unknown. Dentler and Mackler (1964) found a high positive correlation between test originality and general academic achievement. Test originality was also correlated positively with a score based on peer nominations for the "most imaginative" member of a women's dormitory. The sizes of the correlations were unstated in the report.

One of the best known studies which demonstrated an association between creativity test scores and school achievement was that of Getzels and Jackson (1962), although their work has been criticized because of the atypical sample of gifted children involved, and because of the unsatifactory measures of IQ used. A more satisfactory study was undertaken by Cropley (1967a, p.26), who correlated scores from six divergent thinking tests with academic achievement scores. Cropley reported that "The correlation coefficients obtained ranged from .163 to .420 when all children were considered."

A thorough examination of this question was undertaken by Dewing (1970a) in ten schools of Western Australia. School examination marks were available for eight of the schools: in only one school was there a significant correlation (.28) with an overall test index obtained from four divergent thinking tests scored for both fluency and originality. The highest scores were obtained by pupils from schools in areas of high socio-economic level (*rho* = .60), where teachers "can afford to plan more flexible programmes and to be more permissive and informal" (Dewing, *op. cit.*, p.274). These findings raise doubts as to the appropriateness of school examination performance as a criterion for divergent thinking. With the same sample but more appropriate criteria, Dewing (1970b) found a tetrachoric correlation of .59 between the test index and creative performance based on

teacher and peer ratings, creative spare-time activities, and an imaginative study task.

Despite doubts raised as to the appropriateness of academic achievement as a criterion for divergent thinking ability, studies which use multiple achievement scores and test measures, and which optimise the degree of their inter-relationship by the use of canonical correlation analysis, may "build up" the correlation value to a quite high level. For example, Feldhusen, Treffinger, Van Mondfrans and Ferris (1971) obtained a canonical correlation of .62 between seven divergent thinking scores using standard instructions and grades in four school subjects. When simple correlations are used, with large samples, correlation values are usually low but fairly consistently positive. For example, Cicirelli (1965) found significant correlations between Minnesota Tests of Creative Thinking scores and reading, arithmetic and language achievement scores, with twelve positive correlation values between .11 and .37, for 609 sixth-grade pupils. Nine of the validity correlations were still significant after IQ was partialled out.

Several predictive validity studies, both short- and long-range, have been conducted with the Torrance Tests of Creative Thinking. In most studies reviewed by Torrance (1972b) tests have been administered to school children, and diverse criteria have been employed such as the originality of a written story, other tests of productive thinking and asking "creative" questions in class (Torrance's Table 1). Of more direct interest for the present research, Strom and Larimore (1970) reported a study involving measures of the effectiveness of relevant adult work: for a group of elementary teachers involved in a project which emphasized creative teaching, verbal fluency from the Torrance Tests correlated .60 with a composite rating of teaching success.

In the long-range studies described by Torrance (1972b, Table 2), follow-up ranging from five to twelve years has allowed a more extensive investigation of creative achievements. Moderate correlations between

Torrance Test scores and creative achievements during follow-up have been obtained with r values of about .5 to .6. It is to be noted, however, that these values apply to composite measures or involve the use of multivariate (canonical) correlation, and such values would not be typical of correlations between an individual test and criterion. The largest such study was that of Torrance himself with a follow-up period extending to twelve years following initial testing of pupils from the University of Minnesota High School, using seven of Torrance's verbal tests. After a seven-year period, total fluency (number of relevant responses) correlated .44 with an overall index of the number of creative achievements which included both artistic and scientific activities (Torrance, *op. cit.*, Table 3). After twelve years, the corresponding correlation between total test fluency and quantity of creative achievements had dropped to .31 for men and .28 for women (Torrance's Table 4), but remained significant. (The data for fluency rather than other test scores are quoted here since this is the main measure used in studies reported in subsequent chapters.)

Torrance (1966) has also summarised evidence concerning the concurrent validity of his divergent thinking tests to that date. Again, many studies were with children, using "indirect" criteria. For instance, high scorers tended to have a reputation for wild ideas, and to be alienated from authority, adventurous, independent, and so on. Undergraduates who obtained high scores on the Torrance tests tended to consider themselves as adventurous, individualistic, energetic, and versatile (Weiser, as reported by Torrance, 1966). Similarly, Biggs (1970b) found positive correlations between divergent thinking scores and a measure of independence of study behaviour, amongst both Arts and Science faculty students in Melbourne. Torrance (1966) cited a number of other studies by himself and postgraduate students showing that pupils nominated as creative or as showing divergent ability by their peers or by teachers, tended to gain high scores on the Torrance tests.

Differential validity

To some degree divergent fluency scores may reflect general intellectual ability, as shown in the previous chapter. Indeed some authors have implied that the validity of divergent thinking tests derives largely from this general factor which is partially represented by almost any ability test (*e.g.* Burt, 1962). It is important therefore to demonstrate that tests have differential validity, in the sense that they relate to performance of a divergent kind and yet not to other aspects of performance which do not require divergent thinking. Similarly, one might expect tests to show validity only when the assessed group is in a situation (or occupation) allowing divergent performance, and when the tests used have some bearing on that performance.

A relevant study illustrating this proposition was conducted with a large sample of 503 Duke University freshmen by Wallach and Wing (1969). They found that high and low scorers on divergent fluency were significantly differentiated with respect to accomplishments in extra-curricular activites involving art, science, leadership and writing, as predicted. Participation in activities not requiring divergent thinking, such as music, dramatics and social welfare, did not significantly distinguish high and low fluency scorers.

Whilst Wallach and Wing's study gave strong support to the validity of divergent thinking tests, some ambiguity in interpreting the results remains. High and low scorers on divergent fluency were differentiated in terms of general achievement, as well as in terms of predicted accomplishments. This suggests that test scores and achievement *are* affected by some general characteristic. The method of presenting the creativity tests, by mail with no time-limit or other pressure, may have meant that scores were affected by the student's level of intrinsic motivation. The most successful students "are most strongly committed to particular lines of

endeavor which are carried on for reasons intrinsic to the tasks themselves" (Wallach and Wing, 1969, p.129). In later chapters of the present thesis, various pieces of evidence support the idea that a high level of divergent fluency should be regarded not as a fixed "ability", but as reflecting a skill or style of performance which a person may develop. This results from specialised channelling of his "ideational resourcefulness" (Wallach and Wing, 1969, p.127) into areas of interest where divergent thinking is relevant.

Despite the inter-correlations between divergent thinking tests using different materials (described in the previous chapter), some differential validity in relation to stimulus materials might be expected if divergent thinking tests do reflect specialised channelling of skills. For example, C.A. Jones (as reported by Guilford, 1967, p.163) considered the judged creativity of sixth-grade pupils from samples of writing and of artwork, in relation to scores on divergent production tests. A composite score based on six tests using verbal materials correlated .58 with creativity in writing and only .32 with creativity in artwork. On the other hand, a composite score based on seven figural tests correlated .54 with creativity in artwork and only .40 with creativity in writing.

In a similar vein, it may be noted that the Purdue Creativity Test involves stimulus-drawings of objects, such as machine parts, which are relevant to engineering designs: the test scores were shown to relate to the chances of engineers being judged highly creative by project supervisors, in three groups of industrial engineers (Lawshe and Harris, 1960, Figures 1-3). In a study of research scientists, the quality of responses on a "New Scientific Uses" test correlated .25 with ratings of "general creativeness and originality" (Gough, 1961). It may be, then, that the content matter of divergent thinking tests should appeal to the interests of assessed groups to be effective. In support of this point, Hudson (1966b, p.615) quoted an example of a boy with unusual technical inventiveness

who nevertheless gave "few and relatively banal" responses on the Unusual Uses test. Hudson concluded that "certain individuals focus their minds closely only on topics which they find of absorbing interest".

The limitations of divergent thinking tests

Although there is a wide range of evidence supporting the validity of divergent thinking tests, some contrary evidence has also been published. Golann (1963, p.552) noted studies which at that time had shown rather poor validity for Guilford-type divergent thinking tests. However, in several studies which have been interpreted as negating the validity of these tests, results have suggested some limited validity, or data have been obtained under conditions such that validity might be underestimated.

An example of a study showing some limited validity is that described by Gilchrist (1969). In the case of second-year architecture students at Melbourne University, those who had high academic achievement in architecture tended to obtain high scores on three out of four divergent fluency measures; but those who were judged more creative in their design projects obtained significantly high scores on only one of the fluency measures. This limited validity may have been due to the sample being "a highly creative group as a whole", giving a restricted range on the creativity criterion.

Another study which gave complex findings is that by Gough (1976), He found that rated creativity of research scientists and engineers was related to the number of "moderately remote" associations on two word-association tests. However, the criterion was not significantly correlated with scores on the Unusual Uses test.

Babarik (1966) considered the effect of divergent fluency test scores, reduced to a dichotomy, on both scientific and design "creativity" as rated by supervisors or instructors. There was no significant main effect of fluency either for physical science researchers and development engineers,

or for product and visual design students. However, the apparent lack of validity of fluency test scores in this study, as in Gilchrist's, might be an artefact of restricted range, in that "all these groups were highly creative". Moreover, only a single word-fluency test was employed, so that the reliability and range of the divergent fluency measure may have been low.

It was noted in the previous chapter that the Remote Associates Test is often considered as a "creativity" measure, although it is related more to convergent than divergent ability. Nevertheless, the study by Andrews (1965) using that test is worth considering here, since his results suggest that positive relationships between divergent thinking tests and on-the-job performance measures, may be restricted to groups working in conditions which allow divergent thoughts to flourish. In his investigation of the scientific productivity of scientists working in industry, or university and government laboratories, he found that the Remote Associates Test was positively correlated (biserial r = .37) with scientific productivity only for a small group high in motivation, influence, status and self-confidence. *Negative* correlations (r between -.32 and -.65) occurred for groups with low influence, low communication, or low status.

Conclusions

Many divergent thinking tests, whether scored for fluency or for originality, have been shown to have low to moderate validity when assessed against a variety of divergent performance or achievement measures. For a number of reasons, including the multifarious nature of creativity criteria, and the many influences upon them, high validity coefficients are the exception. High values have been obtained when multiple or canonical correlations have been used to optimise multivariate composites for divergent test scores and/or criteria scores. Such composite variables have not

generally been subject to cross-validation, which is an essential check.

Nevertheless, validity has been found to a sufficient extent to demonstrate the relevance of divergent thinking assessment to achievements in the arts, humanities and sciences, as well as more general areas of endeavour. Whilst validity may not be high enough to justify the use of divergent thinking tests for making crucial decisions about individuals (as in employment selection), it certainly justifies the continuing use of tests in the research exploration of personality structure.

PART C

RELATIONSHIPS AMONGST DIVERGENT THINKING, AESTHETIC PREFERENCE, AND ARTS-ORIENTATION VARIABLES

Chapter 7. A correlational study of individual differences

Chapter 8. Validity of the Graves Design Judgment Test and Barron-Welsh Revised Art Scale

Chapter 9. Artistic and scientific occupational interests in relation to aesthetic preferences and divergency

Chapter 10. Further studies of arts and science orientations

Chapter 11. Effects of training courses relevant to divergency

Chapter 12. Development of a potential scientist: a case study

CHAPTER 7

A CORRELATIONAL STUDY OF INDIVIDUAL DIFFERENCES

Introduction

This chapter is rather complex, and a guide to its structure follows. The chapter is concerned with a correlational study designed to investigate the relationships between fluency of divergent production, aesthetic preferences for aspects of stimulus complexity, orientation towards the arts, and other relevant personality variables. The theory of "openness to divergent stimulation" provides one primary theme for the study, and relevant evidence from the literature is discussed first. An alternative hypothesis giving a central role to arts-sciences orientation is then discussed, followed by some consideration of other relevant personality characteristics.

General features of the test battery are described, and the rationale and formulation of new instruments created for the study are described, together with an outline of procedures used for other standard tests. In presenting the results, those concerned with the consistency of measures are given, followed by an examination of the "openness to divergent stimulation" predictions. Correlations with arts-orientation variables and with the aesthetic preference tests are then considered. Further subsidiary results are described, and finally the main conclusions are summarised.

Openness to divergent stimulation

One of the most influential writers on the relationship between aesthetic preferences and divergent thinking ability has been Barron. Initially, exploratory studies of personality variables associated with liking complex figures and disliking simple figures in the Welsh Figure

Preference Test were reported (Barron and Welsh, 1952). At that stage, subjects who preferred complex figures included artists and "deviants", and were considered by a group of psychologists to be cynical, pessimistic and hostile. The Barron-Welsh Art Scale (B.W.A.S.) was subsequently formalised and used in further studies of high and low scorers, referred to as "complex" and "simple" persons. Barron reported in 1953 that complex persons were fluent, original, flexible, independent and with good aesthetic "taste", but they also possessed less desirable characteristics such as maladjustment and anxiety. In subsequent research, the psychophathological correlates of preference for complexity received less emphasis, and the original association with artistic ability was expanded to include creativity in general.

In 1958, Barron considered that "certain uniformities do seem to characterize highly original scientists and artists". Following the application of a variety of tests, many of a novel kind, to artists, writers, postgraduate students from various disciplines and other groups, Barron described creative persons in the following terms: "especially observant ... independent in their cognition ... hold many ideas at once ... more complex ... have more contact than most people do with the life of the unconscious ... broad and flexible awareness of themselves", and so on. Creative persons thus appeared to be sensitive to diverse stimulation arising from external sources and from within themselves.

Smith (1968) noted that "Little or no effort has been directed toward evaluating existing theoretical constructs or developing a systematic theory of creativity". However, Barron's findings were consistent with efforts "Toward a Theory of Creativity", as a contribution by Rogers (1959) was entitled. Rogers proposed that one of the main conditions associated with creativity was openness to experience. "In a person who is open to experience each stimulus is freely relayed through the nervous sytem, without being distorted by any process of defensiveness ... It means the

ability to receive much conflicting information without forcing closure upon the situation". In their review of "a common pattern of personality traits among creative persons", Dellas and Gaier (1970) include openness to stimuli and wide interests in their specificiation. Although not expressed in this way, the theoretical proposition appears to be tantamount to the postulation of a general personality factor covering openness to divergent stimulation in all forms: these include exteroceptive stimuli reflecting states of the physical world; various signals which are contingent on one's own state, such as interoceptive and kinaesthetic stimuli, and social communications from others about oneself; and "inputs" deriving from neural activity and experienced as thinking and imagining.

The theory expressed in this way is extremely wide-ranging, and somewhat "loose" in its conception. It may be expressed in terms of more specific informational concepts, as the way information is encoded rather than in terms of sensitivity to stimulation. Evans (1967) noted that if a person, as an information transducer, encodes incoming stimuli in a form having high "constraint redundancy", there must be a corresponding loss in "discrimination redundancy", other informational terms remaining equal. Evans presented this point in terms of quantified information, but it is used here in a less strict form, since information content cannot be quantified in most situations. In more general terms, then, some people may prefer to encode stimuli so as to emphasize consistency, order or common features (*i.e.* with high constraint redundancy) whilst others prefer to encode stimuli so as to emphasize their differences, discrepancies, or peculiar features (*i.e.* using multiple discriminanda).

It is important to realise that such encoding strategies are not consistently related to the *efficiency* of informational processing. As Evans showed, the utility of either strategy depends on the nature of the information retrieval problem which the person faces. For instance,

constraint redundancy might improve performance in reproduction tasks, whereas multiple discriminatory cues might benefit performance in tasks requiring discrimination or divergent responses. A similar contrast between tasks was investigated by Munsinger and Kessen (1965). It was hypothesized that when an observer inspected a figure to find the "one thing" it reminded him about, he would find the task easier for shapes of low informational value; whereas when inspecting for "many things", shapes of high informational value would be easier. These hypotheses were confirmed. It may therefore be inferred that one reason for individual differences in preference for complexity with abstract figures may be variation in the self-imposed task set by the observer, to perceive one interpretation or many (*cf.* Golann, 1962, Experiment 1).

A further theoretical speculation which supports the specification of Barron and Rogers' theory in terms of informational processing, is provided by Neisser (1963). He distinguished between straightforward sequential thinking, and multiple-channel, simultaneous processing which may be more appropriate for novel problems. Moreover, Neisser recognised that: "People differ widely in the extent to which they are free to use the multiplicity of their own thoughts."

It is clear that the idea of creative persons being open to divergent stimulation, or coding information so as to retain its full complexity, can account for many of the otherwise paradoxical findings concerning the correlates of creativity. The creative person seeks for and is able to consider many alternative ideas, given a novel problem; he prefers stimuli such as designs or works of art which are complex or unusual; but he is also aware of sources of disturbance within himself, symptoms of anxiety and conflicting or undesirable impulses. Such suffering as that engendered by the fearful dreams of Robert Hooke, or the despair of Emily Bronte, may be the price to be paid for a creative imagination.

This aspect of the theory has been nicely exemplified in a letter to the press by the British painter John Bratby (1972): "I am writing to you about the question whether ... personal disintegration, emotionally and psychologically, in the artist can lead to more liberated and finer work ... In about 1960 I decided that good painting could be created in safety, security and within certain self-protective confines, and on this philosophical basis I worked for a decade ... One year ago now I abandoned this philosphy, and painted and lived with no regard for self-protection, psychologically or materially ... I felt that for a decade previously I had locked away violent and valuable creative forces and suppressed them ... The work I have done in past months seems to me to have benefited enormously". It is not implied by this argument that creative persons tend disproportionately to have psychiatric illnesses. The ancient myth of the "mad genius" has often been refuted (see Pickering, 1974, pp.284-296). The "madness" of original thinkers represents unconventionality and eccentricity rather than serious psychopathology, in most cases. Nevertheless, there appears to be some connection between emotionality and creativity.

The broad range of the Barron-Rogers theory applies not only to the types of stimulation which it encompasses, but also to the types of activities which are supposedly related. The "complex" person searches for and prefers ambiguous situations; perceives the confusions within his immediate social and physical world; and encodes the available stimuli so as to enhance rather than reduce their diversity. If these dispositions are in fact all highly correlated, then the theory of "openness to divergent stimulation" as a personality factor is indeed powerful. Barron (1968) considered that the factor "has shown itself in a wide variety of tests".

Many of the findings by Barron and his colleagues concerning comparisons between highly creative members of various professions and "average" members are consistent with the theory. For instance, groups of highly creative

writers, architects and scientists obtained higher scores on the B.W.A.S. than comparative groups from these professions (data tabulated by Gough, 1961, pIII-16). Creative women mathematicians were more often described as complicated as well as individualistic and less conventional compared with a comparison group (Helson, 1961). Creative architects described themselves as independent and enthusiastic, but also obtained scores above the norm on M.M.P.I. Psychiatric scales: "The more creative a person is the more he reveals an openness to his own feelings and emotions" (MacKinnon, 1962a). Similarly, independent students who did not yield to the feigned judgement of others in a size-matching task, considered themselves to be emotional as well as original, and scored higher on the B.W.A.S. compared with a group who did yield to the consensus judgement (Barron, 1963).

A varied assortment of other studies may be interpreted as consistent with the theme of the creative person being open to complexity, and both inner and outer diversity. Schneider (1950), writing on "creative thrust" from the psychoanalytic point of view, stated: " ... we tap and transform our unconscious. This is what the true artist - and the truly creative scientist - has always done". This notion of tapping the unconscious may be considered an openness to a particular form of internal emotionally-laden stimulation. In his biographical study of six creative geniuses who suffered illness but used it for their own creative purposes, Pickering (1974) emphasized both their unconventionality and their emotionality. Richard Feyman, the eminent physicist, described in a television interview how the research physicist must try to see the world afresh. His father told him to wonder what the world might seem like to a "Martian", as one way to achive the openness of vision required for creative thinking.

Further evidence using experimental methods may be said to demonstrate a positive association between cognitive abilities of a creative kind and openness to complex or divergent stimulation, although presented by authors from a variety of other points of view. For instance, as long ago as 1927,

Weber found that the ability to imagine the object portrayed by an incomplete pattern was correlated with peference for more complex versions of a "cross" design. The ability of more "creative" subjects, in this case high scorers on the Remote Associates Test, to utilise normally irrelevant aspects of stimuli in perceptual and anagram-solving tasks, was shown in experiments by Gamble and Kellner (1968) and Mendelsohn and Griswold (1964). Wallach and Kogan (1965b) reported that children who had high scores on divergent thinking tests tended to allow more deviant instances in the Pettigrew Category-width Test.

Zuckerman (1972) reviewed several studies showing that various tests of originality correlated positively with scores on his Sensation Seeking Scale; and Farley (1976) found that low scorers on this Scale showed significantly lower fluency on Torrance's Unusual Questions test, compared with high or intermediate scorers. The personality dimension of "Intolerance of ambiguity" (Budner, 1962) might be regarded as the converse of openness to divergent stimulation, since Budner reported that its correlates included such variables as "favourable attitude to censorship", "conventional", and (amongst medical students) a preference for specialities having easier diagnostic tasks. Similarly, intolerance of ambiguity was reported to be positively correlated with originality by Guilford, Christensen, Frick and Merrifield (1957). Provus (1966) noticed that students who were good at suggesting original solutions when facing a simulated crisis situation were also able to view problems with a variety of perspectives. Maw (1970), in summarising his studies of curiosity in children, reported that those high in peer-rated and teacher-rated curiosity tended to show reflective and impulsive creativity, and "to select the more unbalanced and incongruent designs" from sets of geometrical figures. Similarly, Eisenman and Robinson (1967) found that high-school students who scored high on a questionnaire concerned with personality characteristics reputed to be associated with creativity, also tended to prefer more complex polygons.

Several studies have been construed as confirming the hypothesis that creative persons report greater awareness of their emotional feelings, in various ways. For instance, Eysenck and Castle (1970b) found that artists scored higher on neuroticism than non-artists. Taft and Gilchrist (1970) found significant correlations between level of self-reported creative activities and such self-descriptive adjectives as emotional and impulsive, as well as observant and unconventional. Similarly, ideational fluency and impulsivity gave low positive correlations in the study by Guilford *et al.*, 1957. Cross, Cattell and Butcher (1967) found that visual artists obtained high scores on the second-order factor of anxiety using the 16PF test.

This miscellaneous collation of evidence may be criticised on three grounds. Much of the evidence may be interpreted in terms of personality factors of a more specific nature; the evidence is compatible with the theory of openness to divergent stimulation, but does not confirm its discriminant validity. Moreover, the evidence is selective, in that there are other studies which have not found the predicted relationships, or have obtained contradictory results. Thirdly, the characteristics shown by selected groups of "artists" may not be appropriate for testing a theory which purports to account for "normal" variation.

Consider some of the evidence contradicting the "openness to divergent stimulation" theory. One basic question is whether preference for different forms of complexity in visual stimuli is general or specific. The writer found no significant correlation between measures of aesthetic preference for three aspects of visual complexity: for multiplicity of elements, for asymmetry, and for heterogeneity (Rump, 1968a). Supporting evidence was obtained by Clapp and Eichorn (1965) and Smock and Holt (1962). With regard to the wider question as to whether creative persons like all types of complex situations, Eisenman (1969a) emphasized the multifaceted nature of creativity, and found that with subjects who obtained high scores on his questionnaire "concerned with personality components of creativity",

there was "a tendency for them to be complex in either the impersonal or the personal sphere, but not in both" (p,693). Gough (1961) found no significant correlation between the rated creativity of research scientists and their scores on Barron's questionnaire scale of preference for complexity. It would seem therefore that the notion of a unitary dimension of personal complexity associated with creativity is not generally confirmed.

The supposed emotionality of creative persons is also contra-indicated by some studies. Jones (1964) found that creative scientists were fluent and adventurous as predicted, but were also relatively *low* in anxiety, and emotionally stable. Cornwell (1969) found in his multivariate study of students that preference for complex figures in the Welsh Figure Preference Test was *negatively* correlated with anxiety and ergic tension using Cattell's 16PF test. Moreover, Dentler and Mackler (1964) reported that subjects who obtained low scores on Cattell and Scheier's measure of pro-tension gave a greater number of original responses; and similarly White (1968) found that subjects who obtained *low* scores on the 16PF second-order factor of anxiety gave high ideational fluency scores. However, Eisenman (1968) found a curvilinear relationship between preference for complex polygons and anxiety. Innes (1972) found no significant correlation between measures of fluency in divergent production and neuroticism on the Eysenck Personality Inventory. Similarly, Feldhusen, Denny and Condon (1965) reported no significant correlation between fluency and Sarason's General Anxiety Scale scores. The evidence is confused, but does not generally support the hypothesized positive correlation between creativity variables and emotionality.

Confirmation for this conclusion was given by the analysis of personality test data obtained during third-year undergraduate practical classes supervised by the writer. Fluency scores on Form B of the Torrance Tests of Creative Thinking were obtained for two independent groups. Forty-two students were given the Figural Tests and sixty-nine the Verbal

Tests. Fluency scores were correlated, as expected, with the number of responses given to the Rorschach Inkblots presented by slide projection in the manner described by Hire (1950): for the Figural Tests, $r = .53$ ($p < .01$) and for the Verbal Tests, $r = .29$ ($p < .05$). However, there was no indication that high fluency scores were associated particularly with determinants indicative of emotionality. Indeed, the highest correlations were with the F (Form) determinant, often interpreted as indicating degree of emotional control (Klopfer and Davidson, 1962): for the Figural Tests, $r = .35$ ($p < .05$) and for the Verbal Tests, $r = .42$ ($p < .01$). Similarly, when fluency scores for the two groups were correlated with the six Cattell's 16PF (form B) scales relating to the second-order Anxiety factor (Cattell, Eber and Tatsuoka, 1970, p.116), eleven of the twelve correlations were not significant. The one significant correlation suggested that high Figural Fluency was associated with emotional *stability*: the correlation with Cattell's Factor C was .29 ($p < .05$). These findings together with the others reviewed above, indicate that high divergent fluency is not reliably associated with a high degree of emotional sensitivity.

None of the above studies was designed explicitly to test the major facets of the "openness to divergent stimulation" theory. Moreover, the researches by Barron, MacKinnon, *et al.*, were conducted largely with highly selected groups rather than with a "normal" sample, although the theory is assumed to generalise to variation amongst ordinary individuals. Full statistical details, such as the sizes of inter-group differences or correlation values, were often not given in published reports: instead, the "high-lights" were selected, and presented in general rather than precise statistical form. Moreover, the publication of some studies in different but overlapping reports may have given a spurious impression of the replication of findings (*e.g.* Barron, 1963, 1965 and 1969).

Whilst a theory must be judged according to the accumulation of relevant evidence, an experiment designed specifically to test the theory

of openness to divergent stimulation seemed opportune. For a theory to be scientific it must be capable of refutation by experiment (Popper, 1963). If the experiment was to be effective, a statement of predictions was required, with the use of appropriate measures, and the inclusion of variables which might offer alternative explanations.

It was hypothesized that openness to many divergent ideas, measured in terms of fluency on divergent thinking tests, is positively correlated with self-reported creative independence and with openness to other forms of diverse stimulation, *viz.* complex visual stimuli, and complex internal feelings such as those associated with anxiety and emotional arousal. With regard to visual stimuli, use of the B.W.A.S. was clearly appropriate, but in addition it was considered necessary to distinguish two of the features of preference for complexity in that scale, preference for asymmetry and for multiplicity. Individual differences on these two variables appear to be independent, as noted above, and further tests were required for their separate assessment.

Details of the tests are described below, but it is informative to illustrate first the nature of Barron's conception of the "complex" person by summarising a case-study recounted in his 1963 book. "Paul" was an American postgraduate student, different from most students, and deliberately so. His first remark in Barron's study was a challenge to the interviewer: "Why do you have the window open on such a cold day?". His divergent responses to the tests may be illustrated by his ending to a Thematic Apperception Test story: "All, however, turns out well; he grows up and becomes an insipid bore, marries, has several children whom he sends off for lessons in meat cutting, and lives amiably without ever having heard of Freud." Paul was intelligent, being at the 98th percentile of graduates on the Miller Analogies Test, whilst scoring much worse on a simpler test which did not arouse his interest. The Rorschach stimulated his imagination:

e.g., "A woman diving into a dark pool of water. Waves are breaking on either side of her, the water turning white at the crest of the waves." Paul described himself as independent, intelligent, unstable and churlish. He obtained a high score on the B.W.A.S., and had drawn and painted extensively for a six year period. Thus Paul displayed the combination of divergent thinking, emotionality, and sympathetic reaction to complex stimuli hypothesized for the creative person.

An illustrative case-study of a "simple" person was not so readily found, other than psychiatric accounts. Patients may be considered to control their aggression through adherence to some scheme of rigid discipline, such as that of an extreme political party which "permits of no slightest deviation", described by Lindner (1956, p.77) in his case-study entitled "Come over, Red Rover". It might be considered that the "authoritarian personality" described by Adorno *et al.* (1950) provides an approximation to Barron's "simple" person, as Sanford (1961) commented; but the concept of authoritarianism is too closely bound to political attitudes to correspond with Barron's conception. Instead of psychological case-studies from such sources, a biographical account of "Jack Nash" written by Eugene Burdick (1963) and described as a mainly factual account, is summarized. Burdick met Nash when both were naval pilots at gunnery school near Honolulu. Nash had grossly restricted interests, and mechanisms were his forte. He was able to dismantle and re-assemble a complex gun after only one demonstration, without a flaw. Talking to Nash was like talking to a badly-written textbook on mechanics. Asked about Shanghai, he spoke of the poor maintenance facilities. Asked about the girls there, he replied "Same as everywhere else." Originality, fluency, emotionality, and aesthetic interests were alien to his character. Even flying was no adventure for him, the aircraft's novel stimulation passed him by. He explained: "I never feel a thing like that ... It's just a machine. I like to have it working right."

These two case-studies summarised above illustrate the two polar clusters of traits representing the dimension of "openness to divergent stimulation". They do not, of course, demonstrate that the conception is applicable to correlations between the traits for a general sample of individuals. The experiment described below tested the hypotheses that divergent fluency is linearly correlated with self-perceived creative independence, emotionality, and aesthetic preference for complex stimuli. Alternative hypotheses which might account for some of the previous findings are discussed below. These hypotheses have suggested additional variables for inclusion in the correlational analysis.

Arts-Sciences Orientation

The main alternative interpretation for many findings in the creativity literature concerns the importance of arts versus sciences as fields of interest. It is portentous that Barron's exemplar of an individualist, Paul, was an amateur artist, whereas Burdick's character, Nash, was interested only in applied science. Indeed, Barron acknowledged that "the impulse to create in the arts does seem to arise in rather different sorts of persons than does the impulse to create in scientific or mathematical theory" (1965, p.88). Barron reviewed a number of studies of productive scientists and listed their general characteristics (*op. cit.*, p.85). These included emotional stability, control of impulse, superior intelligence, and liking for order, method and exactness, which contrasted with the characteristics of artistically creative groups like writers, artists and architects. Perhaps, therefore, the divergence-convergence dimension is related to the person's orientation towards the arts or the sciences. The apparent close connection between creativity and the B.W.A.S. would then be explained, since the Scale was originally validated using criterion groups of fine-arts students.

The importance of arts-sciences orientation has been emphasized in the

research of Hudson (1966a, 1968), mainly with English sixth-form grammar-school boys. They were classified as "divergent" if they scored high on open-ended tests of fluency but low on a convergent (IQ) test; and as "convergent" if they had high IQ but low scores on fluency. The other pupils not fitting either category (about 40% of the total) were classified as "all-rounders". Hudson (1966a, Appendix A) found that a majority of divergers were specialising in history and modern languages, whereas most convergers were specialising in physical sciences or biology. Hudson (1968) accounted for this relationship in the following way: " ... in all constructive brainwork, a tension exists between the need to innovate and the weight of established principle ... (and) convergers and divergers will differ in their reaction to this dilemma. The first will tend to plump for those routes through the academic system - mathematics, physical sciences, classics - in which the weight of accepted authority is greatest." Divergers, on the other hand, prefer arts subjects which have more scope for individual opinion and expression.

Hudson (1968) went on to postulate that divergers are less yielding to authority in other ways. He formulated a questionnaire which reflected the degree to which subjects (15 year old boys) tended to agree with the given views of graduates. Of convergers in Hudson's sample, 57% obtained high scores on the yielding questionnaire, whereas only 25% of divergers did so. (Hudson has usually presented his data in this dichotomised fashion rather than giving the appropriate correlation between divergent thinking and personality scores.) Several authors have similarly noted that creative persons may be particularly reluctant to yield to authorities when their opinions clash. MacKinnon (1962a) noted that one of the creative architects in his study "was advised by the Dean of his School to quit because he had no talent".

It seems likely that educational systems which do not encourage early specialisation, dividing students taking arts from those taking sciences,

might show less relationship between the primary area of study and divergency variables compared with results within the British educational system. Bergum and Cooper (1977) found that Texas undergraduates in Liberal Arts and in Science Schools did not vary significantly from their overall data for seven Schools with regard to reporting themselves "creative" and "original". There were, however, other Schools with significant variations, which supported the general supposition that different types of person tend to predominate in different educational or professional fields; in particular, relatively more students in Agriculture or in Architecture considered themselves "original", whilst fewer students in the Business School considered that they were "creative" or "original".

Although specialisation in arts or sciences is less pronounced in North American secondary-schools than in England, there are nevertheless indications of the relevance of an arts orientation for variables associated with creativity. For example, Child (1965) found a correlation of .25 between his Esthetic Judgment Test and Barron's Independence of Judgment Scale. Child also noted that variables associated with artistic interests were related to his Esthetic Judgment Test, such as extent of art-education ($r = .5$) and interest in art galleries ($r = .5$). It is valid therefore to conceptualise a cluster of inter-related arts-orientation variables associated with aesthetic preferences and with an independent attitude. It seems likely that the relationship between creativity in men and their "feminine" interests (*e.g.* Mackinnon, 1962a) is a reflection of arts-orientation, since "feminine" interests refer to such fields as painting and poetry. Further support for Hudson's thesis was derived from MacKinnon's (1962b) study of 124 American architects: a correlation of .35 was found between rated creativity and the Aesthetic Value Scale of the Allport-Vernon-Lindzey Study of Values.

From the findings discussed above, it seems clear that art-sciences orientation is related to divergence-convergence, and that this relationship

might account for some other features of the creative personality as described by Barron and his colleagues, and particularly those concerning aesthetic preferences. The tentative findings concerning the preferences of arts and science faculty groups described in chapter 2 support this view. Arts-sciences orientation variables were therefore included in the present experiment, to test this alternative to the "openness to divergent stimulation" theory. The literature on differential personality traits associated with study or work in arts and in sciences is discussed further in chapter 10. It is here necessary to admit certain problems with the concept of arts-sciences orientation, despite its heuristic value.

First, it is self-evident that the concept covers two distinct regions at the "arts pole", the humanities and fine-arts. It is admitted that the term "arts-science orientation" is deliberately ambiguous in this respect, since it seems possible from the evidence that both regions may be related to divergency. Educational levels both in the humanities and in fine-arts were considered in the experiment. A second problem, which has been acknowledged by Hudson, is that the nature of a subject as presented in secondary school or university depends on the teacher as well as on its intrinsic content. For example, a language may be taught as a set of convergent rules applied to a fixed vocabulary, rather than as a means of individual communication. Science may be taught by some teachers as a means of making exciting discoveries, rather than as a series of authorized procedures and laws. Moreover, a student may be taking a course not because of his own talents or preferences, but because of his parents' ambitions. These problems imply that although educational specialisations may be objectively assessed, the resulting variables must be regarded as rough indications of the preferred style of learning rather than as "pure" measures. Similarly, an assessment of achievements is affected by opportunity, good fortune, persistence, and so on, and should be considered as a rough indication of ability in the area concerned, rather than as a perfect

criterion measure. An implication of these problems is that even if areas of interest were closely dependent on cognitive styles such as convergence-divergence, moderate rather than high correlation values would be expected.

Even without these methodological problems, the linkages between convergence and study of sciences, and between divergence and the study of arts are unlikely to be strong. For the sciences patently have many divergent, original thinkers and "problem finders" (Mackworth, 1965), even if the modal science student be convergent in style. Koestler (1972, chapter 2) described several examples of divergent thinking by eminent modern physicists, and referred to their characteristic "school-boy humour". Conversely, there are students of fine-arts who are nevertheless convergent in style, such as the subgroup called by Beittel (1964) "academic" students who "lack most of the personality characteristics we have isolated as related to the capacity for creative action." From Hudson's research, then, one would predict positive correlations, but of moderate value, between variables reflecting arts-sciences orientation and variables reflecting divergent fluency and an independent attitude.

Sex

Hargreaves (1977) has recently reviewed evidence concerning sex differences in divergent thinking, and has suggested that girls tend to obtain higher fluency scores on verbal tests of divergent thinking. However, Hargreaves himself obtained no significant sex difference in fluency scores in two experiments, despite differences in the content of responses. Wallach and Kogan (1965a) found no significant sex difference on their index for creativity obtained by summing standardized scores over a number of divergent tests. Similarly, no significant sex difference "for originality, flexibility, ideational fluency, and the creativity self-rating scores" was reported by Feldhusen, Denny and Condon (1965, p.42). Moreover, Babladelis (1978) found no gender or "sex-role concept" differences on the Remote

Associates Test. Cropley (1967a, p.63) argued that girls would be expected to perform poorly on divergent thinking tests since "Unorthodoxy is, even today, far more reprehensible in females than males." Nevertheless, Anderson and Cropley (1966) had obtained an "insignificant correlation" between sex and originality factor-scores with a large sample of children aged about 13½ years. A small sex difference became apparent in their study only when extreme groups of the most original and least original children were selected. Hutt (1972) also believed that "men more often have a capacity for divergent and imaginative thinking" (p.101), despite the fact that Bhavnani and Hutt (1972) reported higher divergent fluency scores for primary-school girls than for boys. Hutt (1972, p.103) asserted that an extensive study by Shouksmith (1970) "bears out this prediction" that adult males score higher than adult females: in fact Shouksmith reported very similar ideational fluency scores for men and women on each of three divergent thinking tests (measures 14-16 in his Tables 1 and 2, pp.170-171). Only a minority of studies have reported slightly higher divergent thinking scores for boys in line with Cropley's and Hutt's views (*e.g.* Cropley and Field, 1968; Hudson, 1968, p.23).

Part of the confusion with regard to sex differences is due to an unfortunate terminological ambiguity. As Hutt (1972, p.96) correctly points out, girls tend to be more adept at convergent language-usage tasks, such as spelling and composing sentences. This ability may be referred to as "verbal fluency"; but it is, or course, quite different from "fluency on verbal divergent thinking tasks" on which females differ little from males according to the available evidence. It is relevant to note that girls do not generally perform better than boys on verbal *reasoning* with convergent tests (Hutt, 1972, p.96).

Further confusion stems from the fact that men are in the majority with regard to outstanding leaders in many professions and creative activities (Hutt, *op. cit.*, pp.100-101, 135-139). This may well reflect different

ambitions in men and women, and not any difference in divergent ability. It is also commonly considered that women face biases hindering their creative achievements in modern western cultures (*e.g.* Terman, 1947; Barron, 1965). However, Mischel (1974) found that "sex bias was highly specific to certain fields". Moreover, recent studies in Australia have found no significant difference between the educational and vocational aspiration levels of secondary-school boys and girls (Hall, 1976), and no evidence of a cultural stereotype which devalues competitive achievement by women (Winkler, 1975).

Although the evidence suggested little cogency for sex differences with regard to divergent fluency, it was considered necessary to obtain equal numbers of males and females for the experiment, and to treat sex as a control variable in the analysis.

Intelligence

It was pointed out in chapter 5 that convergent intelligence is generally unrelated to divergent thinking ability in high IQ groups such as university students. Since the experimental subjects formed such a group, it was expected that any correlations between divergent fluency and other personality variables would be little affected by variations in IQ. In Barron's (1963) study of originality with 100 U.S.A.F. captains, a correlation of .33 was obtained between the composite originality score and intelligence assessed by the Concept Mastery Test: even so, twenty-three personality test measures were still significantly correlated with originality after intelligence was partialled out, such as those reflecting self-assertiveness, emotionality, and ability to integrate diverse stimuli. It was considered necessary to include an intelligence test in the present experimental battery, as a precaution.

Extraversion

Some of the characteristics of highly creative people suggest an extraverted disposition, particularly in so far as this relates to impulsiveness and adventurousness. Eysenck (1967b) stated that fluency tests "were found to be correlated with extraversion". This assertion is supported by some studies, such as those by White (1968) and Di Scipio (1971), although higher fluency scores for extraverts applied only to the stable subgroup in the latter study. On the other hand, some studies have suggested that creative groups such as artists may tend towards introversion (*e.g.* Cross, Cattell and Butcher, 1967; Eysenck, 1972). Montgomery (1975) has reviewed the inconsistent literature, and himself found no significant correlation between extraversion and divergent thinking variables in either his initial experiment or a later follow-up study, with adolescents. Innes (1972) similarly found nonsignificant correlations for both males and females between extraversion and two fluency measures. Furthermore, Anderson and Cropley (1966) obtained no significant difference on extraversion as measured by the Junior Maudsley Personality Inventory between two extreme groups of children high and low on originality.

Whatever convolutions the literature displays, extraversion is an important variable to consider because of its theoretical interpretation. Eysenck (1967b) stated that extraverts "strive for relatively high amounts of stimulation". This notion is similar to that of openness to divergent stimulation, although based on the arousal characteristics of stimulation rather than its informational value. In the field of aesthetic preferences, a few studies support Eysenck's view, if "amount of stimulation" is assumed to be proportional to stimulus complexity. For example, Day (1966) found a significant correlation of .33 between extraversion, using the E.P.I., and the Barron-Welsh Art Scale. Moreover, Bartol and Martin (1974) reported that subjects selected for high scores on extraversion tended to

prefer complex random polygons with more independent turns, and Lane (1970) reported a similar finding with regard to preference for more "jagged" polygons. On the other hand, no significant correlation was found between extraversion and preference for complex abstract paintings (Osborne and Farley, 1970).

Eysenck (1941b) used a test having one-hundred reproductions of paintings as stimulus materials, which was intended to assess a factor of preference for bright impressionist paintings (regarded as "stimulating") rather than dull conventional pictures. He found that the test was highly correlated with extraversion, although the finding must be regarded as tentative since only fifteen subjects were tested. On the other hand, Rosenbluh, Owens and Pohler (1972) found that extraverts tended to be "sympathetic with" classical paintings ("embodying lucidity, simplicity, dignity") rather than with Romantic paintings, which appears somewhat at odds with Eysenck's findings. Burt (1939) reported that "extraverts" (on a bipolar factor contrasting an aggressive versus an inhibitive display of emotions) tended to prefer "sensational" pictures if they were also unstable; but stable extraverts preferred sober, realistic paintings, which does not accord with Eysenck's hypothesis. In Jamison's (1972) study extraverts preferred more realistic pictures, in that there was a negative correlation of -.5 between extraversion and preference for abstraction in photographic pictures.

It may be that extraversion is related to aesthetic preferences for certain types of content rather than "stimulation" or "complexity" in the abstract. For instance, it may have been the greater meaningfulness of complex random polygons (as found by Munsinger and Kessen, 1964) which appealed to the extraverted groups in Bartol and Martin's study described above. The nature of the relationships between extraversion and fluency or extraversion and aesthetic preferences is not clear from this survey of the literature, but they are of sufficient relevance to include in the investigation.

Social Desirability

A further variable for consideration is social desirability response set. Edwards (1957) has shown that this variable is pervasive in its effects on personality attributes as assessed by questionnaires. Moreover, Cronbach (1968), following a re-analysis of the Wallach-Kogan data, has suggested that divergent fluency is related to "social responsiveness". For example, high scoring pupils on the fluency factor tended to seek their teacher's attention. Such high scorers might therefore have a general social desirability response set, which might in turn affect scores gained from personality questionnaires. As a check on this possibility, the Edwards Scale was included. It should not be inferred from this precaution that the writer accepts Cronbach's conclusions. Indeed, it may be that fluent subjects are more independent in their judgement and therefore may show *less* conformity to the social norms represented in the social desirability scale. Dellas and Gaier (1970) listed a lack of concern for social norms amongst the traits which have been reported as characteristic of creative persons.

Age

The subject's age is conventionally controlled for measures of intelligence by use of the intelligence quotient, whereas studies of divergent fluency have often not taken age into account. Indeed, T-scores recommended for the Torrance Tests of Creative Thinking and based on fifth-grade data, were stated to be "rather satisfactory at all educational levels" (Torrance, 1966, p.71). Nevertheless, in the case of the Torrance Verbal Tests Form B given to school grades one to six in Wisconsin, the correlation between grade and mean fluency was .97, $p < .01$ (calculated from Torrance's Table 5.10). On the other hand, Horn and Cattell (1967) found no significant age trend for divergent fluency in adulthood. Although it was considered that any age effect would be slight amongst the university students in the present study, it was investigated as a precaution.

Method

Subjects

Students enrolled in the first-year psychology course at The University of Adelaide were initially invited to participate in the study by letter. They were randomly sampled except that only those less than 30 years old and with English as their native language were included. Enough invitations to eligible students were sent (111) to ensure a final sample of 50 males and 50 females. The mean age was 20.9 years (SD = 3.3) for males and 19.7 years (SD = 2.0) for females. Of the eleven eligible students who declined to take part, six did so because of timetable difficulties, and the remaining five did not attend the test sessions for unknown reasons. Little bias from selective volunteering was likely. With a total sample of one hundred, a product-moment correlation of .2 is significant at the .05 level of confidence. It was considered therefore that this sample size provided sufficient statistical power.

Participants in most cases were completing a course commitment to assist in Department research, and the initial letter asked that volunteers for this particular experiment should be "diligent and sincere" in their approach to the tasks. Confidentiality of the results, and the fact that individuals would be given an outline of their own results on request, were also stressed. It was expected that by using a "client contract" (Lovell, 1967), response distortion and lack of motivation would be minimized. The students had not received formal courses on aesthetics or divergent thinking, and were informed that the research topic was "Individual differences in aesthetic preferences and in personality".

Tests and scoring

As far as possible, tests were selected that were reliable, relevant to the hypotheses under investigation, and suitable for the student sample.

In the case of two constructs, preference for multiplicity in designs (PM) and emotional activation, available tests were limited and other tests were therefore systematically constructed.

With regard to assessing the degree of preference for multiplicity, previously reported tests were extremely limited in the range of figures sampled. For example, some measures of PM have been derived solely from random polygons (*e.g.*, Bartol and Martin, 1974), and others solely from geometrical figures like the Birkhoff polygons (*e.g.*, Brighouse, 1939). As well as a wide sampling of regular and irregular types of figure, experimental control of the other main complexity variables (asymmetry and heterogeneity of elements) was required within the test.

With regard to assessing sensitivity to emotional feelings, it was considered that the N scale of the Eysenck Personality Inventory was appropriate, but an additional measure of emotionality was required with no direct reference to psychopathology. The Emotional Activation scale was therefore devised.

Several self-report and "objective" tests of divergent independence were available, but were not included in the battery for various reasons. The second order factor of Independence from the 16PF test would have been relevant, but would have taken too much of the subjects' total time available for testing (about 2½ hours). Hudson's (1968, p.9) questionnaire measure of "yielding" was relevant, but an Australian version developed by Rigby (1975) was found to have low internal consistency. "Objective" tests, such as the Asch experimental method used by Barron (1958) or the Test 19 "Time Estimates for Everyday Tasks" (scored for extreme response choices) recommended by Cattell and Warburton (1967) as having a high loading on Independence, were considered to cover too narrow a range of behaviour to be satisfactory. Therefore a new scale for Creative Independence was devised and combined with Emotional Activation on a Self-description Checklist. This and the PM measure are described in detail below, followed by a brief

summary of other tests used, including the Personal Data Sheet from which variables concerning the subject's arts-sciences orientation were derived.

The Pattern Preference Test

This test was composed of 16 items, each of which involved four patterns shown by slide-projection. The patterns were all abstract designs, projected as black on white, and are illustrated in Figure 7.1. Instructions to subjects were as follows: "As each slide is shown, decide which of the four patterns or shapes you prefer. Tick the position of the one liked best in the corresponding rectangle." On the subject's response sheet, for each item there was a rectangle representing the slide, divided into quandants corresponding to the four patterns. The subject indicated his preference by ticking the quadrant corresponding to the position of the pattern on the projection screen. To allow him to do this, an interval of about 3 seconds was allowed between slides, each slide being shown for 13 seconds by means of a Kodak timer fitted to the Carousel projector. The area occupied by the four designs on the screen was approximately 100 cm wide by 85 cm high, and was viewed from a distance of 4m to 9m. All subjects sat within a 30^0 sector on either side of the perpendicular to the screen.

The four patterns within each item were composed of similar elements, and were (a) symmetrical with regular elements (4 items), or (b) symmetrical but with otherwise "random" elements (4 items), or (c) asymmetrical with regular elements (4 items), or (d) asymmetrical with random elements (4 items). Within items, the only variable differentiating the four patterns was the number of elements. For example, the four patterns for Item 1 were all asymmetrical and composed of random quadrilateral outlines, whilst the number of these quadrilateral outlines varied from two to eight. For each item, the preference for multiplicity (PM) score was 1, 2, 3 or 4 depending on the complexity of the preferred pattern; for example, if the eight-quadrilateral pattern was ticked for item 1, the score for that item

was 4. The possible range of scores for the whole test was therefore 16-64.

Although the patterns were drawn by the writer specifically for the P.P.T., they were in most cases similar to patterns used previously in the study of aesthetic preferences. Acknowledgements are included in Table 7.1, which sets out the design of the test.

Position and order effects were controlled in the following ways. For each type of pattern, each order of complexity (1 to 4) appeared in each of the possible four positions on the screen (as shown in Table 7.1). The sixteen items were presented in the given order, which was determined by random allocation with the restriction that items having symmetrical patterns alternated with items having asymmetrical patterns.

Self-description Checklist

Adjectives and adjectival phrases were selected which described different aspects of the concepts "Creative Independence" and "Emotional Activation", or their opposites, in the opinion of the writer. All items were reported to be relevant to the concept of preference for complexity (Welsh, 1959) or to creativity (Taft and Gilchrist, 1970). By taking antonyms it was possible to obtain equal numbers of "positive" and "negative" items to control for acquiescence response set. The initial set of 40 items was then presented to an independent "judge" for sorting into five categories: "creative independence", "opposite to creative independence", "emotional activation", "opposite to emotional activation", and "uncertain". As a result of this check on the apparent meaning of the concepts, four items were deleted as the judge's allocation was inconsistent with the writer's initial opinion. A further group of ten psychology graduates showed 85 percent agreement on average with the final allocation of adjectives.

The final form of the Checklist included 18 items scored for the Creative Independence scale (9 scored for a positive response, and 9 scored for omission); and 18 items scored for the Emotional Activation scale

Table 7.1. Design of the Pattern Preference Test

The characteristics of the four patterns constituting each item are coded as follows in the right-hand column of the Table:

Arrangements of patterns (and scoring scheme): W = $\begin{array}{|c|c|}\hline 1 & 2 \\ \hline 4 & 3 \\ \hline \end{array}$ X = $\begin{array}{|c|c|}\hline 4 & 1 \\ \hline 3 & 2 \\ \hline \end{array}$

Y = $\begin{array}{|c|c|}\hline 3 & 4 \\ \hline 2 & 1 \\ \hline \end{array}$ Z = $\begin{array}{|c|c|}\hline 2 & 3 \\ \hline 1 & 4 \\ \hline \end{array}$

Type of element: Ran = Random elements; Reg = Regular elements.

Type of symmetry: A = asymmetrical;
H = horizontal axis of symmetry;
V = vertical axis of symmetry.

Item	Type of design	Elements	No. of elements	Characteristic
1	[f]Black & white designs	Quadrilaterals	2,4,6 or 8	Z,Ran.,A
2	[b]Regular polygons	Sides	6,12,24 or 48	X,Reg.,H&V
3	Hexagon patterns	Hexagons	2,4,8 or 12	Y,Reg.,A
4	[e]Spirographs	Petals	8,12,16 or 32	W,Reg.,H&V
5	[d]Block polygons	Sides	5,10,20 or 40	X,Ran.,A
6	Hexagon patterns	Hexagons	2,4,8 or 12	Y,Reg.,H&V
7	Wavy lines	Lines	4,7,11 or 15	Z,Reg.,A
8	[d]Block polygons	Sides	7,14,22 or 36	X,Ran.,V
9	[a]Random straight lines	Lines	4,8,16 or 32	Y,Ran.,A
10	[c]Square matrices	Cells of matrix	4^2,6^2,8^2 or 10^2	W,Ran.,H&V
11	[e]Spirographs	Whirls	2,4,6 or 8	W,Reg.,A
12	Wavy lines	Lines	4,7,11 or 15	Z,Reg.,V
13	[c]Square matrices	Cells of matrix	4^2,6^2,8^2 or 10^2	W,Ran.,A
14	[a]Random straight lines	Lines	4,8,16 or 32	Y,Ran.,H&V
15	[b]Regular polygons	Sides	3,6,12 or 24	X,Reg.,A
16	[f]Black & white designs	Quadrilaterals	1,2,3 or 4	Z,Ran.,H&V

Footnotes. Designs are similar to those used in the references shown:

[a]Berlyne(1960, p.38, Fig.2-1)

[b]Davis (1936)

[c]Dorfman and McKenna (1966)

[d]Munsinger and Kessen (1964)

[e]Rump (1968a)

[f]Rump (1968b)

Figure 7.1. Pattern Preference Test

The sixteen items which follow, each consisting of four patterns, form the Pattern Preference Test. Items were presented by means of slide-projection.

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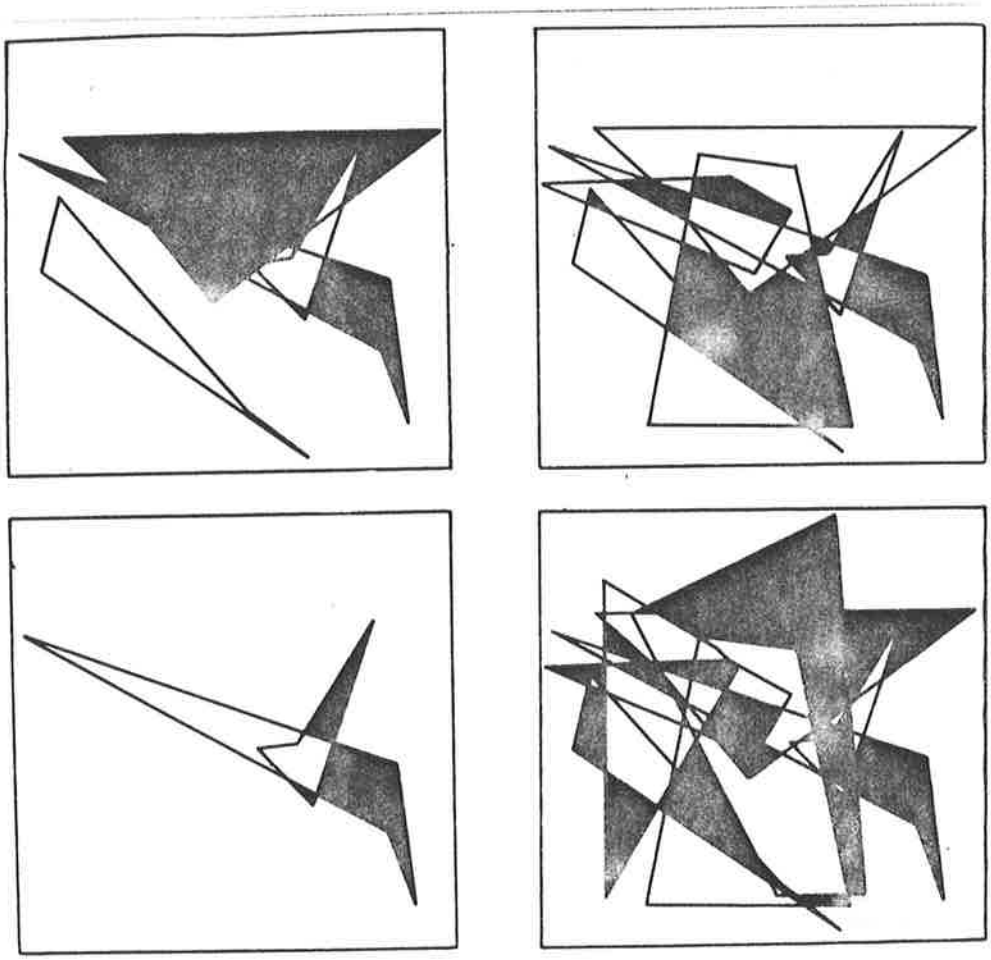

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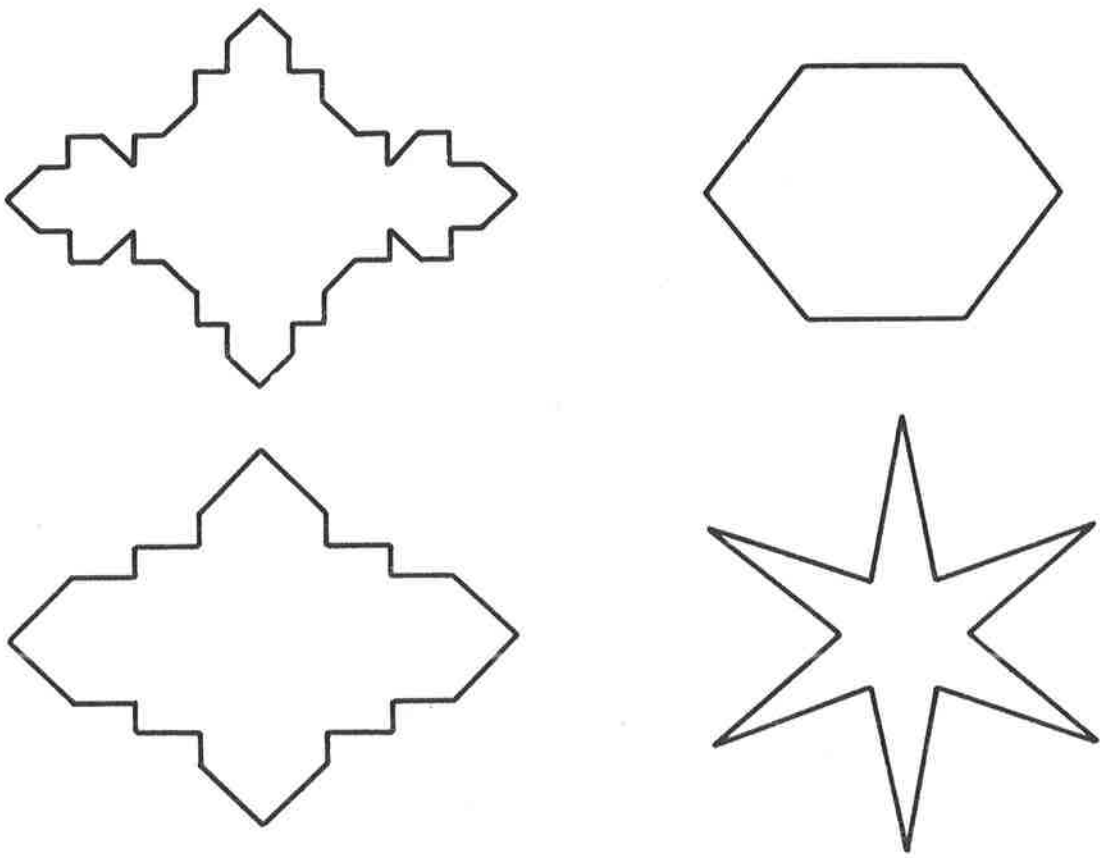

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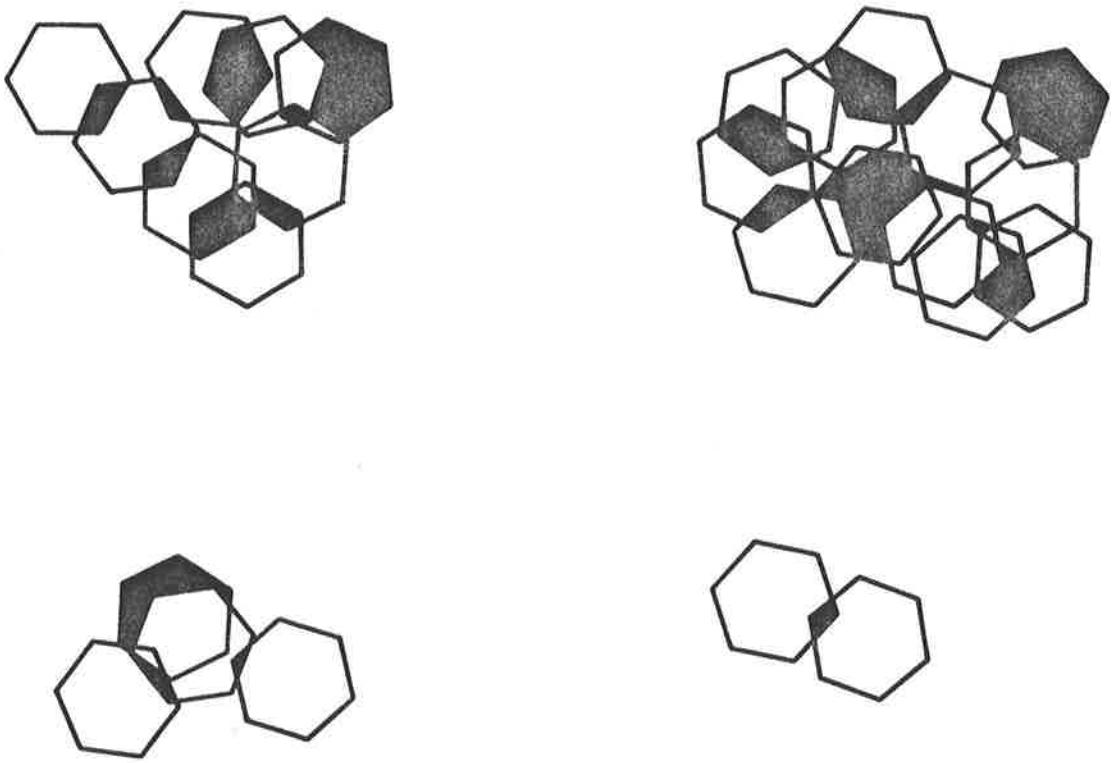

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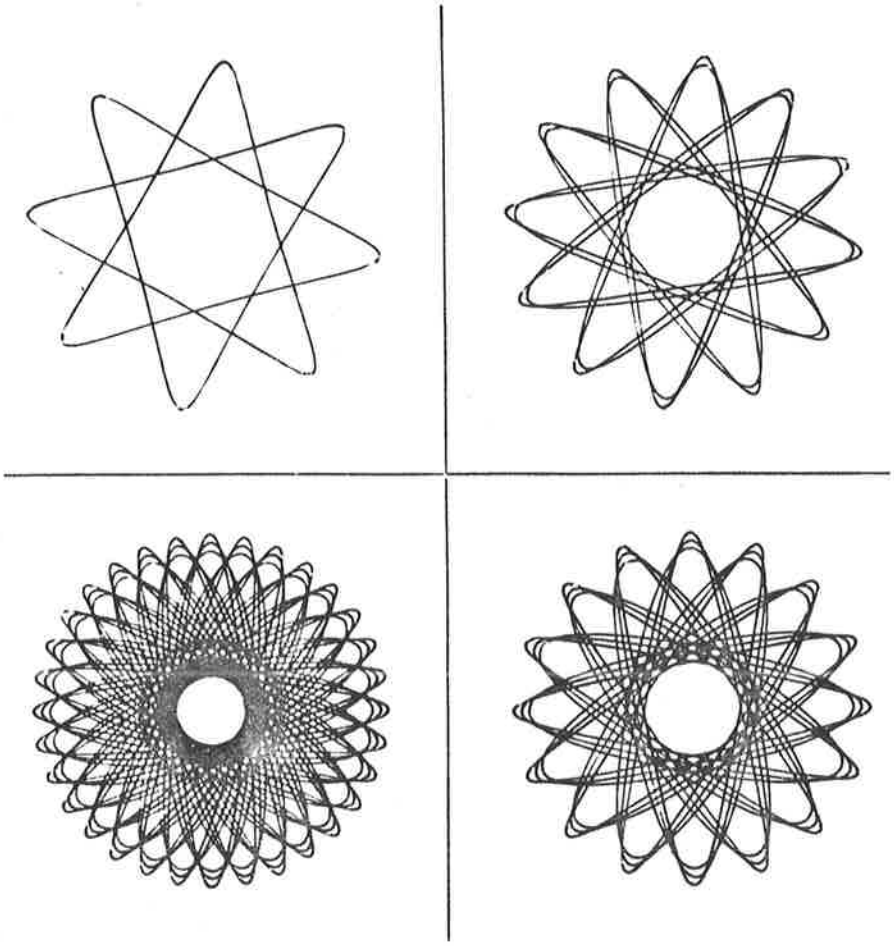

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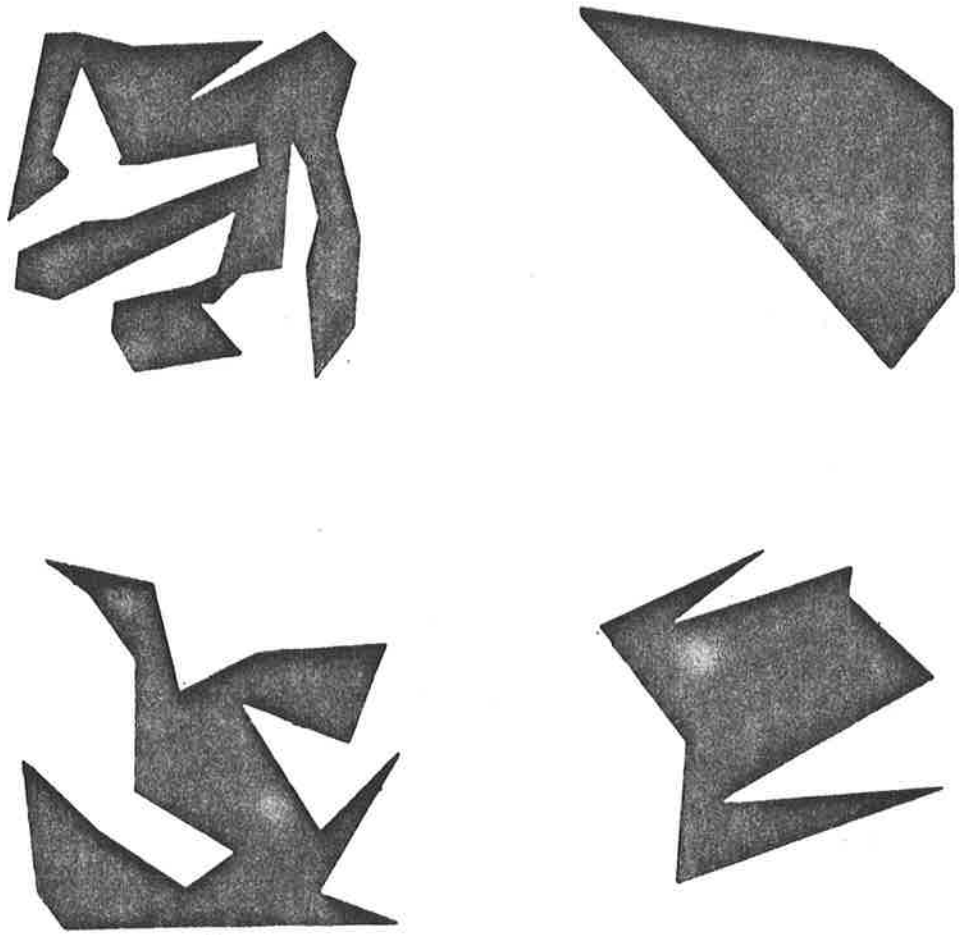

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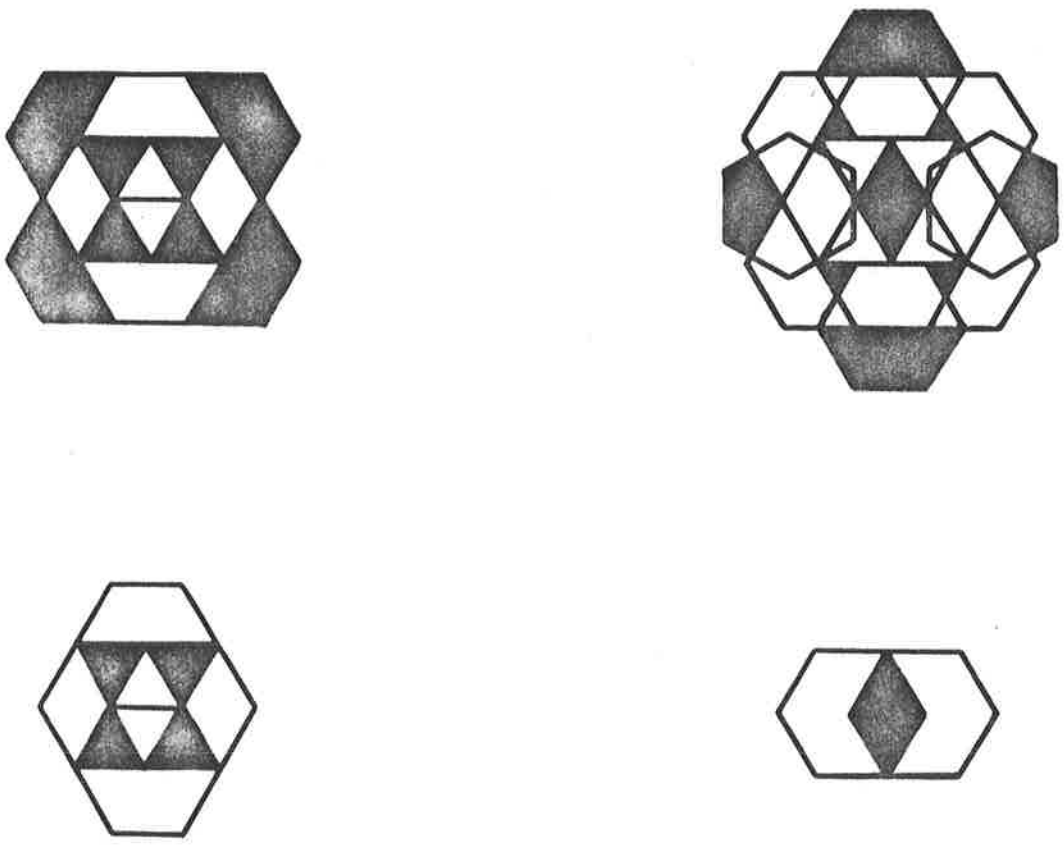

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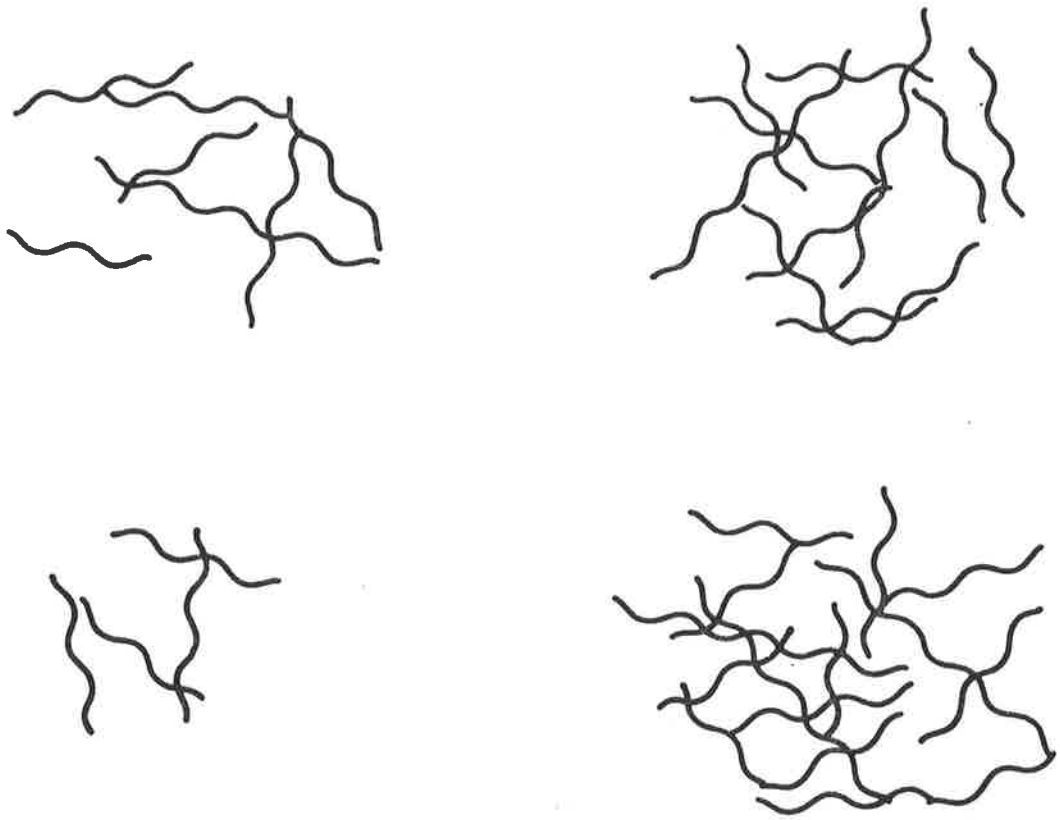

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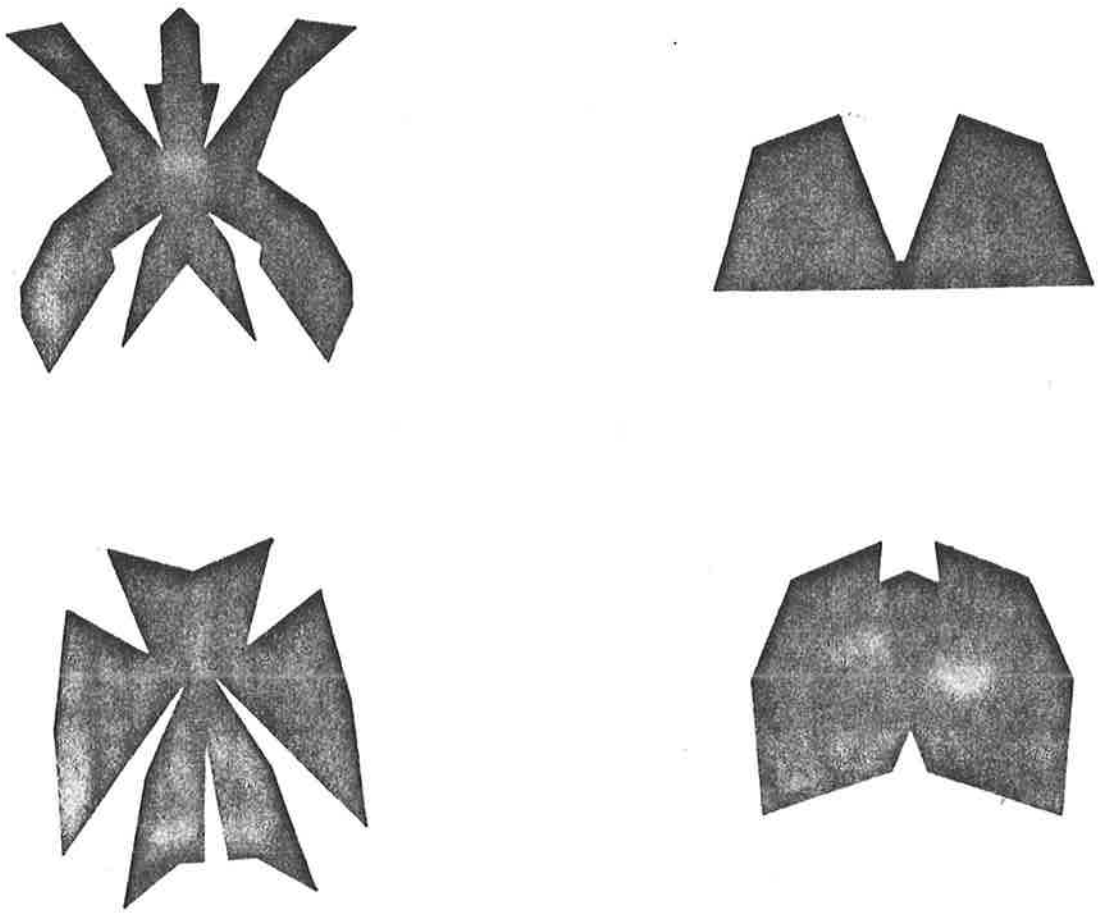

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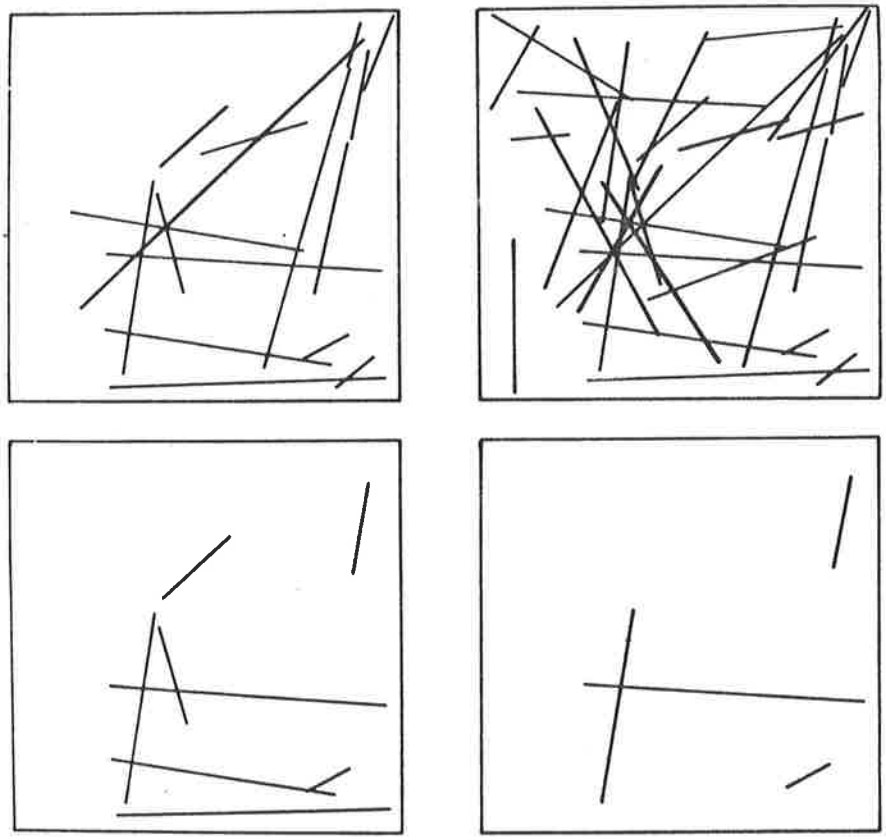

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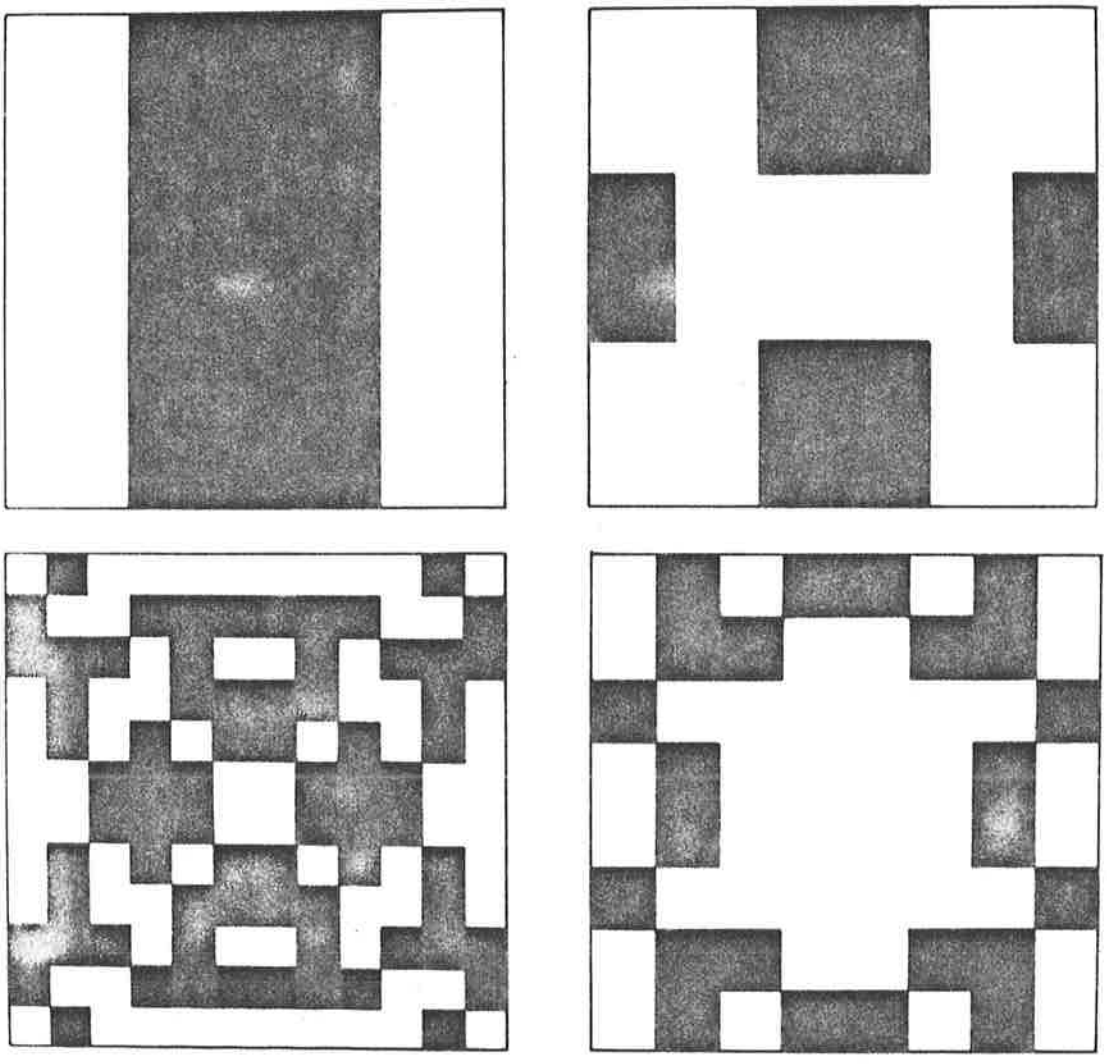

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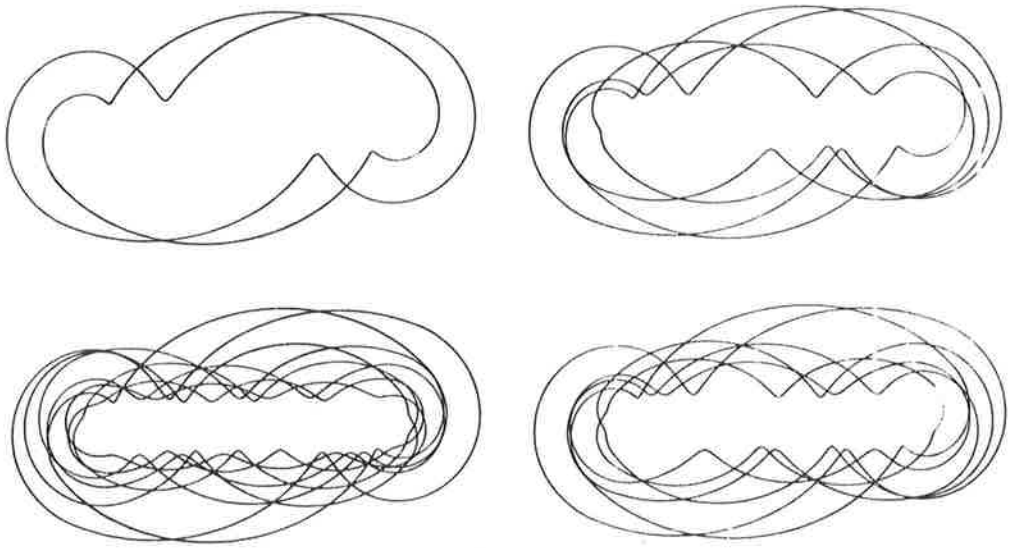

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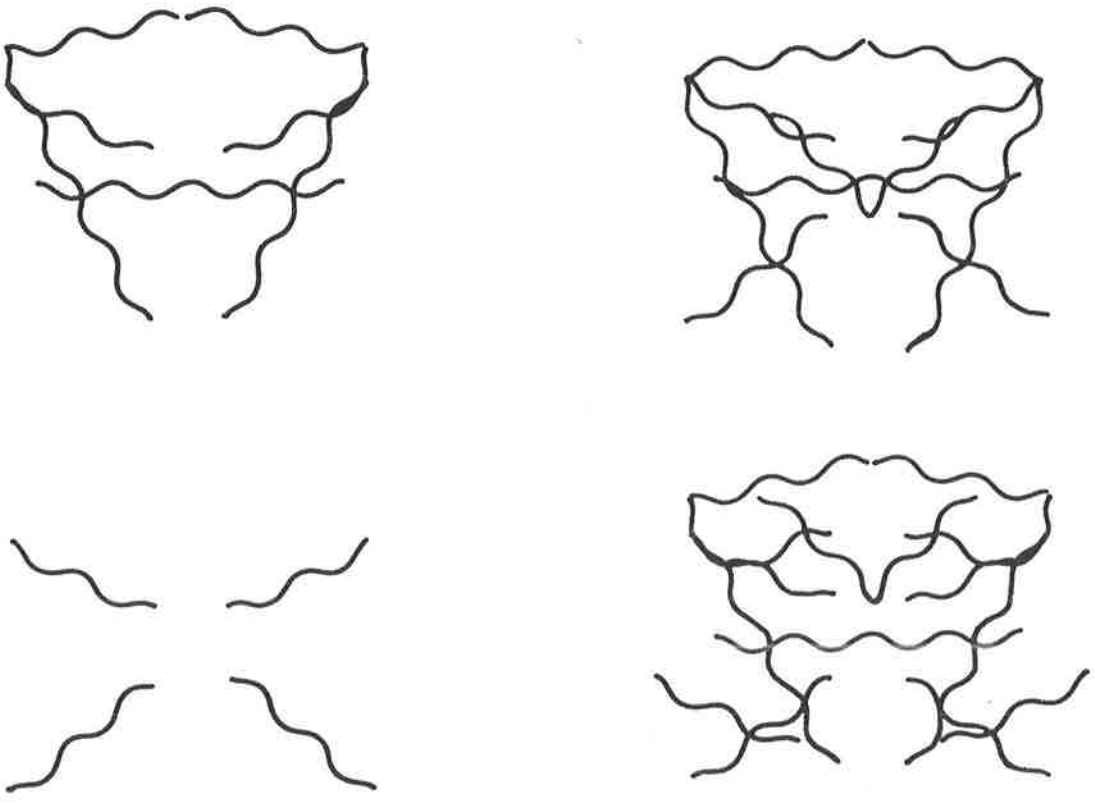

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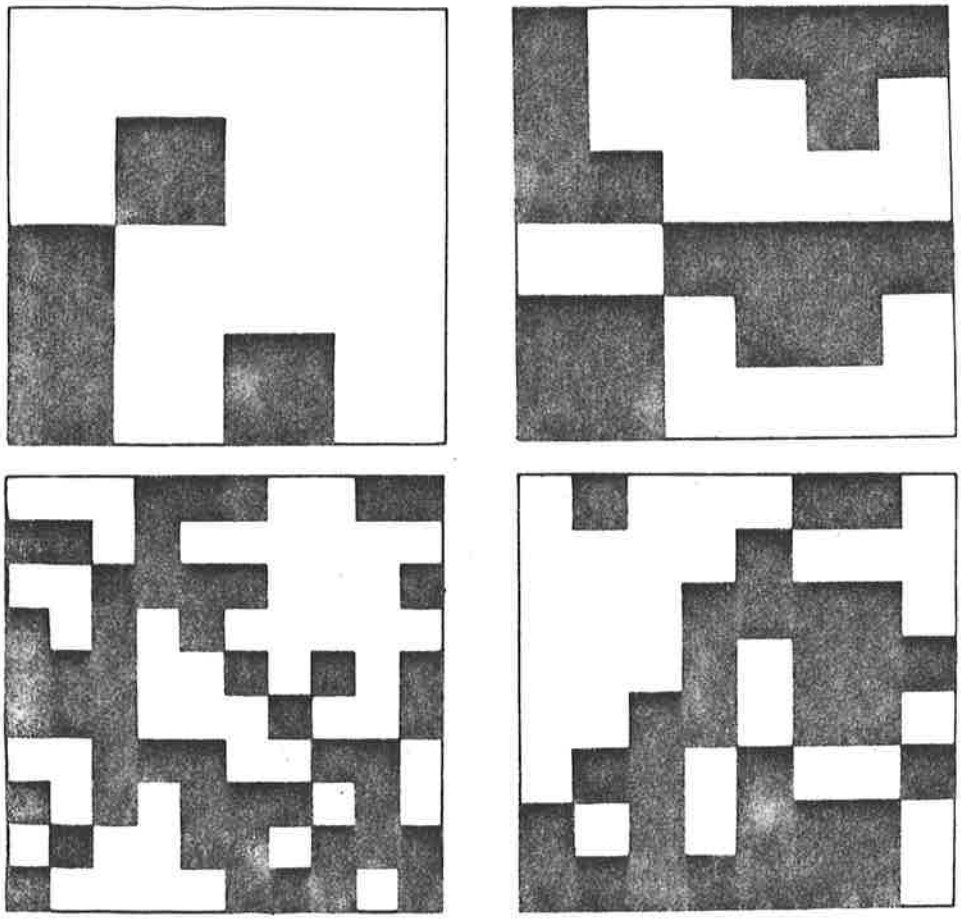

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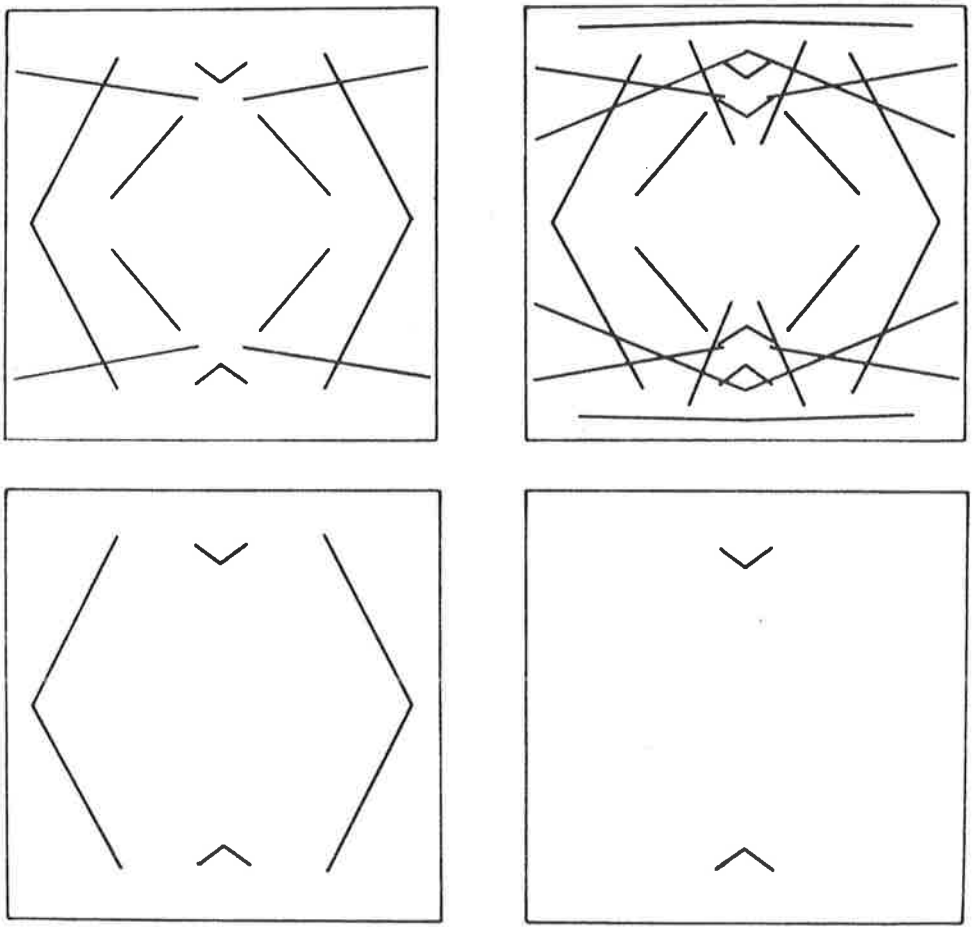

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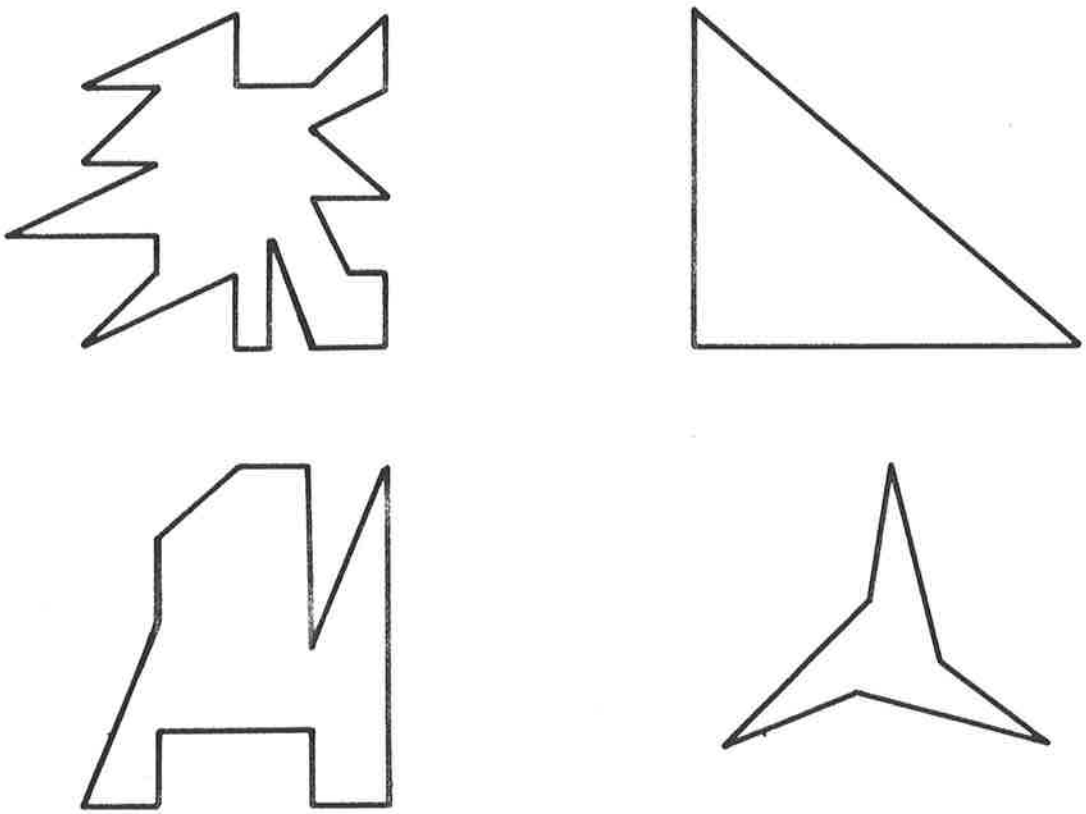

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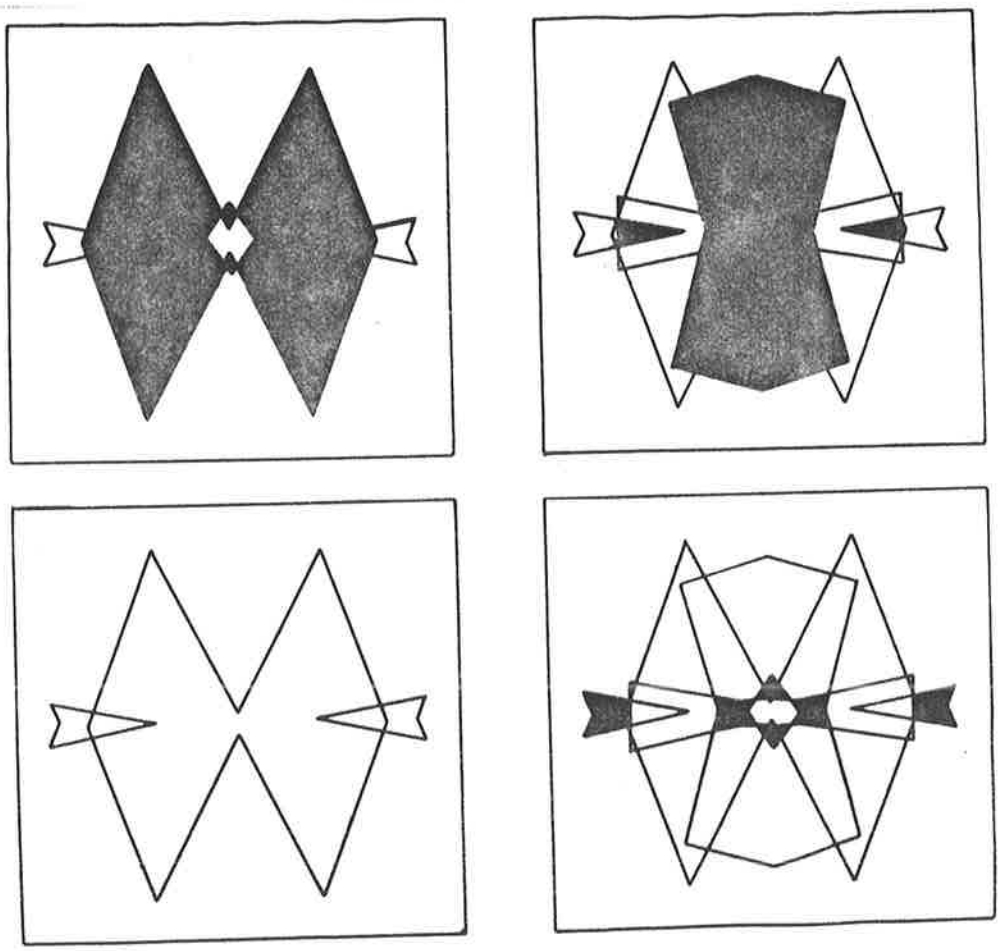


Figure 7.2. Self-description Checklist

Note: The coding in parenthesis below each item was not present on the Checklist as used in the study. The coding shows whether the item was scored for Creative Independence or for Emotional Activation, and whether it was scored for ticking (+) or for not ticking (-).

Tick each word listed that you feel applies to yourself, in the corresponding circle.

Tick about half the items if possible.*

Leave the circle blank if you feel the word does not apply to yourself.

versatile (CI+) 0	independent (CI+) 0	conventional (CI-) 0	cynical (CI+) 0
energetic (EA+) 0	hurried (EA+) 0	stable (EA-) 0	moody (EA+) 0
imaginative (CI+) 0	peaceable (EA-) 0	aggressive (EA+) 0	outspoken (CI+) 0
reserved (EA-) 0	touchy (EA+) 0	different from others (CI+) 0	unadventurous (CI-) 0
patient (EA-) 0	rebellious (CI+) 0	creative (CI+) 0	boring (CI-) 0
self-conscious (CI-) 0	restless (EA+) 0	play it safe (CI-) 0	do not take risks (CI-) 0
enthusiastic (EA+) 0	pleasure-seeking (EA+) 0	conservative (CI-) 0	contented (EA-) 0
easygoing (EA-) 0	gentle (EA-) 0	unemotional (EA-) 0	few novel ideas (CI-) 0
irritable (EA+) 0	tired (EA-) 0	individualistic (CI+) 0	easily influenced (CI-) 0

Check that you have read through each of the four lists. Thank you.

For use of tester:

	C.I.	E.A.
+		
-		
=		

*This sentence was added to the instructions in subsequent uses of the checklist (see Chapter 8).

(9 scored for a positive response, and 9 scored for omission). The total set of 36 items was then arranged in a random order, with simple instructions, on the response sheet shown in Figure 7.2. This also shows the scoring scheme, which gives values for each scale within the possible range of 0 to 18.

Personal Data Sheet

In addition to sex and age, respondents were asked to indicate their degree of orientation towards the arts by answering several questions. Two concerned the extent of formal education in fine arts: "Have you received any education in painting and drawing, art appreciation, or the history of art? If so, give details" and "Have you passed any examination in art? If so, give details." The answers were scored as follows, to give the "fine-arts education" variable: "none" scored 0; art classes for less than three years whilst under 18 years scored 1; high-school or other senior art classes for at least three years, or adult education (or similar) art classes when at least 18 years old, or a "pass" at a public examination in art, scored 2; art classes for one year in a university, teachers' college or tertiary-level school of arts, or under the personal tuition of an artist of repute, scored 3; art classes for at least two years in a university, *etc.*, scored 4. The score allotted to the subject was that of the highest level reached, from 0 to 4.

Interest in the arts was gauged by means of the following question: "To what extent are you interested in art and design? Please tick the appropriate answer below". The possible responses with their scale values were: "hardly at all" (1); "not much" (2); "about average" (3); "above average" (4); and "very much" (5).

Two questions were used to assess level of artistic achievement: "Have you ever exhibited any of your own works of art?" and "Have you ever won any prize for a work of art?" Respondents were asked to give details

of any such exhibitions or prizes. In most cases these involved the Open-air Art Exhibition held annually in Adelaide and sponsored by the Advertiser newspaper. Answers were scored as follows to give the "artistic achievement" variable: "none" scored 0; any public exhibition of a painting, drawing, sculpture, photograph or film scored 1; any school prize for art work or similar minor prize scored 2; and any prize won at a public art exhibition or tertiary-level school of art exhibition scored 3. It had been established in a preliminary enquiry that scientific achievements were too rare at first year university level to be worth including as a variable.

The student's Faculty was also recorded and treated as a variable by scoring 5 for the Faculty of Arts, and 1 for the Faculties of Science or Medicine. Students from the Faculty of Ecnonomics were given an intermediate score of 3, since the schedules of courses for the B.A. and B.Econ. degrees overlapped considerably, whilst the latter also included science-like courses such as Accounting and Statistics. The variable was termed "Arts faculty". Whilst admittedly crude as a scale, the formation of this variable allowed it to be treated by correlational analysis in the same way as other arts-orientation variables.

Students were asked to write their names on the Personal Data Sheet, so that any omission or ambiguity on the tests might be queried later if not noticed during the sessions. All other response proformae were identified by the subject's code number which was also printed on the Personal Data Sheet.

Divergent Thinking Tests

Three tests were used to assess fluency of divergent production. The tests were given as intellectual problems and not as playful games, since in the writer's experience many university students object to the latter approach as inappropriately "childish". This might be considered

a "convergent" reaction in itself, but it is emphasized that in the present study a measure of divergent thinking ability was needed, and not the student's flexibility in assuming a playful, imaginative, child-like role. In any case, Ward (1971) found that game-like administration of divergent thinking tests did not appear to affect responses much; and Nicholls (1971, Table F) reported that his factor I representing divergent performance under game-like conditions was moderately correlated with his factor III representing divergent performance under test-like conditions, with r = .42 for boys and r = .48 for girls.

The Uses test (with "key" and "shirt-button" as items) and the Similarities test (with "milk and meat" and "curtain and rug" as items) were chosen from tests used by Wallach and Kogan (1965b). These authors reported that the fluency scores from both tests were highly reliable (with split-half correlations of .93 in each case), were correlated highly with the originality of responses (with correlations of .67 and .71 respectively), and that they correlated moderately with each other (.74). In the present study, originality and flexibility were not scored in addition to fluency, since these response characteristics are usually highly correlated with fluency (scored from the same protocol), and fluency is more reliably scored. For example, Torrance (1966) found that fluency gave an inter-scorer reliability of over .9 and was correlated about .8 with originality and flexibility (using Form A Verbal of the Torrance Tests of Creative Thinking). Indeed, fluency and originality were clearly inter-related in Christensen, Guilford and Wilson's (1957) theoretical analysis: the more responses an individual gives to a particular divergent-production problem, the lower the probability (*i.e.*, the greater the originality) of his later responses. Hargreaves and Bolton (1972) concluded that "calculation of anything other than Fluency scores adds little information". Moreover, Ward (1971) argued on the basis of his data from three studies of children that "uniqueness is mediated by

fluency", so that clearly the latter is the primary variable for assessment. The writer agrees with the above arguments, and considers that scoring only fluency from divergent thinking tests is justified.

The instructions for the three divergent thinking tests carefully specified the tasks and included examples, so that should inept responses occur, this would not be due to uncertainty as to the requirements for these novel tasks. Instructions for the Uses test included the following: " ... Each object has a common use, which will be stated. Another possible different use will be pointed out also. You are to list other different uses as quickly as you can think of them. Use only short phrases, and make sure that your suggestions are different from one another." Scoring was not simply achieved by counting the total number of responses, as has often been done in previous research. Rather, each response was first checked to ensure that it fulfilled the task requirements. To be counted, a response had to be a "use"; a mere association with the object, such as "Florida Key" as a response to the object "key", was not counted. Moreover, suggested uses had to be different from the examples specified and from the respondent's other suggestions for the same object. When two or more very similar uses were given, only one was counted. With these qualifications, the score was the number of relevant responses. Scoring assistants were employed, and to ensure consistency, any problematic response was referred to the writer. In addition, a complete listing of all responses judged not to be "uses" was maintained for the present and later studies, to act as a scoring-guide. Also listed were any sets of "uses" considered to be "not different from one another" and thus given one point only. The resulting scoring-guide is shown in Appendix 7.1.

Instructions for the Similarities test included the following: " ... The two objects will have an obvious similarity, which will be stated. Another different similarity will be pointed out also. You are to list

other similarities as quickly as you can think of them. Use only short phrases, and make sure that your suggestions are different from one another." The Similarities Test was scored under the same principles as the Uses Test, the number of apt responses being counted. The scoring-guide, showing responses considered not to meet the task requirements, is shown in Appendix 7.2

For the third measure of divergent thinking, Guilford's Controlled Associations Test was used (French, Ekstrom and Price, 1963). This test also was reliable and objective in its scoring. It was used with the standard instructions, and involved four stimulus words in each of its two parts. A published scoring-guide was available, but proved inadequate. A more comprehensive scoring-guide for appropriate and inappropriate responses was compiled, and is shown in Appendix 7.3.

The format of the scoring-guides, with their emphasis on inappropriate responses, may give the false impression that scoring was censorious or that responding was careless. In fact, any response was counted in the score no matter how divergent, so long as it met the task requirements; and only a small proportion of irrelevant or repetitive responses were given.

Each of these three tests had two parts, and 6 minutes were allowed for each part, giving a total of 36 minutes response time for the overall divergent thinking assessment. There was thus a strict time schedule imposed on the subjects. However, Cropley (1972b) reported that originality scores under conditions of "limited time" (up to 10 minutes) and "unlimited time" (in practice, up to 1¼ hours) were moderately correlated ($r = .52$) for Torrance's Circles test, so that time-limits are probably not critical in the assessment of individual differences in divergent thinking. After reviewing the evidence, Hattie (1977) concluded that untimed conditions "are not as satisfactory as timed test-like conditions". Renner (1978, p.339) reached a similar conclusion.

An overall divergent fluency score was calculated from the three tests.

The scores from each test were first standardized, and then added. The total scores were finally converted to a T-score scale, and rounded to the nearest integer.

Barron-Welsh Art Scale

The Art Scale, derived from the Welsh Figure Preference Test, was used to assess preference for complex visual stimuli. The standard booklet was used, with a duplicated response sheet similar to that available for the whole Welsh Test but covering only the items included in the Barron-Welsh Art Scale booklet. It was scored for the Revised Art Scale (R.A.S.), a balanced scale involving 60 items (Welsh, 1959).

Graves Design Judgment Test

The Graves D.J.T. was used as a measure of preference for complex visual stimuli in the specific sense of preference for asymmetrical designs. It was used in the standard form, but as well as being scored in the conventional way (Graves, 1948) a more specific preference for asymmetry (PA) scale was obtained. This was a 72-item scale, using the first 76 "abstract design" items on the Test, excluding Nos. 14, 31, 32 and 68. These four items were excluded because two independent judges were undecided or disagreed as to which of the designs forming each item was the more asymmetrical. For the 72 included items, the score was the number of items for which the more asymmetrical design was preferred. In all but two cases (Items 15 and 76), the direction of scoring for the PA was the same as for the Graves D.J.T. score. The PA scale was "rationally" derived, but it is similar to the preference for asymmetry factor empirically extracted from the test by Eysenck (1967a).

ACER Advanced Test, AL

This test provided a measure of verbal convergent intelligence, and was used to check that the divergent thinking score and any of its correlates

were not an "artifact" of IQ. The test was reasonably suited to the level of intelligence of the sample according to the manual (Australian Council for Educational Research, undated), but a few students obtained the maximum score which produced a truncation at the equivalent IQ value of 135. One subject did not undertake this test and wrote: "Sorry to spoil your results, but I hate IQ tests." He was allotted the mean IQ score for male subjects, although his previous and subsequent academic career suggested that this was an underestimate of his intelligence. Six other subjects had taken the test or a similar one before, although not within the previous eight months. Any practice effect was assumed to be negligible.

Eysenck Personality Inventory, Form A

The N scale of the E.P.I. was used as an indication of sensitivity to internal stimuli of an anxiety-provoking kind, as part of the test of the "openness to divergent stimulation" theory. In addition, the E scale was used because of its possible relationships with divergent thinking ability and aesthetic preferences. The L scale was used as a measure for social desirability response set, although it has but few (9) items.

Edwards Social Desirability Scale

The Edwards (1957)Scale was used in the form of a duplicated questionnaire, without other filler items. It was headed "S.D. Questionnaire", with the instructions: "Read each statement, and decide whether it is true as applied to yourself or false as applied to yourself. If true, write '√' in the square marked T; or if false, write '√' in the square marked F."

Procedure

Tests were administered during two sessions lasting approximately one hour and one-and-a-half hours respectively. Six such pairs of sessions were organised so that groups were small enough to allow close supervision and checking for omissions on response sheets. The final eight subjects had to be tested individually at times to suit their convenience in order

to complete the sample. In most cases the inter-session interval was one week, but owing to timetable problems and illness twelve subjects attended their second session later, after a mean inter-session interval of 9 days.

Easier and more interesting tests were given in the first session so that subjects would be encouraged to attend the second session. In the latter, an untimed questionnaire was used to provide a "break" between the timed intellectual tests. The test order was as follows: (first session) Personal Data Sheet, Graves D.J.T., Pattern Preference Test, Barron-Welsh Art Scale, Self-description Checklist; (second session) E.P.I. Form A, Advanced Test Form AL, Edwards Social Desirability Scale, Uses, Similarities, Controlled Association Test.

In all cases instructions were provided on the test booklet or response sheet, and the main instructions were repeated orally by the writer. Subjects were told the time limits for each timed test. Some care was taken to ensure that students who volunteered did complete all tests. Any response ambiguities (*e.g.*, on the Personal Data Sheet) or item omissions (*e.g.*, on the E.P.I.) were corrected by a "follow-up" with the student. There were thus no "missing data" apart from the one estimated IQ mentioned above.

Data Analysis

The tests were scored by hand, using stencils where appropriate. The main statistical analysis was by means of a local product-moment correlation programme run on the University of Adelaide's CD 6400 computer. Several subsidiary analyses were completed by "hand" calculation, whilst a multiple-correlation analysis was completed using the S.P.S.S. programme (Nie, *et al.*, 1970). The arts-orientation variables were essentially ordinal, and therefore Tau values were calculated as a check on the r values for relationships involving these variables.

With regard to tests of significance, when specific directional hypotheses derived from previous research were under examination, one-tailed tests were applied; when the effects of variables like age and sex were under examination or when *ad hoc* features of the data were noted, two-tailed tests were

applied.

Results

Preliminary examination for the consistency of measures

Those tests used in the study which have a standard printed format are highly reliable, according to their respective manuals. However, other measures were obtained of a more "experimental" kind, and evidence of their reliability was sought. In particular, the degree of generalisation across items or subscales, or across tests intended to reflect similar constructs was obtained.

With regard to fluency of divergent production, the three tests each consisted of two items, and "split-half" reliability coefficients were calculated. Values are given in Table 7.2, together with estimates of whole-test reliability using the Spearman-Brown formula. Each test gave a corrected reliability coefficient greater than .8 for males and for females. Moreover, the three tests showed a satisfactory degree of external consistency, with inter-test correlations between .43 and .69 (see Table 7.3). Thus individual differences in fluency scores for the three tasks were sufficiently inter-related to justify the summation of the three (standardized) test scores to form an overall "divergent thinking" variable.

Fluency scores were positively skewed, as has usually been found; this is illustrated for the Uses Test in Figure 7.3. However, no normalising transformation was applied, in order that derived statistics would reflect the raw data as closely as possible, and because Havlicek and Peterson (1976) have reported that "r is insensitive to rather extreme violations of the basic assumptions of normality and type of measurement scale". Moreover, combining the three test scores helped to normalise the distribution.

It was important to check the coherence of the Creative Independence and Emotional Activation scales from the Self-description Checklist, since these were rationally formulated measures which had not previously been used.

The Alpha coefficient was calculated over all subjects, using the Kuder-Richardson Formula 20: for Creative Independence, Alpha was .65; and for Emotional Activation, Alpha was .57. Similar Alpha values were subsequently obtained with two further independent groups: .66 and .59 respectively with 70 adult-education students tested by the writer; and .65 and .63 respectively with 211 South Australian Institute of Technology students tested by Rigby (1975, p.128-130). These values indicated moderate reliability for the scales. Higher values could have been obtained by empirical selection of adjectives, but this might have unduly narrowed the conceptual range intended for the scales.

Internal consistency for the Checklist might have been higher were it not for the formation of balanced scales, since any acquiescence response set in ticking adjectives would have reduced the consistency between items scored for checking and those scored for not checking. The split-half reliabilities using the two types of item to form subscales, were as follows, when the Spearman-Brown correction was included. For the Creative Independence scale, the split-half reliability was .53 ($p < .01$) for males and .62 ($p < .01$) for females, which indicates a satisfactory degree of consistency between the two types of item, for research purposes. For the Emotional Activation scale, however, the split-half reliability was only .17 and .33 for males and females respectively, so that this scale must be regarded as having little consistency between the two types of item incorporated within it.

With regard to "social desirability" responding, one would expect a positive correlation between the Edwards Social Desirability scale and the L scale from the E.P.I. Both scales reflect the tendency to answer in the "approved" direction, but items on the L scale are more "extreme". Because of this, the average proportion of answers in the socially desirable direction was only 21% for the L items compared with 78% for the Edwards

Table 7.2. Split-half correlations for three divergent thinking tests

(Each test consists of two items. Whole-test reliabilities using the Spearman-Brown correction are given in brackets)

	N	Associations	Uses	Similarities
Males	50	.77 (.87)	.85 (.92)	.69 (.81)
Females	50	.69 (.82)	.77 (.87)	.78 (.87)

Notes: 1. All values are significant, with $p < .01$, one tailed tests.

2. The apparent slight discrepancies with the corrected reliabilities arise from their calculation using accurate r values to four decimal places, rather than the rounded values shown.

Table 7.3. Correlations amongst three divergent thinking tests

(For 50 males, upper-right segment; for 50 females, lower-left segment)

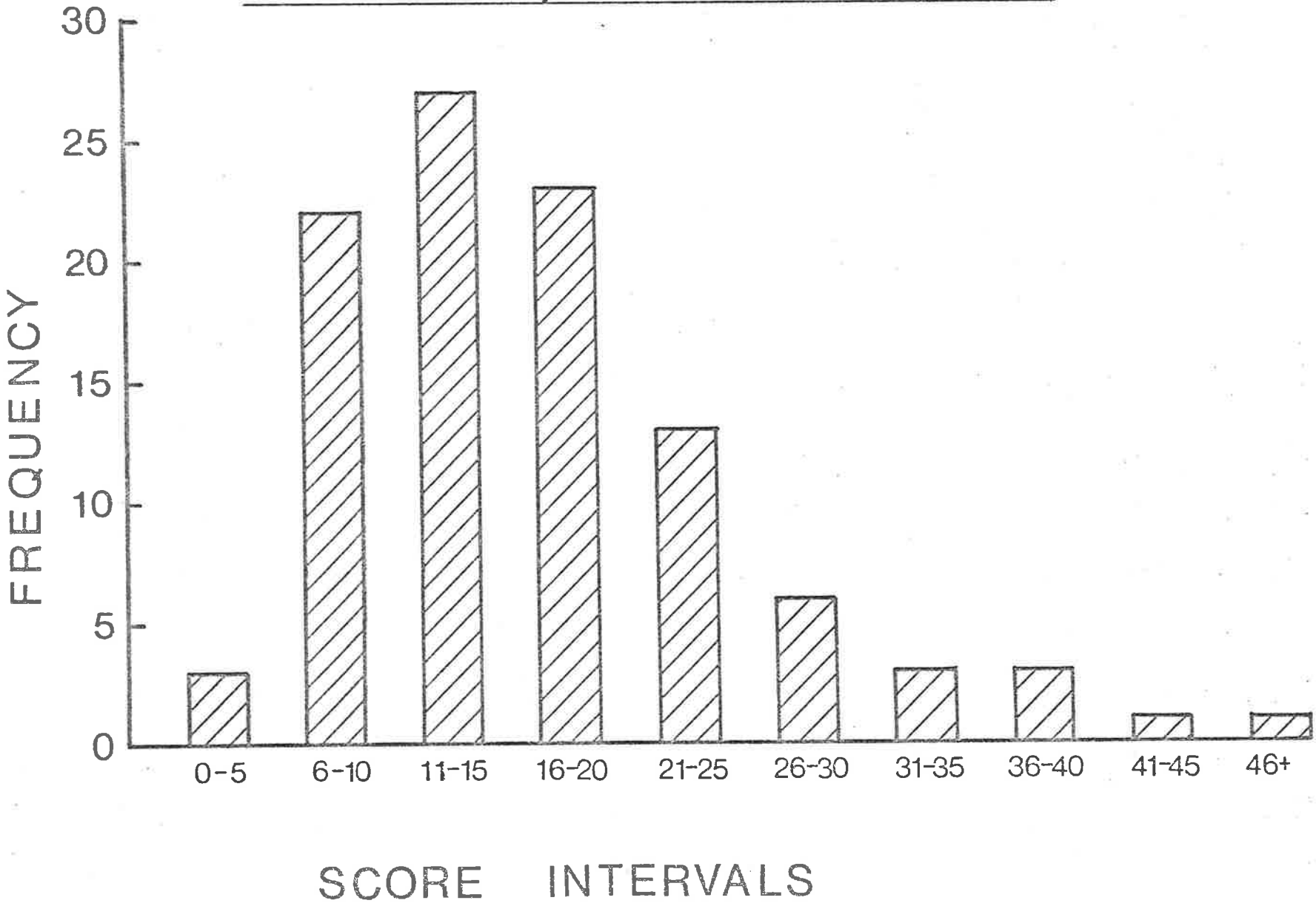
	Associations	Uses	Similarities
Associations		.52	.43
Uses	.47		.64
Similarities	.63	.69	

Notes: 1. All values are significant, with $p < .01$, one-tailed tests.

2. In a subsequent study by the writer of two independent groups of University of Adelaide students (males and females combined), taking Psychology I in a different year from the main correlational study, the correlations between Uses and Similarities were .65 ($N = 124$, $p < .01$) and .75 ($N = 117$, $p < .01$), supporting the tabulated findings.

Figure 7.3

Distribution of fluency scores on the Uses Test (N=100)



items, in the present sample. Thus, one would expect a significant correlation between the two scales, but not a large one owing to the very different types of item involved. In fact the obtained correlation was .25 over the 100 *Ss* ($p < .01$). The two measures were therefore not very similar, even though both reflect social desirability responding to some degree. It is likely that the L scale is more appropriate for detecting high-scoring dissemblers rather than normal variation in social desirability responding.

Although an examination of test-retest reliability was not part of the experimental design, the temporal stability of the Edwards scale could be checked for 82 subjects in the sample, in a partial manner. These subjects had been given 23 of the 39 scale items six months prior to the study, embedded amongst other items in a questionnaire given for another purpose. The stability coefficient for the whole scale, estimated from the test-retest correlation for the 23 items adjusted by the Spearman-Brown formula, was .80 ($N = 82$, $p < .01$). This high value is consistent with the reliability coefficient of .83 reported by Edwards (1957, p.31).

The experimental scale devised to measure preference for multiplicity of elements in designs (PM) was provided with equivalent subscales of symmetrical and asymmetrical items. Do individual differences in PM generalise over the two types of item? Despite the basic nature of this question, no findings have previously been reported specifically to answer the question. The obtained split-half reliability, using the Spearman-Brown correction, was .84 for males and .78 for females. In view of the wide range of types of design included in the test, its reliability is very satisfactory. It is emphasized that although people who prefer multiplicity of elements in symmetrical designs are also likely to prefer multiplicity in asymmetrical designs, it does not follow that there is any correlation between PM and preference for asymmetry itself. This important point may

be expounded by means of a sporting analogy. Suppose each sportsman is highly consistent in the degree to which he prefers to bat rather than to bowl, whether playing cricket or baseball. This consistency would not imply any correlation between liking to bat and preference for cricket.

In summary, fluency of divergent production, creative independence, social desirability, and preference for multiplicity were assessed with a high degree of reliability. The Emotional Activation scale was of doubtful consistency in that responses to the "positive" and to the "negative" items on the scale were only slightly related. Other variables were known to have high reliability from information provided in the relevant test manuals.

Examination of the "Openness to divergent stimulation" theory

With the ready availability of computers, it has become conventional to analyse correlation matrices by complex methods such as factor analysis. This was not done with the present data for two reasons: no single "dimension" was postulated by the theory under examination, because specific correlations between distinct constructs were hypothesized; moreover, examination of the correlation matrix contra-indicated any general factor analysis since there were many small nonsignificant values, together with coherent patterns of easily-interpreted significant values. The writer holds the view that the factor-analytic model should be chosen when it is appropriate for testing a particular hypothesis. In other *ad hoc* cases when there are many small correlations in the matrix, the conversion of correlations to "common factor loadings" may be misleading (Comrey, 1973, p.209-211 and 225).

A second statistical consideration was whether any special precaution was required against Type I errors in view of the several tests being conducted. The study did not employ a large number of variables in a "shot-gun" approach, and indeed correlations were used to test specific hypotheses. Each correlation might be regarded as a datum from a sub-

experiment in the sense discussed by Fisher (1951, pp.202-203). For this reason, each correlation was tested for significance in the normal way, with no special protection for the overall Type I error rate. As an additional check on the reliability of the main findings, relevant correlations were calculated for males and females separately as well as for the total sample.

The correlations with the total divergent thinking score that are relevant to the "openness to divergent stimulation" theory are presented in Table 7.4 The results generally disconfirmed the experimental hypotheses based on the theory. In most cases the correlations were not significant, and were near zero. The only exception was in the case of the Creative Independence scale, which gave a correlation over all subjects of .26 ($p < .01$) with the total divergent thinking score. Whilst this result was consistent with Barron's theory, the other nonsignificant correlations suggest a more restricted interpretation. The result was interpreted as a validation of the scale, and as showing that divergent thinking ability is one of the personality characteristics leading to a "divergent" self-assessment.

Given the previous empirical and theoretical support for the "openness to stimulation" theory, it is relevant to consider why its predictions might have generally failed in the present experiment. It was not that the measures were unreliable, since most have been found satisfactory in this respect. The sample may have been somewhat homogeneous, but variation in performance on the divergent thinking tests was sufficiently wide: for example, on the Uses test the standard deviation was 8.5 around a mean number of responses of 16.9. Moreover, the measures were sufficiently discriminating, since several significant and meaningful correlations did occur, as described below. Failure to confirm the "openness to stimulation" theory cannot be explained by any bias of the writer, since some confirmation of the theory had been expected.

Table 7.4. Pearson's correlations with divergent thinking to test the "openness to divergent stimulation" theory

(The theory predicted that each correlation would be positive)

Variables	Divergent thinking correlations		
	Males (N = 50)	Females (N = 50)	All Ss (N = 100)
Self-perceived divergence:			
Creative Independence	.25*	.28*	.26#
Sensitivity to internal stimuli:			
Emotional Activation	.03	-.01	.00
Neuroticism	-.04	.17	.05
Preference for complex visual stimuli:			
Barron-Welsh R.A.S.	.08	-.03	.04
Preference for asymmetry	-.06	-.14	-.10
Preference for multiplicity	-.01	-.24	-.09

# $p < .01$ * $p < .05$ (one-tailed tests)

Much of the research at the University of California Institute of Personality Assessment and Research which suggested the theory has been based on extreme groups, such as America's most creative writers, architects, and so on; findings therefrom may not be generalisable to "normal" groups. Much of the previous research has been based also on the use of many variables, such as hundreds of check-list adjectives treated as separate variables, and many *ad hoc* items used in Q-sorts. Cross-validation of results derived from such "shot-gun" methods has generally not been undertaken. For example, Gough (1961) reported that the creativity of 45 research scientists might be very accurately "predicted" from personality variables, with a multiple correlation as high as .96, using the 19 best predictor variables from the 57 available. However, such a result cannot be taken at face value for the reason described below.

When the number of predictors (q) is large, the sample multiple correlation (R) is a biased estimate of the true value R^1. Indeed, even if $R^1 = 0$, the sample R will approach unity when the value of q approaches the value of N, the number of subjects. From the formula given by Bock (1975, p.380, formula 6.1-12), the following relationship may be deduced. If $R^1 = 0$ and $N > q$, the chance expectation for the sampled multiple correlation is approximately given by: R (expected) $= \sqrt{[(q-1)/(N-1)]}$. Thus as q approaches N, the numerator and divisor of the equation approach equality and the sample R approaches unity, even though the population value is zero. When the number of variables is equal to or greater than the number of subjects, it is impossible to obtain an unbiased estimate of the true multiple correlation value. Under these circumstances, Gough's findings could be regarded as substantial only if his multiple regression equation were shown to give successful predictions on cross-validation.

Examination of divergent thinking and arts-sciences orientation

If there is a broad tendency to be oriented towards the sciences or oriented towards the arts, as envisaged by many writers (*e.g.* Snow, 1964), the artistic interest, education and achievement scales should be inter-related even though they measure distinct constructs. Indeed, some degree of inter-relationship is implied by the nature of the scales, in that a person who had exhibited a painting and thereby gained a high score on artistic achievement would necessarily have been highly interested in art at some time in his life, and probably would retain that interest.

The obtained correlations amongst the arts-orientation variables are shown in Table 7.5. In terms of the total sample, five of the six positive correlations were significant. The highest correlation was between fine-arts education and arts faculty: the two variables had no self-evident connection in that the University included no fine-arts or history of visual arts courses in the Faculty of Arts curriculum. Although the correlations were sufficient to justify the concept of differential orientation towards the arts amongst students, the obtained values were small and required the retention of separate variables in further analyses. It should be noted that the artistic achievement variable had an "L-shaped" distribution, with 88% of subjects scoring zero, so that its possible correlations with other variables might thereby have been restricted. However, any such restriction would be marked only if the other variable were skewed in the opposite direction and the potential correlation were high (McNemar, 1969, pp.186-7). The similarity of Tau values to the Pearson's r values (see Table 7.5) provided further assurance on this point.

The correlations between the arts-orientation variables and divergent fluency are shown in Table 7.6. All correlations were positive, and the four values for the total sample were significant. The result most cogently in line with Hudson's (1966a) finding was the correlation of .26

Table 7.5. Pearson's and Kendall's correlations amongst four arts-orientation variables

Pairs of variables	Males: 50		Females: 50		All Ss:100	
	r	τ	r	τ	r	τ
Fine-arts education, Interest in the arts	.22	.17*	.15	.16	.20*	.19#
Fine-arts education, Artistic achievement	.32*	.26#	.21	.23#	.21*	.22#
Fine-arts education, Arts faculty	.31*	.26#	.41#	.39#	.36#	.33#
Interest in the arts, Artistic achievement	.31*	.23#	.36#	.36#	.31#	.32#
Interest in the arts, Arts faculty	-.02	-.00	.17	.18*	.09	.10
Artistic achievement, Arts faculty	.10	.10	.26*	.27#	.21*	.22#

# $p < .01$ * $p < .05$ (one-tailed tests)

Table 7.6. Pearson's and Kendall's correlations between divergent fluency and arts-orientation variables

(From Hudson's research, it was predicted that the correlations would be positive)

Variables	Divergent fluency correlations					
	Males : 50		Females : 50		All Ss : 50	
	r	τ	r	τ	r	τ
Fine-arts education	.47#	.28#	.13	.12	.30#	.21#
Interest in the arts	.42#	.30#	.15	.14	.28#	.22#
Artistic achievement	.23	.18*	.32*	.20*	.21*	.15#
Arts faculty	.27*	.25#	.28*	.23#	.26#	.24#

# $p < .01$ * $p < .05$ (one-tailed tests)

Table 7.7. Stepwise multiple regression of divergent thinking on standardized age and arts-orientation variables

Multiple correlation = .43 ($F_{5,94} = 4.32$, $p < .01$)

	"Predictor" variables				
	Age	Interest in arts	Fine-arts education	Arts faculty	Artistic achievement
β-weights (standardized variables) :	.16	.21	.14	.12	.11
Significance on entry to the equation: F=	4.23	9.20	4.01	2.00	1.18
Significance on entry to the equation: p<	.05	.01	.05	N.S.	N.S.

between arts faculty and divergent fluency, a relationship which was about equally evident amongst individuals of either sex.

Over all subjects, the strongest correlate of divergent thinking was fine-arts education. Despite this, the relationship was not significant for females separately. The correlation (r) of .13 for females was not significantly lower than the correlation of .47 for males (using the usual method of conversion to Fisher's Zeta, $p = .07$, two-tailed test). Although the sexes were not significantly different, it is legitimate to speculate as to why the correlation might be relatively low for females. Possibly taking fine-arts courses at high-school and thereafter is regarded as a more conventional activity for girls than for boys, and is not strongly associated with any divergent ability or imaginative flair. The most prominent feature of Table 7.6 is the consistent pattern of positive correlations (whether indexed by r or by Tau) for both sexes between divergent thinking and the four arts-orientation variables. At this point it is worth reiterating that there was an interval of about one week between the assessment of arts-orientation and divergent thinking ability.

It was envisaged above that divergent fluency might be related to age. In fact, the subject's age had a small positive correlation with the divergent thinking score that was significant for the total sample ($r = .20$, $p < .05$, two tailed test). Older subjects also tended to have had a longer period of fine-arts education ($r = .29$, $p < .01$, two-tailed test). The partial correlation between divergent thinking and fine-arts education with age controlled was .25 ($t = 2.57$, 97 d.f., $p < .01$). The partial correlation between divergent thinking and arts faculty with age controlled was .21 ($t = 2.17$, 97 d.f., $p < .05$). Thus these relationships remained significant after removal of the effect of age.

In addition to the basic correlations described above, the multiple correlation between arts-orientation variables and divergent thinking was

found. Fluency of divergent thinking acted as the criterion, whilst the arts-orientation variables served as "predictors"; in addition, the effect of age was controlled by entering it first in the multiple regression equation. The size of the multiple correlation was relevant, to show the overall degree of relationship between fluency and orientation towards the arts. Moreover, the partial regression coefficients from the equation for standardized variables were also informative, as indicators of the strength of relationships independent of the other effects.

The results of this analysis are shown in Table 7.7. The overall multiple correlation with five predictor variables was .43 ($p < .01$). The variable making the largest independent contribution to the relationship was interest in the arts, with a β-weight for the standardized variable of .21 ($p < .01$). The next variable was fine-arts education, with a β-weight of .14 ($p < .05$), although each of the variables other than interest in the arts made a similar contribution to the equation. It would appear from this analysis that divergent thinking ability is related at least as closely to general interest in fine arts as to education in the humanities which has been stressed by Hudson.

IQ was not included in the multiple regression analysis, since it had a negligible correlation with divergent thinking: $r = -.01$ for the total sample. As noted in chapter 5, independence of divergent ideational fluency and convergent intelligence is usually found in university groups or other high IQ samples. The present sample had a mean IQ well above the general average (see Table 7.10).

Arts-orientation variables were little related to IQ, although there was a significant *negative* correlation in the case of fine-arts education ($r = -.22$, $p < .05$, two-tailed test). This result was consistent with Hudson's hypothesis that convergers tend to select a scientific education rather than an education in arts.

The relatively small role played by IQ in accounting for differences between individuals within the present sample was the reason for not utilising IQ in any "divergent/convergent bias" score as did Hudson in his studies of British schoolboys. It was also considered to be unnecessary to include an intelligence test in subsequent studies reported in this Part.

Creative Independence, divergent thinking, and arts orientation

From Hudson's account of his "divergers", they not only lean towards arts and away from science, but also have a self-image which incorporates *inter alia* the domain of creative independence. It was predicted therefore that the Creative Independence scale would correlate positively with both divergent thinking and with the arts-orientation variables. The relevant data are shown in Table 7.8.

Creative Independence correlated significantly with fluency of divergent production and with interest in the arts, but not with fine-arts education, artistic achievement or arts faculty. As with other relationships, the results were similar for r and Tau indices. It was suggested above that the correlation of Creative Independence with divergent fluency indicated that the latter was one of the personality characteristics associated with a divergent self-assessment. It is relevant to note that Rigby (1975) found a strong negative linear relationship between Creative Independence and "favourable attitude to authority". It seems therefore that the Creative Independence scale reflects a fairly broad area of personality concerned with social independence and unconventionality, which to some degree overlaps with divergent thinking ability and artistic interests. Unlike divergent thinking, however, it is not clearly related to such performance variables as artistic achievement. It may be appropriate to distinguish between divergent thinking ability and divergent self-assessment, with the development of the latter being only partly influenced by the former. A similar

distinction was made by Kelly (1979), following his factor analysis of divergent thinking tests, divergent attitude scales, and moral and religious variables.

Aesthetic preference tests and their correlates

The results have been discussed so far mainly in relation to particular hypotheses concerning the correlates of divergent thinking or divergent self-assessment. The importance of the arts-orientation variables has been stressed. The relationships with aesthetic preference tests are also of central interest. As well as the conventional score for the Graves D.J.T., the more specific PA scale was obtained. However, the PA and D.J.T. scores were highly correlated, with r = .97. It was concluded that the Graves Test largely reflected preference for symmetry. Because of the high correlation between the two variables, it is unnecessary to present results for the special scale in addition to those for the conventional D.J.T.

With regard to relationships between the Art Tests, an important finding was the independence of the Graves D.J.T. (reflecting preference for asymmetry) and the P.P.T. (reflecting preference for multiplicity): r =-0.03, not significantly different from zero. This result confirmed the similar one obtained in an earlier experiment (Rump, 1968a). The independence of these two aspects of preference for complexity in designs showed the value of their separate measurement in the present study. Furthermore, the arguments presented in chapter 2 for the separate analyses of the two concepts were supported. Finally, the separation of the concepts in the analyses of the Welsh data (in chapter 4) and the Berlyne data (in chapter 3) was further justified by the present finding.

In view of the mixed nature of the R.A.S. (Moyles, Tuddenham and Block, 1965; Rump, 1968a), positive correlations were expected with both the Graves D.J.T. and the PM scale. The obtained correlations were significant,

Table 7.8. Pearson's and Kendall's correlations between Creative Independence, divergent fluency and arts-orientation variables

(From Hudson's research, it was predicted that the correlations would be positive)

Variables	Creative Independence correlations					
	Males : 50		Females : 50		All Ss : 100	
	r	τ	r	τ	r	τ
Divergent fluency	.25*	(.17*)	.28*	(.19*)	.26#	(.18#)
Fine-arts education	.12	(.10)	-.06	(-.01)	.03	(.04)
Interest in the arts	.42#	(.40#)	.25*	(.17*)	.33#	(.29#)
Artistic achievement	.16	(.16)	.12	(.09)	.09	(.08)
Arts faculty	-.01	(-.03)	-.12	(-.14)	-.06	(-.08)

# $p < .01$ * $p < .05$ (one-tailed tests)

Table 7.9. Pearson's and Kendall's correlations of aesthetic preference tests with arts-orientation variables and with Creative Independence

(From miscellaneous previous research on the validity of such tests, it was predicted that correlations would be positive)

Variables	Aesthetic preference tests					
	Graves D.J.T.		Barron-Welsh R.A.S.		Rump P.P.T.	
	r	τ	r	τ	r	τ
Fine-arts education	.14	(.09)	-.06	(-.05)	.01	(.02)
Interest in the arts	.28#	(.23#)	.24#	(.17#)	-.04	(-.01)
Artistic achievement	.10	(.13)	-.17	(-.10)	-.08	(-.06)
Arts faculty	.14	(.10)	-.02	(.03)	.00	(.00)
Creative Independence	.09	(.05)	.20*	(.12*)	.03	(.03)

# $p < .01$ * $p < .05$ (one-tailed tests)

but low; $r = .27$ ($p < .01$, one-tailed test) and $r = .19$ ($p < .05$, one-tailed test) respectively. These data support the idea that the R.A.S. reflects preference for various aspects of figural complexity, but that it does not measure preference for any particular aspect in a precise manner. It may be noted that Lane (1970) reported that R.A.S. scores showed little consistency with preference for multiplcity socres assessed using random polygons varying in number of turns.

The correlations between art tests and other variables were also informative. Their generally low values were surprising in view of reports as to the tests' validities and (in the case of the R.A.S.) broad application. None of the three tests was significantly correlated with divergent thinking, and indeed the correlations were consistently close to zero (see Table 7.4). Hare and Gaier (1971) similarly found nonsignificant correlations between the Barron-Welsh Art Scale and a divergent production test ("Making Objects") with three student groups; however, their samples were very small.

The preference for multiplicity scale, although internally consistent, had no significant correlation with any other variable in the analysis, other than its low correlation with the R.A.S. The absence of relationships between preference for multiplicity and other personality characteristics was also reported in an earlier study by the writer (1968b, Experiment III).

It would seem that preference for multiplicity of elements in designs is not the central personality dimension that some reports have presaged. It is emphasized that none of the previous reports specifically included the measurement of preference for multiplicity over a range of types of designs. For example, Dorfman and McKenna (1966) used only random matrix patterns, and reported that a higher proportion of art students (28%) preferred a pattern with most cells compared with non-art students (14%); however, the difference was not significant by Fisher's exact method ($p > .05$, writer's calculation). As noted above, the R.A.S. is influenced

by preference for asymmetry, which might therefore be responsible for some of its previously reported relationships, rather than preference for multiplicity.

Even though the Graves D,J,T, and Barron-Welsh R.A.S. were not related to divergent thinking, evidence of their validity with respect to education and achievement in fine arts was expected. However, as Table 7.9 shows, the only arts-orientation variable that correlated significantly with the two tests was interest in the arts. The R.A.S. was also significantly correlated with Creative Independence, so that these two variables and interest in the arts formed an interconnected trio. On the other hand, the D.J.T. was slightly more satisfactory in its claimed role as an indicator of aesthetic judgement, in the sense that it had consistently positive correlations with the art-orientation variables, which was not the case with the R.A.S. (see Table 7.9). The question of the validity of these two art tests is further explored in the following chapter. It was hypothesized that significant validity coefficients might be obtained with more heterogeneous subject samples, and chapter 8 records the results obtained with such samples.

Although individual differences are the centre of interest in this chapter, the opportunity may be taken to examine a particular feature of aesthetic preferences for the group as a whole, stemming from the use of parallel symmetrical and asymmetrical halves for the P.P.T. For each item within either subscale, four patterns of varied numbers of elements were viewed. For convenience, the "multiplicity of elements" dimension is here referred to as "complexity". It was expected that the complexity level of the most liked design from symmetrical patterns would be greater than the complexity level of the most liked design from asymmetrical patterns. This expectation was derived from the notion of the inverted-U curve for informational preferences (discussed in chapter 2), in that the typical subject would maximally prefer an asymmetrical design of some intermediate complexity level;

and when choosing from symmetrical designs, he would maximally prefer one of greater complexity, to compensate for the reduction of information arising from the constraint redundancy of the symmetrical patterns (Munsinger and Kessen, 1964). The expectation was also consistent with the notion of optimal arousal, in that more stimulating complex patterns would be required to compensate for the lower "collative stimulus property" in the case of symmetrical patterns (Berlyne, 1965). Moreover, consideration of aesthetic principles led to the same conclusion, in the sense that it was reasonable to claim that very complex designs have a greater "need" of organisation for their aesthetic appreciation.

Thus, various explanations were conceivable for the predicted phenomenon that the mean PM subscale score for asymmetrical items would be lower than that for symmetrical items. In fact the two values were 19.41 and 22.46 respectively. The mean difference of 3.05 was tested for significance by calculating the difference-score for each subject, and applying a single-sample test against the null hypothesis value of zero: $t = 8.18$, 99 d.f., $p < .01$. (Only 18% of subjects gave difference-scores in the non-predicted direction.) These results are particularly interesting because they are incompatible with Eysenck's (1942) aesthetic formula, which implies that the most complex design should be most preferred for both symmetrical and asymmetrical types; the formula would thus lead to the false prediction that both sub-scale scores would be near the maximum of 32. Similarly the results are contrary to Birkhoff's formula (1933, p.13), which implies that (with "order" controlled) the *least* complex should be most aesthetically pleasing; this would lead to the false prediction that both PM subscale scores would be near the minimum possible score of 8. Clearly the results obtained were incompatible with either of these formulations

Certain features of the art tests may be illustrated by means of written comments volunteered by subjects. It was recognised by some that

the Pattern Preference Test was concerned with multiplicity of parts. This led a few subjects to state their personal attitude to this aspect of designs: *e.g.*, "I am not keen on cluttered-up designs". Others recognised the operation of competing aesthetic principles, of the kind discussed in chapter 2: *e.g.*, "Throughout these tests there is a conflict between choices on the basis of (1) good design lying to some extent in simplicity, and (2) designs being so simple as to be unimaginative and uninteresting:. For some, reactions depended on the position of the item in the series: *e.g.*, "At the beginning (about items 1 to 8) the more complex ones were interesting (with better spatial use), but later they became a little overbearing". In general the P.P.T was regarded as more problematic than the Graves D.J.T., but this may simply have been due to the need to scrutinize four designs within each item as compared with only two or three in the Graves Test.

Several subjects noted the major theme of the Graves Test: *e.g.*, "a definite series of balance to unbalance"; "I enjoyed ... those which tended towards geometrical symmetry"; and "I seemed to prefer designs which are more evenly spaced (symmetrical) in the squares". Such recognition of the theme did not necessarily lead to a stereotyped response: *e.g.*, "I have not always chosen all those in a particular group, for various reasons". Even if a consistent response strategy were adopted, it might be aesthetically sophisticated, *e.g.*, "Most of my choices were based on whether or not a design gave me a feeling of comfort, balance and solidity. Some of the designs were chosen because of the vitality and definable aim they seemed to have. Also a choice was easy to make when the design seemed fulfilled - that is, seemed to have a purpose to disappear within itself, seemed inwardly bending, or seemed to explode outwards purposely."

These quotations are given partly to demonstrate that although the art tests appeared to have low concurrent validity assessed against external

variables, they did succeed in generating individual aesthetic response styles, and were undertaken with care by the participants.

Social desirability responding

None of the art-orientation, divergence, or aesthetic preference variables was significantly affected by social desirability response set, in terms of correlations with the Edwards SD scale or the E.P.I. L scale. However, the N scale from the E.P.I. was strongly affected, in that those subjects who responded in the socially desirable direction tended to obtain low N scores: $r = -.79$ ($p < .01$, one-tailed test). A one-tailed test was justified in the case of the N scale, since Edwards (1966) has shown the influence of social desirability responding on many psychopathological scales. The L scale was also correlated with N : $r = -.25$ ($p < .01$, one-tailed test).

The E scale was significantly correlated with the L scale: $r = -.25$ ($p < .05$, two-tailed test). However, this relationship was confined to females, for whom the correlation was $-.40$ ($p < .01$), whilst no significant relationship was evident for males separately ($r = -.05$). The effect of social desirability on the E scale must be considered doubtful, since no significant correlation was found with the Edwards SD scale itself ($r = .18$, not significant, two-tailed test).

The Edwards SD scale was significantly correlated with two other variables, IQ ($r = -.24$, $p < .05$, two-tailed test), and Emotional Activation ($r = -.26$, $p < .01$, two-tailed test). The relationship with IQ was unexpected, and perhaps suggests that the more intelligent person sees less need to dissemble when participating in personality research compared with less intelligent subjects. The relationship with Emotional Activation is discussed in the following section in the context of other findings with that scale.

The influence of social desirability responding on E.P.I. scales contradicted the assertion in the manual that social-desirability responding

"has not been found to play an important part under ordinary conditions" (Eysenck and Eysenck, 1964). Although this topic was of peripheral relevance to the present thesis, the findings were of sufficient interest to justify further investigation. This proceeded along two lines: additional student groups were tested, using the Crowne-Marlowe D scale for assessing social desirability responding, in order to overcome the criticism that the Edwards scale overlapped with psychopathological scales in its item content (Crowne and Marlowe, 1960); and data supplied by John Court for clinical groups were analysed to determine social desirability effects in a practical context. The results of that research have been published (Rump and Court, 1971), with the present sample of 100 students being included as "Group 1" in that report.

For the purpose of this thesis, it is sufficient to remark that since the publication of the 1971 paper, the effect of social desirability on the N scale has been replicated (Stanley, 1973). Moreover, a similar negative correlation between the L and N scales has been observed with the junior version of the test (the J.E.P.I.) given to three groups of grammar-school, technical-grammar, and comprehensive-school pupils by Finlayson (1972).

The Emotional Activation scale and its correlates

Since the Emotional Activation scale was devised for the present study, its validity requires further consideration even though the scale failed to correlate significantly with divergent thinking. The scale was intended to assess emotional sensitivity, but without any direct reference to mal-adjustment. It was therefore expected to have some overlap with the emotionality associated with the N scale, and also possibly with the impulsivity associated with the E scale from the E.P.I. Thus positive correlations with both N and E scales were expected, and these were obtained with values of .32 and .39 respectively ($p < .01$, two-tailed tests). Although the Emotional Activation scale may reflect general emotionality

in the way intended, it must be admitted that such a factorially mixed concept might be confusing rather than clarifying. However, "extraversion" itself appears to suffer from the same ailment (Eysenck and Eysenck, 1963; Howarth and Browne, 1972). Indeed the apparently well-defined concept of "impulsivity" may be multifactorial (Eysenck and Eysenck, 1977).

A further problem in the case of the Emotional Activation scale was the influence of social desirability responding, in that there was a negative correlation with the Edwards scale ($r = -.26$, $p < .01$, two-tailed test). Because of the doubtful internal coherence of the Emotional Activation scale, and the influence of social desirability responding, little weight was attached to the scale in subsequent studies. The Self-description Checklist was still useful because of its other scale, Creative Independence.

Mean scores compared with test norms

Mean scores for the sample are compared with "normative" data in Table 7.10. The high IQ of the sample has already been mentioned, and was expected in view of the selection criterion applied to University of Adelaide applicants (Otto, 1974). The students scored higher on extraversion and lower on the lie scale of the E.P.I. than the English student norms, but neither of these characteristics has been consistently found with Australian student samples (Rump and Court, 1971). Koller and Castanos (1969) reported that English students were more neurotic than Australian students, but this was not confirmed by the present study. Social desirability responding was higher than for U.S.A. students tested by Edwards (1957), but lower than for those tested by Crowne and Marlowe (1960).

The only deviations from test norms of theoretical interest were with respect to the two art tests. The students scored well above U.S.A. (non-arts) students on the Graves D.J.T., and obtained almost double the score of U.S.A. "people-in-general" on the Barron-Welsh R.A.S. According to the test manuals, the sample was therefore probably gifted artistically

and creatively. This proposition was unlikely to be true in view of the method of selecting the sample, and some other explanation of the deviation from the norms was sought. However, a replication of the finding was also required, and the matter formed part of the investigation reported in chapter 8. It may be noted that Welsh (1975, p.210) has recognized that the R.A.S. norm is too low, and has commented that mean scores "seem to have risen to the 25-30 level" in recent studies.

Comparisons between the sexes

Males scored significantly lower on the N scale than females, as shown in Table 7.10. This difference was similar to that reported in the E.P.I. manual (Eysenck and Eysenck, 1964). It was supported by a similar difference on the related Emotional Activation scale, also shown in Table 7.10.

Of equal interest were the many instances when no significant difference between the sexes occurred, despite the occasional reports of such differences in the literature. Mean scores for males and females on divergent thinking were almost identical, supporting the findings of Wallach and Kogan (1965a) and Hargreaves (1977). Similarly, there were no significant sex differences for the Graves D.J.T. and the Barron-Welsh R.A.S. Because of these findings, it was not considered necessary to balance the sexes exactly in the follow-up studies reported in the remainder of this Part.

In the case of the arts-orientation variables, one difference was significant with more females reporting artistic achievements, giving them a mean score of .46 compared with .02 for males. Because of the highly skewed distribution for this scale, a nonparametric test of significance was employed: using Fisher's exact test with the scale reduced to "some artistic achievement" versus "no artistic achievement", the difference was significant ($p < .01$). Although the other arts-orientation variables gave nonsignificant differences, they were consistently in the direction of females gaining higher (*i.e.* arts-oriented) scores. The tendency for more

Table 7.10. Means, and standard deviations in brackets, for the present study and for available normative groups

Variable	Both Sexes Ref.	Norm	Study	Significance of diff. from the norm	Males (N=50)	Females (N=50)	Signif. of the sex diff.
IQ	A	100.00 (15.00)	125.37 (8.39)	.01	125.68 (8.00)	125.08 (8.84)	N.S.
E (E.P.I.)	B	11.09 (4.54)	12.44 (4.13)	.01	12.64 (3.60)	12.24 (4.63)	N.S.
N (E.P.I.)	B	10.01 (5.01)	9.82 (4.64)	N.S.	8.70 (3.96)	10.94 (5.03)	.05
L (E.P.I.)	C	2.26 (1.57)	1.89 (1.54)	.05	1.92 (1.52)	1.86 (1.58)	N.S.
Soc. Des.	D	27.76 (6.5)	30.42 (5.55)	.01	31.48 (4.66)	29.36 (6.18)	N.S.
Soc. Des.	E	31.83 (5.06)	30.42 (5.55)	.01			
D.J.T.	F	49.40 (14.42)	61.10 (11.13)	.01	60.50 (10.42)	61.70 (11.88)	N.S.
R.A.S.	G	18.33 (11.84)	33.15 (12.10)	.01	35.44 (12.16)	30.86 (11.71)	N.S.
Div. Fluency		-	49.92 (10.04)	-	50.49 (10.57)	49.36 (9.54)	N.S.
CI		-	10.52 (3.20)	-	10.56 (3.18)	10.48 (3.25)	N.S.
EA		-	9.00 (2.94)	-	8.28 (2.72)	9.72 (3.00)	.05

References for the normative comparisons:

A. A.C.E.R., undated: Australian students .

B. Eysenck & Eysenck, 1964: English students.

C. Eysenck & Eysenck, 1964: English "normals".

D. Edwards, 1957: U.S.A. students.

E. Crowne & Marlowe, 1960: U.S.A. students.

F. Graves, 1948: U.S.A. students.

G. Welsh, 1959: U.S.A. people.

girls to be interested in the arts and more boys to be interested in sciences is a familiar one, at least in Australian, British and North American experience. For instance in Britain during the last decade, the "swing from science" in secondary schools was found to be partly due to the increasing proportion of girls taking General Certificate of Education "A levels" mainly in arts subjects (Duckworth and Entwistle, 1974).

The females' higher artistic achievement did not appear to be directly connected with the relationships between arts-orientation variables and divergent thinking, for two reasons: (a) there was no corresponding sex difference in the case of divergent thinking, and (b) relationships between arts-orientation variables and divergent thinking were found for both males and females taken separately. In confirmation of this point, Hudson's original (1966a) report concerned sixth-form schoolboys, and his basic finding was later replicated with schoolgirls (1968, p.23) at least to the extent that "divergent girls tend to avoid science subjects".

Discussion of the main conclusions, and introduction to consequent studies

In general, the measures used in this study were reliable and consistent. Nevertheless, most of the hypothesized relationships between indicators of "openness to divergent stimulation" did not occur. Even the "preference for multiplicity of elements in designs" measure, which had a high degree of internal consistency, was related neither to divergent thinking nor to self-assessed creative independence.

The results suggested a sharper focus for relationships amongst variables, the central construct being art-sciences orientation. Although there was no direct connection between divergent fluency and aesthetic measures, interest in the arts was correlated positively with divergent thinking and creative independence on the one hand, and with the Graves D.J.T.

and Barron-Welsh R.A.S. on the other. It seems reasonable to postulate that a high level of interest in the arts is associated with divergent, individualistic, and even nonconforming traits, as well as being associated with aesthetic preference for asymmetrical designs. The science-oriented undergraduate appears to prefer symmetrical designs, think convergently, and is socially conforming rather than individualistic.

Hudson's research on the relationship between divergent bias and the selection of arts and humanities courses of study has been replicated by other workers in both England and Australia. This evidence is reviewed in a subsequent chapter. The present findings extended Hudson's conclusions by providing a link with the evidence of Barron and his colleagues. For as well as linking divergent thinking with education in the arts (meaning literature and the humanities), the findings also linked divergent thinking to interest and education in fine-arts, as shown particularly by the multiple regression analysis (Table 7.7). The aesthetic preference measures, such as the Barron-Welsh R.A.S. and the Graves D.J.T., are perhaps related to divergent thinking only when the measures in question are strong indicators of interest in fine-arts. In the present study, both art tests showed only weak validity in this respect (Table 7.9). The notion of the Barron-Welsh R.A.S. as an index of creativity or of "personal complexity" was contra-indicated, whilst its role as a (weak) correlate of interest in the arts was vindicated.

These findings are similar to these of Yčas and Pascal (1974), although their presentation was in terms of subgroup differences rather than correlations They reported (in their Table III, rows "E" and "DC") that both divergent bias and the R.A.S. were positively associated with academic preference for arts subjects (Anthropology, English and Philosophy) and with the Omnibus Personality Inventory scales of Thinking Introversion, Estheticism and Complexity; both were negatively associated with preference for science subjects (Mathematics, Physics and Biology) and the scales of Conventional

Masculinity and Practical Orientation. This pattern of relationships was similar for divergent thinking and the R.A.S. even though (as in the present study) these two variables were not closely related themselves. The authors concluded that divergent bias may be seen as "a secondary indicator of the esthetic mode of thought" (p.36).

The results of the present study pointed the way to more extended investigation of certain issues. For instance, PM was unrelated to either arts-orientation or to creativity variables, which suggested that the preference dimension underlying the validity of the two art tests might be the other aesthetic preference variable, PA. Since this dimension of preference was assessed by the Graves D.J.T., it was postulated that the Graves Test would demonstrate correlations with both arts-orientation variables and Creative Independence when tested with a more heterogeneous sample than provided by university students. This issue is discussed in the following chapter.

The present findings suggested that interest in artistic occupations rather than interest in scientific occupations might be related both to divergent thinking scores and to aesthetic preferences. This possibility was examined in a study using Holland's Vocational Preference Inventory.

A further issue was concerned with the generality of the arts-sciences difference in divergent thinking ability. Most of the previous research has been with senior secondary-school children or junior undergraduates studying arts or sciences. It was thought desirable to extend the range of the investigation by testing further university groups and other tertiary education groups; by including fine-arts students as well as groups studying the humanities; by including applied science as well as academic science courses; and by taking groups at various stages in their degree courses. As well as exploring the generality of the arts-sciences difference in divergent thinking ability, differences in aesthetic preferences were similarly studied. In particular, one issue was whether high scores on the

Graves D.J.T. and the Barron-Welsh R.A.S. would be found particularly for groups of fine-arts students, which would be expected if fine-arts education played a specific role over and above general interest in the arts.

Whether or not fine-arts courses play a specific part in encouraging creativity or certain aesthetic preferences, the correlations with arts-orientation variables suggest the possibility that educational learning experiences may be important. In particular, a question of relevance to the present thesis was whether "creativity training" courses and similar "mind-broadening" experiences would affect both divergent thinking and aesthetic preference variables concurrently. This was considered in a study of the effects of adult education courses.

The above discussion emphasizes the arts pole of the arts-science conception. The results of the present study could equally be described with a converse emphasis: for instance, enrolment in the Faculty of Science was associated with low scores on divergent thinking. This raises the issue of the nature of scientific education, which is briefly discussed in chapter 10. However, the present study did not attempt to assess science orientation separately from arts orientation (this is done in chapter 9), but assumed that the two are competing orientations. It is recognised that this is an assumption, and that it is clearly not applicable to all persons, cultures and educational systems. For example, the High Renaissance springs to mind as the period "when Italian artists turned to mathematics to study the laws of perspective, and to anatomy to study the build of the human body" (Gombrich, 1966, p.210), and when "'science' was used in its original broad sense of 'knowledge'" (Chamberlin, 1965, p.167). In the seventeenth century also, intellectual interaction between science and the arts was commonplace (Rhys, 1961).

Nevertheless, most secondary-school pupils in Britain and Australia currently choose between "The Two Cultures" (Snow, 1964). In the universities, despite efforts to have multi-disciplinary introductory years

or some subjects taught across several schools or faculties, most students choose a clearly science-based or arts-based curriculum. Those disciplines which attempt uneasily to bestride the cultural divide, such as arthitecture or psychology, attract students of differing talents. Clark (1957, chapter 7) described the many differences amongst "America's Psychologists", and Cronbach the same year regretted "The two disciplines of scientific psychology". Students may be taught by a sharply divided faculty with either literary-humanistic leanings or a scientific-mechanistic approach. As illustrations of this point, Hudson (1972a) discussed the alternative views of psychological enquiry, and MacKinnon (1962b) commented on the dual requirement of the architect's role.

The last study in the series, reported in chapter 12, concerns an attempt to exemplify in a single case the ontological processes which Hudson (1968) suggested might foreshadow the "convergent scientist". Two anecdotes may serve to illustrate the ramifications of this concept. These arose from observations made by the writer shortly after the completion of the present study. A member of the South Australian Legislative Council, a science graduate of the University of Adelaide, was reported to have said during discussion: "We look to the universities to train the professions, and they should not be bent to research... We must curtail the liberties of the staff." The second example of the convergent scientist's need for control and precision occurred in a science student's third-year examination paper in Psychological Statistics: "All points lie exactly on the predicted line, and this is true only when all points lie exactly *on* the predicted line."

CHAPTER 8

VALIDITY OF THE GRAVES DESIGN JUDGMENT TEST AND BARRON-WELSH REVISED ART SCALE

Introduction

Evidence concerning validity

In the main correlational study, neither the Barron-Welsh R.A.S. nor the Graves D.J.T. demonstrated much evidence of validity, although the manuals have claimed that the scales generalise fairly well to measures of artistic achievement (Graves, 1948; Welsh, 1959). Painting and design are the main relevant fields of application, although the R.A.S. has also been related to creativity in other fields such as writing (Welsh, 1959), and has even been used to provide "an independent measure of creative potential" (Cashdan and Welsh, 1966). Yet in the present main correlational study of 100 university students, the correlations between artistic achievement and the art test scores were negligible: $r = .10$ for the D.J.T. and $r = -.17$ for the R.A.S.

However, the validity of the two tests required further investigation. The students gave results which suggested that the tests did relate to some aspects of either an artistic or a divergent attitude. The D.J.T. correlated significantly with interest in the arts; similarly the R.A.S. had a low but significant correlation with interest in the arts and also with self-reported Creative Independence. It seemed possible that higher correlation values might be obtained if a more heterogeneous sample of subjects were studied. In particular, it was noted that only twelve of the hundred students reported "artistic achievements", so that the majority scored zero on that scale. It was decided therefore to undertake a further study with a heterogeneous group rather than university students as subjects, including a higher proportion with artistic achievements.

The study was not concerned directly with the question of *predictive* validity: that is, whether or not the art tests might be used for the selection of fine arts students and for similar purposes. From the available evidence, reviewed below, it was clear that such use of the tests would be premature. Indeed, many special ability tests have low validity when correlated with future practical achievements (*e.g.*, Want, 1967). Rather, the research question at issue concerned the concurrent correlates of the underlying dimensions of visual preference reflected by the art tests.

Graves D.J.T.

In an earlier study (Rump, 1968a), it had been found that preference for asymmetry (PA), assessed using six D.J.T. items, was associated with the study of art; whereas preferences for other aspects of complexity (multiplicity of parts in designs and preference for varied elements) were not significantly related to the study of art. It has also been shown that the total D.J.T. reflected PA to a large degree, the correlation between the full scale and the 72-item PA scale being .97 for the hundred students in the main correlational study. It was therefore hypothesized that, with a heterogeneous sample, the Graves D.J.T. would have positive correlations with arts-orientation variables. It was further conjectured that, with a heterogeneous sample, the D.J.T. might also correlate with self-reported creative independence. To what extent does other existing evidence support these hypotheses? Unfortunately, as Anastasi (1961) noted, "Validity data are meagre" for the Graves Test. Possibly this is because it is seen as restricted in relevance to "artistic aptitude", under which heading it is listed by Anastasi (1976). In contrast, the Barron-Welsh Art Scale is listed as a "personality test", and it has been included in many wide-ranging studies.

An important series of studies on the Graves Test was reported by Eysenck. In the first report of the series (Eysenck, 1967a), factor

analysis confirmed that the main dimension underlying test scores was PA. Thus the first factor (following Promax rotation) had 36 items loading greater than $\pm$ .3, and the factor might reasonably be called "preference for asymmetrical designs". In Eysenck's subsequent validity studies, this PA factor was represented by a subscale score based on only the thirteen highest-loading items, leading to a greater distinction between the "factor scores" and the total D.J.T. scores than is justified, in the writer's opinion. However, even the 13-item subscale was reported to be highly correlated with the total score, with $r > .8$ for each of four groups (Eysenck and Castle, 1971). Therefore the factor subscale, the writer's 72-item PA scale and the total D.J.T. score largely reflect the same dimension, preference for asymmetry.

In the validity studies which followed his factor analytic study, Eysenck used contrasted groups rather than correlations across individuals. Very large groups of arts students were compared with groups of non-arts students by Eysenck and Castle (1971). The D.J.T. score was significantly higher for arts students, although the difference was small. With regard to the factor subscale, the authors concluded that "artists are clearly superior to controls". They further considered that the subscale "discriminate better ... than does the whole 90-item scale". It is difficult to accept this second conclusion, since the difference between means for art students and controls was only about 2 raw-score points for males and about 1 for females in the case of the subscale; whereas a larger difference of about 6 points for males and 2 for females was found in the case of the total scale. No scale discrimination indices were reported. The appropriate conclusions would seem to be that significant differences in the expected direction were found for both the subscale and the total scale; but that the difference for the total scale was smaller than expected from the comparisons between fine-arts students and controls reported in the test manual.

Possibly the difference was small in Eysenck and Castle's study because of the diverse groups included as "artists": courses included graphic design, architectural studies, industrial design, *etc.*, as well as fine arts. (The controls were also a diverse collection, including law students, secretarial students, linguists, *etc.*) However, when a selected group of 50 successful students and teachers from the Royal College of Art was given the Graves Test, the mean D.J.T. score was only 50, and not significantly different from the mean for the earlier control group of non-art students (Eysenck, 1970). It is clear, then, that the Graves Test does not satisfactorily reflect high artistic ability or aptitude in all cases. That conclusion was substantiated by the further finding that the D.J.T. had "small and inconsistent" correlations with a score derived from part of Child's test of aesthetic sensitivity (Eysenck, 1972). It seems probable that the fine arts students and control students in the 1972 study were a subsample of the subjects discussed by Eysenck and Castle (1971), and no additional consideration of their mean D.J.T. scores is required here. With regard to the general approach of these studies, it may be remarked that the method of comparing groups of rather mixed composition is less satisfactory than the method of correlating over individual subjects, when assessing a test's validity.

One study which employed correlational analysis was that of Lepore (1962). He found that the D.J.T. correlated with various criteria for three groups tested in Rome. Correlations were: .27 with marks obtained by students in a fashion-design course; .29 with marks obtained by students at an institute of fine-arts; and .30 with scores reflecting interest in painting and design obtained by secondary-school pupils.

Additional evidence that preference for asymmetry has only a low correlation with aesthetic *judgement* assessed by other means was provided by Millman and Chang (1966). They found a rank correlation of only .19

between the D.J.T. and the Meier Art Judgment Test. However, it should be noted that their 32 subjects were all "non-art concentrators" so that the correlation may have been affected by sample homogeneity. (The Barron-Welsh R.A.S. was also not significantly correlated with the Meier Test in their study.) Keesee (1968) found that the D.J.T. was not a significant predictor of academic success in commercial art courses. It is to be noted, however, that the courses were mainly not in fine arts but on such topics as photography, design and mechanical drawing.

On the other hand, preference for asymmetry is clearly related to the general distinction between arts and sciences as different areas of interest. Eisenman and Coffee (1964) found that college students specialising in mathematics tended to prefer symmetrical polygons, whereas those specialising in arts courses tended to prefer asymmetrical polygons.

The above findings suggest that a measure such as the Graves Test might distinguish poorly between fine arts students and general arts (humanities students, but might be more directly relevant to the arts-science distinction. The suggestion would be consistent with the view that a person inclined towards science prefers ordered, analysed, systematic knowledge (and symmetrical designs), whereas the arts person more readily accepts change, diversity (and asymmetrical designs). This interpretation of the dimension tapped by the Graves Test is in line with the conclusions derived from the main correlational study. It is further supported by the results of an experiment by Garlington and Shimota (1964). They reported that the Graves D.J.T. correlated significantly with their Change Seeker Index which they regarded as a measure of "the need for variable sensory input", with r = .30. Moreover, Child (1964) found a significant correlation of .30 between the D.J.T. and a test of Humanities Abilities, but a nonsignificant correlation with self-rated "goodness of esthetic judgment in visual arts" (in Child's Table 1). In a further experiment, Child found a negligible correlation

between the D.J.T. and a measure of the agreement between the subject's preference ratings of paintings and experts' ratings of their aesthetic quality (in Child's Table 2).

There are two studies which might be interpreted as suggesting that preference for asymmetry is *negatively* correlated with interest in the arts. Such an interpretation would, however, be false. The first is the study by Eysenck and Castle (1970b), using Birkhoff polygons as stimuli. It seems likely that the subjects were subsamples of the various groups included in the 1971 report (*op. cit.*). The authors concluded that "Artists preferred simple polygons, non-artists complex ones" (p.65), which would appear to be contrary to most other research findings. The first part of the conclusion is also contrary to their own data, which showed that "artists like simple and complex polygons equally" (p.80). In any case, inspection of the two sets of polygons concerned (in Eysenck and Castle's Figures 11 and 12) shows that the distinguishing feature is not symmetry/asymmetry. All polygons in both sets have at least one form of symmetry: for example, the first polygon in their Figure 11 ("preferred by artists" more than controls) is a filled square, and the first polygon in their Figure 12 ("preferred by controls" more than artists) is a filled 6-point star. The distinguishing feature appears to be that most of Eysenck and Castle's Figure 11 polygons include predominant right-angles; whereas most of their Figure 12 polygons are some form of pointed star or steeple. Neither preference for asymmetry nor preference for other forms of complexity seems to be the primary determinant differentiating the arts group from the non-arts controls in this case.

The second study liable to misinterpretation is of much earlier date. Brighouse (1939) also used a selected set of Birkhoff polygons, and reported "a clear and significant trend toward increasing preference for simpler forms with increasing age and experience in art" (p.72). Unfortunately, the

study is difficult to interpret because the five compared groups of subjects involved three distinct independent variables; age, intelligence, and experience in art. In addition, it is important to note that the selection of stimuli was such as to ensure that the dependent variable confounded preference for "complexity" (basically, the number of lines forming the sides to the polygon) with preference for symmetry. This was because Brighouse held "M" constant for each set of polygons, where"M = Order ÷ Complexity", and where Order represents an index of the degree of symmetry. Thus a more complex polygon, in the sense of having many sides, was always more symmetrical within Brighouse's selected sets, in order to hold"M" constant. Therefore, the data in fact demonstrated that groups of greater age or intelligence or experience in art tended to show greater preference for polygons with both fewer sides and *less* symmetry, compared with other groups. Although this finding is ambiguous due to the confounding of variables, it is perfectly consistent with the hypothesis that education in fine arts tends to be associated with *greater* preference for asymmetry. Child (1969, pp.888-889) noted the discrepancy between Brighouse's conclusions and evidence from Welsh's studies, and suggested an explanation in terms of confounding of variables similar to that given above.

In summary, it would seem that measures of preference for asymmetry, and the Graves D.J.T. in particular, are positively correlated with interest and education in fine arts and the humanities generally. PA scales may also relate to interest in stimulus change and divergency, rather than to the ability to make "correct" aesthetic judgements as envisaged by Graves. The test is not suitable as a selection device, since there is no evidence that it predicts good "performance" in students or artists.

Barron-Welsh R.A.S.

Reviewing studies of the nature of this Scale is a complex task.

It is necessary to include work with its precursors, especially the Barron-Welsh Art Scale (B.W.A.S.). This is justified since the R.A.S. (a balanced 60-item scale) and the B.W.A.S. (not balanced, with 62 items) are very highly correlated: "for all practical purposes the scales are equivalent" (Welsh, 1969). In addition some reports have included separate scales for complex items (C) and simple items (S).

It is clear from inspection of the R.A.S. figures that the Scale itself is complex. It confounds three aspects of complexity (asymmetry, multiplicity of parts, and heterogeneity of elements) in its figures (Rump, 1968a). To the extent that PA determines responses on the R.A.S., a significant correlation with the Graves D.J.T. would be expected. Millman and Chang (1966) did report a moderate correlation between the tests, with rho = .46. The value obtained in the main correlational study above was not as high: $r = .27$ ($p < .01$). To some extent the tests do reflect similar personality characteristics. For instance Garlington and Shimota (1964) obtained the same correlation ($r = .30$) between each of the art tests and their Change Seeker Index. Nevertheless, the R.A.S. is likely to be affected by other preference variables than PA, and probably this feature has contributed to confused results. It is difficult to assess the validity of the R.A.S. "without a clearer statement of what the test is designed to measure" (Baird, 1972).

Moyles, Tuddenham and Block (1965) demonstrated that the confounding of stimulus dimensions applied to the 400 items of the Welsh Figure Preference Test (W.F.P.T.) as a whole, and went on to select 24 items such that their mean rated complexity and mean rated asymmetry were almost independent across the subset. The correlation across the 24 items between an item's mean rating and its preference ranking was then determined separately for complexity and for asymmetry, with each individual subject. Thus a high positive correlation between the preference ranking and asymmetry ratings would

indicate that the subject liked symmetrical designs and disliked asymmetrical designs, independently of their general complexity. In fact, individual correlations ranged from .58 to -.39, so that some subjects clearly preferred symmetrical items and others preferred asymmetrical ones. The average absolute value of the correlation between liking and asymmetry was .28 for men and .25 for women. The authors concluded that PA accounted "for only a minor share of the variance", since the absolute correlation value was small for many subjects; and that it was not "a very important determinant of liking for designs". Their data do *not*, in the writer's view, show that individual differences in PA are unimportant. Such a conclusion would be like discounting introversion-extraversion as a personality dimension on the ground that many people do not consistently give *all* the introverted responses or *all* the extraverted responses on a questionnaire. Moyles, Tuddenham and Block were correct in pointing out the confounding of stimulus dimensions within the W.F.P.T.; but their conclusion that PA is unimportant as one of the determinants of preferences on the W.F.P.T. was not justified. In any case their selected set of 24 items may well be different in characteristics from those included on the R.A.S. or B.W.A.S.

Eysenck and Castle (1970a) have criticised the B.W.A.S. for its inclusion of different types of figures, as shown by factor-analysis of liking responses using rotation to oblique structure followed by higher-order factoring. However, most multi-item personality scales can be similarly subdivided into "content areas" by the use of oblique rotation. Moreover, the level of analysis chosen for interpretation (depending on the number of higher-order analyses employed) is not determined by the mathematical outcome, but by the analyst's subjective choice. Eysenck and Castle preferred the level of analysis giving four factors. However, higher-order analysis of these gave a single factor having loadings with signs corresponding nicely (for all but two items) with the B.W.A.S. scoring scheme. This single-factor solution suggests that the B.W.A.S. does have some degree of

internal consistency, despite the various types of figures that it includes.

Although the above studies do not invalidate the R.A.S., they do indicate its relatively complicated nature. It might be expected therefore that findings with regard to the correlates of the R.A.S. would be variable. Indeed, inconsistent findings might arise, depending on which feature of the test items predominantly influenced the subjects concerned. Several studies involving the R.A.S. are subject to a further problem which might be expected to lead to inconsistencies. These studies have involved the analysis of hundreds of co-variables (such as all items of the Gough Adjective Check List treated as separate variables), with no allowance for the increase in Type I errors which may thereby arise. For example, in Barron's study of originality with 100 U.S.A.F. captains, the originality criterion was examined in relation to 200 test scores including the B.S.A.S., 76 ratings, and 300 adjectives, all treated as separate variables (Barron, 1963; and various other reports).

Examples of consequential inconsistencies may be found even within the W.F.P.T. manual (Welsh, 1959). High B.W.A.S. scorers are reported to be "gloomy", but low scorers are also reported to "always look on the dark side". Those who prefer complex figures are "patient", but in another study "impatient". Preference for complexity/asymmetry is related to "intellect", but in another study "the intellectual modes do not separate" the groups. High scorers on the R.A.S. are reported as considering themselves "cold" and "individualistic", but also as "suggestible" and "high on social skills" (pp.14 and 15). Baird (1972) comments that of the many aspects of personality initially reported to correlated with the B.W.A.S., "only a few of them have been supported by other research". In an earlier review, Aiken (1967) came to similar conclusions.

Welsh (1975, Appendix A, pp.205-227) has provided a useful summary of many validity studies for the test, although his account is somewhat

over-optimistic. In briefly describing some of the published findings, it is convenient to consider first those which relate to ability or education in fine arts; and then to consider other characteristics, particularly those concerned with originality and independence.

In the initial development of the B.W.A.S., it was found that items disliked by artists and art students were "of the simple-symmetrical sort, while almost all of the items that they *liked* significantly more often (than controls) were complex-asymmetrical". In a cross-validation study, 30 artists gave a mean "Preference for Complexity" score of 39 (using a 65-item scale), whilst 30 non-artists gave a mean of 18 (Barron and Welsh, 1952). Rosen (1955) similarly found mean scores on the B.W.A.S. of 39-41 for 3 groups of fine-arts students and teachers, with a small group of non-arts teachers having a mean score of 22.

Later research has sometimes indicated smaller differences between fine-arts groups and controls. For example, Welsh (1966a) compared R.A.S. scores for students in the fine-arts division of a school with those for students in the academic division, and found means of about 34 and 30 respectively. In one study, Child (1962) obtained a significant correlation of .45 for Stanford students (and a nonsignificant value of .32 for Yale students) between the B.W.A.S. and the degree to which the student's preference order for various pictures concurred with their aesthetic value as determined by graduates of fine arts. Yet, in a subsequent larger-scale study, Child (1965) found a correlation for Yale students which, although significant, was only .18, between the B.W.A.S and the student's "esthetic judgement", again assessed by using the evaluation of pictures by art experts as the criterion. Recently, however, Lang and Ryba (1976) found marked differences in mean R.A.S. scores for student artists (42), music students (32) and control students (24), showing that the revised scale is clearly linked with art education. Similar results were obtained by Raychaudhuri

(1963) in Calcutta. These results contradict Eysenck's (1970) notion that art tests in recent years have lower validity because, he stated, "There is a growing belief that there are no basic principles in aesthetics".

Further studies give indirect or partial support to the belief that preference for some form of complexity in drawings is related to interest in fine arts. Cornwell (1969) used the separate C and S scales from the W.F.P.T. He found that S (simplicity) was negatively correlated with the Aesthetic Value scale from the Allport-Vernon-Lindzey Study of Values ($r = -.34$); however, C (complexity) did not have the expected positive relationship ($r = -.03$). It is assumed that S and C were scored in the direction of "liking" rather than "disliking", although this is an inference from Cornwell's paper, and not directly stated. Beittel (1963) obtained ratings of 20 pictures on semantic-differential scales from experienced fine-arts teachers and graduates, and found that they tended to value the more complex pictures, in that the correlation between their good-bad rating scale and the complex-simple scale was .5.

Skager, Schultz and Klein (1966) considered from their results that "the high correlation observed between scale values ... and choice of major in fine arts is consistent" with Barron and Welsh's findings. However, the "scale values" referred to in the quotation were stated to represent "Simplification (high) *v.* complexity of treatment (low)" in the two sets of drawings concerned. Since the relevant correlations with choice of a major in fine arts (rather than applied arts or architecture) were .57 and .21 across 25 students for the two sets of drawings, it would appear that those students majoring in fine arts tended to produce drawings with greater *simplification*. Therefore, their results (as reported) do *not* support the B.W.A.S. relationship between preferred complexity and interest in fine arts. Skager *et al.*'s results did demonstrate the importance of various aspects of complexity in judgements of drawings, but their precise implications must be considered doubtful.

In summary, several studies have indicated that the R.A.S. and B.W.A.S. are positively associated with receiving a fine-arts education. It is to be noted that the studies do not show whether distinguished artists tend to obtain higher scores than "unknown" artists or fine art students. Nor are the obtained correlation values and differences sufficiently large or consistent to justify use of the R.A.S. for selection purposes.

Turning to creativity and independence variables, findings have been somewhat varied in relation to the B.W.A.S. It is probable that one of the reasons for this is that different types of subjects have been used. Barron (1953) compared high and low B.W.A.S. scorers amongst graduate students, and found *inter alia* that high scorers tended to be rated as fluent and original by psychologists who observed them. Correlational details were not given. Barron (1963) reported two additional studies of relevance. Students who showed "independence" in an Asch-type experiment, which involved making perceptual decisions in the face of a group consensus, obtained a mean B.W.A.S. score of about 20, and this was significantly greater than the score of about 17 by those who were "Yielders". U.S.A.F. captains were given eight originality tests, and two groups of extremely high and extremely low scorers were selected. The "original" group obtained higher scores on an Independence of Judgement questionnaire, yielded less readily in an Asch-type experiment, and obtained a score of 19 on the B.W.A.S. compared with 13 for "unoriginals". In addition, Cashdan and Welsh (1966) found that talented adolescents who obtained very high R.A.S. scores also scored significantly higher on the Change scale of the Gough Adjective Check List, and tended ($p < .10$) to score higher on Autonomy, compared with an extremely low R.A.S. group. Strong confirmation of Barron and Welsh's findings has been reported by Lang and Ryba (1976), who found a correlation of .47 between the R.A.S. and verbal fluency on the Torrance Tests of Creative Thinking.

Other validity studies have used a further variety of measures relevant

to creativity. Golann (1962) found that the R.A.S. was correlated with a questionnaire measure of "creativity motivation", the average value for eight samples being .23 calculated from his Experiment 2 data. Two studies are of particular interest because they employed "on the job" ratings of originality, in one case with fine arts students and in the other case with scientists. Rosen (1955) obtained a correlation as high as .40 between the B.W.A.S. and ratings of originality for the art products of fine-arts students. Gough (1961) found a similar correlation of .41 between the B.W.A.S. and supervisory ratings of "general creativeness" in the work of industrial research scientists. It is pertinent to remark that each of the above studies showing a clear relationship between the B.W.A.S./R.A.S. and originality or independence has involved adolescent or adult groups for whom originality and independence might be considered relevant and valuable characteristics. This is not the case for several studies which have failed to obtain expected relationships, as described below. Some studies have been with children, and in this connection Hargreaves and Bolton (1972) have noted that "the age variable is possibly crucial in these relationships".

Ward (1968) obtained nonsignificant correlations averaging .19 between the R.A.S. and various tests of creativity, with 7 and 8-year old boys. Similarly McWhinnie (1969a) obtained eleven nonsignificant correlations (out of twelve) using various creativity tests with fourth or fifth grade children. (McWhinnie did not state whether the B.W.A.S. or the R.A.S. was used.) Schaefer (1968) studied groups of creative and non-creative high-school pupils (as assessed both by teachers and by means of divergent thinking tests); of the four independent contrasts between creative and control groups' mean R.A.S. scores, only one was significant, with creatives scoring higher than controls. It may be noted incidentally that the sex difference reported by Schaefer may equally be described as an arts-science difference in R.A.S. scores, owing to confounding of variables in the design.

Three other studies which have obtained nonsignificant results cannot be regarded as providing firm evidence for various reasons. Child (1965) found no significant correlation between the B.W.A.S. and four originality tests; but it was also noted that "no general dimension of originality has been measured" by the four tests. Lucas and Dana (1966) found no relationship between the R.A.S. and the Remote Associates Test (regarded by the authors as a measure of creativity); since there was a total of six subjects in the experiment, their evidence is rather weak. Eisenman, Hannon and Bernard (1966) obtained a low association between self-reported creativity and an *ad hoc* measure of preference for complex polygons (where "complex" referred to many-sided and/or asymmetrical polygons); the association's marginal nonsignificance ($.10 > p > .05$) and the complicated instructions incorporating different "sets", make this experiment difficult to interpret. A similar study of 20 art students by Taylor and Eisenman (1964) was more conclusive in that students chosen by their art teacher as more artistically creative tended to prefer complex polygons and to produce more complex designs to a significant degree.

In summary, the R.A.S. and its precursor the B.W.A.S. are related to the study of fine arts, and to interest in the arts and humanities generally. They are also related to variables concerned with self-reported independence, objective tests of independence, and to divergent thinking. These relationships do not extend to samples of children. The results may be interpreted as showing a relationship between preference for asymmetry and the arts-science interest dimension. To the extent that this interpretation is correct, it would be expected that the R.A.S. might be less reliably related to artistic interest and creative independence than the Graves D.J.T., since the latter is a clearer measure of PA.

Evidence concerning norms

A remarkable feature of many of the studies reviewed above is the number

of non-art groups which have scored above the supposed "norms" for both tests. For example, the mean D.J.T. scores obtained by Eysenck and Castle (1971) were 52 for males and 56 for females in the case of very large varied groups of non-art students. The overall mean for all the non-art student groups given by Graves (1948) for normative comparison was only 49.40 for both sexes combined. Another sample which obtained low scores consisted of patients suffering from epilepsy (Lansdell, 1962; pre-operative means given in Lansdell's Table 1). The mean score obtained in the main correlational study was even higher than those given by Eysenck and Castle: 61.10 for 100 students, which was significantly above Graves' "norm". How may this be explained? In fact Graves' three samples of "college non-art students" were not taking general university courses. They were students from three Institutes taking vocational courses in retailing, dental technology, and engineering. Rather than representing a general non-arts tertiary student group, the samples represented science and commerce in their orientation. The difference between "Art" and "Non-art" groups reported in the manual was thus largely due to the arts-science dimension. This would in turn explain why other investigators using mixed non-arts control groups have obtained less striking differences from fine-arts student groups. It would also be expected that a heterogeneous group of people-in-general would obtain higher scores than the science specialists mainly represented by Graves' "Non-art" college norm.

Welsh (1959) attempted to obtain for the W.F.P.T. a normative group of 150 "people-in-general". The group obtained a mean R.A.S. score of 18.33. Possibly college technicians and scientists may have been well represented, since many other non-artist groups have since obtained much higher mean scores. It is difficult to think of any other explanation as to why Welsh's group should have had unusually low scores on average. For example, the mean R.A.S. score in the main correlational study was 33.15, and this was

significantly above Welsh's norm. Moreover, "anomalous" high scores have not been confined to student groups: Pang and Schillinger (1968) obtained a mean R.A.S. score of 28.2 for trustee prison inmates. They also referred to a study of adolescents with a mean of 32.7, and this value is more typical of adolescent groups than the mean given in the manual. For instance, Schaefer (1968) tested eight groups each containing one-hundred high-school students and found mean scores between 30.0 and 38.7; and Welsh (1966b) himself quoted a mean of 31.58 for 368 high-school students, on the R.A.S.. Barron's (1969, p.110) "control group" of Mills College students obtained a mean B.W.A.S. score of 30.9, which was similarly well above the supposed norm for the B.W.A.S. given by MacKinnon (1961) as 13.9 for 343 "unselected adult males", elsewhere listed as 300 "non-Artists" (MacKinnon, 1962b, p.30).

Failure to recognise the inadequacy of the norms for the W.F.P.T. has had important consequences. For example, MacKinnon (1962b) reported mean B.W.A.S. scores for various professional groups such as writers (31.5), research scientists (24.0) and general architects (his Group III, 26.1), without realising that the average student may achieve about the same score, as shown above. Barron (1969) reported a study of 118 Italian twins in secondary schools where the mean B.W.A.S. score was 28. Now such a mean value is not unusual, and yet Barron was led by the inadequate normative data to suggest the following: " ... it seems possible that a higher than average level of aesthetic discrimination may be carried in the Italian gene pool" (p.123). Since similar "high" scores using the W.F.P.T. have been obtained in America, Britain and Australia, recourse to an *ad hoc* genetic hypothesis to account for the Italian result is unnecessary. Indeed, Welsh (1975, p.224) pronounced a stronger judgement: "This genetic hypothesis is merely absurd."

Because most professional groups have been found to score above the supposed level of "people-in-general", attention has not sufficiently been

drawn to the large variation in scores between professional groups. Baird (1972) pointed out that "the mean for the *most* creative male mathematician is about the same as the mean for the *least* creative architects". One of the greatest contrasts is between artists and research scientists (MacKinnon, 1962b, p.30). This supports the conclusion reached from the review of validity studies for both Art Tests, that preference for asymmetry is positively related to interest in the arts and the humanities generally, and negatively related to interest in physical science. It may also be predicted that a heterogeneous group of "normal" subjects would score, on average, significantly above the "norms" for the two tests.

Aims of the Art Test Validity Study

The study was designed to test the following hypotheses, derived from the foregoing arguments and evidence.

Hypothesis 1: The Graves D.J.T., and the preference for asymmetry (PA) scale, have positive correlations with education in fine arts, interest in the arts, and artistic achievement, when the sample is heterogeneous.

Hypothesis 2: The Graves D.J.T., and the preference for asymmetry (PA) scale, have positive correlations with the Creative Independence scale, when the sample is heterogeneous.

Hypothesis 3: The Barron-Welsh R.A.S., because it confounds distinct aspects of figural complexity, has less reliable correlations with arts-orientation variables compared with those for the Graves D.J.T.

Hypothesis 4: The mean score for each of the Art Tests estimated from a heterogeneous "normal" sample, is higher than the supposed "normative" value given in the corresponding test manual.

Since the four hypotheses were clearly directional and based on previous evidence, it was considered appropriate to use one-tailed tests of significance.

Subjects

In line with the arguments put forward by Eysenck (1975), it was not considered necessary to obtain a strictly random sample, although people-in-general were required. Subjects were obtained from two sources: visitors to University of Adelaide "Open Days", including a few who were students or staff from departments other than Psychology (66 subjects); and members of an Adult Education class studying German at Adelaide (29 subjects). Subjects were tested in small groups; within each group about half the *S*s were given the Graves and half the Barron-Welsh Test. To achieve this, test materials were distributed on the tables in the test room with the two tests alternating. Details of the two groups so formed are given in Table 8.1. They are similar in composition with regard to size, source, sex and age. The large standard deviation for age (14.4 years) illustrates the heterogeneous nature of the samples, the total range being 8 to 65 years. The two groups contained higher proportions with artistic achievements compared with the sample of one hundred students, and the two groups were very similar in this respect.

Procedure

Small groups were invited to volunteer for a study of aesthetic preferences, "so that Australian preferences might be compared with American results". They were assured that their personal results would be confidential, and that they could be told their own score. (Each *S* who wished to know his Art Test score was later told its value in relation to the local student "norm" from the main correlational study; and he was given an interpretation which avoided "socially undesirable" implications, together with advice about the possible low validity of the tests).

Subjects were asked to complete three items in the following order:

1. An Individual Record Sheet, on which they gave personal data, and details of their formal education in fine arts, interest in the arts, and artistic achievement (as in the main correlational study).
2. The Graves *or* Barron-Welsh Test, using the standard printed instructions for each. In the case of the Graves Test, the standard answer sheet was used; in the case of the Barron-Welsh R.A.S., no printed answer sheet was available so that the duplicated answer sheet was used as before.
3. The Self-description Checklist, for the Creative Independence and Emotional Activation scales, as used in the main correlational study except for the additional instruction: "Tick about half the items if possible". This additional instruction has become standard for all subsequent applications of the Checklist, in order to reduce the small proportion of subjects who tick very few items. However, no apparent effect on the mean scores or standard deviations for the scales was found, these results being given in detail in Appendix 8.1.

Pearson's correlation values were calculated. In view of the very similar results obtained with Kendall's Tau in the main correlational study, it was considered unnecessary to obtain Tau values in the present case.

Results and Discussion

Hypotheses 1 and 2

The correlations between the Graves D.J.T. and the preference for asymmetry scale on the one hand, and the arts-orientation variables and Creative Independence on the other, are shown in Table 8.2. Significant positive correlations were obtained with these variables, giving strong support to Hypotheses 1 and 2. The PA scale gave validity coefficients as high as (or higher than) the full D.J.T. scale, which supports the contention

Table 8.1. Characteristics of subjects in the Art Test Validity Study

	Sample given the Graves Test	Sample given the Barron-Welsh Test
Number of subjects	48	47
Open day subgroup	36	30
Adult education subgroup	12	17
Males	26	21
Females	22	26
Mean age (years)	27.46	27.60
S.D. for age (years)	14.41	14.44
Percentage reporting artistic achievements	18.7	17.0

that preference for asymmetry is the underlying dimension relevant to an artistic and divergent attitude.

The correlation of the D.J.T. with fine-arts education was somewhat higher (.43) than with artistic achievement (.29). This suggests that the Test is not an accurate indicator of potential artistic ability (in the context of selection for a fine-arts college, for instance), even though those who have already studied fine arts do tend to obtain higher scores than others. No significant correlations were obtained between the D.J.T. and Emotional Activation, age or sex.

Hypothesis 3

Table 8.2 also compares the correlations obtained using the Graves D.J.T. with those using the Barron-Welsh R.A.S. The latter gave non-significant correlations with interest in the arts, artistic achievement, and Creative Independence, in complete contrast to the D.J.T. results. The R.A.S. did have a significant correlation of .24 with fine-arts education.

The significance of the difference between each of the pairs of independent correlations was assessed using the usual method of conversion to Fisher's Zeta. The correlation for the R.A.S. was significantly different from that for the D.J.T. only in the case of the Creative Independence scale. Hypothesis 3 may be considered to be tentatively supported by these results. It may be concluded that the R.A.S. is a somewhat unreliable indicator of creativity, possibly because it confounds distinct aspects of figural complexity.

The R.A.S. was not significantly correlated with Emotional Activation, age or sex. In this respect the two art tests were similar.

Creative Independence and arts-orientation variables

In the main correlational study, Creative Independence was positively correlated with rated interest in the arts. This finding was replicated

in the present study (see Table 8.3). It is clear that those who see themselves as interested in the arts also tend to regard themselves as having characteristics indicative of creative independence. Both variables were derived from self-reports. Nevertheless the finding is not trivial, since the two variables do not have any close methodological relationship, and the finding is supported by their corrrlations with divergent fluency in the main correlational study. Moreover, further significant correlations were found in the present case with fine-arts education and with artistic achievement (Table 8.3).

Hypothesis 4

Mean scores on the Art Tests are given in Table 8.4. The mean score on the Graves D.J.T. for the present sample was 56.77, which was significantly higher than the mean for non-art students of 49.40 given in the manual. Treating the latter value as the null hypothesis expectation, the obtained deviation of 7.37 gave $t = 3.38$, d.f. = 47, $p < .01$. This would suggest that the non-art students whose results were given by Graves do not provide a suitable normative standard for use with Australian people generally. Indeed, in the sample of 48 people, 71% scored above the mean score given by Graves.

Similarly, the mean score on the Welsh R.A.S. for the present sample was 31.96, which was significantly higher than the normative value of 18.33 given in the Test manual for people-in-general. Treating the latter value as the null hypothesis expectation, the obtained deviation of 13.63 gave $t = 6.75$, d.f. = 46, $p < .01$. It would seem that the "people-in-general" whose results were given by Welsh do not provide a suitable normative standard for use with Australian people generally. Of the 47 subjects, 79% scored above the mean score proposed as the "norm".

Many other groups from different countries have also been reported with mean scores above the supposed norm on the R.A.S., as described in the

Table 8.2. Correlations with the aesthetic preference tests

(Note: The Graves D.J.T. and the P.A. scale scored from the same test were highly correlated, r = .98)

Variable	Aesthetic preference tests			Significance
	P.A. scale	Graves D.J.T.	Barron-Welsh R.A.S.	Difference in correlations, D.J.T. vs. R.A.S.
	r	r	r	z
Fine-arts education	.43#	.43#	.24*	0.97
Interest in the arts	.36#	.35#	.05	1.52
Artistic achievement	.33*	.29*	.07	1.08
Creative Independence	.42#	.41#	-.16	2.83#

# $p < .01$ * $p < .05$ (one-tailed tests)

Table 8.3. Correlations with the Creative Independence scale

Variable	Correlation with C.I. (N = 95)
	r
Fine-arts education	.32#
Interest in the arts	.43#
Artistic achievement	.19*

# $p < .01$ * $p < .05$

Table 8.4. Means and standard deviations for the two Art Tests, from data provided in the manuals, and as found in the main correlational study and the validity study

Graves D.J.T.

Source	Subjects	N	Mean Score	S.D.
Graves, 1948	U.S.A. college students: Non-Art	374	49.40*	14.42
Graves, 1948	U.S.A. college students: Art	661	74.30	8.45
Main correlational study	Adelaide University students	100	61.10	11.13
Art test validity study	Adelaide general sample	48	56.77	15.11

Barron Welsh R.A.S.

Source	Subjects	N	Mean Score	S.D.
Welsh, 1959	U.S.A. people-in-general	150	18.33	11.84
Welsh, 1959	U.S.A. creative writing students	48	42.13#	11.55#
Main correlational study	Adelaide University students	100	33.15	12.10
Art test validity study	Adelaide general sample	47	31.96	13.85

*The median value given by Graves was 48, and some writers have incorrectly cited this as the mean.

#The mean and S.D. for creative writing students were calculated by the writer from data for three samples given by Welsh.

section headed "Evidence concerning norms". It seems reasonable to conclude that the R.A.S., like the D.J.T., had an atypical low-scoring normative group. As can be seen from Table 8.4, the present groups obtained mean scores between the values provided for creative-writing or fine-arts students and those for the normative groups.

Conclusions

Given a heterogeneous group of subjects, preference for asymmetry as measured by the Graves D.J.T. is moderately correlated with education in fine arts, interest in the arts, and self-reported creative independence. To some degree, the test is also correlated with artistic achievement. On the other hand, the R.A.S. is less reliably linked with these variables, even though copious previous research has indicated its validity. It would appear that the Graves D.J.T. may be regarded as reflecting similar personality characteristics to those which have previously been associated with the R.A.S. (This chapter has been published in abbreviated form by Rump, 1977.)

It is possible that the relationship between PA and education in fine arts depends on the "specific training" involved, as Eysenck (1972) concluded. Or it might be that most forms of such training allow the student to appreciate a wider variety of designs, including asymmetrical ones: Clair (1939) noted with respect to students' responses to paintings that "the trained individual gives a wider variety of responses". A further possibility is that preference for asymmetry, creative independence, and divergent thinking are associated with interest in the arts and humanities and negatively associated with interest in the physical sciences, rather than being specifically concerned with painting itself. The following two chapters include further investigations of this topic through the examination of several diverse groups interested in the arts or sciences.

CHAPTER 9

ARTISTIC AND SCIENTIFIC OCCUPATIONAL INTERESTS IN RELATION TO AESTHETIC PREFERENCES AND DIVERGENCY

The results described in the two previous chapters show that an arts orientation is positively related to both divergent fluency and preference for asymmetrical designs. Those investigations were derived mainly from previous "creativity" research, although the results themselves suggested the central importance of differential interests, in the arts or in the sciences. This theme is extended in the present chapter, by considering relevant theories of occupational interest and choice.

Theories of vocational choice have been critically compared by Osipow (1968). He pointed out that much of the theoretical development in this area has involved the postulation of some general consistency amongst a person's self-concepts and abilities, his educational and occupational choices, his attitudes and values, and the nature of educational courses and occupations. For example, Super (1951, p.92) hypothesized that: "In choosing an occupation one is, in effect, choosing a means of implementing a self-concept" (original italicized).

With such theoretical views, it is clear that occupations are construed in terms of various types, rather than in terms of specific jobs. Moreover, a person has direct experience of few occupations, and indeed none when he makes his first relevant choice. Thus an implication of Super's hypothesis and similar notions is that people generally acquire somewhat accurate "stereotypes" of occupational groups early in life by indirect means. Butcher (1969a, p.49) described ratings of occupations by British thirteen-year-olds as "remarkably realistic". Certainly arts and science occupational stereotypes are strongly evident in the views of secondary school children, as Hudson (1976b) found. Hayes (1973) argued that initial occupational

choice may be made on the basis of an incomplete self-concept focussed on economic rather than on psycho-social characteristics.

The view that the nature of a person's work is related to various aspects of his personality, is widely held. For instance, Kumarappa (1958) writing in the context of the Indian economy considered that work "furnishes an excellent background for man to display his scale of values and develop his personality".

Little (1972b) has similarly advocated a general model of personality based on "man as specialist". Even within a particular profession such as psychology, Little argued, a person's specialised interests help to determine the nature of his viewpoint. For example, in a study of fourteen prominent psychologists, Little found a significant correlation of .57 between their interest in people ("person orientation", scored from the Strong Vocational Interest Blank) and the "personalism" of their theories as assessed by experts' ratings.

Nevertheless, certain limitations of an approach to personality based on educational or occupational preferences are immediately apparent. In some places, the range of available occupations may be severely restricted; a theory of occupational choice which is apt for people in a modern urban area may not apply to people living in an isolated fishing village. Occupational choice may also be restricted during a period of economic recession. Even when such restrictions do not apply, there is a wide variability of persons within any occupation; therefore theories postulating the concordance of personality and chosen occupation are concerned mainly with group tendencies, rather than with individual cases, notwithstanding their derivation from the field of vocational guidance for individual clients.

A further problem in using occupational preference as a criterion for distinguishing personality types is that occupational choice may be greatly restricted for certain groups within the community, such as the intellectually retarded. Moreover, women are more constrained than men in many countries by

Table 9.1. Categories of occupational interests from diverse sources, corresponding with Holland's "types"

Source	Method	Categories					
Holland, 1975	Scale analyses for the Vocational Preference Inventory	Realistic	Intellectual	Artistic	Social	Enterprising	Conventional
Closs, 1975	Factor analysis of the Occupational Interests Guide	Practical	Scientific	Artistic, Literary	Social service		Computational, General service
Kuder, 1960	Analysis of preferred activities for the Kuder Preference Record (Vocational)	Mechanical, Outdoor	Scientific	Artistic, Musical, Literary	Social service	Persuasive	Computational, Clerical
Miller, 1958	Item analysis for the Rothwell-Miller Interest Blank	Mechanical, Practical, Outdoor	Scientific	Aesthetic, Musical, Literary	Social service, Personal contact	Persuasive	Computational, Clerical
Guilford, Christensen, Bond & Sutton, 1954	Factor analysis of 100 ten-item scales	Mechanical	Scientific	Aesthetic	Social welfare	Business	Clerical
Thurstone, 1931	Factor analysis of the Strong Vocational Interest Blank		Science	Language	People	Business	

social or religious traditions. In 1977, 63% of women at work in South Australia were in clerical, sales, service and recreational occupations, compared with only 19% of men, according to information published by the State Government (South Australian Premier's Department and Department of Labour and Industry, 1978). Theories of vocational choice may occasionally appear to be rather male-oriented. This point may be illustrated by a quotation from Holland's (1973) book. He described the artistic type as follows: "He perceives himself as ... feminine" (p.15). The statement was intended to apply equally to women, but the meaning of the term is somewhat different when describing a female artist.

Despite these limitations, there does appear to be a fair degree of consensus as to the types of occupational interests which may be usefully distinguished, and some evidence for their relevance to several aspects of personality in a modern urban society. Table 9.1 shows Holland's (1973) six types together with similar categories proposed by other workers. The first column in Table 9.1 refers to the category of occupational interests with a practical emphasis, the second column refers to a scientific category, the third column refers to a category (or in some cases, categories) of artistic occupations, and so on. All six studies listed in the Table, using a variety of questionnaires and methods of analysis, distinguish both scientific and artistic interests.

Holland's scheme might appear to be an exception, since he refers to an "intellectual" rather than a "scientific" type. The term "investigative" has also been used (Holland, 1973, p.2). The reason for considering Holland's intellectual type to correspond with a dimension of scientific interest is that this type of person is stated to be "Scientifically inclined", to have "High scientific, research and math ability", and to "Value contributions to science" (Holland, 1975, p.10). Moreover, the 14 occupations scores for the Intellectual Scale on Holland's Vocational Preference Inventory are all scientific by nature.

There is reasonable evidence to support the notion that occupational interests and choices have sufficient consistency to justify their exploration in relation to personality. For example, corresponding interest scales have been found to correlate in expected ways: the Kuder Science Scale correlated .71 with Holland's Intellectual Scale, for a group of high school girls; whilst the Kuder Artistic, Musical and Literary scales correlated .26, .38 and .38 respectively with Holland's Artistic Scale (Rezler, 1967).

A moderate degree of concordance has usually been found between measures of occupational interests and corresponding vocational choices (Crites, 1969, pp.254-257). For example, artists and art teachers tended to have their highest score on Holland's Artistic Scale; whilst research scientists, engineers and chemists tended to have their highest score on the Intellectual (scientific) scale (Holland, 1975, Tables 17 and 23). In Australia, Underwood (1968) used a 60-item inventory of occupations, job attributes, subjects of study, and vocational goals, which were scored for degrees of preference. A strong bipolar factor emerged with preference for mathematics and for the jobs of mathematician and physicist contrasted with preference for art and the jobs of industrial designer and architect.

Moreover, most people do appear to acquire a fair range of impressions with regard to occupational areas, on which they may base their own preferences. These impressions are sufficiently general amongst senior high school and tertiary level students to be regarded as stereotypes. Holland (1973, p.57) summarised relevant American research as follows: "Taken together, these studies of occupational images strongly suggest that stereotypes are stable over time, have validity, and to a lesser degree are selectively perceived according to social status, intelligence, and degree of involvement in the occupation in question".

Occupational interests have also been shown to relate fairly

consistently to educational specialisation, as would be expected if people do selectively train for those vocations which appeal to their interests. For instance, male graduate students in arts departments at the University of North Dakota tended to obtain high scores on Holland's Artistic Scale and on the Allport-Vernon-Lindzey Aesthetic Values Scale; whilst those in science departments tended to obtain high scores on Holland's Intellectual Scale and on the Allport-Vernon-Lindzey Theoretical Values Scale (Williams, 1972). In Australia, Taylor and Kelso (1973) reported very high consistency of this kind. Of 26 male students studying applied chemistry in various college courses, 25 were "Intellectual" types on Holland's Vocational Preference Inventory; and of 29 male students studying in art, film and television courses, 22 were "Artistic" types on the Inventory. Also in Australia, using the Rothwell Interest Blank, chemistry students gave high scores for the scientific category, whilst architectural students gave high scores for the aesthetic category (Miller, 1958, Table 13).

Some research indicates that even junior secondary-school pupils have clearly differentiated orientations towards the arts or sciences, before educational specialisation has occurred. Butcher (1969b) reported a factor-analytic study of about one thousand Scottish school children aged 13 years. A well defined factor of "scientific orientation" emerged, with high loadings on eleven variables including a rating of the career of "research chemist", "rating of science as school subject", "Kuder Preference Record (scientific interest)", and "school marks in science". Neither divergent thinking tests nor aesthetic preference tests were included in this otherwise wide-ranging study. Lunt (1967, p.85) found that the majority of schoolboys at King Edward's School reported that they chose their direction of specialization by 14 years of age. The review by Pont (1970) showed how entrenched "The Arts-Science Dichotomy" is, at least in Britain.

The above discussion is sufficient to justify the conclusion that occupational and educational interests, values and choices form fairly

consistent patterns, at least with adolescent or adult persons who are not unduly restricted in their opportunities and experience. The question which remains is whether these patterns relate to relevant competencies, and to other wide-ranging aspects of personality. In order to apply some order to this account, the question will be discussed with respect to Holland's personality theory in particular. He has emphasized strongly the interdependence of vocational interests and personality variables, and his theory therefore forms an important background for the present studies. At the same time, certain aspects of Holland's theory suggest additions to the conclusions drawn in earlier chapters.

Holland's Theory of Careers

Holland's theory has been extensively elaborated over many years, but its main postulate is as follows (Holland, 1973, p.2):

> "In our culture, most persons can be categorized as one of six types: realistic, investigative, artistic, social, enterprising, or conventional."

The instruments used to define the six personality types have usually been Holland's Vocational Preference Inventory or Holland's Self-Directed Search. The former was used in the present study. It has one technical problem. The six main scales are correlated with the Acquiescence scale, with correlation values from .42 to .72 for groups of high-school boys and girls (Holland, 1975, Table 4). Thus a person's scores depend to some extent on his general tendency to report interest in many occupations. This artefact should be allowed for in interpreting results using the scales.

Of particular interest in the present context are the Artistic and Intellectual (*i.e.* scientific) scales. The Artistic person tends to be interested in occupations like "author" and "commercial artist". Both fine-arts and humanities are included in the occupations listed on the

Vocational Preference Inventory and scored for the Artistic scale. The Intellectual scale includes both pure and applied sciences, such as "chemist" and "aeronautical design engineer".

The personality traits associated with groups having their highest scores on the Artistic or the Intellectual scales have varied somewhat from publication to publication, as research findings have accumulated. Table 9.2 summarises the main personality characteristics which have been confirmed for the Artistic type and the Intellectual type, according to Holland (1973, pp.15-18). To assist the present discussion, personality characteristics have been grouped in the Table to show those which were similar for the two types, those which were distinctly different, and the remainder.

Both artistic and intellectual types were considered by Holland to be independent and introspective, in summarising much research. The traits which differentiated the two types, and which most clearly related to the findings of the two previous chapters, were as follows. The artistic type was stated to be original and imaginative. This is consistent with the positive correlations reported in this thesis between divergent thinking scores and arts-orientation variables. Holland's statement has also been supported by the significant positive correlations between Artistic and Literary interest scales (from the Occupational Interests Guide) on the one hand, and a "Creativity" scale (from Cattell's 16 PF test) on the other, as reported by Closs (1975, Table A6.4, p.149). The relevance of a divergent approach to artistic endeavour is also illustrated by Csikszentmihalyi and Getzels' (1970) research: they reported that the aesthetic quality of student-artists' drawings was significantly correlated with a "concern for discovery".

The artistic type was also seen as disorderly and complicated in Holland's account (see Table 9.2). This might be regarded as consistent with the positive correlations between preference for complex asymmetrical designs and arts-orientation variables reported in the previous chapters.

Table 9.2. Stated characteristics of Holland's Artistic and Intellectual types (adapted from Holland, 1973, pp. 15-18)

Note: Traits have been grouped to show those which appear to be similar for the two types, those which appear to be distinctly different, and the remainder.

SIMILAR TRAITS		DISTINCTLY DIFFERENT TRAITS	
Artistic	Intellectual	Artistic	Intellectual
Independent	Independent	Artistic interests	Scientific interests
Nonconforming	Unpopular, critical	Artistic abilities	Scientific abilities
Introspective	Introspective, introverted	Disorderly	Methodical, rational
		Emotional	Passive
		Impulsive	Cautious, reserved
		Intuitive	Analytical

OTHER TRAITS	
Artistic	Intellectual
Original	Intellectual
Imaginative	Curious
Impractical	Precise
Complicated	Pessimistic
Idealistic	Unassuming
Feminine*	

*"Feminine" is Holland's term. In terms of the scales used in defining this "trait" it represents a mixture of such characteristics as emotional sensitivity and aesthetic interests. Some of the other "traits" are ambiguous or complex also.

Table 9.3 Mean scores on relevant ability and divergent attitude variables differentiating artistic and intellectual (scientific) interest-groups, with discrimination indices

Notes: 1. Mean scores were extracted from Holland's data (1968, Tables 2 and 5).

2. The discrimination index, ω^2, was calculated by the writer. The statistic is used as a measure of the relative strength of an effect; when there are just two groups, the statistic indicates the extent of the difference between them in relation to total variation (Vaughan and Corballis, 1969).

3. All differences shown between the artistic and intellectual (scientific) groups were significant using t-tests calculated by the writer from Holland's tabulated data ($p<.01$).

VARIABLES	FEMALE STUDENTS			MALE STUDENTS		
	ARTISTIC (N = 1284)	INTELLECTUAL (N = 554)		ARTISTIC (N = 630)	INTELLECTUAL (N = 1774)	
	mean scores		ω^2	mean scores		ω^2
Scientific competencies	2.87	4.51	.10	3.66	5.22	.07
Mathematical ability (self-rating)	1.86	2.36	.06	2.09	2.61	.06
Artistic competencies	13.89	9.68	.09	12.32	7.32	.12
Life goals:						
Developing scientific theory	1.23	1.74	.10	1.45	2.10	.09
Producing artwork	1.97	1.56	.03	1.95	1.39	.08
Originality (self-rating)	2.59	2.31	.03	2.85	2.47	.05
Artistic originality	22.20	19.81	.05	21.87	17.86	.11
Nonconformist (Orientation survey)	3.11	2.82	.01	3.74	3.25	.01
Conservatism (self-rating)	2.10	2.22	.01	2.17	2.29	.00

No direct investigations of divergent thinking tests or aesthetic preferences have been undertaken by Holland and his co-workers, as far as the writer is aware. The present study was undertaken to fill this apparent gap in the evidence. There has been a directly relevant investigation using the Aesthetic scale from the Allport-Vernon-Lindzey Study of Values. Getzels and Csikszentmihalyi (1968, Table 3) reported significant correlations with five divergent thinking tests ranging from .22 to .31, for female art-school students; whilst for males, only one of the tests (Object Questions) gave a significant correlation of .32. For females, the Aesthetic scale was also significantly correlated (.20) with art grades, whilst for males the scale was significantly correlated (.26) with teacher-ratings of "Originality and Artistic Potential".

Holland's theory has been presented in terms of distinct "types". Nevertheless, the evidence suggests that Vocational Preference Inventory scores are better construed as fairly independent dimensions representing varying degrees of interest in different areas of activities. The Vocational Preference Inventory's Artistic and Intellectual Scales are independent if the acquiescence artefact is partialled out: the partial r value is .03 for girls and .08 for boys (calculated from data given in Holland, 1975, Table 4). Similarly in Australian research, there was a negligible correlation between aesthetic and scientific interests using the Brook Reaction Test: the Aesthetic scale gave a correlation value of only .12 with interest in Biological Sciences and -.07 with interest in Physical Sciences (Athanasou, Fox and Jenkins, 1978).

Initially, Holland's research was with restricted groups of talented students (National Merit finalists), but subsequently much wider groups have been studied, often over extended periods. For instance in one of the largest studies (Holland, 1968) of 1,576 male and 1,571 female college students, 76% of predictions were confirmed for comparisons across the

six personality types with males, and 84% were confirmed with females. However, the differences in the case of personality variables have been small in many cases, and somewhat inconsistent across the sexes and across different studies. Holland has recognised the limited accuracy of prediction afforded by his theory: "The VPI scales, as personality scales, provide a broad range of descriptive information but the reliability of such information is usually low" (1975, p.22).

Group differences are thus often consistent with Holland's descriptive theory, but nevertheless there may be considerable overlap between groups. This is illustrated in Table 9.3 showing data for Artistic and Intellectual (scientific) interest groups (from Holland, 1968, Tables 2 and 5). As may be seen, the groups tended to differ in competencies and life-goals in ways consistent with the findings reported in the two previous chapters. For example, the Artistic group assessed itself as more original, and reported more nonconfirming and less conservative attitudes. Nevertheless, as the ω^2 values in the Table show, the differences between these two groups accounted for only about one-tenth of the variance or less. It is possible that British and Australian Arts and Science educational groups might be more differentiated than Holland's American interest groups because of earlier educational specialisation.

Independent research groups have confirmed that there is a positive but low degree of predictive congruence between personality descriptions and occupational preferences. For example, Wall, Osipow and Ashby (1967) asked college students to rate the degree to which they matched each of Holland's personality-type descriptions, to indicate occupational preferences and to complete the Strong Vocational Interest Blank. There was some consistency between these three indicators of "personality type".

Studies which have used more detailed and independent measures of particular personality traits have indicated rather poor construct validity for the Holland scales. For example, the first attempt to test Holland's

theory in Australia, using the Vocational Preference Inventory and the California Psychological Inventory (CPI) with college students, gave few predicted differences between types: "A disappointingly small number of CPI scales discriminated significantly between the types" (Taylor and Kelso, 1973, p.205). When the scales derived from Holland's Self-Directed Search were correlated with ability scales from the Armed Forces Vocational Aptitude Battery given to high-school girls, only 25 of the 54 predictions were as expected (Kelso, Holland and Gottfredson, 1977).

It might be objected that in these studies, measured aspects of personality were not selected so as to be particularly relevant to occupational types. A more satisfactory study in this respect of direct interest in the present context is that by Morstain and Smart (1976), who investigated the educational attitudes of 237 faculty members at an American university. They found that academics in scientific disciplines (Investigative type) preferred formal, structured teaching methods and valued formal assessment of students, to a greater extent than academics in artistic disciplines (Artistic type).

A somewhat neglected feature of Holland's theory is the concept of "status level" in vocational interests. Initially, "status level" was conceptualised as part of the variation of individuals within each occupational type, due to intelligence and self-evaluation (Holland, 1959). More recently, "status level" has been construed as an ordering of the occupational types themselves. "Enterprising" persons were predicted to have the highest level of aspiration and level of achievement. The lowest level was represented by the Realistic type. Both Artistic and Intellectual types were considered to be intermediate in level (Holland, 1973, p.58). Whilst the importance of status in considering occupational choice (meaning both the social status of the occupation and the intellectual and aspirational status of the person) is unquestionable, Holland's

proposition as to the ordering of the types does not accord well with the evidence adduced below.

Of the six interest scales on the Vocational Preference Inventory, the one which had the highest positive correlation with the Inventory's Status scale for high school pupils was the Artistic scale: for boys the correlation was .42 and for girls .41 (Holland, 1975, Table 4). Further evidence favours the proposition that both Artistic and Intellectual (scientific) interests are positively related to variables reflecting academic and intellectual status. Relevant correlations bearing on this point have been extracted from extensive data presented by Kelso (1976, Tables 13 and 14), and are given in Table 9.4. Both scales were positively correlated in a fairly consistent manner with four variables concerning educational level, for both male and female students. These results illustrate the point that students interested in arts or science tend to share a concern for educational and intellectual advancement. Both groups may be contrasted with those who score high on Holland's Realistic and Conventional scales: the latter scales tended to correlate negatively with educational-level variables in Kelso's study.

There are several studies which further illustrate the contrast in intellectual level between those with scientific or artistic interests on the one hand, and those with "practical" interests on the other. Holland (1962) reported that both Artistic and Intellectual (scientific) types tended to aspire to graduate study. Several studies have found high-status occupational groups with high scores on both Holland's Artistic and Intellectual scales, including college professors, computer programmers, engineers and doctors (tabulated by Holland, 1975, Table 17). Rosenberg (1957, Table 3) found that students wishing to enter careers in arts (architecture, journalism, drama and art) scored highest on a measure of "Self-Expression-Oriented Values", and that those wishing to enter scientific careers scored next highest: these two groups contrasted with low-scoring

Table 9.4. Correlations between Holland's artistic and investigative (scientific) interest scales, and variables relevant to academic status

(Data extracted from Kelso, 1976, Tables 13 and 14)

MALE STUDENTS (329 ⩽ N ⩽ 386)		
VARIABLE	ARTISTIC	INVESTIGATIVE, SCIENTIFIC
	CORRELATIONS	
Extent of academic orientation in the student's school program	.25+	.11*
Level of educational expectations	.33+	.23+
Level of previous learning	.27+	.17+
School involvement	.16+	.08

FEMALE STUDENTS (480 ⩽ N ⩽ 523)		
VARIABLE	ARTISTIC	INVESTIGATIVE, SCIENTIFIC
	CORRELATIONS	
Extent of academic orientation in the student's school program	.15+	.38+
Level of educational expectations	.21+	.45+
Level of previous learning	.12+	.28+
School involvement	.17+	.12+

* $p < .05$ + $p < .01$

students who were considering practical occupations such as sales-promotion, hotel work and real-estate.

Perrone (1964, Table 4) gave various intellectual tests to school pupils who had given their occupational preferences, and been grouped accordingly. It was found that girls in a "general cultural" group scored higher on verbal IQ than those in an "organisation" group, most of whom preferred clerical work. For boys, both the general cultural and the scientific groups scored higher on IQ and on creativity tests, compared with a lower-status "service" group. An incidental finding fitting this general picture was mentioned by Cattell and Butcher (1968, p.209). Two questionnaire items which loaded positively on a factor of curiosity in children were: "I want to learn more about how the world works and science explains things" and "I want my pictures to be beautiful and pleasant to look at". Thus both scientific and artistic interests may be related to intellectual curiosity.

Hypotheses concerning the relationships between Holland's Artistic and Intellectual scales on the one hand, and various aesthetic, divergency and personality measures on the other, were tested in a correlational study. Details of the hypotheses are given after the experimental procedure has been described.

Experimental Procedure

Students were asked to complete four tests. Age, sex and university faculty were also recorded. Tests were as follows:

1. The Torrance Tests of Creative Thinking: Figural Test B. The tasks were scored for fluency, flexibility, originality and elaboration. It was considered desirable in this study to include a measure of originality (rather than only fluency) since Holland has mainly emphasised this aspect of divergency in relation to his Artistic scale.

2. Self-description Checklist, as described in the two preceding chapters. It was scored for Creative Independence and Emotional Activation scales.
3. The Barron-Welsh Art Scale, scored for the Revised Art Scale.
4. Holland's Vocational Preference Inventory. The Artistic, Intellectual, Masculinity, Status and Self-control scales were relevant to the present investigation.

The timed Torrance Figural Test B was completed under the writer's supervision by subjects tested in six small groups. The three other tests were completed in the subjects' own time during the following week.

Raw scores on all variables were used for correlational analyses. To obtain biserial correlations, sex was scored 1 for male, and 2 for female; and faculty was scored 1 for Science (or Mathematical Science) faculties and 2 for Arts (or Law) faculties.

Because the Torrance variables, other than fluency, are difficult to score, an experienced (graduate) scorer was employed, Philip Smith. He had previously given reasonably high inter-scorer reliability (Rho) coefficients for Figural Test A in another study of 40 children, with coefficients for fluency, flexibility, originality and elaboration of .95, .90, .74 and .73 respectively (Chorney, 1978). All other tests were objectively scored, using stencils, all scores being double-checked.

Subjects

Subjects were 70 third-year psychology students at The University of Adelaide who completed the tests as a practical-work assignment for a course on "personality". This cohort had undertaken relatively little previous study of personality prior to the third-year course, and the tests were completed early in their course. Whilst all subjects had some experience with other psychological tests, they had not previously completed the particular tests used in the study. Both individual and group results were provided to students subsequently as part of the teaching programme.

The sample had a mean age of 22.6 years (SD = 6.1). There were 25 males and 45 females, with 49 in Arts and 21 in Science faculties. Their examination marks for the personality course were included in the analysis, except that one girl missed the examination through illness.

Hypotheses

The specific hypotheses predicted from Holland's work and from the findings discussed in the preceding chapters, were as follows. It was predicted that the Holland Artistic scale would be positively correlated with Arts faculty membership, female sex, figural originality, fluency, flexibility and elaboration (from the Torrance Test), Creative Independence, Emotional Activation, Barron-Welsh Revised Art Scale, and Holland's Status scale. It was predicted that negative correlations would be obtained with Holland's Masculinity and Self-control scales.

With regard to the Intellectual scale, negative correlations were predicted with Arts faculty membership, Emotional Activation, and the Barron-Welsh Revised Art Scale. Positive correlations were predicted with Holland's Status and Self-control scales, and with the examination mark. No predictions were made with regard to the divergent thinking variables in relation to the Intellectual scale. The reason for this is that high scores on the latter are associated (by Holland) with a methodical, cautious approach to problems, which suggests convergence; but also high scores are associated with an intellectual and inquisitive attitude, which suggests divergence.

Results and Discussion

Correlations relevant to the stated hypotheses are given in Table 9.5. Those with the Artistic scale are discussed first, followed by those with the Intellectual scale. For the Artistic scale, all correlations were in

the predicted direction. Low, but significant, positive correlations were obtained with Arts faculty membership, female sex, figural originality and fluency, Creative Independence, the Revised Art Scale, Holland's Status scale and Emotional Activation. A significant negative correlation was obtained with the Masculinity scale, as predicted. Moreover, this last correlation between the Artistic and Masculinity scales was surprisingly similar for males and females separately, with values of -.50 and -.55 respectively ($p < .001$ in each case). It should be noted that there is no item-overlap for these two Holland scales.

The Holland scales were affected by Acquiescence response set. It was therefore necessary to check that the two significant correlations between the Artistic scale and other relevant Holland scales remained significant after Acquiescence had been partialled out. The required partial correlations with the Artistic scale were for Masculinity -.50 ($p < .001$), and for Status .32 ($p < .01$). Thus controlling for Acquiescence made little difference to these relationships.

Three predicted correlations with the Artistic scale were *not* significant the positive correlations with flexibility and elaboration, and the negative correlation with the Self-control scale. No explanation can be offered for these discrepant results. However, it may be noted that the predicted negative correlation with Self-control was significant for females separately ($r = -.47$ $p < .001$).

The results for the Intellectual scale were quite different. Predicted correlations with the Intellectual scale were generally negligible. The highest tabulated correlation was -.31 with the Self-control scale, and this was contrary to the predicted direction. Only the predicted positive correlation with the examination mark was confirmed ($r = .24$). Why did the predictions generally fail with this scale, if it provides a measure of scientific occupational interests? Various possible explanations were explored.

Table 9.5. Correlations with Holland's Artistic and Intellectual scales, for 70 university students

Note: In the columns headed "Hypoth", the direction of the hypothesized correlation is specified. One-tail tests were employed for predicted correlations.

Variable	Artistic scale			Intellectual scale		
	Hypoth.	r	p<	Hypoth.	r	p<
Arts faculty	+	.29	.01	-	.06	N.S.
Female sex	+	.35	.001		.15	N.S.
Holland's Masculinity Scale	-	-.59	.001		-.02	N.S.
Originality	+	.21	.05		.16	N.S.
Fluency	+	.24	.05		.12	N.S.
Flexibility	+	.11	N.S.		.06	N.S.
Elaboration	+	.05	N.S.		.16	N.S.
Creative Independence	+	.27	.05		.12	N.S.
Barron-Welsh R.A.S.	+	.21	.05	-	-.06	N.S.
Holland's Status scale	+	.39	.001	+	-.08	N.S.
Emotional Activation	+	.29	.01	-	.21	N.S.*
Holland's Self-control scale	-	-.18	N.S.	+	-.31	N.S.*
Examination mark #		.20	N.S.	+	.24	.05

*The direction was opposite to that predicted, so that these two correlations were deemed nonsignificant using the one-tail procedure.

#Based on 69 available cases.

Note: The Artistic and Intellectual scales were not significantly correlated when Acquiescence was partialled out (partial r = .02).

It was thought that the Intellectual scale might have a restricted range within this specialised sample. However, the standard deviation was 3.7, which was not much less than that for the Artistic scale (4.3). Similar standard deviation values were obtained for the Intellectual scale with large, diverse groups of college students used for standardisation: 4.3 for males and 3.9 for females (Holland, 1975, Tables 19 and 20). Clearly, the Intellectual scale did not have an unduly restricted range in the present sample.

It was considered that a "natural science" subscale from the Intellectual items might give a clearer picture. The subscale was formed from those items giving natural science occupations such as meteorologist, and excluding five other occupations on the Intellectual scale such as anthropologist. The subscale gave correlation values similar to those for the total Intellectual scale. Nevertheless, it seems possible that high scores on the scale may reflect either scientific interests in particular, in some cases, or a general intellectual orientation in other cases. If so, the scale is somewhat ambiguous in relation to divergent traits, as suggested above in the section elaborating hypotheses to be tested.

Another possible explanation is that arts-science effects mainly stem from orientation towards arts rather than orientation towards science. This would suggest in turn that preference for complexity and a divergent mode of thinking are congenial to, and stimulated by, educational and professional experience in the arts; whilst interest and education in the sciences does not necessarily impose a restricted or convergent approach.

No further evidence on these speculations is available, and it is appropriate to concentrate interpretation on the significant results obtained with the Artistic scale. These provide support for the conclusions from the two previous chapters, that orientation towards the arts is associated both with preference for complex figures and with divergent thinking variables, to a low degree. Additional expectations deriving from previous research using Holland's Inventory were confirmed, that an artistic orientation is

associated with emotionality, with high-status vocational aspirations and with preference for occupations commonly liked by women.

Conclusions

Several conclusions concerning the nature of arts-science differences may be drawn from the previous and the present research findings using Holland's Artistic and Intellectual scales.

Wide-ranging differences between persons interested in arts occupations and those interested in scientific occupations have been reported, including differences in competencies, preferred activites, and personality traits. Observations in any particular experiment should therefore be seen as part of more general patterns. Nevertheless, differences in scores between artistic and scientific interest groups are often small in relation to overall individual variation; similarly, correlations between artistic orientation and other personality variables are usually low. Correlations of Holland's Artistic scale with figure preferences and with divergent thinking variables in the present study were consistently in the predicted direction, but low.

In these circumstances it is not possible to hold that personality characteristics such as convergence-divergence are major determinants of occupational or educational choice. Rather, various characteristics, including level of academic ability, specific competencies, preferred modes of thinking and attitudes may each play some part in influencing individual decisions as to educational and career path.

Particular differences between arts and science interest groups should be seen against a backcloth of certain similarities. Tertiary students in both areas are intellectually able compared with their peers with more practical jobs or training courses. Both groups share a tendency to be introspective and to show greater intellectual curiosity than average. They may tend to differ in their preferred modes of thinking and in their

aesthetic preferences, but share some appreciation of academic growth.

Following from this point, it should not be thought that the relatively poor divergent thinking ability of science-oriented students (described in chapter 7) demonstrates any general lack of intellectual ability amongst scientists. Previous research on occupational interests shows clearly that preference for scientific occupations tends to be linked with high educational aspiration and achievement, and intellectual curiosity. Although there are convergent dispositions allied to scientific interests, such as having a methodical, cautious and precise approach to problems, these do not necessarily indicate any broad intellectual handicap amongst science students.

CHAPTER 10

FURTHER STUDIES OF ARTS AND SCIENCE ORIENTATIONS

Results described in the three previous chapters showed that it was useful to consider "arts orientation" as a central construct. It was operationalised in terms of variables such as the extent of education in fine-arts, university faculty, interest in art and design, and artistic achievements. Measures of arts orientation tended to be positively related to scores on divergent thinking tests and to self-assessed creative independence. Moreover, an arts orientation also tended to be associated with preference for complex figures, and particularly asymmetrical designs. The relationships between aspects of creative performance and scores on the Barron-Welsh Art Scale sometimes reported in the literature were thus seen as indirect, with arts orientation as the crucial intervening construct.

Further studies were undertaken to examine the relevance of arts orientation in various contexts. The first study investigated arts-science specialisation at matriculation level amongst South Australian secondary school pupils. At the tertiary level, fourteen varied arts and science groups were tested in a second study. This investigation included fine-arts as well as arts-faculty groups, and engineering as well as science-faculty groups. In a third study, the effects on examination performance of differences between arts and science students' preferred cognitive styles, were investigated.

Before considering these studies, it is appropriate to examine previous evidence concerning differences between arts and science groups in abilities, cognitive styles, and personality characteristics relevant to the present research. The general literature is summarised first, followed by particular consideration of research comparing arts and science groups on divergent thinking variables.

Reported characteristics of arts and science groups

Much of the research reviewed in this section was exploratory rather than organised around any consistent theoretical scheme. Adequacy of methodology has varied. In some cases arts and science groups were compared, in others a group was compared with some normative sample, whilst in a few studies no comparison group was used other than that implied by the tester's prior experience. To allow a systematic overview of the findings, these have been tabulated under five headings, for each of four sampled categories of subject.

The four types of sample are (*a*) general arts, (*b*) visual arts, including fine-arts and commercial art; (*c*) natural sciences; and (*d*) applied physical sciences, mainly engineering. Within each of the first three categories, enough studies were found to justify the separate listing of student and professional samples.

Findings are summarised in Table 10.1 for those characteristics considered relevant to the present thesis. Characteristics are tabulated under five general headings: cognitive abilities; personality traits, attitudes or activities relevant to divergence/convergence; independence or social conformity; aesthetic and situational preferences, interests or values; and emotionality or passivity. In addition to findings relevant to these topics, the Table indicates the country of the sample and the general nature of the indicators used.

It is acknowledged that summarising information in this brief form provides only a rough guide, since the precise interpretation of any finding depends on the selection of samples, the measures used, the size of group differences, and procedural details. Moreover, it is recognised that the Table shows some bias towards the presentation of differences rather than similarities between groups, together with a neglect of variability within groups. As an illustration of this point, Eiduson (1962) writing about

Table 10.1. Relevant personality characteristics of arts and science samples

(a) General arts (b) Visual arts (c) Natural science (d) Applied science

Key to columns in the Table

Column 1: Reference (author/s and date)

Column 2: Country in which the sample was obtained

Column 3: Nature of the information obtained in the study, coded as follows:

Code letter	Meaning	Code letter	Meaning
A	Aesthetic preferences	P	"Projective" response interpretations
B	Biographical information	Q	Questionnaire responses
C	Cognitive test data	R	Ratings by others
D	Data from interview impressions	S	Several (review of previous studies)

Column 4: Type of sample

Column 5: Summary characteristics

Findings are stated as succinctly as possible. Characteristics are given in positive form if possible: when the sample gained lower mean scores than the comparison sample or norm, the antonym of the measured trait may be given as the group's characteristic. The five areas which are relevant to the writer's studies reported in this chapter are separately tabulated as follows:

Column 5i: Cognitive abilities

Column 5ii: Divergent or convergent attitudes or activities

Column 5iii: Independence or social conformity

Column 5iv: Aesthetic and environmental preferences, interests or values

Column 5v: Emotionality or passivity

Table 10.1 continued. (a) General arts groups (students)

(1)		(2)	(3)	(4)	(5i)	(5ii)	(5iii)	(5iv)	(5v)
Welsh	1959	U.S.A.	A	Creative writing students	--	--	--	Prefer complex figures	--
Anderson	1960	Aust.	Q	Humanities students	--	Adventurous	Dominant, radical	--	Warm, tense
Rees & Goldman	1961	U.S.A.	B,Q	Students with achievements in the arts	--	--	Low regard for social mores	--	Emotionally labile
Sanford	1961	U.S.A.	Q	Students majoring in English	--	High on creative traits	Nonconforming	--	--
Nichols & Holland	1963	U.S.A.	B,C Q,R	First-year college students with literary achievements	Verbal aptitude	Original, creative activities	Dominant	Artistic achievements	Expressive
Heim, Povey & Watts	1965	G.B.	C	University arts faculty students	"Commit oneself" on word knowledge test	--	--	--	--
Helson	1966	U.S.A.	A,B,C, P,Q,R	Women students with many artistic activities	Verbal ability, high school achievements	Creative, original, imaginative	Autocratic, rebellious, independent	Prefer complex figures, high artistic interest	Emotional, impulsive
Goldschmid	1967	U.S.A.	Q	Students of humanities	--	Intuitive	Dominant	--	Low self-control
Eisenman	1969b	U.S.A.	C,Q	Students majoring in English	Divergent fluency	Creative personality	--	--	--
Povey	1970	G.B.	C	Sixth-form pupils (arts)	High on verbal tasks	--	--	--	--
Lewis	1970	Aust.	Q	University arts students	--	Consider arts. fac. "playful"	--	--	--
Little	1971	G.B.	Q	Psychology students with arts-orientation	--	--	--	--	"Person-oriented"
Hare & Gaier	1971	N.Amer.	A,C	Student writers	--	--	--	Prefer complex stimuli on Barron-Welsh Art Scale	--
Entwistle	1972	G.B.	B,C,Q	Tertiary student of languages & humanities	Verbal aptitude	--	Radical	High aesthetic interests	--
Barron (Ch.8)	1972	U.S.A.	D,Q	Student dancers	--	Original, imaginative	Independent	Artistic, seek new experiences	Energetic, emotional, anxious
Entwistle (p.101)	1973	G.B.	Q	Tertiary students (linguists)	--	--	Radical	High on aesthetic value	High neuroticism
Zeldow	1973	U.S.A.	Q	Student playwrights	--	Flexible, spontaneous	Individualistic, unconventional	--	Impulsive

Table 10.1 continued. (a) General arts groups (professionals)

(1)		(2)	(3)	(4)	(5i)	(5ii)	(5iii)	(5iv)	(5v)
Terman	1955	U.S.A.	B,C,Q,R	Intelligent male humanities graduates	--	Diverse school activities	Felt different from others	--	--
Drevdahl & Cattell	1958	U.S.A.	Q	Writers and artists	Intelligent	Venturesome, imaginative	Assertive, self-sufficient	--	Tense and sensitive, but stable and controlled
Thorndike & Hagen	1959	U.S.A.	B,C,Q	Architects	High intellectual and visual perception scores	--	--	--	--
Thorndike & Hagen	1959	U.S.A.	B,C,Q	Writers	High IQ and achievement in verbal school subjects	Many verbal free-time activities	--	--	--
Bennett, Seashore & Wesman	1959	U.S.A.	C	Liberal arts graduates, tested earlier in high school	High verbal and abstract reasoning; spelling, sentences and numerical abilities	--	--	--	--
MacKinnon	1962	U.S.A.	C,Q	Creative architects	Intelligent, high scores on Embedded Figures	--	Independent	Aesthetic interests, preference for complex figures	--
Hall & MacKinnon	1969	U.S.A.	Q	Creative architects	--	Intuitive	Low "achievement-via-conformance", high antonomy	High on aesthetic value	Low self-control
Barron (Tables 7.3, 7.4, 7.5)	1969	U.S.A.	B,D,Q	Writers of high repute	High intellect, verbally fluent	Unconventional thought processes, flexibility	Value independence	Aesthetically reactive	High psychopathology scores, but high ego-strength
Bachtold & Werner	1973	U.S.A.	Q	Eminent women authors	Intelligent	Imaginative, adventurous	Radical, self-sufficient	--	Emotional, sensitive
Bachtold	1976	U.S.A.	Q	Writers and artists (professional women)	Intelligent	Spontaneous, adventurous	Assertive, radical	--	Affected by feelings, impulsive
Allport (Table 5.2)	1978	U.S.A.	Q	Literary workers	--	--	--	High on Aesthetic Value, assessed earlier when students	--

Table 10.1 continued. (b) Visual arts groups (students)

(1)		(2)	(3)	(4)	(5i)	(5ii)	(5iii)	(5iv)	(5v)
Munsterberg & Mussen	1953	U.S.A.	P,Q	Outstanding fine-arts students	--	Self-expression needs	Non-conforming	Emphasize Aesthetic Values	Guilt feelings
Rosenberg	1957	U.S.A.	Q	Students planning to enter art or architecture as profession	--	Self-expression oriented values	--	--	--
Nichols & Holland (Table 14)	1963	U.S.A.	B,C,Q, R	First-year college students with graphic-art achievements	--	Original, creative activities	--	--	Expressive
Eisenman & Coffee	1964	U.S.A.	A	Students majoring in art	--	--	--	Prefer asymmetrical polygons	--
Hammer	1966	U.S.A.	P,R	Creative fine-art students	--	Creative, original responsiveness	Independent, rebellious	--	Range of emotional feeling
Babarik	1966	U.S.A., Canada	C,R	Creative visual design, fine-arts students	Give superordinate word associations	--	--	--	--
Cross, Cattell & Butcher	1967	G.B.	Q	Visual artists and gifted art students	Intelligent	Imaginative	Independent, assertive	--	Emotionally liable, tense, anxious
Hare & Gaier	1971	N.Amer.	A,C	Students taking Art majors	--	--	--	Prefer complex stimuli on Barron-Welsh Art Scale	--
Barron (Chs 4 & 5)	1972	U.S.A.	A,C,D, P,Q	Students of visual arts	--	Flexible, spontaneous	Individualistic, unconventional	Prefer complex stumuli on Barron-Welsh Art Scale , high aesthetic judgement	Impulsive, feelings of anxiety, perplexity
Zeldow	1973	U.S.A.	Q	Student artists	--	Flexible, spontaneous	Individualistic, unconventional	--	Impulsive
Csikszentmihalyi & Getzels	1973	U.S.A.	Q	Senior art school students	--	Imaginative, high 'general creativity'	Self-sufficient, unconventional, casual, radical	--	Reserved, desurgent
Taylor & Kelso	1973	Aust.	Q	Art, film and television students	--	Flexibility	Low socialization, irresponsible	--	Low self-control
Woodward	1975	U.S.A.	B,C,Q	Students in art courses	High figural creativity, verbal originality	--	High antonomy, "progressivism"	High "aestheticism", complexity	Impulse expression

Table 10.1 continued. (b) Visual arts groups (professionals)

(1)		(2)	(3)	(4)	(5i)	(5ii)	(5iii)	(5iv)	(5v)
Roe	1946	U.S.A.	D,?	Outstanding male artists	Superior intellect	--	--	--	Sexually responsive
Steiner	1953	U.S.A.	P	Commercial artists	Generalized thinking	Creative responses	--	--	Sensitive, responsive
Eiduson	1958	U.S.A.	P	Artists (both "normal" and "neurotic")	--	Original, novel in thinking	--	--	Sensitive, responsive
Thorndike & Hagan	1959	U.S.A.	B,C,Q	Artists, designers	High visual perception scores	--	--	--	--
Welsh	1959	U.S.A.	A	Artists	--	--	--	Prefer complex figures	--
Barrucand & Barrucand	1967	Austria	B	The artist, A. Kubin	--	--	--	--	Anxious, neurotic
Rawls & Slack	1968	U.S.A.	P	Artists	--	Rich imagination, 'loose' associations	Unconventional ideas	At ease in ambiguous situations	Emotional
Bachtold & Werner	1973	U.S.A.	Q	Eminent women artists	Intelligent	Imaginative, adventurous	Radical, self-sufficient	--	Emotional
Rom	1973	Israel	B,D,P	Individual contemporary painter	--	--	Indifferent to political and social problems	Complex distorted figures in paintings	Shy, underdeveloped social interests
Scamell	1977	U.S.A.	Q	Art teachers	--	--	--	High on Aesthetic Value	--
Allport (Table 5.2)	1978	U.S.A.	Q	Artistic workers	--	--	--	High on Aesthetic Value, assessed earlier when students	--

Table 10.1 continued. (c) Natural science groups (students)

(1)		(2)	(3)	(4)	(5i)	(5ii)	(5iii)	(5iv)	(5v)
Rosenberg	1957	U.S.A.	Q	Students interested in science for a career	--	--	--	--	Low "People-Oriented Values"
Nichols & Holland (Table 7)	1963	U.S.A.	B,C,Q, R	First-year college students with science achievements	--	Original	Self-confident	--	Expressive, but self-controlled
Hudson	1963	G.B.	C	Schoolboy science specialists	High IQ, spatial and numerical abilities	--	--	--	--
Knapp	1963	U.S.A.	P	Students majoring in science	--	--	--	--	Ressession of affect
Perrone	1964	U.S.A.	C,Q	Pupils (15-20 years) giving science occupational preferences	High IQ and divergent thinking	--	--	--	--
Goldschmid	1967	U.S.A.	Q	Students majoring in science	--	--	Submissive, authoritarian	Low aesthetic interests	Impulse inhibition
Pohl & Pervin	1968	U.S.A.	C	Male university science students	High mathematical aptitude	--	--	--	--
Child	1969a	G.B.	B,C,Q	Technol. univ. science students	High IQ	--	--	--	Stable
Biggs	1970a	Aust.	Q	University science students	--	Dogmatic	--	--	--
Povey	1970	G.B.	C	Sixth-form pupils (science)	High IQ	--	--	--	--
De Russy & Futch	1971	U.S.A.	C	Science students	Fast on Embedded Figures Test		--	--	--
Kline	1971b	G.B.	Q	Sixth-form science pupils	--	--	"Obsessional" traits	--	--
Entwistle	1972	G.B.	B,C,Q	Tertiary students (natural sciences, mathematics)	Numerical aptitude	--	Conservative	Low aesthetic interests	Stable
Duckworth	1972	G.B.	C,Q	Grammar-school pupils (science)	Intellectual, high academic achievements	--	--	--	--
Forrest & Smith	1972	G.B.	C	School pupils choosing science	Intellectual ability		--	--	--
Little	1972a	G.B., U.S.A.	Q	Students majoring in physical science	--	--	--	--	Low "Person-orientation"
Selkirk	1973	G.B.	C,Q	Sixth-form pupils taking specialist science courses	High academic ability		--	--	--
Rump & Smolicz	1974	Aust.	C	Science students taking psychology	Numerical aptitude	--	--	--	--
Ormerod & Duckworth	1975	G.B., U.S.A.	S	Senior school pupils specialising in science	High IQ, maths ability	--	--	--	--
Kempa & McGough	1977	G.B.	C,Q	Sixth-form pupils studying maths	Preference for symbolic rather than verbal information	--	--	--	--
Cawthron & Rowell	1978	Aust.	Q	University science students and staff	--	Agree with "convergent" views of science: should be logical, factual, one theory, etc.	--	--	--

Table 10.1 continued. (c) Natural science groups (professionals)

(1)		(2)	(3)	(4)	(5i)	(5ii)	(5iii)	(5iv)	(5v)
Roe	1950	U.S.A.	P	Physical scientists	--	Restrained ideation	--	--	Anxious
Roe	1953	U.S.A.	B,P	Physical scientists	--	--	--	--	Avoid personal contacts
Cattell & Drevdahl	1955	U.S.A.	Q	Eminent research scientists	Intelligent	--	Dominant, self-sufficient	--	Inhibited
Terman	1955	U.S.A.	B,C,Q,R	Intelligent male physical-science researchers	Early scientific aptitude	Few school activities, few adult "service" activities	Low sociability	--	--
Cattell	1959	U.S.A.	B	Eminent physical scientists	Intelligent	--	Dominant, self-sufficient	--	Stable, inhibited
Bennett, Seashore & Wesman	1959	U.S.A.	C	Science graduates, tested earlier in high school	Verbal reasoning, numerical and spelling ability	--	--	--	--
Thorndike & Hagen	1959	U.S.A.	B,C,Q	Physical scientists	High general ability	Earlier scientific activities at home and school	--	--	--
Gough & Woodworth	1960	U.S.A.	Q	Research sciences "initiators"	--	--	Dominant, high socialization	--	Self-controlled
Siegelman & Peck	1960	U.S.A.	B,D,P,Q	Doctoral candidates in chemistry	Intelligent	Seek creativity, curious	Desire independence	Want controlled, orderly environment	Control impulses, but anxious about work failure
Gough	1961	U.S.A.	A,C,Q,R	Industrial research scientists	High IQ, high general information	--	--	High on aesthetic value	--
Helson	1961	U.S.A.	D,R	Women mathematicians ("Comparison group")	--	--	Conventional	--	Defend against impulses, cheerful
Roe	1961	U.S.A.	S	Productive scientists	--	--	Independent	Prefer "resolvable" disorder	Impulse control, asocial
Eiduson	1962	U.S.A.	D,P	Research scientists	--	Oriented towards new ideas	Self-reliant	Prefer structured work situation	Reject impulsiveness
McClelland	1962	U.S.A.	S	Creative physical scientists	Analytic, hard working	--	--	Dislike art	Avoid complex emotions
Chambers	1964	U.S.A.	B,Q	Creative chemists	Maths ability	High initiative	Dominant	--	--
Barron	1968	U.S.A.	Q	Scientists	--	Judgmental type	--	--	--
Parloff & Datta	1968	U.S.A.	Q	Research scientists	Disciplined effectiveness	--	Self-assurance, adaptive autonomy	--	--
Greene	1976	U.S.A.	D	Scientists receiving psychotherapy	Objective cognitive style	--	--	--	--
Sofman, Hajosy & Vojtisek	1976	U.S.A.	C	University science faculty	Fast on Embedded Figures Test	--	--	--	--
Bachtold	1976	U.S.A.	Q	Scientists (professional women)	Intelligent	Adventurous	Assertive, radical	--	Reserved, tough-minded
Winkler	1978	Aust.	B,Q	Female academics (science, medicine)	--	--	Conservative in sex role attitudes	--	--

Table 10.1 continued. (d) Applied science groups (students and professionals)

(1)		(2)	(3)	(4)	(5i)	(5ii)	(5iii)	(5iv)	(5v)
Moore & Levy	1951	U.S.A.	B,P	Successful engineers	--	Orderly, but ingenious	--	--	Tense
Steiner	1953	U.S.A.	P	Engineers	--	Systematic, with poor creative imagination	--	--	Tense, controlled
Harrison, Tomblen & Jackson	1955	U.S.A.	B,D,P, Q	Mechanical engineers	Strive for achievement	Orderly, unimaginative	Approve authority, conforming, but self-sufficient	Fond of structive, intolerant of ambiguity	Stable
Terman	1955	U.S.A.	B,C,Q, R	Intelligent male applied engineers	Early aptitude in science	Few school activities	--	--	Reserved
Thorndike & Hagen	1959	U.S.A.	B,C,Q	Engineers in general	Intellectual, mathematical, spatial ability	--	--	--	Low social participation
Bennett, Seashore & Wesman	1959	U.S.A.	C	Technical graduates, tested earlier in high school	Verbal, abstract and mechanical reasoning; numerical and spatial relations abilities	--	--	--	--
Izard	1960	U.S.A.	Q	Graduate engineers, engineering students	High need for achievement	--	Deference	Prefer order	Low need for affiliation
Babarik	1966	U.S.A.	C,R	Creative engineers and scientists in industry	Give "subordinate" word associations	--	--	--	--
Barrett & Thornton	1967	U.S.A.	C	Engineers	Fast on Embedded Figures Test	--	--	--	--
Davis	1967	U.S.A.	C,Q,S	Engineers	High IQ	Restricted interests	Authoritative, conforming, but self-sufficient	Prefer order, low aesthetic interest	Stable
Pohl & Pervin	1968	U.S.A.	C	Male university engineering students	High mathematical aptitude	--	--	--	--
Entwistle	1972	G.B.	B,C,Q	Tertiary students of applied science	Numerical aptitude	--	Conservative	Low aesthetic interests	
Taylor & Kelso	1973	Aust.	Q	College applied chemistry students	--	Inflexible	--	--	--
Taylor & Kelso	1973	Aust.	Q	College engineering students	--	--	Submissive	--	Self-control
Horn, Turner & Davis	1975	U.S.A.	Q	College engineering students, and high-school pupils intending to study engineering	--		--	--	Stable

a sample of research scientists emphasized the many differences within the sample, although there were also some similarities. Moreover, although several studies have reported personality traits associated with creativity amongst artists, Roe (1946) in her study of outstanding male artists reported: "For a number of these subjects there are in their Rorschachs no indications of creative ability." Thus Table 10.1 represents only a simplified account of significant tendencies amongst the samples studied.

Literature on aesthetic preference tests which has been reviewed in earlier chapters is not repeated in the Table, apart from a few representative items. Moreover, research on convergence/divergence and directly relevant to Hudson's theory is generally excluded from the Table, being described separately in the following section. Findings represented in the Table are described starting with column 5i and proceeding through to column 5v.

Examination of column 5i shows that both arts and science samples may be described as having high intellectual ability. Nevertheless, high convergent intelligence is more particularly characteristic of science samples, whether students or professionals, pure or applied. This might be considered to support Holland's categorisation of those with scientific occupational preferences as "Intellectual".

In addition, particular cognitive abilities appropriate to science are clearly evident (Table 10.1, sections *c* and *d*, column 5i), including reasoning with spatial, numerical and symbolic materials. The realisation of potential ability may be enhanced by strong motivation for achievement and work effort, especially in the case of professional scientists. Cognitive abilities associated with arts samples include verbal facility and divergent fluency, as well as visual ability in the case of architects and artists (Thorndike and Hagan, 1959). In a theoretical discussion of the competencies needed by scientists and artists, Gardner (1977, p.111) noted that their "emphasis in goals and methods is strikingly different."

With regard to indicators of divergent activities and dispositions, various general arts and fine-arts samples have been described as adventurous, original, creative, imaginative, intuitive, flexible, spontaneous and self-expressive (Table 10.1, sections *a* and *b*, column 5ii). On the other hand section *d* of the Table shows that applied scientists (mainly engineers) have been reported as having restricted interests, and as orderly, unimaginative and inflexible. These characteristics would appear to be associated with a convergent attitude.

The natural science samples present mixed findings in this respect. Whilst some studies have reported such "convergent" characteristics as dogmatism, restrained ideation and restricted range of activities, in other studies professional science samples and high-achieving science students have been described as original, adventurous, curious, and showing initiative. The evidence from column 5ii of the Table therefore suggests that "convergent" traits are particularly characteristic of engineers, but that "creative" traits may be evident among selected groups of natural science students with high achievements, and among scientific research workers.

These findings do not conflict with Holland's conclusions stemming from occupational preferences described in the previous chapter, but do provide additional detail. In Holland's terms, the differences between applied and research scientists may be accounted for by secondary features of his Vocational Preference Inventory codes. Thus, in Holland's acccount, research scientists gave first and second highest scores on the Intellectual and *Social* scales respectively, whereas three out of four groups of engineers gave their highest scores on the Intellectual and *Realistic* scales (Holland, 1975, Table 17). It is this additional "Realistic" aspect, perhaps, which is consistent with the clearer "convergent" profile of the applied scientists. On the other hand, it is feasible that a more creative personality profile is associated with research on the frontiers of pure science, which

"seldom proceeds in the straightforward logical manner imagined by outsiders" (Watson, 1968, p.xi).

The entries in column 5iii of Table 10.1 relate to independence or social conformity. Capacity for independent thinking is considered necessary for creativity. Conversely, "conformity tends to destroy creativity by alienating the creator both from reliance on his own thought processes, and from contact with basic reality" (Crutchfield, 1962, pp.120-121).

General arts samples and visual arts students are frequently reported as dominant, radical, assertive, self-sufficient, independent, unconventional and non-conforming. There is some evidence showing that such characteristics apply also to professional workers in the visual arts, although few relevant studies have been reported. Historical evidence concerning artists is somewhat equivocal. Clark (1964, p.63) commented on the relationship between the artist and society throughout history: "at certain periods these individuals are isolated, at others they enlist behind them a whole army of assent and participation". For an artist to succeed, Clark (1964, p.64) emphasized "the importance of an accepted iconography" with which the artist may communicate to his public. Thus artists have to be independent and yet attuned to their patrons and their public, just as "Architects are businessmen as well as artists" (Barron, 1969, p.70). Gardner (1973, p.334) similarly remarked that the artist "may disdain and scorn the audience, but he is, in a very real sense, as dependent upon it as the performer is".

Applied science samples in Table 10.1 (section *d*, column 5iii) are described as approving authority, showing deference, and as conforming, submissive and conservative. They may also be self-sufficient. The natural science samples (both student and professional) are in some cases reported as conservative, submissive and highly socialized, but in other cases are reported as radical, dominant and independent. The latter characteristics tend to be associated with successful research scientists,

rather than science students. It would seem that the "creative" traits of independence and self-sufficiency are relevant to productive scientific work, even though these traits are not characteristic of the average science student. The totality of this evidence, as summarized in Table 10.1 (column 5iii), suggests that Holland's description of Artistic and Intellectual (scientific) types as being similarly "independent" is somewhat oversimplified.

Evidence concerning the degree of aesthetic interest (column 5iv in Table 10.1) supports the conclusions drawn in chapters 7 and 8. Not only do visual arts samples obtain high scores on aesthetic value scales, but so also do general arts samples, both student and professional. Interest in aesthetic objects and values may therefore be seen as associated with a general humanities/arts orientation, rather than being limited to groups with special education or professional expertise in fine-arts. On the other hand, natural and applied science samples tend to have low aesthetic interests and may indeed be reported as disliking art. Moreover, the findings considered in previous chapters concerning the association between science orientation and preference for symmetry in designs are supported by the tabulated results. They are also extended, in that professional scientists are reported in several studies to prefer an ordered, well-structured environment generally, including their working environment (see sections *c* and *d*, column 5iv of the Table).

The results presented in column 5v of Table 10.1 are more difficult to summarise, because the areas of emotionality and passivity include diverse traits. Nevertheless, most of the findings in these areas suggest that arts samples are emotionally labile, impulsive, and tense. On the other hand the science samples are more often found to be stable, reserved, and with high self-control. However, some science samples are also described as tense or anxious, and Siegelman and Peck's (1960) research indicates that this may be related to specific anxiety about scientific work and the possibility of failure in research. The high tension, when it occurs

amongst research scientists, may therefore be associated with their high need for achievement.

The scientists' tendency to avoid emotional arousal may be associated with a low degree of personal affiliation and inter-personal contact, as indicated by several studies (see Table 10.1, sections *c* and *d*, column 5v). It is tempting to relate these findings concerning low emotionality and personal involvement to the physical scientists' preference for control and order (described above). Perhaps other persons are more complex, more difficult to categorise and control than the physical scientists' preferred objects of study. Such an inferred connection between low emotionality and preference for simplicity may be unjustified, however, in view of the nonsignificant relationships between emotional activation and preference for complexity or asymmetry found in the main correlational study.

Many studies were more extensive than would appear from the above summaries. The large investigation by Goldschmid (1968) is particularly relevant to the present studies and is worthy of a more detailed description. He obtained science and humanities scores based on ratings of major fields of study, for graduates of several American universities. The various samples had been given one or more of five personality questionnaires on admission to their universities. Regressions of personality variables on ratings for (a) science and (b) humanities, were found for both original and cross-validation samples. The results showed "that particular personality patterns are indeed associated with educational choice". Science graduates tended to be prudent and conventional, whereas the humanities graduates valued independence. Science was associated with control of impulses, whereas the humanities were associated with emotional expression and anxiety. The humanities graduates expressed a wide range of divergent interests, and were imaginative and outspoken, whereas the science graduates were restricted in their interests, reserved and lacking spontaneity in their social behaviour. In terms of implied cognitive functioning, science was associated with

preference for a problem-solving approach, humanities with preference for imaginative, innovative thinking. These results nicely match those described in previous chapters. However, Goldschmid's conclusions were based solely on questionnaires and his study did not include cognitive or aesthetic tests.

Additional studies extend the themes developed above, but cannot be readily tabulated. For instance, Hudson (1967a) noted that science specialists among a sample of able British secondary schoolboys associated the concepts "valuable" and "intelligent" with "dependable", unlike the arts specialists. Thus arts and science groups may have somewhat different value systems in relation to their studies. Similarly, Sprecher (1963) reported that engineers, but not psychologists, regarded technical competence as important for creative work in their professions. Hudson and Jacot (1971) even found clear but puzzling arts-science differences in family relationships. Analysing entried in "Who's Who", they found that eminent male arts specialists were much more likely to be unmarried than eminent scientists. In a more detailed study of the reported family life of married research students, Hudson (1972b) found that arts and social science students more often reported that their marriage was "eventful", whilst physical science students more often reported that their marriage was "peaceful". Possibly these findings might be taken as consistent with the greater social conformity of physical scientists.

Watson (1968, p.69) in his account of the discovery of "The Double Helix" gave a sympathetic but critical description of the restrictions imposed by a severely "convergent" form of scientific training in the life of the late Rosalind Franklin. "The years of careful, unemotional crystallographic training had left their mark. She had not had the advantage of a rigid Cambridge education only to be so foolish as to misuse it ... As model building did not appeal to her, at no time did she mention

Pauling's triumph over the α-helix". Watson implied that a more open-minded approach to her research might have allowed Dr. Franklin to play a greater role in the subsequent discovery of the structure of the DNA molecule which was assisted by "playing" with possible molecular models.

Several writers have suggested that convergers are attracted to science because, at least for the student, convergent tasks are involved. Biggs (1970b) expressed this conception succinctly: "the Science task consists essentially of building upon existing knowledge within explicit logical or conceptual constraints, while the Arts task involves coping with a large amount of comparatively novel and unstructured material". The scientist's search for order in natural phenomena by building upon existing knowledge is nicely exemplified by Mendeleev's discovery of the Periodic Law of chemical elements, as described by Kedrov's (1966) historical analysis.

Other work has suggested that fundamental differences in coding strategies may underlie differing approaches to professional problems. Broadbent (1977) presented a few individual cases studied experimentally. These suggested that some types of professional tasks, such as scientists' classifications of objects, encouraged mnemonic coding in terms of a hierarchical structure. Other professional tasks encouraged use of a diverse overlapping network of mnemonic associations, which might be more suited to the humanities' main subject matter, persons.

Despite the separation of the arts and science viewpoints shown by the reviewed evidence, these viewpoints should not be regarded as entirely and inevitably distinct. Benthall (1972, p.151), for example, considered that the use of modern science and technology in artistic productions has contributed to attempts "to redefine art as a mode of enquiry much closer to science". Roubertoux (1970) studied Parisian high-school students majoring in sciences who nevertheless visited visual arts exhibitions: their questionnaire responses displayed low sociability and high restraint

characteristic of science students, but high anxiety more typical of arts students.

Comparisons between arts and science groups in divergent thinking

Studies of most direct relevance to the findings reported in previous chapters are those involving divergent thinking tests. Hudson (1966a, Appendix A, Table 3) presented data from four schools showing that a higher proportion of sixth-form boys studying arts subjects were extreme divergers and a higher proportion of those studying science subjects were extreme convergers. Two features of Hudson's data were neglected in his discussion: the modal category was that of "all-rounders"; and the association between arts and divergence was only moderate. The degree of association, ϕ, was .35, calculated by the writer after grouping Hudson's data for arts and for science subjects. This value is of the same order as the analogous relationship described in the writer's main correlational study.

Subsequently, Hudson (1968) found a similar but weak association with sixth-form girls. He suggested that some convergent girls attracted by science might nevertheless study arts subjects from respect for "convention". Elsewhere, Hudson (1966b, p.613) referred to his findings as displaying "a surprisingly sharp Arts/Science discrimination", which seems somewhat overstated.

Subsequent research indicated that Scottish undergraduates taking arts or science subjects tended to differ in line with Hudson's findings, with a higher proportion of divergers amongst arts students (MacKay and Cameron, 1968). The implication of this finding is that such differences are not restricted to conditions of intensive specialization existing in the English sixth-forms studied by Hudson. Moreover, Dennis Child (1969b) found that at an age before educational specialization occurred, ability in science

was positively associated with convergent ability and negatively associated with divergent ability. Using factor analysis on IQ and divergent thinking tests with pupils aged 12-14 years in English comprehensive schools, a bipolar factor was found with loadings on divergent thinking variables contrasting in direction with loadings on IQ and marks in science subjects.

Further confirmation of Hudson's observations was provided by Child and Smithers (1973). Amongst first-year university students, 66% were found to be "all-rounders": however, if the remainder with a cognitive bias were considered, 66% of convergers were taking sciences, whilst 75% of divergers were taking non-science courses.

Pont (1970, pp.170-172) reviewed additional unpublished British research, which generally supported Hudson's work. However, not all studies have obtained significant differences on divergent thinking measures comparing secondary school arts and science groups (*e.g.*, Mills, 1970; Haddon and Lytton, 1971). Cameron (1968) found that there was an expected positive correlation between scores on a "Meanings of words" divergent test and knowledge in arts; but a "Uses of objects" divergent test correlated positively with scientific knowledge. This latter finding suggested that the better performance of arts students on divergent tests might be restricted to more "verbal" tests. On the other hand, Rump and Dunn (1971) found no such restriction, with both verbal and non-verbal divergent tests giving different mean scores for arts and engineering students.

Pont (1970, p.152) noted that although there had been attempts to reduce specialization, "the degree of specialization in both English and Scottish schools is unparalleled in any other country". It is of interest therefore to consider whether arts-science differences in divergent thinking have been consistently reported in Australia, where the educational systems were originally based on British experience but where educational specialization may be less.

Cropley (1967b) found no tendency for able science students at the University of New England to be convergers, but there were only 38 such students in his study. In a larger group of first-year Melbourne University students, Biggs (1970b) found that those in arts scored higher on three tests of divergence compared with those in science. Furthermore, in a large sample study at the University of New England, science students tended to be convergers and arts students divergers (Field and Poole, 1970). Rowell (1978b) found a similar relationship amongst Diploma in Education students at the University of Adelaide, who had graduated in arts or in science.

Cropley and Field (1968) reported "a disproportionately large number of convergers among the science specialists", with fifth-and sixth-form schoolboys in New South Wales. No such tendency was found amongst a corresponding group of schoolgirls. Indeed, schoolgirls gave a significant correlation of .25 between originality on divergent thinking tests and scores on a test of scientific achievement in a further study (Cropley and Field, 1969)

A relevant but different type of study was undertaken by Prosser (1973), who assessed whether Ph.D. students in Australia tended to be convergent by undertaking thesis topics similar to preceding ones in the same department. He suggested that "the tendency for teacher domination and highly similar projects is most noticeable in the area where research is traditional, *i.e.*, pure science".

In summary, it would seem that Hudson's findings have been replicated in both Britain and Australia, at the secondary and tertiary levels of education. There is only slight evidence that Hudson's findings may extend to advanced study or professional groups.

This last point leads to a specific issue arising from the literature, the effect of length of education in arts or science on convergence/divergence. It might be thought that differing educational regimes produce differences between arts and science specialists. However, two lines of argument suggest that self-selection on entry to arts and science streams (and

subsequently) mainly determine the observed contrasts, rather than the period of specialized training. First, some research, such as that by Povey, has shown differences between arts and science groups tested at an age before specialization occurred, the groups being formed some time after testing (reported by Pont, 1970, pp.173-4). Moreover, there is some evidence that a longer period of specialized training does not increase existing personality differences. Csikszentmihalyi and Getzels (1973) found that personality scores for second and third year art-school students were almost identical, and tentatively concluded "that the personality profile of the young artist is most likely not the result of socialization into the professional training institution, but was present prior to entrance into the art school" (p.93).

The second line of argument concerns studies which suggest that more senior, able or creative scientists are often divergers. These studies are described below, and support the findings concerning professional research workers in natural science summarised in the previous section. The findings imply that arts-science differences in divergent thinking apply mainly to the early years of specialization in secondary schools and universities, whilst later experiences in arts or sciences may even reduce differences due to initial self-selection.

Successful senior science students may be divergent thinkers: Cropley (1967b) found that eleven out of fifteen able science students admitted to honours degree courses (fourth year) were divergers. Hudson (1968, p.78) reported data for Cambridge students who scored high or low on an entrance paper which included divergent thinking problems: of high scorers, 78% obtained upper-second or first class examination passes in their third year, for various subjects including science, as against 33% for low scorers. No such discimination occurred in their first-year examinations, suggesting that divergent thinking is especially relevant to independent, advanced study.

Further confirmation of the findings from these small-scale studies was obtained by Lawrence (1969). She reported that "Creativity was found to be an important factor in achieving Honours in schools where emphasis is placed upon individual research initiative". In her study, Honours science students obtained *higher* divergent thinking scores than Honours arts students, although the opposite was the case for pass degree students, giving a significant interaction effect. Christie (as reported by Nuttall, 1973) found no association between cognitive bias and faculty amongst senior (third-year) university students, using data from tests completed at school. Such findings support the conclusions drawn in the previous section: despite the average science student's convergent tendencies, senior science students and scientific research workers may excel on both divergent and convergent tasks.

It seems likely, then, that undergraduate science students generally tend to be convergent thinkers; but that selected "high-level" science students and workers are very capable generally. Differences would appear to result from selection (both self-selection and faculty-selection) rather than resulting directly from a longer period of scientific study.

Descriptions of three empirical studies relevant to arts-science differences follow. The first study was concerned with evidence of an arts-science distinction in senior secondary-school pupils' examination enrolment-patterns and achievements.

Study a. Analyses of inter-subject relationships in the South Australian matriculation examination

Some coherence amongst arts-orientation variables was demonstrated in previous chapters. Moreover, there is evidence from Britain that the majority of senior secondary-school students and university students specialise in arts or in science; and they perform better in one area or the other (Pont, 1970). For example, Selkirk (1973) reported that grades from the "Ordinary level" examination obtained by eighty Northumberland pupils holding eight or more passes "showed strong evidence of Arts/Science bias". Little (1971) devised an arts-science orientation score derived from indicators of interest on a 55-item "fields of study list". For 42 Oxford undergraduates, the test-retest reliability over a 6-week period was .92, showing the high stability of this dimension.

Large-scale studies which included both cognitive tests and examination marks were undertaken at Port Moresby (Papua) by Ord (1970). In a factor analysis with Varimax rotation of data from 241 final-year secondary-school pupils, marks in school certificate English gained a high loading (.718) on a factor which additionally gave high loadings for verbal reasoning ability, reading ability, and word knowledge; whereas marks in school certificate Mathematics and Science had high loadings (.870 and .698 respectively) on a second factor which additionally gave high loadings for such variables as reasoning and numerical abilities (Ord's Table 8). Similarly differentiated factors were found in an analysis of data from 54 preliminary-year students at the University of Papua and New Guinea, with English and History having high loadings on one factor and Mathematics and Science having high loadings on a second factor (Ord's Table 9).

It is nevertheless worth checking the degree to which arts and science courses tend to form distinct areas of study in the South Australian context, particularly since attempts have been made to avoid undue specialisation.

For example, The University of Adelaide Matriculation Committee (1978) confirmed the principle that a matriculated student should "have had a general education, including both scientific and literary studies".

It was appropriate to undertake the present study on the secondary-school matriculation examination (normally taken at about 17 or 18 years of age). For normal matriculation in South Australia during 1977, at least five subjects were presented at one examination. The main constraint on selection from the 37 approved subjects was such as to reduce specialisation. Matriculation subjects were divided into two groups, with seven scientific and mathematical subjects in Group II and all other subjects in Group I: at least one subject from each group was required for matriculation (The University of Adelaide, 1977, p.151). Thus students oriented towards arts courses nevertheless undertook at least one scientific subject from the seven available in Group II.

Hypotheses

It was postulated that:

a1. Patterns of correlations between matriculation subject marks in South Australia show some distinction between arts and science achievements as well as a dimension of general academic achievement.

a2. Patterns of conjoint subject selections for the matriculation examination in South Australia show some evidence of arts and science orientations.

Initial data, and indicators of similarity between matriculation subjects

The analyses for this study were undertaken by the writer whilst a member of the Grading and Scaling Committee of the Public Examinations Board of South Australia. The matriculation data were provided by the Board, which has given permission for the analyses to be reported. The analytic methods used, and the opinions expressed as to the interpretation of results, are those of the author and not of the Board or its Grading and Scaling Committee.

The relationship between any pair of matriculation subjects may be assessed in two independent ways. Two subjects may be regarded as related if examination marks tend to be similar across candidates who sit both. Alternatively, two subjects may be regarded as related to the extent that they tend to attract the same students and thus have many candidates in common. Both examination marks and common candidatures were considered in the present study. Correlations between examination marks and indices of the degree of joint candidature were subjected to separate analyses.

Available data for the 1977 South Australian matriculation examination included: Correlations (r_{ij}) between final percentage marks awarded in pairs of subjects, i and j; number of candidates (n_{ij}) on which each correlation was based; the total enrolment in each subject (n_i, n_j, *etc.*); and the numbers of candidates taking one subject, two subjects, and so on, to six subjects in the examination. Whilst most candidates take five or six subjects to fulfil the normal matriculation requirements, some candidates enrol for fewer subjects. The initial correlational data are shown in Table 10.2 for the fourteen matriculation subjects with at least 500 candidates. The analyses were restricted to these large-candidature subjects.

The correlation values shown in Table 10.2 were regarded as direct indicators of similarity, and were entered directly into the analyses. To assess the degree to which candidates tended to select similar subjects, a further similarity index was derived for each pair of subjects from the conjoint candidatures, n_{ij}. The resulting index, S_{ij}, was defined so as to reflect the degree to which candidates taking both subjects (n_{ij}) exceeded the chance expected number, as a proportion of the maximum possible difference:

$$S_{ij} = (n_{ij} - e_{ij})/(\text{Maximum value of numerator}).$$

The term e_{ij} represented the chance expected number of candidates enrolled for both subjects if they were selected independently. Details of the calculation are provided in Appendix 10.1, and values obtained are shown in Table 10.3.

Table 10.2. Correlations between 1977 matriculation marks for fourteen subjects, and sizes of the conjoint candidatures

Notes: Data were provided by the South Australian Public Examinations Board, and used with its permission. Product-moment correlations are given above the diagonal; and conjoint candidatures from which correlations were derived are given below the diagonal. Correlation values are given to two decimal places, but values to four places were used in the analyses.

Subject	Total enrolment	Matriculation Subject 1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Modern European History	2808		.72	.46	.70	.73	.43	.57	.66	.54	.56	.50	.47	.41	.37
2. Classical Studies	1587	588		.49	.71	.70	.54	.63	.68	.58	.62	.36	.38	.60	.47
3. Art	1262	394	314		.45	.49	.38	.41	.45	.42	.41	.41	.35	.21	.18
4. English	6506	2156	1305	951		.68	.44	.50	.58	.53	.51	.50	.46	.48	.46
5. Australian History	1731	393	364	251	1315		.46	.55	.59	.51	.61	.56	.47	.50	.49
6. Geology	1520	478	287	214	947	291		.63	.51	.64	.56	.65	.50	.23	.27
7. Geography	3781	1197	575	497	2595	734	846		.60	.63	.56	.58	.50	.53	.53
8. Economics	2869	950	352	232	1827	514	446	1144		.63	.69	.68	.56	.58	.55
9. Biology	5981	2224	1305	1000	4557	1347	1104	2838	2001		.64	.67	.56	.58	.59
10. Physics	2667	243	59	102	1371	91	118	696	548	703		.81	.72	.75	.74
11. Chemistry	2505	229	76	83	1306	84	83	633	426	767	1989		.78	.77	.77
12. Mathematics IS	2886	768	304	290	2066	386	431	1196	939	2104	996	939		.88*	.88*
13. Mathematics I	2011	163	43	63	1017	51	41	471	405	354	1619	1439	0		.88
14. Mathematics II	2004	161	43	62	1014	51	41	470	405	354	1615	1437	0	2001	

* Assumed values

Table 10.3. Similarity index values (S_{ij}) for pairs of matriculation subjects based on 1977 conjoint candidatures

Notes: Indices were calculated by the method given in Appendix 13.1, from data provided by the South Australian Public Examinations Board, and used with its permission. Values are given to two decimal places, but values to four places were used in the analyses.

Subject	Total enrolment	Matriculation Subject													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Modern European History	2808		.28	.21	.67	.12	.22	.31	.24	.72	-.27	-.27	.17	-.35	-.36
2. Classical Studies	1587			.19	.75	.16	.13	.23	.11	.76	-.69	-.57	.07	-.70	-.70
3. Art	1262				.65	.13	.11	.27	.06	.72	-.32	-.41	.12	-.44	-.45
4. English	6506					.66	.47	.56	.49	.66	.32	.33	.60	.30	.30
5. Australian History	1731						.12	.31	.19	.70	-.56	-.57	.11	-.67	-.67
6. Geology	1520							.47	.19	.63	-.35	-.51	.18	-.70	-.70
7. Geography	3781								.28	.66	.11	.10	.30	.08	.08
8. Economics	2869									.59	.09	.05	.23	.08	.08
9. Biology	5981										-.01	.05	.63	-.34	-.34
10. Physics	2667											.77	.28	.78	.78
11. Chemistry	2505												.28	.68	.68
12. Mathematics IS	2886													1.00*	1.00*
13. Mathematics I	2011														1.00
14. Mathematics II	2004														

* Assumed values

A problem arose from the restriction affecting Mathematics subjects which was specified in Statutes (The University of Adelaide, 1977): because of some overlap in syllabi, an examination in the subject Mathematics IS may not be presented with Mathematics I or Mathematics II. Therefore no empirical similarity indices could be obtained for the Mathematics IS/I or IS/II combinations. Hypothetical values were assumed for inclusion in the analyses, equal to the values obtained for the available Mathematics I/II combination. The similarity between Mathematics IS and Mathematics I and II must be regarded as assumed by this procedure. The assumption is justified in that the pattern of other correlation values is highly similar for the three subjects. Thus the correlations of Mathematics I, II, and IS with Chemistry were almost identical, .77, .77 and .78 respectively; similarly the correlations with Physics were .75, .74 and .72 respectively.

Analyses

(i) Factor analysis. Factor analysis was used to obtain a simple account of the relationships between matriculation subjects in terms of main vectors of factor loadings. The factor analytic model involved certain difficulties in this context. In particular, correlations between subject marks were based on varying subsets of the total cohort of candidates, so that there was no guarantee that the matrix of correlations was internally consistent. Furthermore, in the case of the similarity indices based on conjoint candidatures, the indices were "quasi-correlations" with uncertain metric properties. Again, there was no assurance that the matrix was internally consistent. A final difficulty was the use of artificial values for the Mathematics IS/I and IS/II combinations, mentioned above.

In view of these points, the factor analytic solution was regarded as providing an approximate indication of subject groupings. Furthermore, only initial factors were used without rotation; and interpretation was attempted only for the two factors with Eigenvalues

greater than 1.2 in each case. The largest off-diagonal correlations or similarity values were used for the initial estimates of communalities (Nie *et al.*, 1975, method PA2).

(ii) Cluster analysis. Cluster analysis did not involve technical difficulties to the same degree as factor analysis since the only assumption was that the similarity values might be meaningfully averaged when clusters were formed. Hierarchical centroid cluster analysis was employed, as specified by the GENSTAT programme (Alvey *et al.*, 1977), to determine whether matriculation subjects tended to fall within arts and science groupings. Weighted means of correlational or "conjoint candidature" similarity indices were used to determine the merging of subjects into clusters. This method was considered to give a more stable hierarchy than other possible methods based solely on individual values. Properties of the centroid method have been discussed in relation to other clustering techniques by Lance and Williams (1967).

Results

Correlation matrix. The unrotated factor pattern matrix derived from correlations between subject marks is given in Table 10.4. The interpretation of the two factors was clear. Factor 1, on which all subjects obtained positive loadings greater than .5, represented general academic achievement in the matriculation examination. Factor 2 represented a bipolar contrast between achievement in arts and achievement in mathematics and physical sciences, and thus confirmed Hypothesis a1. Thus literary subjects and Art obtained positive loadings between .28 and .39 on Factor 2, whilst the physical sciences and mathematics subjects obtained negative loadings between -.15 and -.52. The four other subjects, Geology, Geography, Economics and Biology (called the "Centre Group" by the Public Examinations Board Grading and Scaling Committee), obtained very small positive loadings between .04 and .

Table 10.4. Factor pattern matrix for 1977 matriculation subjects based on correlations between marks

	Factor 1	Factor 2
Interpretation	"General academic achievement"	"Arts versus Science achievement"
Eigenvalue	8.3	1.6
Percentage variance	59.2	11.7

Subject*	Factor Loadings	
Modern European History	.74	.39
Classical Studies	.77	.37
Art	.51	.30
English	.72	.28
Australian History	.75	.28
Geology	.63	.19
Geography	.74	.13
Economics	.80	.12
Biology	.77	.04
Physics	.85	-.15
Chemistry	.84	-.27
Mathematics IS	.80	-.44
Mathematics I	.80	-.46
Mathematics II	.78	-.52

*Subjects are listed in order of their Factor 2 loadings.

Figure 10.1. Hierachical cluster analysis for 1977 matriculation subjects based on correlations between marks

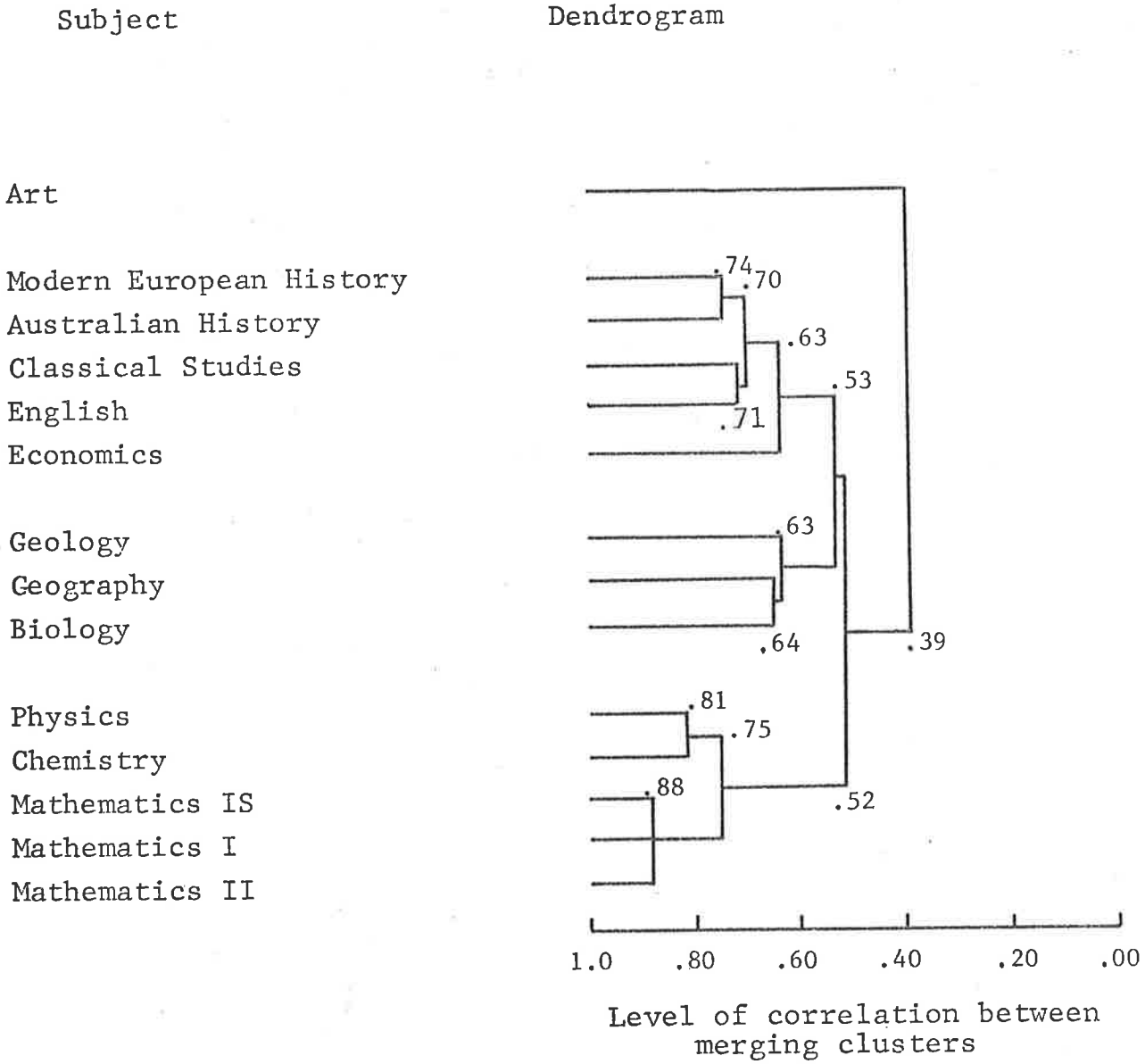
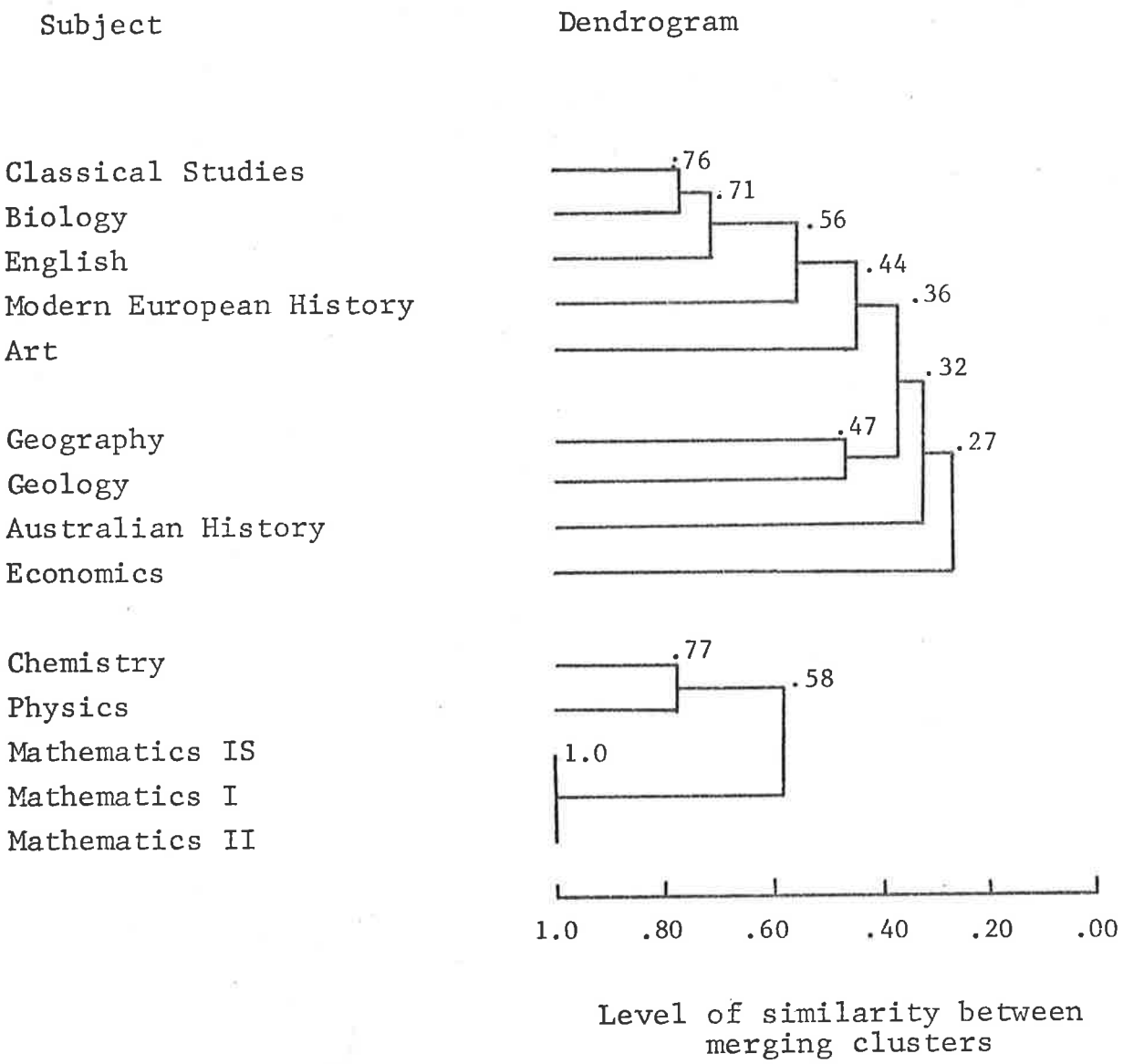


Table 10.5. Factor pattern matrix for 1977 matriculation subjects based on "conjoint candidature" similarity indices

Interpretation	Factor 1 "Arts versus physical sciences and mathematics orientation"	Factor 2 "Total enrolment artefact"
Eigenvalue	5.6	4.1
Percentage variance	39.9	29.3
Subject*	Factor Loadings	
Classical Studies	.74	.18
Australian History	.67	.17
Biology	.66	.75
Geology	.62	.18
Art	.53	.27
Modern European History	.50	.38
English	.31	.92
Geography	.26	.60
Economics	.16	.48
Mathematics IS	-.27	.91
Chemistry	-.69	.36
Physics	-.72	.39
Mathematics I	-.94	.49
Mathematics II	-.94	.49

* Subjects are listed in order of their Factor 1 loadings.

Figure 10.2. Hierachical cluster analysis for 1977 matriculation subjects based on "conjoint candidature" similarity indices



The hierarchical cluster analysis of the correlation matrix provided a generally similar but more detailed picture, shown in Figure 10.1. At the correlation level of .7, three clusters were formed: literary arts subjects (Modern European History, Australian History, Classical Studies and English); mathematics and physical science subjects (Mathematics I, II and IS, Physics and Chemistry); and a "central" cluster of Geology, Geography and Biology.

These clusters were very similar to the groups formed by consideration of Factor 2 loadings (in Table 10.4). However, two differences were noted. Art did not join the literary arts cluster, but rather was the last subject to merge with all other subjects as a whole. This was because Art had lower correlations with other subjects in general, and merged only at the .39 correlation level. In the factor analysis, the overall lower correlations for Art resulted in Art having the lowest loading on Factor 1, "General academic achievement".

The second difference was that Economics was a "centre subject" in terms of its loading on Factor 2, but merged with the literary arts cluster rather than with the central subjects in the cluster analysis. In view of these results, Economics may be regarded as having some similarities with both literary arts subjects and with more scientifically-based subjects like Geology.

Conjoint candidature similarity matrix. The unrotated factor pattern matrix, derived from similarity indices based on conjoint candidatures, is given in Table 10.5. The interpretation of the main extracted factors was fairly clear, although not as straightforward as with the factors based on subject marks.

Factor 1 represented orientation towards arts or towards physical sciences and mathematics. Arts subjects obtained positive loadings between .31 and .74, whilst physical sciences and mathematics subjects obtained negative loadings between -.27 and -.94. Biology and Geology were anomalous,

in that they obtained high positive loadings consistent with their large common candidatures with arts subjects. This feature arose from the matriculation requirement mentioned above which implied that students with an arts-orientation must nevertheless take at least one science subject: such students tended to select Biology or Geology rather than the five other science subjects available.

Factor 2 was interpreted as largely an artefact reflecting the size of the *total* candidature in each subject. The three highest loadings were for English, Mathematics IS and Biology, and these subjects also had the highest total candidatures (as shown in Table 10.3). It was hoped that the form of the similarity index used would sufficiently control for the sizes of total enrolments, but the presence of Factor 2 suggested that the index did not entirely succeed in this respect.

The hierarchical cluster analysis provided a more detailed picture of the pattern of candidatures (see Figure 10.2). Again the physical sciences and mathematics formed a coherent cluster within a similarity level of .58 or higher. The mainly arts cluster was less coherent, but included Classical Studies, English, Modern European History and Art within a similarity level of .44 or higher. The central subjects (Geography, Geology, and Economics) joined the arts cluster at a lower level of similarity (.27 or higher). The "looser" clustering obtained with arts subjects is similar to a finding reported by Selkirk (1973, p.11) for English sixth-formers: "Arts subjects are not perceived by pupils as being inter-related to anything like the extent that Science subjects are." Two anomalies occurred within this generally consistent scheme. Biology fell within the arts cluster; this was interpreted as due to the requirement that at least one science subject be taken for normal matriculation, as noted in interpreting the factor analytic results. The second anomaly was that Australian History joined the arts cluster at only a weak similarity level (.32), after the arts and two "central" subjects (Geography and Geology) had already merged.

Conclusions from Study a

The factor analyses and cluster analyses provided evidence in support of Hypotheses a1 and a2, in that "arts *versus* mathematics and physical science" dimensions and clusters were found from correlations between marks and from conjoint candidatures. In addition, certain subjects were generally intermediate between arts and physical science groups in the analyses, *viz.* Geography, Geology, and Economics. Biology was also an intermediate subject in terms of the correlational analyses, but was grouped with arts subjects in terms of its conjoint-candidature pattern.

It was considered that exceptions to the general findings were due to particular features of certain subjects. Marks in Art were not highly correlated with those in other subjects, presumably because performance in Art is affected by special aptitude as well as general academic ability. Biology was taken by many arts-oriented students and was therefore in the arts cluster formed on the basis of conjoint candidatures. Economics, Geology and Australian History were also somewhat inconsistent in their degree of involvement with the arts group.

Study b. Comparisons between diverse arts and science groups on measures related to divergent thinking and aesthetic preferences

The main aim of this study was to replicate and extend the main correlational study, in this case by using the method of contrasts between groups. Measures of orientation towards the arts, divergency and aesthetic preferences were obtained for fourteen diverse groups. Three main contrasts were undertaken: (a) university arts faculty with science and engineering faculty groups; (b) fine-arts with other arts (humanities) groups; and (c) science faculty with engineering faculty groups.

A minor additional aim arose from the inclusion of members of Mensa in the study. Mensa is a voluntary organisation of persons who attain an IQ score above the 98th percentile. Mensa members were of interest since Southern and Plant (1968) reported that in the U.S.A. members scored high on Aesthetic Value and Achievement *via* Independence scales, *inter alia*. Similarly, in Australia, Taft (1971a) found that members scored high on creative, unconventional, independent and imaginative self-rating scales, and also reported more often engaging in creative activities such as painting, compared with student controls. Therefore in the present study Mensa members were contrasted with all other (student) groups, in the expectation that they would obtain high mean scores on arts-orientation measures, divergency and aesthetic preference scales.

Tests and scoring

The following tests were administered during group testing sessions, and scored for the variables indicated:

(i) Personal Data Sheet, as described in the main correlational study. From this the following variables were extracted: age, sex, level of tertiary study (1st, 2nd or 3rd year), fine-arts education, interest in the arts and artistic achievement. In the case of Mensa members, each was asked to specify whether his educational background was

primarily in arts or science subjects.

(ii) The Uses and Similarities tests, as described in the main correlational study, scored for divergent fluency.

(iii) The Self-description Checklist, using the revised instructions as described for the "art-test validity" study, scored for Creative Independence and Emotional Activation scales.

(iv) The Barron-Welsh Art Scale scored for the Revised Art Scale, and the Graves Design Judgment Test scored in the standard manner. However, three subjects in the case of both the art tests missed out one item: their scores were adjusted *pro rata* on the basis of completed items.

Subjects

The basic characteristics of the fourteen intact groups are given in Table 10.6a. There was no overlap between the present subjects and those involved in the three previous chapters. Each subject was involved in a single testing session, but several alternative sessions were arranged for some of the groups so as to encourage broad participation in the study (see Table 10,6b).

There were five arts and nine science groups tested, giving a total of 374 subjects. As well as first-year university groups, second- and third-year groups were also included so as to obtain an indication of whether length of tertiary study in arts or science made any significant difference to mean scores. Attendance was voluntary, and individual results were provided for all subjects subsequently. In almost all cases, a reasonably high proportion of students in the classes invited to participate in the testing sessions did so. However, only a small proportion of students from South Australian Institute of Technology classes attended their testing sessions (see Table 10.6b) so that Group 13 may have included atypical applied science students who were particularly interested in the research topic. (Classes were informed in advance that the research involved personality

Table 10.6. Characteristics of arts and science groups tested in Study b

(a) Main characteristics

Group No.	Institution	Type of course	Level of study (year)	Number of Ss
		Arts groups		
1	Uni. of Adelaide	Arts faculty	1	49
2	Uni. of Adelaide	Arts faculty	3	34
3	Flinders Uni.	Hist. of Fine Arts	2,3	16
4	S.A. School of Arts	Fine Arts Dipl.	2-4	23
5	Mensa	Varied arts	-	9
		Science groups		
6	Uni. of Adelaide	Medical faculty	1	19
7	Uni. of Adelaide	Science faculty	1	30
8	Uni. of Adelaide	Science faculty	2	19
9	Uni. of Adelaide	Science faculty	3	12
10	Uni. of Adelaide	Engineering faculty (mechanical)	2	32
11	Uni. of Adelaide	Engineering faculty (electrical)	2	40
12	Uni. of Adelaide	Science faculty (Organic chemistry)	2	56
13	S.A Institute of Technology	Various applied science	1-3	17
14	Mensa	Varied science	-	18
	Total Number			374

/ continued

Table 10.6 continued.

(b) Additional characteristics

Group No.	Number of testing sessions	Attendance at test sessions (% of class size)	Sex of Ss Males	Females	Mean age (years)
		Arts groups			
1	6	91%	16	33	18.06
2	4	89%	19	15	24.00
3	2	42%	7	9	21.69
4	1	64%	7	16	20.22
5	1	-	4	5	30.78
		Science groups			
6	6	79%	16	3	17.89
7	6	97%	16	14	18.33
8	3	83%	16	3	22.00
9	1	92%	6	6	22.17
10	1	91%	32	0	20.38
11	2	77%	40	0	19.68
12	3	68%	40	16	19.71
13	5	<10%	12	5	22.06
14	1	-	15	3	28.00

differences, and that tests of artistic preferences, original thinking and aspects of personality were involved.)

A further point to note concerning the composition of groups is that there were no female students in the engineering faculty samples, unlike any other group (see Table 10.6b). Sex differences were shown to be relatively unimportant in the main correlational study, except that males obtained significantly lower scores than females on the Emotional Activation scale. This point needs to be considered therefore in the interpretation of results for that scale.

General procedure

All groups were tested using standard instructions by the writer, in some cases aided by an assistant. Test sheets were numbered, and subjects assured that results would be treated confidentially. Subjects were asked to say if they had completed any of the tests before (none had). Items were completed in the following order: Data sheet, Uses, Similarities, Graves, Checklist and Barron-Welsh Scale. Sessions lasted just over an hour.

Hypotheses

The main hypotheses examined were as follows:

b1. University arts groups tend to obtain higher mean scores than university science groups on the test variables (arts-orientation, divergent fluency, the Creative Independence and Emotional Activation scales, and the two aesthetic preference scales).

b2. Within the arts groups, fine-arts students tend to obtain higher mean scores on the test variables than arts faculty students.

b3. Within the science group, science faculty students tend to obtain higher mean scores on the test variables than applied science (engineering faculty) students.

b4. Mensa members tend to obtain higher mean scores on the test variables than the student groups.

Methods of analysis

One-way analyses of variance were undertaken using SPSS (Nie, *et al.*, 1975). Specific *a priori* contrasts between groups were tested (one-tailed tests) corresponding to the main hypotheses, as follows:

b1.	University arts	(Groups 1, 2 and 3)
versus		
	University science	(Groups 6 to 12)
b2.	Fine arts	(Groups 3 and 4)
versus		
	Arts faculty	(Groups 1 and 2)
b3.	Science faculty	(Groups 7, 8, 9 and 12)
versus		
	Engineering faculty	(Groups 10 and 11)
b4.	Mensa	(Groups 5 and 14)
versus		
	Students	(Groups 1 to 4 and 6 to 13)

In addition, Duncan's multiple range test was employed for each variable to give an overall *a posteriori* indication of significantly different subsets of groups. The α level used was .05, in accordance with convention.

In cases when the Bartlett-Box test indicated significant between-groups variation in *variance* (using $\alpha = .05$), the contrast between means was tested using separate variances to estimate the standard error of the contrast, with degrees of freedom adjusted by Satterthwaite's formula (Winer, 1971, p.42). In the event, this precaution made little difference to the obtained significance levels.

Results

Results are given in Tables 10.7 to 10.16. For each test variable, a Table having three sections provides the following information:

(a) overall significance of variation amongst group means and variances;

(b) results for the four specific contrasts required to test hypotheses b1 to b4; and

Table 10.7. Fine-arts education: means, standard deviations and significance tests for 14 arts and science groups

Note: Groups have been ordered by mean scores in section (c).

(a) Overall analyses

AOV (means)		Bartlett-Box test (variances)	
F	p<	F	p<
55.15	.001	2.95	.001

(b) Specific a priori contrasts

Hypothesis	Contrast difference	t	d.f.*	1-tail p<
b1	0.99	10.00	94	.001
b2	3.06	23.86	57	.001
b3	0.13	1.24	102	N.S.
b4	0.62	2.53	11	.05

(c) Group statistics, and Duncan's multiple-range test

(Groups not bracketed by a common line have significantly different means, $\alpha = .05$)

Group	Mean	S.D.	Duncan's test subsets
6	0.11	0.32	
1	0.37	0.64	
11	0.38	0.59	
7	0.40	0.62	
10	0.41	0.67	
12	0.41	0.73	
9	0.50	0.67	
14	0.67	0.77	
2	0.71	1.27	
13	0.71	0.92	
8	0.79	0.86	
5	2.56	1.33	
3	3.19	0.40	
4	4.00	0.00	

* Separate variances used, with adjusted d.f.

Table 10.8. Interest in art: means, standard deviations and significance tests for 14 arts and science groups

Note: Groups have been ordered by mean scores in section (c).

(a) Overall analyses

AOV (means)		Bartlett-Box test (variances)	
F	p<	F	p<
9.66	.001	3.22	.001

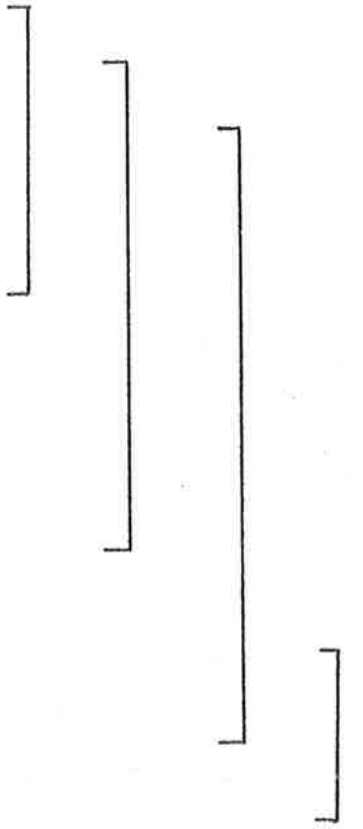
(b) Specific a priori contrasts

Hypothesis	Contrast difference	t	d.f.*	1-tail p<
b1	0.71	5.78	106	.001
b2	0.94	6.19	60	.001
b3	0.17	1.10	96	N.S.
b4	-0.04	0.12	12	N.S.

(c) Group statistics, and Duncan's multiple-range test

(Groups not bracketed by a common line have significantly different means, α = .05)

Group	Mean	S.D.	Duncan's test subsets
11	2.60	0.81	
7	2.90	0.71	
9	2.92	0.90	
12	2.95	0.82	
5	3.11	1.69	
10	3.16	1.02	
6	3.21	0.86	
13	3.29	0.85	
8	3.42	1.26	
1	3.45	0.91	
14	3.56	1.10	
2	3.62	0.99	
3	4.13	0.81	
4	4.83	0.39	



* Separate variances used, with adjusted d.f.

Table 10.9. Artistic achievements: means, standard deviations and significance tests for 14 arts and science groups

Note: Groups have been ordered by mean scores in section (c).

(a) Overall analyses

AOV (means)		Bartlett-Box test (variances)	
F	p<	F	p<
6.15	.001	11.77	.001

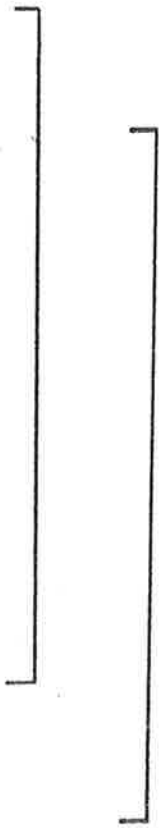
(b) Specific a priori contrasts

Hypothesis	Contrast difference	t	d.f.*	1-tail p<
b1	0.09	0.91	25	N.S.
b2	0.81	4.31	37	.001
b3	-0.07	0.74	89	N.S.
b4	0.13	0.56	10	N.S.

(c) Group statistics, and Duncan's multiple-range test

(Groups not bracketed by a common line have significantly different means, $\alpha = .05$).

Group	Mean	S.D.	Duncan's test subsets
12	0.05	0.30	
2	0.06	0.24	
6	0.11	0.32	
11	0.13	0.56	
1	0.14	0.50	
8	0.16	0.50	
9	0.17	0.58	
14	0.17	0.51	
7	0.20	0.61	
13	0.29	0.69	
10	0.31	0.78	
3	0.56	1.09	
5	0.67	1.32	
4	1.26	1.18	



* Separate variance used, with adjusted d.f.

Table 10.10. Divergent fluency (Uses test): means, standard deviations and significance tests for 14 arts and science groups

Note: Groups have been ordered by mean scores in section (c).

(a) Overall analyses

AOV (means)		Bartlett-Box test (variances)	
F	p<	F	p<
4.84	.001	2.74	.001

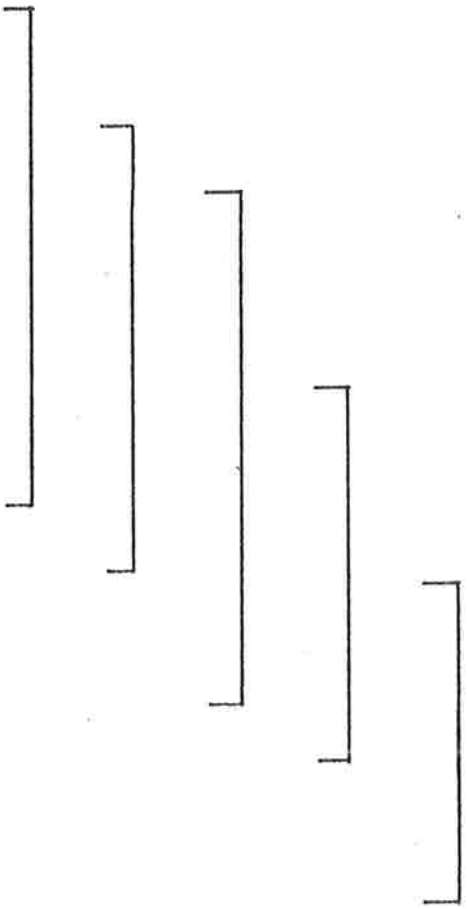
(b) Specific a priori contrasts

Hypothesis	Contrast difference	t	d.f.*	1-tail p<
b1	3.53	4.16	111	.001
b2	-0.67	0.60	74	N.S.
b3	2.56	2.90	93	.01
b4	5.13	3.51	13	.01

(c) Group statistics, and Duncan's multiple-range test

(Groups not bracketed by a common line have significantly different means, $\alpha = .05$)

Group	Mean	S.D.	Duncan's test subsets
11	10.58	3.99	
10	11.19	5.09	
12	12.05	6.31	
9	12.58	5.37	
7	12.93	5.49	
4	13.70	3.87	
13	13.76	5.88	
6	13.89	6.98	
1	14.53	5.67	
8	16.21	8.20	
3	16.94	5.14	
2	17.44	8.36	
14	18.44	5.19	
5	19.44	7.67	



* Separate variances used, with adjusted d.f.

Table 10.11. Divergent fluency (Similarities test): means, standard deviations and significance tests for 14 arts and science groups

Note: Groups have been ordered by mean scores in section (c).

(a) Overall analyses

AOV (means)		Bartlett-Box test (variances)	
F	p<	F	p<
3.30	.001	3.48	.001

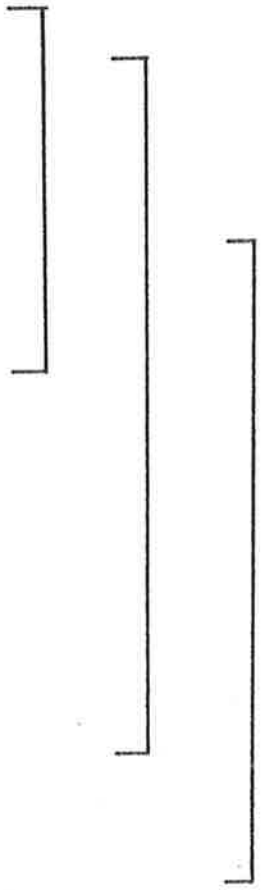
(b) Specific a priori contrasts

Hypothesis	Contrast difference	t	d.f.*	1-tail p<
b1	2.65	2.96	126	.01
b2	-1.54	1.31	87	N.S.
b3	3.16	3.10	80	.01
b4	3.03	1.83	11	.05

(c) Group statistics, and Duncan's multiple-range test

(Groups not bracketed by a common line have significantly different means, $\alpha = .05$)

Group	Mean	S.D.	Duncan's test subsets
11	14.10	5.21	
10	14.97	6.10	
4	15.17	4.91	
12	15.84	6.36	
9	17.00	3.44	
7	17.37	5.32	
1	18.02	6.91	
6	18.37	8.61	
13	19.29	5.63	
3	20.19	5.05	
2	20.41	7.99	
5	20.56	9.14	
8	20.58	11.24	
14	20.72	4.44	



* Separate variances used, with adjusted d.f.

Table 10.12. Examples of responses to the Unusual Uses test, by an average applied science student and an average arts student

Subject No. 464 (Group 11), 19 year old male electrical engineering student, fluency score 10.

Objects

Key	Shirt-button
Screwdriver	To fasten pockets
Start a car	As a mattress button
Wind up a clock	Decoration
Decoration	To keep two surfaces apart
To keep two surfaces apart	
Jam a door open	

Subject No. 513 (Group 2), 20 year old female arts faculty student, fluency score 17.

Key	Shirt-button
To stop a nose bleed	To sew an eye on doll
To dust a ledge	To hold up stocking
To dig up weeds	To put in rattle
To undo a screw	To replace missing button
To clean finger-nails	To scrape paint off
To close a lock	To put stopper on draw-string
To scrape paint	To lever lid off
To dig holes	To clear a blocked slot
To draw in sand	

Table 10.13. Creative Independence: means, standard deviations and significance tests for 14 arts and science groups

Note: Groups have been ordered by mean scores in section (c).

(a) Overall analyses

AOV (means)		Bartlett-Box test (variances)	
F	p<	F	p<
3.59	.001	1.57	N.S.

(b) Specific a priori contrasts

Hypothesis	Contrast difference	t	d.f.	1-tail p<
b1	0.39	0.87	360	N.S.
b2	2.05	3.17	360	.001
b3	0.00	0.01	360	N.S.
b4	1.39	2.00	360	.05

(c) Group statistics, and Duncan's multiple-range test

(Groups not bracketed by a common line have significantly different means, $\alpha = .05$)

Group	Mean	S.D.	Duncan's test subsets
12	8.52	3.59	
1	9.90	3.91	
11	10.33	3.62	
9	10.42	3.18	
10	10.44	2.55	
2	10.71	3.79	
7	10.87	3.08	
13	11.00	2.89	
6	11.05	2.99	
8	11.74	2.49	
14	11.94	2.53	
3	12.00	3.27	
5	12.44	1.94	
4	12.70	2.53	

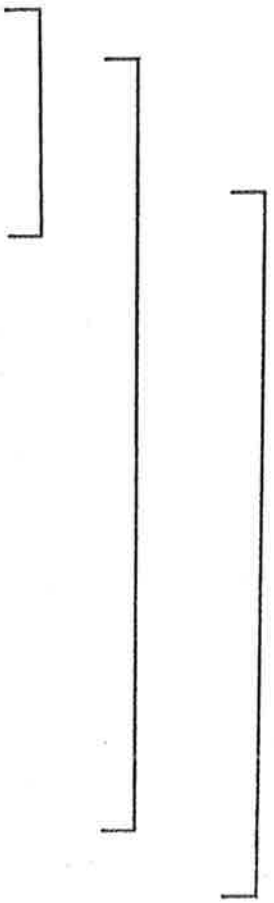


Table 10.14. Emotional Activation: means, standard deviations and significance tests for 14 arts and science groups

Note: Groups have been ordered by mean scores in section (c)

(a) Overall analyses

AOV (means)		Bartlett-Box test (variances)	
F	p<	F	p<
1.44	N.S.	0.52	N.S.

(b) Specific a priori contrasts

Hypothesis	Contrast difference	t	d.f.	1-tail p<
b1	0.49	1.14	360	N.S.
b2	1.03	1.63	360	N.S.
b3	1.36	2.66	360	.01
b4	0.17	0.24	360	N.S.

(c) Group statistics, and Duncan's multiple-range test

(Groups not bracketed by a common line have significantly different means, $\alpha = .05$)

Group	Mean	S.D.	Duncan's test subsets
10	7.31	3.08	
11	7.90	3.01	
14	8.33	2.83	
2	8.35	2.71	
12	8.57	3.15	
9	8.67	3.03	
1	8.92	3.36	
8	9.21	3.05	
4	9.26	2.77	
6	9.26	3.23	
7	9.40	3.49	
13	9.76	3.56	
5	9.78	4.29	
3	10.06	3.68	

Table 10.15. Graves Design Judgment Test: means, standard deviations and significance tests for 14 arts and science groups

Note: Groups have been ordered by mean scores in section (c)

(a) Overall analyses

AOV (means)		Bartlett-Box test (variances)	
F	p<	F	p<
4.60	.001	1.19	N.S.

(b) Specific a priori contrasts

Hypothesis	Contrast difference	t	d.f.	1-tail p<
b1	3.98	2.67	360	.01
b2	-3.77	1.75	360	N.S.*
b3	6.10	3.48	360	.001
b4	7.57	3.26	360	.001

(c) Group statistics, and Duncan's multiple-range test

(Groups not bracketed by a common line have significantly different means, $\alpha = .05$)

Group	Mean	S.D.	Duncan's test subsets
4	50.13	12.54	
11	53.03	8.89	
6	53.74	9.03	
10	54.13	13.33	
12	55.18	11.64	
7	55.43	11.13	
13	56.94	12.27	
2	59.00	11.30	
1	61.43	10.29	
8	61.84	12.08	
3	62.75	7.14	
14	64.44	8.38	
5	65.67	10.56	
9	66.25	10.62	

* The contrast difference was in the direction opposite to that predicted

Table 10.16. Barron-Welsh Revised Art Scale: means, standard deviations and significance tests for 14 arts and science groups

Note: Groups have been ordered by mean scores in section (c).

(a) Overall analyses

AOV (means)		Bartlett-Box test (variances)	
F	p<	F	p<
4.39	.001	0.84	N.S.

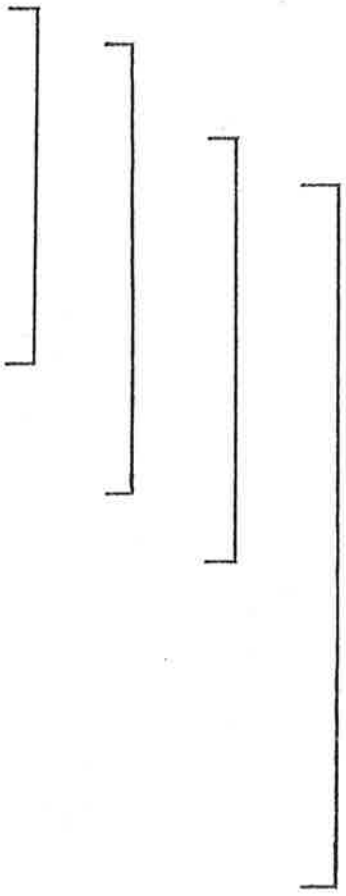
(b) Specific a priori contrasts

Hypothesis	Contrast difference	t	d.f.	1-tail p<
b1	1.76	1.14	360	N.S.
b2	-10.30	4.59	360	N.S.*
b3	6.99	3.83	360	.001
b4	- 0.87	0.36	360	N.S.

(c) Group statistics, and Duncan's multiple-range test

(Groups not bracketed by a common line have significantly different means, $\alpha = .05$)

Group	Mean	S.D.	Duncan's test subsets
4	20.78	9.62	
10	24.84	13.48	
11	26.93	11.37	
5	27.11	5.75	
3	28.63	10.15	
13	28.82	10.03	
7	29.40	11.72	
14	32.17	10.90	
8	32.63	12.93	
2	33.26	11.89	
12	33.38	11.52	
6	34.58	12.74	
9	36.08	10.16	
1	36.73	10.55	



* The contrast difference was in the direction opposite to that predicted.

(c) group means in order from smallest to largest, standard deviations, and the results of applying Duncan's multiple range test.

Before examining the data for each variable, general features may be noted. All overall tests of significance of differences amongst the 14 group means were significant at the .001 level, except for the Emotional Activation scale which gave a nonsignificant overall *F* ratio. Although there was such a clear indication of heterogeneity amongst group means for eight test variables, examination of the information presented in section (c) of the Tables shows that there was considerable overlap amongst groups. This was expected in that several groups were essentially "replications" of other groups in the design. Most weight in the interpretation of results is placed on the specific contrasts. For five test variables, these contrasts were undertaken using separate variances to estimate the standard error, since heterogeneous variances were indicated by the five corresponding Bartlett-Box tests.

As expected, the arts groups and particularly the fine-arts groups had received more fine-arts education than science groups: contrasts b1 and b2 are significant at the .001 level (Table 10.7). Mensa members had also received a high level of fine-arts education (for contrast b4 , $p < .05$), although inspection of group means (Table 10.7) shows that this applied to members with a mainly arts education (Group 5) and not those educated mainly in science (Group 14). Arts groups, and particularly fine-arts groups, also gave high ratings of their interest in art, as expected: contrasts b1 and b2 were again significant at the .001 level (Table 10.8). There was no significant distinction between pure and applied science groups, or between Mensa groups and the remainder in the case of interest in art.

With respect to artistic achievement, the only significant contrast (b2, Table 10.9) was that between the fine-arts students (Groups 3 and 4) and the arts faculty students (Groups 1 and 2). The School of Art students (Group 4) obtained a mean score almost double the next highest score.

This point is of some importance for the interpretation of other results. For example if divergent thinking were particularly associated with artistic creativity, then the divergent fluency scores should also give a significant b2 contrast. On the other hand, if divergent thinking were associated with a general arts orientation, and not specifically with fine-arts training and achievements, then the b1 contrast (and not the b2 contrast) should be significant for the divergent fluency scores.

In fact for both the Uses and the Similarities tests, the b1 contrast between university arts groups and university science groups was significant, whereas there was no significant difference between fine-arts and arts faculty groups (section b of Tables 10.10 and 10.11). From this evidence it would appear that a general orientation towards the arts (humanities, fine-arts and literature) is associated with divergent fluency, rather than fine-arts training having a specific role.

For both divergent fluency scores, engineering students scored significantly lower than other science groups, whilst Mensa members scored significantly higher than other groups (contrasts b3 and b4 , section b, Tables 10.10 and 10.11).

The responses of arts and science groups to the divergent thinking tests appeared to differ qualitatively as well as in terms of the number of responses. The science students, and particularly engineering students, were somewhat restricted to conventional or technical lines of thought. To take an extreme case, one science student could think of only one "unusual use" for a key, as a paper weight. The nature of the responses may best be illustrated by comparing the responses of two typical students on the Uses test, as shown in Table 10.12. The electrical engineering student and the arts faculty student selected as examples were chosen on the basis of having a fluency score near the average for their respective groups. The way in which the art student's responses diverged from the conventional use for a key is evident even in her first response, "to stop a nose bleed".

Her responses were varied, as may be seen from the Table, but at the same time they were realistic rather than fantastic. The higher scores of arts students generally did not stem from willingness to give bizarre responses, but rather from facility with divergent thinking within realistic constraints (*cf.* Rump and Dunn, 1971).

With regard to year-level of study, which was taken as an indication of the period of tertiary study mainly in arts or in science, no marked effect on fluency was apparent. For both measures of fluency, the third-year arts faculty group (Group 2) scored higher than the first-year group (Group 1); whereas the third-year science faculty group (Group 9) scored lower than the first-year group (Group 7), as shown in section b of Tables 10.10 and 10.11. This suggested that the arts-science difference was accentuated by length of specialised study. However, these differences were very small and not significant using Duncan's method. Moreover, the second-year science group (Group 8) gained somewhat high scores, rather than being intermediate between the first- and third-year science groups. Thus the evidence suggested no consistent effect of years of tertiary study.

Although it was expected from the evidence presented in the three previous chapters that university arts groups would score higher on the Creative Independence scale than university science groups, contrast b1 (Section b of Table 10.13) was not significant. On the other hand, fine-arts students scored significantly higher than arts faculty students (contrast b2), and Mensa members scored significantly higher than others (contrast b4), as shown in Table 10.13. The three highest scoring groups (Groups 3, 4 and 5) on self-assessed Creative Independence were the same three groups which scored highest on artistic achievement and fine-arts education. It would therefore seem that artistic creativity may be particularly associated with self-assessed independence. However, it should be noted that in the correlational study of one hundred students, the Creative Independence scale was not significantly correlated with artistic achievement, despite its significant correlation with interest in fine-arts.

Groups showed little variation in the Emotional Activation scale. Engineering groups obtained the lowest scores (contrast b3, sections b and c of Table 10.14). In view of the sex difference obtained for this variable in the main correlational study, their low scores may be interpreted as due to the entirely male composition of the engineering groups.

University arts groups scored higher than science groups on the Graves Design Judgment Test, as predicted (Table 10.15, contrast b1). The Table also shows that science faculty groups obtained significantly higher scores than engineering faculty groups (contrast b2), and that Mensa members obtained higher scores than students overall (contrast b4). These findings parallel those found for divergent fluency, and support the notion that an arts-orientation is associated with both divergency and preference for symmetrical designs.

The fine-arts groups did not obtain high scores on either of the aesthetic preference scales, despite their validation with criterion groups of this kind. Indeed, on each of the aesthetic preference scales the School of Art students gained the *lowest* mean score of the 14 groups. One implication of this finding is that the relationship between an arts orientation and preference for complexity should not be considered to derive from any immutable aesthetic "principle". Rather, it would appear that the scores of particular fine-arts groups might tend to reflect their teachers' views on principles of design. The course lecturer in the present case was Mr. G. Samstag, and he was asked how he thought his students would respond to the test designs. He replied that they might have difficulty in deciding whether to favour simple symmetrical or complex asymmetrical designs, since both types could be seen to have some value within the "abstract expressionism" and "hard-edge" styles. (Mr. Samstag's own scores illustrated this point, in that they were near the mid-point of the aesthetic preference scales.)

Engineering groups obtained low scores on the Barron-Welsh scale as well as the Graves test (contrast b3, Tables 10.15 and 10.16). This finding confirmed that applied science groups have a strong preference for simple symmetrical figures, as well as scoring particularly low on emotional activation and divergent fluency, as envisaged from the review of previous studies.

The main conclusion from the art test results appears to be that there is a reliable association between faculty of specialisation and preference for asymmetry (as shown by the significant b1 and b3 contrasts). This may be interpreted as consistent with the notions of orientation towards the arts or sciences, and preferred perceptual-cognitive styles.

Conclusions and implications from study b

The main results may be summarised by considering the significant contrasts in turn. University arts faculty students scored higher than science and engineering faculty students on interest and education in fine-arts, divergent fluency, and preference for asymmetry as indicated by the Graves Test. There was no such significant contrast for the Creative Independence or Barron-Welsh scales, however. Fine-arts groups were differentiated from arts faculty groups by their high arts-orientation scores, of course; but with regard to other personality variables they were distinguished only by their high Creative Independence scores. Mensa members obtained not only high Creative Independence, but also high divergent fluency and Graves test scores; thus the findings of Taft (1971a) were supported and extended. Engineering students scored lower than science faculty groups on both fluency and aesthetic preference scores.

On the whole, therefore, there was reliable support for several of the predictions. In particular, it may be noted that the pattern of significant contrasts was identical for the two divergent fluency scores and the preference for asymmetry (Graves test) score, in that hypotheses b1, b3

and b4 were confirmed for each of these three variables. The main inconsistency between the results and expectations derived from the literature, involved the failure of the Barron-Welsh scale to distinguish arts faculty students, fine-arts students, or Mensa members from their comparison groups. This "failure" was foreshadowed by the results for the Barron-Welsh scale presented in chapter 8.

The low divergent fluency of science and applied science students has been documented. Some writers have attributed this characteristic of science students to unimaginative teaching that does little to encourage the process of discovery in science. For instance, although sixth-form teachers in Britain saw practical work as "an opportunity to find out facts and principles by investigation", few science students noticed this finding-out element in their practical work (Kerr, summarised by Richmond, 1973, p.131). Thornton (1968) noted that one of the reasons for the "swing from science" might be the "dull life of intellectual routine" presented by science teaching, and urged that science teachers should convey a balanced mixture of observation and speculation. Jordan (1966, p.49) reported relevant comments by University of Adelaide students on their secondary-school science experiences: for example, "In doing science at this level where all the facts needed to pass an exam are already typed out, very little independent thinking is required". Thring and Laithwaite (1977) argued that inventiveness was inhibited by stereotyped teaching of science in schools. Similarly Hudson (1966b, p.613) considered that "the tenor of scientific education ... is antipathetic to problems which do not have a single right answer".

Other writers have suggested that the problem lies with the very nature of science, as taught at school. Potts (1968) reported that fourteen- and sixteen-year old pupils regarded science as having already solved most problems: "There is little curiosity about science: so much is now established fact." Science subjects are also commonly regarded as difficult to study and are therefore avoided by some pupils (Duckworth and Entwistle, 1974).

The examination system has also been held responsible for discouraging a creative approach to science in schools. Hudson (1964) considered that "the present system of examinations eats into precisely those years of a scientist's life which - for mathematicians and physicists at least - are golden". The question of whether science students prefer, and are better at, a "convergent" style of examination is discussed in Study c below.

The lack of any clear evidence to show that the length of specialised scientific education increases convergence suggests that pupils selectively specialise in science in concordance with their existing attitudes, preferences and competencies, rather than being forced to abandon a divergent style as a result of teaching or examinations. Nevertheless, the association between science specialisation and convergence may be regarded as undesirable, given the need for imaginative thinking in scientific endeavour. As Cohen (1958) remarked: "... all models of scientific theory are in the first instance achievements of the metaphorical imagination". In scientific research, "problem finding is more important than problem solving" wrote Mackworth (1965). Far from being stultifying, as school science may sometimes be, "Research in the physical or life sciences is one of the most exhilarating of human pursuits" (Titterton, 1969).

Study c. Faculty differences and divergent thinking in relation to examination performance

As described in the chapter concerned with the validity of divergent thinking tests, the latter have frequently been found to correlate with school examination performance. For example, Nuttall (1973, p.122-123) found that two out of four divergent thinking tests showed significant positive correlations with about half the English "O-level" examinations studied. However, in such cases the tests may be reflecting general intellectual ability, particularly in view of the wide range of ability sampled: Nuttall found that the effect attributable to divergent thinking was negligible when convergent ability was partialled out using multiple regression. Lavin (1965, p.107) listed flexibility and originality as divergent characteristics associated with high academic performance, following a review of several studies. However, Miller (1970, p.106) concluded: "There is as yet no evidence that creativity tests *added to school grades* improve the prediction of success and failure in higher education" (emphasis added). One might expect rather little relationship between divergent thinking and examination performance in tertiary-level courses requiring much accumulation of information, particularly in the initial years of study. Of the 100 Psychology I students tested in the main correlational study, 93 sat a three-hour sessional examination in psychology about two months after the test sessions. The correlation between their divergent fluency score and examination percentage mark was negligible ($r = .05$)

On the other hand, significant positive correlations have been found between divergent thinking scores and university achievement in architecture involving creative design. For example, Gilchrist (1969) reported that for architecture students, divergent fluency "is almost uniformly and more consistently related to Academic Achievement". A student supervised by myself (Milne, 1977, Table 8) found a significant correlation of .3 between

total marks in architecture (for eight architectural courses at the end of first year) and divergent fluency. Similarly, Buttle, Freeman and M'Comisky (1965) concluded from their small-scale study that divergent thinking "is closely related to creativity in architectural design".

Using multiple regression, Smithers (1973, p.22) found that the Uses divergent thinking test was a significant predictor of final degree performance at the University of Bradford for non-scientists ($\beta = .21$). The test was not a significant predictor in the regression analysis for the final degree status of physical scientists and pharmacists.

The evidence suggests, then, that different areas of study may be differentially related to particular interests and cognitive abilities. This point was made by Cropley (1967a, p.27). He noted in particular that "high levels of creativity are differently related to success in different subject areas"; and that divergent thinking scores tend to be "particularly related to achievement in language tests, and least related to achievement in arithmetical tests" which "emphasise the finding of single correct solutions'

Entwistle (1972) obtained correlations between verbal aptitude and first-year examination marks for students at three English universities: the correlation was .18 for students in humanities but -.29 for those in applied science. Similarly, Pohl and Pervin (1968) found that "cognitively abstract" scores from the Schroder Paragraph Completion Test correlated with academic performance -.50 for engineering students, but .39 for humanities students.

Other studies give indirect support to the notion of inter-faculty differences in style of performance. Lewis (1961) undertook a factor analysis of school marks in several subjects, and found a scientific ability factor independent of the strong "general scholastic performance" factor. Rowell (1978a) has shown that science graduates have a somewhat lower performance than arts graduates in Diploma in Education assessments, and has suggested that this may be partly because of the largely arts-type assessments used

(essays, and essay examinations). Analysis of the scholastic and personality correlates of first-year university students' examination results suggests that "selection will need to attend differentially to ... degree subject" (Hamilton, 1970, p.240).

The specificity of relationships is especially notable in the motivational area. Jones, Mackintosh and McPherson (1973) concluded: "Even at the level of faculties, there are variations in what counts." For instance, they found that "having a job in mind" was correlated .28 with first-year mean marks at the University of Edinburgh for *law*, but -.22 for *sociology*. Thistlethwaite (1963, Table 7, p.275) reported interesting comparisons across 36 different colleges, for different discipline groups. He found, for instance, that relative production of successful doctoral degrees was positively correlated with flexibility of the curriculum for the Arts and Humanities disciplines, but negatively correlated for the Natural Sciences disciplines. Thus aspects of the college environment for success in Arts did not encourage success in Sciences.

Although one might expect divergent thinkers to do better than convergers in arts subjects, some contrary evidence has been obtained. Field and Poole (1970) found that convergers obtained more high-level passes after their first year at the University of New England, in both arts and science. These authors suggested that "students are introduced to large amounts of fundamental material which simply has to be mastered", and which thereby involves mainly convergent processes.

Milne (*op. cit.*, Table 2), in his study of first-year architecture students, obtained correlations between various questionnaire scales, test scores and activities, and average grade for arts and for science matriculation courses separately. Achievement in arts was positively correlated with such variables as literary interests ($r = .55$, $p < .001$), fluency on the Listing Hypotheses test ($r = .52$, $p < .01$), literary activities ($r = .38$, $p < .05$), and fine-art activities ($r = .34$, $p < .05$). Achievement in

science was positively correlated with leadership activities ($r = .40$, $p < .05$), and scientific interests ($r = .37$, $p < .05$); and negatively correlated with interest in people ($r = -.61$, $p < .001$), fine-art activities ($r = -.41$, $p < .05$), and the Creative Independence scale ($r = -.33$, $p < .05$).

McVey (1978) has pointed out the difficulty of making public examinations "fair" when comparing arts and science subjects. It is possible that more "convergent" examinations with each item having a single correct answer, such as multiple-choice papers, might appeal to science students. Richmond (1973) discussed the use of such examinations for science subjects in Britain, and considered them worthwhile. Thomson (1966) found that with pupils studying physics, a multiple-choice test (ETS Advanced Placement Examination, Part I) correlated .52 with teachers' assessments, whilst a more "divergent" test requiring problem-solving and descriptions (Part II) correlated .45.

Rowntree (1977, pp.149-158) discussed "Convergent *vs*. Divergent Assessment", and noted that an objective test using multiple-choice questions "is the ultimate in convergent assessment". Since science students tended to be more convergent, it was hypothesized in the present study that they would perform relatively better on objective tests compared with essay-type examinations, related to the same course of study. This hypothesis was examined by a series of analyses of examination results in psychology at The University of Adelaide.

In addition, when students could select different types of examination question, it was hypothesized that science students would show a greater preference for objective questions than essay questions, compared with arts students.

In indirect support of this prediction of an inter-faculty difference, Cox (1973, footnote to p.200) reported that arts students were much more frequently critical of British A Level examinations than were mathematicians and physical scientists. Mowbray and Davies (1967) compared "short-note" with essay examinations, and found greater inter-examiner reliability with the former.

The writer knows no reports of inter-faculty comparisons of differences between essay examinations and other "objective" forms of examination. However, research by Bentley (1966) is relevant in that he showed that the relationship between achievement and divergent thinking ability depends on the form of the achievement examination, in the manner hypothesized here. Weekly achievement examinations were given to 75 students in a graduate course on educational psychology. The examinations were divided into four subtests differing in their character, so that two "divergent-type" achievement scores and two "convergent-type" achievement scores were obtained. Scores from a divergent thinking "Test of Imagination" were then correlated with the achievement scores. The divergent thinking scores correlated significantly with two achievement scores which involved (i) divergent responses, and (ii) evaluation and judgement ($r = .53$ and $.38$ respectively). The divergent thinking scores did not significantly correlate with two achievement scores which involved (iii) multiple-choice items requiring convergent cognition, and (iv) completion and short-answer items requiring recall of material ($r = .03$ and $.11$ respectively).

The study described below examined an implication arising from Bentley's research and from Study b above. Since arts faculty students tend to be divergers and science faculty students tend to be convergers, inter-faculty differences in performance on different forms of achievement examinations should occur.

Subjects and their examinations

Four groups of psychology students at The University of Adelaide were involved. In each case their examination performance was analysed in order to compare those in the Faculty of Arts with those in the Faculty of Science. Students who did not sit all examinations or who handed in blank scripts were excluded from the analyses. Groups and their examinations were as follows.

Group i involved Psychology I examinees in 1970. Their percentage marks for a 3-hour, 6 question, sessional essay examination were compared with percentage marks for three end-of-term objective papers totalling 5½ hours. The objective papers contained a total of 157 questions involving multiple-choice, sentence-completion, and brief answers, including 19 on elementary statistics.

Group ii involved Psychology I examinees in 1976, and Group iii was a similar cohort examined in 1977.

The aim of analysing these further groups was partly to provide replication, and partly to determine the effect of excluding the first term's objective paper from the analysis. In these years the first-term paper included the only statistics component of the year's assessment, the inclusion of which might have favoured science faculty students. Moreover, this first-term paper was the first assessment in psychology for most students, and had been found to correlate less highly with the total assessment than other components. It was therefore deemed desirable to investigate inter-faculty differences using only the second- and third-term objective examinations, compared with the final essay examination. A further reason for replicating the analysis in these later years was that a deliberate attempt had been made to introduce a greater requirement of initiative and integration in the essay examination, with factual knowledge being tested by the objective papers. It was thought that this change of emphasis might have enhanced the hypothesized inter-faculty difference.

Arts and science representations in the analyses for Groups ii and iii were balanced, by excluding every "nth" candidate from the arts list, where the value of n was pre-determined so as to result in equal numbers for both faculties. For both Groups, the essay examination was 3 hours, with four questions to be answered from six on the paper. The objective examination used in the analysis consisted of two 1½-hour papers containing a total of 88 (Group ii) or 75 (Group iii) questions of a multiple choice, sentence completion and brief answer type.

Group iv involved third-year psychology students, examined in 1968, 58 in the arts faculty and 13 in the science faculty. Although the courses and examinations taken by the arts and science students were somewhat different, all received a course of lectures on Signal Detection Theory and its application to empirical data in psychology. All students were set five questions on the course as part of a three-hour examination. Two of these questions required answers of an objective convergent kind: for example, "From the rating-scale data given below find: (a) $z(S|s)$ and $z(S|n)$ for each category ..." The other three questions required essay answers: for example, "Why does vigilance decline? Discuss this question in the light of Signal Detection studies." Sufficient choice was allowed on both arts and science papers to enable the student to answer both convergent questions or to avoid them. For the comparison of marks, only students who completed at least one question of each type were included in the analysis.

The numbers of students included in each of Groups i to iv for the analysis of marks, are given in Table 10.17, for arts and science faculties separately.

Analyses

Each student's differential performance on the two types of examination was calculated as the percentage mark on the objective examination minus the percentage mark on the essay examination. Consideration was given to standardising marks before taking differences, but this was not done for these reasons. It was desirable to retain information as to the level of performance on each type of assessment relative to the Faculties' pass level of 50 percent; and in any case the standard deviations for the two types of examination were fairly similar (see Table 10.17).

The significance of each comparison between arts and science faculties was determined using Student's t. Two-tail tests were employed, because of

the paucity of previous evidence related to the experimental hypotheses.

Results and discussion

The main results are given in Table 10.17. For the initial Psychology I group the mean difference-score for Science (11.9) was significantly larger than that for Arts (7.9), as predicted. Unexpectedly, this result was not replicated for the later Psychology I groups, which gave nonsignificant faculty differences in the "objective *versus* essay" score. It would appear that any relative disadvantage suffered by arts students taking objective examinations was not evident when they had some previous (first-term) experience with this form of examination (see Table 10.17). Perhaps when students are placed in the situation of having to demonstrate a degree of both convergent and divergent ability in a university course, with no choice of assessment offered, cognitive bias associated with an arts or science orientation may be overcome.

Although the results for Groups ii and iii did not confirm the hypothesis proposed earlier, they suggested a more restricted form of the hypothesis. Possibly an arts-science contrast in performance on specific, convergent-response questions and on essay questions occurs mainly when students know during their preparation that they have a choice of either form of assessment. Group iv provided a convenient opportunity to test this hypothesis, since the two types of question were provided within the same content area on the same examination paper.

In analysing the marks for Group iv, each student's average mark for objective questions and the average mark for essay questions that he or she answered were obtained, and converted to two percentage values. The difference-score (objective minus essay percentage mark) was then calculated. Table 10.17 shows that the mean difference-score for science students (32.5) was significantly greater than for arts students (10.9), in confirmation

of the hypothesis. Table 10.17 also shows that this significant effect resulted partly from science students performing relatively well on the objective questions, and partly from their relatively poor performance on the essay questions.

The third-year students in Group iv could choose to answer both objective questions. It was hypothesized that a greater proportion of science students would do this. In fact 69% (9 out of 13) of science students did select both objective questions, whereas only 29% (17 out of 58) of arts students did so.

These proportions cannot be directly tested for significance as for a normal 2 x 2 contingency table, since the conditions of choice allowed on the examination papers were not identical for the two faculties. For this reason the exact chance probability of selecting both objective questions was calculated for each faculty. Calculations are given in Appendix 10.2. The chance probability of a student answering both convergent (objective) questions was .3 for the science paper and .4 for the arts paper. The significance of deviations of obtained frequencies from chance expected values was determined using χ^2, as shown in Table 10.18. As may be seen from the Table, science students tended to select the convergent questions, whereas arts students tended to avoid them; the two faculties differed significantly in this respect ($\chi^2 = 12.29$, 2 d.f., $p < .01$).

Implications of Study c results

For one first-year group and for the third-year group, differential achievement on objective as against essay examinations was related to faculty. In these cases, science students received relatively high marks for their answers to objective questions, as predicted. When allowed a choice of questions, as in the case of Group iv, science students tended to select objective questions whereas arts students tended to avoid them in favour of essay questions.

Table 10.17. Comparisons between students in Arts and Science Faculties with respect to percentage marks in Psychology: objective and essay examinations

Group	Statistic	Objective exam.		Essay exam.		Objective - Essay		Significance		
		Arts	Science	Arts	Science	Arts	Science	t	df	p(2 tail)
i	N	210	105	210	105	210	105			
	$\bar{X}$	61.6	66.8	53.8	54.9	7.9	11.9	3.22	313	<.01
	S.D.	16.1	14.3	12.9	11.5	10.4	10.4			
ii	N	145	145	145	145	145	145			
	$\bar{X}$	64.8	61.3	53.7	50.4	11.1	10.9	(-)0.15	288	N.S.
	S.D.	11.5	11.7	13.6	13.0	12.1	11.7			
iii	N	112	112	112	112	112	112			
	$\bar{X}$	59.4	57.6	57.5	54.4	1.9	3.3	0.89	222	N.S.
	S.D.	11.6	13.2	14.0	15.7	11.4	10.6			
iv *	N	46	12	46	12	46	12			
	$\bar{X}$	68.0	73.1	57.1	40.6	10.9	32.5	2.70	56	<.01
	S.D.	24.1	15.0	17.4	12.5	25.0	20.7			

* For Group iv, "specific-answer" and "essay-answer" examination questions were compared, rather than whole examination papers, as explained in the text.

Table 10.18. Comparison between arts and science students in numbers answering both "convergent" questions in a third year final examination

	Observed frequencies (O)		Expected frequencies (E)*	
	Arts	Science	Arts	Science
Students who selected both "convergent" questions	17	9	23.2	3.9
Other examinees	41	4	34.8	9.1
	Discrepancies (O-E)		χ^2 components	
	Arts	Science	Arts	Science
Students who selected both "convergent" questions	-6.2	+5.1	1.657	6.669
Other examinees	+6.2	-5.1	1.105	2.858

Significance of the inter-faculty difference

Total χ^2 = 12.289

d.f. = 2 (the expected frequencies were independent for the two faculties)

$p < .01$

* Expected frequencies were calculated from exact "null hypothesis" probabilities. The latter were obtained in such a way as to allow for the different formats of the arts and science examination papers. Details of the method are shown in Appendix 10.2.

However, the expected difference in marks did not occur in the case of the other two first-year groups. The objective examinations in those groups did not include statistical or numerical questions, whereas the objective papers for Groups i and iv did include such questions. It is possible, then, that the higher performance of science students in two of the comparisons was due in part to their greater (convergent) numerical ability, rather than a more general convergent mode of thinking.

Moreover, the lack of a significant inter-faculty difference for Groups ii and iii suggested that any effect of convergent or divergent bias on examination performance was overcome under conditions where both objective and essay answers were necessary after two or more term's study. This implied in turn that practice on divergent tasks might allow learned improvement on such tasks. The possibility of training for divergency is discussed in the following chapter.

Chapter Summary

A review of the evidence concerning the personality characteristics of arts and science groups supported and extended the findings reported in the three previous chapters. An education or vocation in the arts and humanities was shown to be associated with divergent and with verbal abilities, with preference for complex stimuli and situations, with unconventional independent attitudes, and with interest in aesthetics. Science groups tended to have high convergent intelligence with spatial and numerical facility, restricted interests, conventional, conservative attitudes, stability, and a preference for an ordered, well-structured environment. Convergent characteristics were found more consistently in applied science (engineering) groups, whilst pure research scientists and high-achieving science students show some divergent characteristics.

Three empirical studies were reported. The first confirmed that an

arts-science distinction was evident in matriculation performance and selection of courses, amongst South Australian secondary-school pupils. The second study showed that university arts faculty students scored higher than science and engineering faculty students on interest in fine-arts, divergent fluency and the Graves Design Judgment Test. Fine-arts groups obtained high scores on self-reported Creative Independence. Mensa members obtained particularly high scores, and engineering students particularly low scores on both divergent fluency and the Graves test. The inter-connection between orientation towards the arts, divergency and preference for asymmetrical designs was demonstrated in terms of these inter-group contrasts.

The arts-science distinction was shown to have some relevance to differential examination performance and choice with respect to objective and essay questions, in the third study. However, the results may have been due to differences between arts and science students in verbal *versus* numerical abilities, rather than in the postulated more general divergent *versus* convergent styles.

In interpreting these results, some additional features need to be taken into account. In both the reviewed and current research, overlap between distributions of scores for different groups was considerable, and stated group differences were small in relation to individual variation. Furthermore, predicted differences did not occur in several cases. For instance, university arts groups were not distinguished from university science and engineering groups by scores on the Creative Independence or the Barron-Welsh scales. In addition, there was little indication that differences were accentuated by years of specialised study at the tertiary level.

In integrating these various findings, it would appear that a student's personal characteristics play some part in channelling him in the direction of arts or of science. Relevant characteristics include intellectual abilities, cognitive styles, personality traits and aesthetic preferences.

In general, these characteristics do not act as an absolute barrier to specialisation in any direction. For example, some divergent thinkers may undertake scientific studies and go on to become successful scientific research workers. Such development would presumably be assisted if other characteristics were present, such as high intellectual ability and interests, and willingness to work hard.

The results for Groups ii and ii in Study c, the high divergent thinking scores of certain high-level science groups found in some previous research, and the high divergent fluency scores of the Mensa science group (Group 14) in Study b, together suggest that a divergent approach to tasks may be learnt when the person is motivated to perform in this manner. This possibility is directly investigated in the following chapter.

CHAPTER 11

EFFECTS OF TRAINING COURSES RELEVANT TO DIVERGENCY

The various influences of previous experiences on the individual's divergent thinking, on traits related to creativity, and on aesthetic preferences are noted in chapter 1. This chapter is more particularly concerned with the effects of short training courses relevant to creativity. Various training methods and research on their effectiveness are first discussed. A study is then presented involving six "experimental" groups of students attending relevant adult-education courses and two university student control groups. The main aims of the study were to determine whether short (six week) courses produce significant changes in the students; whether such changes are specific to "creativity training" courses or whether other courses relevant to the stimulation of thinking and information-seeking have similar effects; and whether changes are limited to self-assessed characteristics or involve also divergent-thinking competence and aesthetic preferences.

Creativity training with children and adults

There have been several comprehensive reviews of methods for stimulating creativity, and it is unncesssary therefore to describe these methods in detail here. Much has been accomplished with regard to encouraging pupils' creative activities in the classroom, and Feldhusen and Treffinger (1977) presented thirty-seven reviews of published methods and materials. Treffinger and Gowan (1971) provided a representative list of methods, with references, under 49 headings as to type of procedure.

Torrance (1972a) has tackled the more difficult task of assessing the effectiveness of different approaches to teaching children to think creatively, by summarising the results of 142 studies. He concluded that "it does indeed seem possible to teach children to think creatively. The most

successful approaches seem to be those that involve both cognitive and emotional functioning ... but differences seem to be greatest and most predictable when deliberate teaching is involved" (pp.132-133).

In some studies, generalised effects on personality have been found, but large effects have usually been restricted to attitudes or skills directly implicated in the training procedures. Similar conclusions may apply to procedures used with adults also. Thus, general procedures intended to improve the participants' well-being may affect self-perceptions but have little effect on divergent thinking or aesthetic preferences. For example, Garfield, Cohen, Roth and Berenbaum (1971) found that clients who showed therapeutic improvement during group counselling also changed on their life-style ratings (such as showing more openness to experience), but made no significant gains on divergent thinking tests or the Barron-Welsh Art Scale.

In some reports, learning has been shown to affect some aspects of responding but not others, in ways not clearly related to the contents of the training course. For example, Cropley and Feuring (1971) reported that creativity training given to six-year olds increased their flexibility and originality scores. With regard to the number of ideas produced, boys gave more responses after being rewarded for all responses, whereas girls gave more responses after being rewarded only for clever responses. Thus the effects of training courses are not always of the kind expected from a simple reinforcement-theory analysis.

Are courses of creativity training effective even when pupils are already taught by "informal" methods, and are such courses more effective than providing, say, stimulating art work? These questions were investigated in a study of four classes of nine- to ten-year olds by Franklin and Richards (1977). One informal and one formal class were given divergent production exercises over a six-week period (the same period as involved in the writer's

studies) whilst two corresponding control classes were given art work. Both experimental groups gained on all fourteen measures of fluency and originality from seven different tests. Gains were statistically significant for 9 out of 14 measures with the formal class and for 7 out of 14 measures with the informal class. The control groups improved significantly on only three measures, and this was balanced by significant reductions in scores on two measures. The authors concluded that "improvements are most predictable when deliberate teaching is involved". Nevertheless, it should be noted that the control groups who had art lessons which "concentrated on providing a variety of new and stimulating experiences" did show significant gains on figural divergency. Thus it seems that stimulating educational courses, other than direct creativity training, do have some effects in this area.

Some writers have argued that merely providing an open, non-critical environment for schoolchildren would be sufficient to release pent-up attitudes otherwise "crushed" by school experiences. Stoddard (1959. p.254) considered that: "The urge to inqure, to invent, to perform, was stifled in millions of schoolchildren". Stoddard's point may be illustrated by a personal anecdote. My twelve-year old son's class at school was asked by the teacher to think of "one who works in wood". Children volunteered "carpenter" and "sculptor", but my son's hand remained raised. His answer was "a termite", which fitted the question, was original, and could have been used to elicit comparisons between human and infra-human uses of wood. However, the teacher's stifling response was "There's a fool in every class", with the clear implication that only convergent responses were acceptable.

The importance of training teachers to accept more of their pupils' ideas was stressed by Enochs (1964, as reported by Torrance, 1966, p.38), who found that such training subsequently increased pupils' scores on tests of originality. A more complex study of the effects of giving teachers

creativity-workshop training was reported by Martin (1972). Teachers were treated as experimental or control subjects, with the former having workshop training. Effects were observed by categorising verbal classroom interactions, before and after training, with the "before" scores acting as a covariate control in the analysis of "after" data. Unfortunately (for the purpose of interpreting the data), the workshop sessions were complex in nature in that they included training in both convergent and divergent skills, and in particular training to ask questions designed to encourage either convergent or divergent thinking in pupils. It was found the training resulted in fewer instances of routine and cognitive-memory behaviours in the classroom, and more instances of both convergent and divergent activities. In this case, then, the training enhanced thoughtful activities generally rather than only divergent thinking.

Procedures for stimulating creativity in adults have been reviewed by Stein (1974, 1975), whilst Alpaugh, Renner and Birren (1976) have considered implications for older adults. One of Stein's volumes (1974) is concerned with various methods applying to individuals, for each stage of the creative process; whilst the other volume (1975) is concerned with the application of techniques to groups. Another useful source of information about techniques is provided by Davis and Scott (1971), who have edited a convenient collection of twenty-three previously published articles on "Training Creative Thinking". Among the more well-known techniques are attribute listing (Crawford, 1954), original word associations (Maltzman, Bogartz and Breger, 1958), the idea matrix (Von Fange, 1959), synectics (Gordon, 1961), brainstorming (Osborn, 1963), creativity kits (*e.g.*, Kodak, 1967), lateral thinking (De Bono, 1967), creative problem-solving (Parnes, 1967) and morphological analysis (Zwicky, 1969).

These techniques are designed to increase the number of ideas which participants produce, to increase their range and originality, and to delay

evaluation of novel, complex and possibly fanciful ideas. To the extent that training is successful, it is hypothesized that participants become more creative and independent in their self-image, improve their performance on divergent thinking tests, and prefer more complex stimuli such as those on the Barron-Welsh Scale.

Evidence concerning the effectiveness of proposed methods is partly anecdotal, and in some cases it is difficult to determine the precise cause of any success. For example, Eyring (1959) noted the outstanding scientific creativity of graduates from the G.N. Lewis School of Chemistry at Berkeley, and suggested that this was due to the School's research emphasis, eminent teachers who mingled with the graduate students, free access to equipment, and so on. However, the success of the School may equally have been due to the quality of student it attracted: "With such a student personnel, most systems would have succeeded" (p.9). In some cases fairly dramatic accounts of personality changes to individuals have been reported as a result of creativity courses. For example, Noller and Parnes (1972) quoted a number of positive comments made by participants in the Creative Studies Project at the University of Buffalo, such as this extract: "I want to create my life. I have discovered parts of me that I never knew existed" (p.291).

Studies which involve a clearly specified programme of training, and a control group, provide more satisfactory evidence. One such recent study was that of Burstiner (1977). A workshop in creative management for department store middle-management personnel led to increased divergent thinking test scores, higher self-ratings on creativity and leadership scales, and improved supervisor's evaluations in the work situation. The control group not given training showed no such changes. Programmes which use a variety of exercises have often proved successful in improving skills, although results for later on-the-job creativity are not usually reported. Feldhusen, Treffinger and Bahlke (1970) reviewed studies of the Purdue

creativity programme, which consists of varied exercises with associated audio-tapes. They concluded that "the complex human cognitive abilities involved in creative thinking are amenable to influence by systematic instructional efforts" (p.90).

One recent experimental study is of particular relevance to this thesis in that it demonstrated that university science students could be trained in divergent thinking techniques, and could thereafter apply their skill to scientific discussions (Rosenthal, Morrison and Kinnear, 1977). Sixteen Biology students who volunteered for the experimental condition were given training based on four of De Bono's (1973) lessons: fifteen control students did not receive the training. The two groups were similar in convergent thinking ability. The effect of training was assessed by means of the Circles test scored for fluency, flexibility and originality, and a Biology test scored for fluency and originality. The latter included items like: "Hydra, an aquatic coelenterate, apparently cannot digest carbohydrate. Suggest explanations for this observation." Pre-training scores were used as covariate controls, and post-training scores and delayed post-training scores (after 3 weeks) were analysed. "The effectiveness of the training programme was demonstrated by the fact that differences between groups were of considerable magnitude and consistent." The effects applied to both the tests used, and to both immediate and delayed post-training data.

The question arises as to whether instruction in the form of lectures is as effective as instruction combined with practice of relevant skills using training exercises. Rosenthal, Morrison and Perry (1977) found that scores on divergent thinking tests were higher following a skill-centred practice session using two of De Bono's divergent thinking exercises, compared with scores for a group given a lecture on De Bono's techniques. It may also be noted that training in *convergent* skills which improves IQ scores does not thereby also improve divergent thinking scores (Taylor, de Lacey and Nurcombe, 1974).

Some studies have compared the relative effectiveness of various types of courses or aids to creativity, as well as using a no-training control condition. For instance, Warren and Davis (1969) asked students to "think of ways to change or improve a door knob", and compared performance for four groups tested in different conditions: a group given a short checklist suggesting aspects of objects to stimulate ideas; a group given a longer checklist of questions to stimulate ideas; a group told about the morphological synthesis technique; and a control group. The morphological synthesis group, instructed in combining characteristics to generate new responses, produced more and better ideas than other groups.

In a very large scale study of students in fourth, fifth and sixth grades, Speedie, Treffinger and Feldhusen (1971) compared seven training conditions involving various components of the Purdue creative thinking programme, using an eighth control condition also. Groups were given the Minnesota Tests of Creative Thinking (yielding seven divergent thinking scores) before and seven months after training. On retest, the creativity exercises proved effective compared with the control condition for the measures of verbal fluency and originality, for fourth grade classes only. However, in the majority of comparisons no improvement in scores was found. Thus short-term training does not always produce long-term changes in divergent thinking abilities. Possibly the older fifth and sixth grade pupils considered that they should not repeat responses made on the initial presentation when given the post-training retest, and this inhibited their performance.

One in-service creativity project for teachers, involving both cognitive and emotional training components, was particularly successful in promoting a wide range of changes (Brown, 1968; Mitchell, 1971). Participating teachers tended to change their self-concepts in relevant ways, such as being more receptive to change; their classroom activities changed, with more individual contact with pupils, for instance; and their scores on the

Barron-Welsh Art Scale increased. Their pupils achieved higher mean scores on the Torrance Tests of Creative Thinking, whereas the control pupils showed an overall slight reduction in scores. Another multifacet in-service training programme for teachers, involving both regular creativity workshops and intensive training at a five-week "summer institute", was successful in improving the self-concept scores of teachers and their pupils, and changing classroom activities towards divergent and evaluative processes (Clark and Trowbridge, 1971).

If divergent thinking is stimulated by providing diversity of experience, it may be conversely hypothesized that severe reduction of perceptual stimulation should reduce divergent thinking scores. This hypothesis was tested by Fuerst and Zubec (1968), who restricted subjects to darkness and silence for three days, or to unpatterned light and noise. In general, no reliable effects on ten divergent thinking tests were observed, although experimental subjects did worse on one measure of ideational fluency. It would seem that training experiences related to the required skill are required if divergency is to be strongly affected, rather than simple variation in sensory input.

In practical applications of creativity training, business innovations and scientific and technological problems have received most emphasis. It is relevant also to consider here applications to art work. Madeja (1967) noted that instructional methods of a divergent type for art students "would place emphasis on such values as originality, fluency of ideas, ability to solve problems and see differences" (p.10). A "divergent-instruction" group of art students was given class experiences over nine weeks which stressed visual awareness, visual insight into one's surroundings, visual redefinition and so on. A "convergent-instruction" group was given academic lectures and exercises on the elements and principles of design. A "no special training" control group was also used. Within each group, high and low art ability subgroups were distinguished on the basis of

previous art grades and assessments. Three art tasks using different materials were undertaken by all students after the instruction period, and their products were evaluated by a panel of five raters. The art products of the divergent instruction group received significantly higher ratings than those of the convergent-instruction group on two tasks, but for the high-ability subgroups only (Madeja's Table III). Madeja therefore advised that "instruction for the high art ability student should be more divergent in structure than for those of low art ability" (p.19). Of course it might be that the concepts taught by the "divergent" method were more difficult to grasp than the "rules" taught by the "convergent" method in this particular case. Other writers have suggested that education for creativity should certainly not be restricted to more able students, but is particularly appropriate for mentally handicapped groups (*e.g.*, Kaufmann, 1969; Torrance, 1970).

Although McWhinnie (1969b) used perceptual training rather than a creativity training course, his study is relevant to the present discussion in that the aim of the training was "to enable the individual to resist a set for simplicity-symmetry in favor of a set for complexity-asymmetry" (p.29). McWhinnie's study is of particular relevance to this thesis, in that he measured the effect of training on both the Barron-Welsh Art Scale and the Minnesota Tests of Creative Thinking (non-verbal form). Fourth, fifth and sixth grade classes were given lessons over eight weeks using a booklet with exercises designed to practise the manipulation of complex visual information. Corresponding control classes were given a regular course in art, and further control classes were given no art training. McWhinnie found (his Table V) that "the perceptual training group increased in their preferences for complexity-asymmetry and were significantly different from the two control groups" (p.42). However, there was no corresponding change in the divergent thinking scores. It would therefore seem that the effect of some training courses is restricted to practised skills with

little generalisation to other areas. Evidence on this point is further discussed in the next section.

The limitations of creativity training

Reviews of research in this area have generally been optimistic, at least with regard to the effectiveness of training in cognitive skills relevant to divergent performance. Thus Davis and Scott (1971, p.viii) wrote: "There is no doubt that many components of creative behavior may be strengthened." Nevertheless, there have been several reports indicating negligible effects in some cases. Indeed, Cattell and Butcher (1968) considered that "'Training for creativity' is about as hopeful as training to be intelligent" (p.303). (It is ironic that since that statement was written, the effect of learning experience on IQ has become a very controversial issue.)

Hilgard (1959) also indicated scepticism with regard to the effectiveness of some training techniques, particularly group brainstorming techniques. In this method a group attempts to generate solutions to problems by encouraging others' ideas and by delaying evaluation of these ideas. The basic principle of allowing ideas to be received by group members without criticism was found to be effective in producing more responses, and higher quality ideas in experimental groups (Weisskopf-Joelson and Eliseo, 1961). And Lindgren (1967) found that "brief sessions of brainstorming may be effective with female college students in stimulating creativity in drawing". However, Taylor, Berry and Block (1958) found that "nominal groups" of students working independently thought of twice as many solutions as brainstorming groups. Dunnette, Campbell and Jaastad (1963) confirmed that "nominal" groups produced more solutions even when the brainstorming groups were composed of scientists and advertising men familiar with group participation. Thus whilst some principles underlying brainstorming may be valuable (Russell, 1973), the method has been found to be ineffective

compared with control conditions in experimental studies. Possibly the "unreal" nature of the experimental problems has not provided sufficient intrinsic motivation for participants in these studies. It is not known whether the experience of brainstorming may initiate lasting changes in participants to assist their subsequent creativity; there is no convincing evidence, as Stein (1975, p.113) has pointed out. It may be that brainstorming, like individual "delayed evaluation" techniques, primarily has the effect of individuals altering their standards for the presentation of a response, rather than training them to be generally more creative (Parloff and Handlon, 1964).

Other studies have indicated that very short training sessions may be insufficient to increase divergent thinking scores any more than does prior familiarity with the test measures. Khatena (1970) gave students verbal divergent thinking exercises for only one hour on each of two days. Subjects given the pre-test but no creativity training scored about the same on post-test as those given the training. It should be noted that Khatena's results do not demonstrate the absence of learning. Rather, they indicate that some rapid learning may occur merely as a result of pre-test practice. Hudson (1968, p.65) reported that merely giving school boys examples of ten unusual uses of an elastic band considerably improved their subsequent scores on the Uses test with other items.

Even training over a long period may sometimes fail to improve test scores, perhaps because students become bored rather than stimulated by the tasks. Bachtold and Werner (1970) gave pupils with very high IQ scores written assignments in creative thinking over an eight-months period, and reported that the training "actually decreased somewhat the fluency on divergent thinking tasks and brought about little change in the flexibility of responses". With no clear purpose, these exercises possibly became tedious, particularly to children who may have been biased towards a convergent thinking style.

A number of studies have suggested that generalisation of learning from creativity training courses may not be wide. For example, divergent thinking skills can improve with little change in personality traits associated with creativity. Parnes and Meadow (1963) reported the effects of an extensive creative problem-solving course at the University of Buffalo. The students showed a general increase in the quantity and quality of ideas produced, but personality change was rather limited, with only an increase on the Dominance scale of the California Psychological Inventory. Stein (1975, p.271) summarised the effects of the course: "it results in changes in the students' cognitive abilities but not in their personality characteristics' On the other hand, educational programmes designed to train for "new ways of working with others" may affect personal and social behaviour (Bunker, 1963). Bunker found that changes wrought by group laboratory training when workers returned to their firms might for some subjects involve "an increase of assertive behavior" and for some subjects "increases in sensitivity to others' feelings".

The effectiveness of Maltzman's training technique for developing originality has been extensively studied with respect to transfer of training. Maltzman's technique requires subjects to generate new word associations on repeated presentations of a stimulus word list. Training in the production of uncommon associations in this way, for just a few minutes, is supposed to produce a lasting and general effect on the subject's ability to think divergently. Maltzman, Seymore, Raskin and Licht (1960) found that trained subjects gave a greater number of unique responses to the Unusual Uses test, and that the effects persisted two days, at least. Maltzman, Belloni and Fishbein (1964, p.19) have speculated that more extensive effects might follow from weeks or months of similar training. Evidence provided by Simon, Lotsof and Wycoff (1966) did not support this speculation, in that an asymptote in the learning curve was reached by the third day of training.

With regard to transfer to other problem-solving tasks requiring diverse

associations, the Maltzman technique has produced little benefit. Caron, Unger and Parloff (1963, p.442) found that: "No facilitative effect was demonstrated on either of two forms of the Remote Associates Test as a consequence of originality training." Similarly Brian Johnston (1970), in a thesis supervised by the writer, described his results as follows: "No significant transfer was found to originality of performance on a specially prepared version of the Remote Associates Test", following a four-week period of lessons which included a total of 85 repetitions of the associations training list given to children at school. Simon, Lotsof and Wycoff (1966) investigated the effect of the Maltzman technique, over three and over five days of training, on divergent thinking assessed by the Unusual Uses test and "letter tasks" (scored for word fluency and originality). Although training facilitated uncommon word association, there was "no reliable facilitation of unusual uses and letter tasks".

There is no evidence that the Maltzman technique by itself produces any general improvement in creativity. Indeed, Gallup (1963) after an experiment involving a number of control procedures, concluded that the technique "had not been demonstrated to be advantageous over having Ss work on arithmetic problems, vocabulary tests, or simply doing nothing between trials" (p.927). Stein concluded that any effect of the Maltzman training is reduced "the further one moves away from similarity with the training list" (1975, p.135). It would appear that the Maltzman technique is far too specific in its effects to be regarded as a satisfactory training method for divergent thinking skills.

Conclusions from the literature review, and hypotheses

A variety of methods has been found to stimulate pupils' and trainees' ideas, both in quantity and quality, although there is no firm evidence that any training method alone is responsible for participants' later creative

work of value. All that may be claimed is that participants may improve their attitudes and skills so as to make valuable creative ideas more possible, given the right circumstances and abilities.

Although the variety of effective methods is wide, there is much evidence to suggest that marked learning effects are found only with activities directly involved in the training procedures, and that generalisation is limited. It would seem that eclectic training procedures involving a variety of techniques are of greater value than restricted procedures such as Maltzman's originality training.

Creativity training and other "mind-broadening" courses sometimes fail to bring about significant changes for a variety of reasons. The dependent variable could be irrelevant to the learning experience, or the course boring and therefore ineffective. Training procedures are sometimes too brief for any but the most superficial learning, such as learning to lower one's criterion for the acceptability of an idea. In some cases, the method of instruction may be less important than the instructor, presumably owing to personal styles of teaching (*e.g.* Davis, 1969).

In the empirical study reported below, the effects of six varied adult-education courses relevant to divergent thinking were studied. It was hypothesized that students tested before and after the courses would tend to increase their scores on three types of dependent variable: divergent fluency, self-reported creative independence, and preference for complexity/asymmetry. It was further hypothesized that the increases in scores for the "experimental" groups would be greater than any increases for "control" groups due to the pre-test.

Although not investigated in any precise fashion, a secondary hypothesis was examined, that the effects would be greatest when test tasks were similar to part of the contents of a course. This hypothesis could not be examined with precision, because the contents of the courses investigated were not

within experimental control: the study involved intact groups taking available courses in Adelaide. The variety of courses allowed some assessment of the degree to which direct training effects and more generalised changes occurred.

Study of Effects of Adult-Education Training Courses

Six experimental groups undertaking relevant adult-education courses at The University of Adelaide, and two control groups taking University degree or diploma courses were tested. In the case of six of these groups, professional colleagues who were teaching the courses (Malcolm Hutton, Margaret MacNamara, and Maxine Shephard) conducted the test sessions on the writer's behalf during their classes, using materials and instructions supplied by the writer. The writer tested the other two groups. The results for the first group tested (E1) have been reported at an ANZAAS Congress (Rump and Hutton, 1970).

Courses

The main features of the courses are shown in Table 11.1. The six experimental courses each consisted of six weekly sessions lasting 1½ hours, and were given as evening courses to allow employed adults to attend. There were two types: four groups (E1 to E4) were eclectic creativity-training courses in which various techniques were presented, and students participated in practical exercises to demonstrate their use. The two other experimental groups were also designed to stimulate thinking and encourage a flexible approach to problems and to information-acquisition, but not using creativity-training techniques. Group E5 was a lecture course on both convergent and divergent thinking, with exercises in problem-solving and communication; and Group E6 was a training course on efficient reading, with practical exercises designed to encourage the students to encode new information of diverse kinds with maximum efficiency. This last group might be considered to involve a

Table 11.1. Nature of eight courses in the Effects of Training Courses study

Type	Gp.	Course Title	Lecturer	Year	Summary of topics
Experimental Groups	E1	Creative Thinking & Problem Solving	M. Hutton	1968	Developing new ideas, reducing mental blocks, defining problems brainstorming, synectics, morphological analysis; practical exercises, including "unusual uses"
	E2	Creative Thinking & Problem Solving	M. Hutton	1969	As E1 but with practical exercises not including "unusual uses"
	E3	Creative Thinking & Problem Solving	M. Shephard	1970	As E2, with practical exercises including creative drawing
	E4	Creative Thinking & Problem Solving	M. Shephard	1971	As E2
	E5	Sharpening our Minds	M. Hutton	1969	Sharpening observations, effective methods of learning, clear thinking, debate and communication; with practical exercises in problem-solving and communication
	E6	Quick & Efficient Reading	N. Peard	1971	Selection of reading matter, skimming to grasp essentials, aids to quick reading, improving concentration and confidence; with practice in gaining information from diverse sources
Control Groups	C1	Industrial Sociology	M. MacNamara	1969	Interpersonal behaviour, structure of groups, leadership, work satisfaction, work productivity, organisational change, socio-technical systems (lectures and tutorial discussions)
	C2	Psychology I	E. Rump	1971	Learning, perception, physiological psychology, personality, social psychology, language, statistics (lectures and tutorial discussions)

mainly "convergent" skill. However, the aims of the course were to break habits leading to one-to-one encoding of each printed word, to encourage active re-coding and remembering of material while reading, and to encourage practice with a large amount of varied and unfamiliar written information. Thus the efficient reading course contained aspects which might enhance the flexibility and diversity of ideas, and thereby change participants in "divergent" directions.

With Groups E1 and E3, the two creativity-training lecturers spent part of one session on exercises relevant to particular test variables. Group E1 practised thinking of unusual uses for named objects; Unusual Uses was one test employed to assess the effects of training, but involved items different from those used in the training exercises. Group E3 did some divergent drawing exercises, including the Torrance Circles test, which might be thought relevant to figure preferences; the Barron-Welsh Revised Art Scale was used as a test variable. The other groups did not include practical exercises with direct relationships to test variables.

Adult-education students taking courses not relevant to divergent thinking might have been used as controls. However, this was not arranged because it was considered improper to ask such students to spend an hour of their class time on tasks not relevant to their studies. Instead, university students were asked to volunteer who were studying subjects of an academic nature involving some interest in personality assessment. It was considered that they would therefore be interested in undertaking the tests even though their courses did not involve training in divergent thinking. All subjects in both experimental and control groups were offered information as to the results after the study was completed.

The first control group, C1, consisted of students studying Industrial Sociology. The course involved many part-time and older students, which made the group more similar to the adult-education groups. The second control

group consisted of volunteers from students taking a first-year psychology course, which had not included the topics of creativity or divergent thinking when test-sessions were completed. Whilst the experimental groups were of mixed sex, one control group (C1) was composed entirely of males, whilst the other (C2) was predominantly female. It was assumed that the training and control conditions would have similar effects, if any, on men and women.

It is admitted that these control groups were not ideally matched to the experimental groups, but they did allow an assessment of any effects due to study of academic material new to the students, and any effects due to the pre-test practice itself. None of the subjects included in this study were involved in other experiments reported in the thesis.

Test and Procedures

All experimental groups were given two testing sessions. The first session was given at the start of the first meeting of the group, and the second session was given at the end of the last (sixth) meeting. In the case of the control group C1, sessions were also held near the start and end of their course, which in this case involved an interval of six and a half months. The second control group C2 was tested with an interval of six weeks during the academic year. Thus one control group involved the same time-interval between test sessions as the experimental groups, whilst the other involved sessions near the beginning and end of the academic session. It was envisaged that changes from the first to second sessions would be small in the case of both control groups.

It was considered that all groups should be informed as to the general nature of the tests and given appropriate encouragement to participate. In introducing the first test session, the lecturer explained that the tests were concerned with creative thinking in general, and explained briefly the difference between divergent and convergent thinking in non-evaluative terms as far as possible. It was also explained from the outset that a second

test session would follow later so as to determine any changes. Subjects were reassured that the tests were not measures of general intelligence. This form of introduction was used for experimental and control groups alike.

Four tests were used in this order: Unusual Uses and Similarities (scored for fluency), Self-description Checklist, and Barron-Welsh Revised Art Scale. These tests have been described in chapter 7. Some explanation is required for the selection of the Barron-Welsh Scale as a measure related to divergent thinking. In other studies for the thesis it has been found to give nonsignificant correlations with divergent fluency (chapter 7) and with Creative Independence (chapter 8). Nevertheless, the Scale had been shown to be associated with creativity, divergency, and independence variables in some previous studies (see the review in chapter 8), and it was therefore considered worth retaining it in the present investigation. The question at issue is whether creativity training designed to increase divergent thinking would generalise in its effects so as to produce increased scores on the Art Scale. Such generalisation would be expected if divergent fluency and preference for visual complexity-asymmetry involve allied cognitive styles.

In the case of the divergent-thinking and Art tests, it was considered that direct practice effects would arise if the whole test was used for both sessions; parallel half-tests were therefore used. The Checklist was given in total for both sessions, using the additional instruction to tick about half the items as described in chapter 8.

The parallel half-tests for the Unusual Uses test had either "Key" or "Shirt-button" as objects, and those for the Similarities test used either "Milk/Meat" or "Curtain/Rug". Alternate students did one or other form during the first session, and were given the alternative form for the second session. The Art Scale was divided into two equal parts for the two sessions, involving items 1-42 and items 43-86 respectively. Each part contained 30 scored items, and was balanced with 15 scored for "like" and 15 for "don't like". It was possible to calculate from data on each item given in the

manual (Welsh, 1959) for 150 adults, that the half-scales were reasonably equivalent, with a mean difference of only 0.70 units on half-scales ranging from 0 to 30 units.

Subjects

The number of subjects, sex distribution and mean age are given for each group in Table 11.2. In each case there were several students who did not attend the second test session, in most cases because they had withdrawn from the course earlier. The data for "drop-out" subjects were recorded separately. Clearly the effects of courses could be ascertained only for those subjects who attended the second test session, and these are referred to as "stayers". There was a total of 127 stayers in the experimental groups and 47 in the control groups.

A few subjects did not complete individual tests, so that the degrees of freedom for calculated statistics varied slightly. The number of such missing cases did not exceed three in total over all groups for any variable.

Analyses

Two types of preliminary analyses were undertaken. The two forms of each divergent thinking test were compared, over all groups using the first session data, in order to check their equivalence. It was known from previous research that the fluency scores were similar for these items, but it was considered advisable to check this using two-sample t tests (two tailed).

The second type of preliminary analysis concerned the students who withdrew from courses, the "dropouts". If they were consistently high scorers on the pre-test, and if stayers were low scorers, then improvement of the latter on the second occasion of testing might partially be a regression effect. This possibility seemed unlikely, but it was considered advisable to check the extent of dropout/stayer differences using two-sample t tests (two tailed). These were applied to each group separately since the

Table 11.2. Characteristics of subjects in the Effects of Training Courses study

Group	Subgroup	Total No.	Males	Females	Age in years Mean	S.D.
E1	Stayers	16	7	9	41.6	10.3
	Dropouts	14	6	8	Not recorded	
E2	Stayers	19	10	9	38.2	9.9
	Dropouts	24	15	9	39.5	10.4
E3	Stayers	14	5	9	43.6	12.8
	Dropouts	21	7	14	39.7	11.6
E4	Stayers	21	8	13	36.3	9.6
	Dropouts	17	4	13	40.8	9.7
E5	Stayers	33	9	24	38.1	11.7
	Dropouts	21	2	19	36.0	12.4
E6	Stayers	24	17	7	26.2	13.0
	Dropouts	8	5	3	31.1	17.0
C1	Stayers	22	22	0	27.5	8.4
	Dropouts	5	5	0	23.4	3.1
C2	Stayers	25	5	20	21.5	5.7
	Dropouts	4	4	0	22.5	4.4

proportion of dropouts, and possibly their nature, varied from course to course.

The comparisons between dropouts and stayers are of some incidental interest in their own right, since previous studies have indicated that they tend to show differential personality and attitudinal characteristics. Parnes and Noller (1973) found that students who dropped out of a creative studies programme tended to be impulsive, anxious, and with low academic achievement compared with those who completed the programme. The authors considered that these characteristics were similar to those reported for other academic dropouts. Tinto (1975) has reviewed the evidence concerning dropouts generally, and concluded that several individual characteristics have been reliably demonstrated. At The University of Adelaide, Rump and Greet (1975) reported that students who withdrew during their first year found study difficult, less interesting than expected, and had low motivation towards academic work.

The main analyses for the purposes of this thesis concerned the changes shown by stayers, comparing first and second session scores. It was predicted that experimental group scores would increase in the case of each of the following variables: divergent fluency (Uses), divergent fluency (Similarities) the Revised Art Scale and Creative Independence (from the Checklist). It was further predicted that these increases would be greater than any increases shown by the control groups.

Three forms of analysis were used to test these predictions, in each case using the difference scores (second session minus first session scores). The mean difference-score for each group was tested for significance against the null hypothesis value of zero, using one-tailed t tests. Since standard deviations were fairly similar across groups, the estimate of standard error for these significance tests was in each case derived from the overall within-groups "Mean Square". This method maximises the power of the tests

by utilising all available degrees of freedom for the error term, and increases the reliability of its estimation.

The second type of analysis was undertaken to compare experimental groups with control groups overall. For this purpose a one-way analysis of variance was undertaken for the difference scores, with one planned contrast extracted (for each variable) comparing experimental with control groups (Hays, 1963, ch. 14). The obtained *F* ratio for this contrast was converted to the equivalent *t* value, and a one-tailed significance test applied (Hays, 1963, p.354). No predictions were made concerning the Emotional Activitation scale (from the Checklist). Results for the scale are included with other results, with two-tailed tests applied.

It was considered desirable to investigate the consistency of changes resulting from the training courses using a nonparametric method also, since a mean increase in scores on a variable may represent some persons increasing, others decreasing, and yet others remaining the same. The ratio of those who increased to those who decreased their scores from the first to the second session was obtained by dividing the frequency of positive difference-scores by the frequency of negative difference scores. The significance of the deviation from the null hypothesis value of 1 was determined from the cumulative Binomial distribution (Sign test).

All calculations were completed using programmes written in FOCAL on a PDP8 computer. The dependent variables were analysed separately rather than in multivariate analyses of variance, because they represented distinct concepts even though all were related to divergency.

Results

The two parallel halves of the divergent thinking tests were checked for equivalence, using first session data (for both stayers and dropouts). For the Unusual Uses test, the mean fluency score was 7.34 (N = 143) for the item "Key" over all groups and 6.46 (N = 142) for the item "Shirt-button".

There was no significant difference between these two mean values (t = 1.64, p > .05). For the Similarities test, the mean fluency score was 8.73 (N = 146) for the item "Milk/Meat" over all groups and 9.40 (N = 141) for the item "Curtain/Rug". There was no significant difference between these two mean values (t = 1.04, p > .05).

The second preliminary check was the comparison of stayers and dropouts, to determine whether withdrawals from the course would bias the remaining groups in any marked way. The results are summarised in Table 11.3. It may be seen that the direction of differences varied amongst the groups, and dropouts differed significantly from stayers in only four out of 40 comparisons. In Group E4, dropouts scored significantly lower on Unusual Uses; in Group C2 they scored lower on the Barron-Welsh Scale; and in Group E they scored higher on both the Creative Independence and Emotional Activation scales.

It may be concluded that withdrawals from the courses produced no systematic bias in the groups in almost all cases.. The only group of stayers which might be regarded as a "selected" sample with low first-session scores was Group E1 with respect to the Checklist scales. As reported below, this Group did not show a significant increase in these scores in the second testing session, so that even in this case no "regression to the mean" artefact was apparent for the stayers as a group.

The results for the first main analysis are given in Table 11.4. The difference-scores between second and first sessions were subjected to one-way analysis of variance over the eight groups, and the single planned contrast extracted to compare experimental with control groups. As the Table shows the increase in scores was significantly greater for experimental groups than for control groups, for all variables. The difference between experimental and control groups overall was large and highly reliable in the case of the two divergent thinking tests and the Barron-Welsh Scale.

Table 11.3. Comparisons between dropouts and stayers from eight courses

(Data from the first test sessions were used for these analyses)

Group	Subgroup	Mean Scores				
		Uses	Simil.	Rev. Art Scale	Creative Indep.	Emot. Activ.
E1	Stayers	5.7	7.9	12.0	7.9	6.6
	Dropouts	5.4	6.2	12.4	10.4*	9.4*
E2	Stayers	8.6	11.8	11.1	8.8	7.5
	Dropouts	9.4	12.1	12.0	9.6	8.0
E3	Stayers	5.4	6.1	8.9	8.3	9.5
	Dropouts	6.1	7.6	13.5	10.4	9.0
E4	Stayers	7.8	8.0	12.1	8.9	9.6
	Dropouts	4.8*	6.6	10.5	9.4	8.3
E5	Stayers	4.8	7.8	11.2	8.9	7.7
	Dropouts	4.0	7.0	10.5	9.4	8.6
E6	Stayers	6.4	8.0	13.4	8.9	8.0
	Dropouts	5.4	8.2	11.4	8.4	8.4
C1	Stayers	8.8	10.4	13.5	10.8	8.0
	Dropouts	8.8	12.6	15.0	11.6	5.6
C2	Stayers	9.6	12.1	17.0	10.4	8.9
	Dropouts	7.5	8.7	10.5*	8.8	6.2

* $P<.05$ for the Significance of the difference between Stayers and Dropouts (two-tail tests)

The overall contrasts for the two Checklist scales, whilst statistically significant when tested over all groups in this way, are misleading. The experimental groups' changes from first to second sessions for these two scales were small and inconsistent in most cases; it will be shown when considering results in more detail that the significant contrasts for Creative Independence and Emotional Activation in Table 11.4 are partially due to the control groups' tendency to reduce their scores on the second testing.

A concise summary of the main effects is provided by the nonparametric analysis, in Table 11.5. The Table gives the "Change Ratio" values which show for instance, that in the experimental groups considered overall 2.66 times as many subjects gained in fluency as reduced their scores on the Unusual Uses test, following the training courses. The experimental groups as a whole showed clear and significant gains on the two divergent thinking measures and the Barron-Welsh Scale, using the nonparametric Sign test. The control groups as a whole showed no large or reliable gains in their scores, and indeed in the case of the two Checklist scales more control subjects gave reduced scores than gave increased scores, as shown by the Change Ratios of less than one.

The detailed parametric analyses for each group separately are shown in Tables 11.6 - 11.10. Table 11.6 shows that significant gains in divergent fluency on the Unusual Uses test were made by the four creativity-training groups and also by the group which attended the more general "Sharpening our Minds" course. One of the control groups (C2) also showed a small but significant gain, presumably as a result of practice from the first session. However, the amount of change was less than half the gain shown by any of the creativity-training groups. By far the largest gain was achieved by Group E1, which approximately doubled its initial fluency score on Unusual Uses after creativity training. It was this group which

Table 11.4. Planned contrasts between six experimental and two control groups in their difference-scores (second-session score minus first-session score)

(One-way analysis of variance was applied to the eight groups, and used to test the planned contrast between experimental and control groups)

Variable	Planned contrast (Exp. - Control)	t	df	p<
Unusual Uses	2.29	8.01	163	.01
Similarities	1.95	6.50	165	.01
Barron-Welsh R.A.S.	1.91	4.89	164	.01
Creative Independence	0.70	4.37	163	.01
Emotional Activation	0.68	4.30	163	.01

Table 11.5. Nonparametric assessment of changes following training courses, for experimental groups and control groups

(The "Change Ratio" is the frequency of subjects who had positive difference-scores divided by the frequency of subjects who had negative difference-scores. Those with zero difference scores were excluded from this analysis)

	Experimental groups		Control groups	
	Change ratio	p<	Change ratio	p<
Unusual Uses	2.66	.01	1.35	N.S.
Similarities	1.92	.01	0.95	N.S.
Barron-Welsh R.A.S.	1.71	.01	1.56	N.S.
Creative Independence	1.36	N.S.	0.79	N.S.
Emotional Activation	1.13	N.S.	0.61	N.S.

received training on the task involved, so that the result confirmed the impression gained from previous evidence that direct training is the most effective for divergent as well as convergent skills.

Gains on the Similarities test were also fairly marked, and significant for three of the four creativity-training groups. Neither of the other two experimental groups or the two control groups showed any significant change on this test (Table 11.7).

Changes on the Barron-Welsh Revised Art Scale were in the predicted direction for all experimental groups, and significant in four cases (Table 11.8). These involved three of the creativity-training groups, and Group E6 (the Efficient Reading course). This was the only significant change experienced by Group E6. Perhaps the visual information-processing skills involved in the course encouraged an increased appreciation of the more complex figures on the Art Scale. The largest change was experienced by Group E3, which was the group that did divergent drawing exercises as part of their course.

Changes on the Creative Independence scale were in the predicted direction for all six experimental groups (see Table 11.9), which demonstrates a reliable trend ($p < .05$, using the Sign test). However, in terms of individual groups, the gain was significant only in the case of Group E5 ("Sharpening our Minds"). It was expected that the scale, derived from self-reports, might show marked gains, but in fact all experimental groups showed only slight gains. As noted from the review of previous research, it seems that cognitive skills such as divergent fluency may be affected by training courses more readily than more general divergent personality characteristics.

No predictions were made concerning the Emotional Activation scale, and no significant changes occurred with experimental groups. One of the control groups (C1) showed a significant decrease on the scale. Possibly these commerce and management students were more "relaxed" in the second session, having become familiar with the course (concerned with sociology and human

Table 11.6. Changes following training courses: divergent fluency on Unusual Uses, using half-test forms

(Training courses were given between first and second testing sessions)

Group	Data	First session	Second session	Change (2nd-1st)	Significance t(163df)	p<
E1	Mean	5.71	11.07	5.36	5.21	.01
	S.D.	4.01	3.41	4.29		
E2	Mean	8.58	11.21	2.63	2.98	.01
	S.D.	3.19	4.53	4.28		
E3	Mean	5.36	8.07	2.71	2.64	.01
	S.D.	3.89	5.01	3.67		
E4	Mean	7.76	10.66	2.90	3.46	.01
	S.D.	4.59	5.70	5.18		
E5	Mean	4.81	6.53	1.72	2.52	.01
	S.D.	2.60	3.17	2.89		
E6	Mean	6.42	6.21	-0.21	0.26	N.S.
	S.D.	3.62	2.67	3.44		
C1	Mean	8.82	8.64	-0.18	0.22	N.S.
	S.D.	3.95	3.09	4.09		
C2	Mean	9.60	10.88	1.28	1.66	.05
	S.D.	4.56	4.76	3.26		

Table 11.7. Changes following training courses: divergent fluency on Similarities using half-test forms

(Training courses were given between first and second testing sessions).

Group	Data	First session	Second session	Change (2nd-1st)	Significance t(165df)	p<
E1	Mean	7.94	9.75	1.81	1.79	.05
	S.D.	3.64	4.55	4.65		
E2	Mean	11.79	12.00	0.21	0.23	N.S.
	S.D.	3.76	4.37	4.32		
E3	Mean	6.14	10.07	3.93	3.62	.01
	S.D.	3.16	5.62	4.48		
E4	Mean	8.00	10.55	2.55	2.81	.01
	S.D.	5.21	5.76	3.69		
E5	Mean	7.82	8.55	0.73	1.03	N.S.
	S.D.	3.84	4.11	3.59		
E6	Mean	8.00	9.21	1.21	1.46	N.S.
	S.D.	3.28	4.43	2.80		
C1	Mean	10.36	10.18	-0.18	0.21	N.S.
	S.D.	3.35	4.29	4.54		
C2	Mean	12.12	12.64	0.52	0.64	N.S.
	S.D.	4.57	4.61	4.63		

Table 11.8. Changes following training courses: Barron-Welsh Revised Art Scale using half-test forms

(Training courses were given between first and second testing sessions)

Group	Data	First session	Second session	Change (2nd-1st)	Significance t(164df)	p<
E1	Mean	12.00	13.19	1.19	0.91	N.S.
	S.D.	5.45	6.72	4.37		
E2	Mean	11.11	13.22	2.11	1.72	.05
	S.D.	5.12	6.13	4.04		
E3	Mean	8.93	13.07	4.14	2.98	.01
	S.D.	6.74	6.16	6.61		
E4	Mean	12.14	14.52	2.38	2.10	.05
	S.D.	6.31	8.13	6.34		
E5	Mean	11.21	11.73	0.52	0.57	N.S.
	S.D.	6.41	7.66	5.40		
E6	Mean	13.42	15.75	2.33	2.20	.05
	S.D.	5.67	6.31	5.26		
C1	Mean	13.52	13.00	-0.52	0.46	N.S.
	S.D.	6.50	6.17	4.76		
C2	Mean	17.04	18.20	1.16	1.12	N.S.
	S.D.	5.62	5.60	4.39		

Table 11.9. Changes following training courses: Creative Independence scale

(Training courses were given between first and second testing sessions)

Group	Data	First session	Second session	Change (2nd-1st)	Significance t(163df)	p<
E1	Mean	7.87	8.12	0.25	0.46	N.S.
	S.D.	2.55	2.75	1.91		
E2	Mean	8.79	9.32	0.53	1.06	N.S.
	S.D.	3.84	4.23	2.17		
E3	Mean	8.33	8.58	0.25	0.40	N.S.
	S.D.	3.45	3.53	2.26		
E4	Mean	8.95	9.35	0.40	0.83	N.S.
	S.D.	3.56	3.48	2.89		
E5	Mean	8.91	9.79	0.88	2.33	.05
	S.D.	3.11	3.12	2.53		
E6	Mean	8.87	9.50	0.63	1.41	N.S.
	S.D.	3.43	3.59	1.53		
C1	Mean	10.77	10.50	-0.27	0.59	N.S.
	S.D.	2.86	2.84	2.14		
C2	Mean	10.36	10.20	-0.16	0.37	N.S.
	S.D.	4.19	4.09	1.49		

Table 11.10. Changes following training courses: Emotional Activation scale

(Training courses were given between first and second testing sessions)

Group	Data	First session	Second session	Change (2nd-1st)	Significance * t(163df)	p<
E1	Mean	6.63	6.75	0.12	0.24	N.S.
	S.D.	2.36	3.24	2.33		
E2	Mean	7.53	7.74	0.21	0.43	N.S.
	S.D.	3.41	3.38	1.44		
E3	Mean	9.50	9.50	0.00	0.00	N.S.
	S.D.	3.99	4.62	1.95		
E4	Mean	9.60	9.30	-0.30	0.63	N.S.
	S.D.	4.10	3.99	2.05		
E5	Mean	7.70	7.70	0.00	0.00	N.S.
	S.D.	3.43	3.40	2.33		
E6	Mean	8.00	8.17	0.17	0.39	N.S.
	S.D.	2.65	3.03	1.93		
C1	Mean	8.04	6.95	-1.09	2.42	.05
	S.D.	2.66	2.24	2.43		
C2	Mean	8.92	8.96	0.04	0.09	N.S.
	S.D.	2.83	2.82	2.11		

*Two-tail tests were used for this variable

relations), compared with the first session when they had just begun a new unfamiliar subject.

A summary of the pattern of results is given by Table 11.11, which shows the direction and significance of mean difference-scores. It may be seen that all but one of the twenty-four predicted changes for experimental groups were in the predicted direction. The creativity-training groups (E1-E4) fairly consistently gained higher scores on both divergent fluency and the Barron-Welsh Scale. Although fluency and preference for complexity/asymmetry were similarly affected by training, it should be noted that there is no close relationship. Thus Group E1 gained significantly in fluency but not in preference for complexity/asymmetry; whilst Group E6 gained on the latter, but showed no significant increase in divergent fluency.

Students were keen and interested in their courses and the tests, according to their lecturers, but it was not possible to obtain any long-term indication of how training may have affected their lives subsequently. Nevertheless, some commented spontaneously that they had become more innovative in their jobs. For instance, one of the adult-education participants was a demonstrator in the University's Department of Chemistry. When asked by the writer after creativity-training sessions whether he had found the classes helpful, he replied that they had helped with the tutorial classes which he himself conducted in chemistry. He now introduced students to problems of chemical analysis in a group problem-solving manner, and felt able to stimulate his students to think more about their academic work.

Chapter Summary

Creativity training courses, and similar "mental development" courses, do succeed in developing divergent fluency. The greatest effect is found for tasks which are practised during training. Nevertheless, generalisation is found to a small degree affecting associated personality characteristics, such as self-reported Creative Independence in the present study. Training in divergent thinking also affects aesthetic preferences as measured by the Barron-Welsh Scale, despite the negligible correlations between fluency and the Barron-Welsh Scale found in chapter 7.

Table 11.11. Summary of significant changes following training courses: all variables

(The direction of change and significance level are shown in each case, to summarise the data given in Tables 11.6 - 11.10. A "+" sign indicates the mean score increased from the first session to the second session)

Group	Uses	Simil.	Rev. Art Scale	Creative Indep.	Emot. Activ.
E1	+	+	+	+	+
	.01	.05	N.S.	N.S.	N.S.
E2	+	+	+	+	+
	.01	N.S.	.05	N.S.	N.S.
E3	+	+	+	+	0
	.01	.01	.01	N.S.	N.S.
E4	+	+	+	+	-
	.01	.01	.05	N.S.	N.S.
E5	+	+	+	+	0
	.01	N.S.	N.S.	.05	N.S.
E6	-	+	+	+	+
	N.S.	N.S.	.05	N.S.	N.S.
C1	-	-	-	-	-
	N.S.	N.S.	N.S.	N.S.	.05
C2	+	+	+	-	+
	.05	N.S.	N.S.	N.S.	N.S.

CHAPTER 12

DEVELOPMENT OF A POTENTIAL SCIENTIST: A CASE STUDY

A number of studies reported above show that science students tend to prefer a convergent mode of thinking, have attitudes associated with convergency, and follow the majority preference for symmetrical designs. Hudson has suggested a developmental hypothesis to account for such findings, and his views are examined in this chapter in terms of a case study of a developing scientist, aged 11 years when most of the assessments were undertaken. Essentially, Hudson has argued that a typical convergent scientist develops an interest in science and rational, logical thinking at an early developmental stage (the pre-pubertal, latency stage); and that this interest is an expression of the child's need to control his emotions, particularly his conflicting love-hate feelings towards his parents. The stereotype of the physical scientist develops during the latency period, and "itself embodies ideas of emotional control" (Hudson, 1972a, p.67), associated with strong superego development.

Hudson contrasted the development of convergers and divergers: "crystallizing to different extents and at different stages: the convergent during the latency period, the divergent in adolescence. The internal economy of the convergent child, the future scientist, might be said to gel at the stage of his development when issues of rationality and internal control are paramount" (1972a, p.68). As a result, the converger "cannot proceed, especially into areas of emotional expression, without clear and authoritative route signs" (1968, p.67).

There are three main features to this explanation of physical scientists' developmental characteristics: the demonstration of scientific interests *before* specialisation in secondary school has occurred; the association of scientific interest with a convergent style of thinking before the stage mainly studied by Hudson; and the presence of a high degree of emotional

inhibition, with associated traits such as obsessionalism with underlying inner turmoil and conflict. Clearly it is not claimed that all physical scientists develop in this way, or that all have the same personality characteristics, but only that some have their scientific bent strengthened by emotional repression and sublimation, used as a mechanism of defence.

There is evidence that views about and interest in science, can develop before educational specialisation. Hudson (1970, p.288) reported that the "stereotypes of the scientist change little between ages 11 and 17, while those of the artist are poorly crystallized at 11, and take shape gradually during adolescence". In America, McClelland (1962) noted that scientists usually reveal a strong scientific bent between the ages of five and ten. Similarly Terman (1955) wrote that the achievements of eminent scientists were foreshadowed by their interests and preoccupations in childhood. In Britain, Butcher (1969a) found that "Students of scientific subjects have in general, when at school, decided on their future specialization a year earlier than students of arts subjects".

The evidence that convergent bias is found with future science students at an age before they specialise in science, has been discussed in chapter 10 (Dennis Child, 1969b; and that reported by Pont, 1970, p.173-4). In that chapter also, scientists' emotional stability and concern for objects rather than people was noted. Hudson suggested, however, that this surface characteristic represents a defence against latent emotions. McClelland (1962) supported this interpretation: "scientists in their personal lives are upset by human emotion, perhaps particularly by aggression, so that their withdrawal from people can perhaps be viewed as a mode of defense against conflicts over aggression" (p.165). Helson (1961, p.IV-10) considered that some less creative mathematicians chose the discipline "to protect themselves against their impulse-life ... it represented reason over emotion, cleanliness over messiness, clarity over ambiguity".

As a scientist, Freud himself provided an example of the temptation

to stay within the safe confines of physical science, according to Jones (1953): "In the realm of the visual, of definite neural activities that could be seen under a microscope, he had for many years felt entirely at home; he was as safe there as at the family hearth. To wander away from it and embark on the perilous seas of the world of emotions, where all was unknown and where what was invisible was of far greater consequence than the little that was visible, must have cost him dear" (p.420-421).

Cropley (1967a, p.12-13) presented an interesting example of emotional repression in the life of a highly intelligent, convergent boy. He "displayed very low levels of divergent thinking ... his interests were strictly confined to lawful and logical convergent pursuits like mathematics and chess" and he "was unable to express emotions except when they built up until he was overwhelmed in a flood of tears or a burst of rage". Hudson (1966a, p.73) noted a phenomenon which appeared to support the idea of convergers' pent-up emotions: "A few boys make suggestions which seem, to the adult eye, unusually violent ... not divergers as one might expect, but *convergers* and all-rounders".

Another example of the inhibition associated with convergent thinking was provided by an experiment of Austin (1971). He woke students during periods of rapid eye movement, and found that with divergers 95% of wakings led to dream recall, whereas convergers recalled dreams on only 65% of wakings. "There appears to be a general inhibition or repression among convergers about the emotional and non-rational" (*op. cit.*, p.59) which dreams often include. Holmes (1973) found also that convergers more often give dream reports with elaboration (such as explanations of events), rather than direct reports of the primary visual experience.

In a study of 13½ year old children, Anderson and Cropley (1966) compared those with high and low originality on divergent thinking tests, and found that the latter scored lower on measures of impulse expression and risk taking. The convergers appeared to have learned the general rule

"Don't take risks". They may thus be contrasted with impulsive children, as described for instance by Kagan, Pearson and Welch (1966).

It is usually difficult to select future science specialists until after secondary schooling has commenced. However, an opportunity arose to conduct an intensive case-study with an 11 year old boy who already showed clear scientific interests. He is called Frank in this report. The aim was to illustrate aspects of Hudson's theory by the case, and in particular to determine: (a) whether scientific interests were associated with a convergent style of thinking; (b) whether indications of emotional inhibition, and high superego strength, were to be found; (c) whether there was evidence of past "rebellion" against parental authority, which was resolved by repression; and (d) whether any such defence mechanism was debilitating or limiting, by being associated with the excessive control represented by obsessional character traits.

Method

Frank's background, and interactions with the writer

Frank was born on 27th March 1961. The writer first met him at age 5 years, when staying for a brief visit to his parents, who were seldom-seen family friends living in a Scottish city. Frank took myself and my children round the city's science museum, where he displayed great delight as he moved from one exhibit to another. His scientific interests and achievements developed, and when aged 11 years he agreed to cooperate in the writer's research during visits to each other's families (June - August, 1972).

At the time of the main assessments, Frank was living in Scotland with his parents, 7 year old sister and 2 year old baby brother. His father was a university lecturer in animal physiology. His mother had been a nurse, but was currently a housewife who was studying for an Open University degree. His maternal grandfather was a well-known author of popular texts on animal

behaviour.

Frank attended a local private school, an "Academy" of some repute, and had attended that same school since 5 years old. He had travelled with his family to Canada when 3 years old, and had attended nursery school there for a year.

Forms of evidence concerning Frank's personality, background and behaviour

This report is based on various forms of evidence, listed below. They include cognitive tests, personality questionnaires, projective techniques, interviews, documents and observations of behaviour in the family setting. The following tests were given, using the standard procedures as stated in the manuals except were indicated. They were completed in the order given, the first four during one day, the next five two weeeks later, and the Rorschach a month after that.

(i) Primary Mental Abilities Test (Thurstone, 1958). This test of intellectual performance was selected because it included a measure related to divergent fluency (Word-fluency) as well as four measures of convergent abilities.

(ii) Occupational Interests Guide (Closs, Bates, Killcross and McMahon, 1971). This included the assessment of relative interest in scientific, literary and artistic fields. The test assessed relative and not norm-based interests, which has advantages (Closs, 1976).

(iii) Ai3Q Questionnaire (Kline, 1971a). The questionnaire provides a measure of "obsessional personality". A slightly modified version, to allow use with a child, was devised as explained in Appendix 12.1.

(iv) Rosenzweig's Picture-Frustration Study, children's form (Rosenzweig, Fleming and Rosenzweig, 1948). This projective method was employed to determine whether there were indications of superego defensiveness or inhibition of emotion as suggested by Hudson's developmental theory.

(v) Torrance Tests of Creative Thinking, Form A Verbal and Form A Figural (Torrance, 1966). These provided the main assessment of divergent thinking abilities.

(vi) Bene-Anthony Family Relations Test, using the materials for older children (Bene and Anthony, undated manual). The test indicated various feelings towards other members of the family, but was used particularly to assess the degree of defensiveness and inhibition.

(vii) Barron-Welsh Revised Art Scale (Welsh, 1959). The Scale was used to assess preference for complex figures.

(viii) High School Personality Questionnaire, 1963 edition, Form A (Cattell and Cattell, 1969). The questionnaire assessed several relevant personality traits, such as affectothymia, superego strength, and self-sentiment control.

(ix) Graves Design Judgment Test (Graves, 1948). The test score was considered to reflect preference for asymmetrical designs, as described in chapter 7.

(x) Rorschach Technique (Klopfer and Davidson, 1962). Because the writer had scored Rorschach protocols only for tertiary students previousl the analysis was undertaken strictly according to the manual, and interpretations were restricted to those closely related to well defined aspects of responses. In addition, location and the scoring of original responses (0^{+} or 0^{-}) were considered with the assistance of Small's (1956) manual, which was based on over six thousand Rorschach responses. Evaluation was assisted by use of Manson and Ulett's evalograph (1965).

In addition to these tests, Frank was interviewed for two hours concerning his development, his feelings about parental control and authorities generally, his interest in science, and other creative pursuits. An interview with Frank's mother covered Frank's educational background, his reactions to school interests, emotional behaviour, and perceived influences on his development. A second interview concerned the mother's feelings

towards Frank, as a baby and as a child, particularly in the areas of control and discipline; and the parents' own life histories. All interviews were tape-recorded and subsequently transcribed. Both parents completed the 16 PF questionnaire, form A (Institute for Personality and Ability Testing, 1972).

Documentary evidence relevant to Frank's abilities and cognitive style was in three forms: (a) every term's school grades and reports throughout Frank's primary-school life (over seven years); (b) photocopies of drawings completed when aged 5 and 6½ years, and colour photographs of crayoned and painted pictures completed when 6, 8, and 10 years old; and (c) letters from Frank's mother during the three years following the test sessions, which reported on Frank's progress at school.

Direct observations of Frank's behaviour were possible on several occasions between test sessions, both interacting with adults and with other children of similar age. His scientific collections and home-laboratory experiments were seen. A family friend, a teacher, was asked to describe occasions when Frank acted emotionally during a week's stay with the family, a few months prior to the test sessions.

Results

All test data are summarized in Table 12.1, which presents scores in both raw and standardized form. The standardization data used are stated in each case. The form of standardization differs from test to test in accordance with the convention for each one. Thus the Primary Mental Abilities are described in terms of percentile positions in line with the manual's recommendation, whereas sten-scores are conventional for Cattell and Cattell's Questionnaire. The Interests Guide is not a normative test, but ranks occupational areas in order of interest to the testee.

Table 12.1. Summary of Frank's test data

(i) Primary Mental Abilities Test

Scale		Raw Score	Percentile position*
Scholastic aptitude	(2V+R)	68	>99th
Verbal ability	(V)	24	96th
Spatial ability	(S)	29	>99th
Reasoning ability	(R)	20	>99th
Number ability	(N)	10	32nd
Word-fluency	(W)	38	81st

*Based on Thurstone's profiles for 11 year olds.

(ii) Occupational Interests Guide

Scale	Raw Score	Relative preference (rank 1 = most preferred)
Scientific	25	1
Social service	13	4
Clerical/sales	9	7½
Literary	20	2
Artistic	12	5
Computational	10	6
Practical	9	7½
Outdoor	14	3

The consistency of the profile, as indicated by the Rho correlation between Part 1 and Part 2 rankings, was .42.

(iii) Ai3Q

The raw score for "obsessional personality" was 22. This was 1.02 standard deviations above the mean for over 2,000 sixth-formers given by Kline (1971a), which is equivalent to the 85th percentile, for a Normal distribution.

Table 12.1 (continued)

(iv) Picture-Frustration Study

Time taken: 30 min. Total pattern: E>e>I

Significant trend: towards Intropunitive (-.56)

Scale	% of responses (to nearest integer)	Standard (T) score *
Group Conformity Rating	60	45
Direction of aggression:		
Extrapunitive	56	59
Intropunitive	19	44
Impunitive	25	46
Type of reaction:		
Obstacle-dominance	12	45
Ego-defensive	54	46
Need-persistence	33	56
Superego patterns:		
E	8	48
I	8	48
E + I	17	49
E - E	21	54
I - I	6	44
M + I	33	46

*The standardized (T) scores have a mean of 50 (S.D. = 10), based on norms for 10-11 year olds given in the manual.

Table 12.1 (continued)

(v) Torrance Tests of Creative Thinking

Scale	Raw Score	Standard (T) score*
Verbal Form A:		
Fluency	70	48
Flexibility	40	65
Originality	57	59
Figural Form A:		
Fluency	20	45
Flexibility	18	53
Originality	35	61
Elaboration	116	77

*Based on the T-score conversion tables provided in the manual, derived from fifth-grade school children.

(vi) Family Relations Test

Type of feeling	Direction of feeling	
	Family members receive from child	Child receives from family members
Mainly positive feelings	Baby brother (7+)	Father (7+)
	Father (6+, 2-)	Baby brother (3+)
Ambivalent feelings	Mother (7+, 4-)	Mother (6+, 4-)
Mainly negative feelings	Sister (7-)	Sister (8-)

Order of involvement: Mother (21), Father (15), Sister (15), Baby brother (10).

Egocentric responses: 4 mild negative responses to self, such as "This person in the family sometimes gets too angry".

Defence mechanisms indicated: none to any abnormal degree.

Degree of inhibition of positive feelings: Average.

Degree of inhibition of negative feelings: Average.

Table 12.1. (continued)

(vii) Barron-Welsh Revised Art Scale

The raw Scale score was 47, which was equivalent to a standard (T) score of 76 using the norms given in the manual for 75 U.S.A. men.

(viii) High School Personality Questionnaire

Scale	Raw score	Standard sten score*	Mean sten for Scottish boys #	Interpretation of Frank's score
A	10	6.2	5.2	Average affectothymia
B	8	6.4	-	Slightly high intelligence
C	14	8.0	5.6	High emotional stability
D	11	5.8	6.1	Average excitability
E	12	7.2	6.1	Somewhat assertive
F	8	4.0	5.2	Slightly desurgent
G	15	8.0	5.4	High superego strength
H	10	8.0	5.6	Highly adventurous
I	10	6.8	5.1	Slightly sensitive
J	10	7.0	5.8	Slightly individualistic
O	9	4.8	5.6	Average self-assurance
Q2	16	10.0	6.1	Very high self-sufficiency
Q3	16	9.0	5.0	Highly controlled
Q4	8	5.0	5.3	Average ergic tension

* Using the conversion Table N-4 from the tabular supplement (Institute for Personality and Ability Testing, 1968), and applying the age correction to age 11¼ years as described in the manual (Cattell and Cattell, 1969, p.24-25).

\# Mean sten scores for 300 Scottish boys aged 12-17 years were taken for comparison with Frank's scores from McCann and McQuaid's (undated) test information sheet (Table III).

(ix) Graves Design Judgment Test

The raw score was 56, which was equivalent to a standard (T) score of 61 (86th percentile), using the norms given in the manual for 106 U.S.A. high school (non-art) students.

Table 12.1. (continued)

(x) Rorschach technique

Frank's data are given, together with comparison values for a sample of 100 protocols from 11-year-old American children given by Ames, Métraux and Walker (1959); and normative values for average 11-year-olds obtained from regression-analyses on age by Levitt and Truumaa (1972). Relevant interpretations are given in the text.

Variable	Frank's data		Ames et al.'s (age 11 years) sample	Levitt & Truumaa's norms for 11 yr. olds
General features:				
Total responses	43		19	18
Total time	31 mins		12 mins	-
Reaction time (achromatic)	15 sec		-	-
Reaction time (chromatic)	8¼ sec		-	-
Locations:	Primary scores			
W	30 (70%)		48%	35%
D	4 (9%)	38 additionals	44%	50%
Dd	8 (19%)	12 additionals	8%	15%
d	0			
S	1 (2%)	12 additionals		
Determinants:				
M	8 (19%) (includes 3 M^-)	1 additional	11%	8%
FM	2 (5%)		13%	15%
m,mF	4 (9%)		3%	2%
F	21 (49%)	6 additionals	61.8%	58%
Fc	2 (5%)	3 additionals	3%	-
FK	3 (7%)			
C'F	1 (2%)		1%	-
FC	0 (0%)	2 additionals	2%	-
CF	2 (5%)	1 additional	4%	3%

(Other determinants were absent from the record)

Table 12.1. (continued)

Contents	Primary scores	Ames et al.'s (age 11 years) sample	Levitt & Truumaa's norms for 11 yr. olds
H	7	19%	11%
Hd	2 (21%)		
A	7	50%	52%
Ad	1 (23%)		
AObj	2		
At	1 (2%)	3%	4%
Obj	13 (30%)	13%	-
N (botanic)	5 (12%)	6%	-
Fire,explosion	5 (12%)	2%	-
Basic relationships			
Responses to cards VIII, IX, X.	30%	-	-
F+%	100%	90%	72%
P	3	7	4
O^+	27	-	-
O^-	3	-	-
W:m	30:8	9:2	$6\frac{1}{2}:1\frac{1}{2}$
Sum C=$\frac{(FC+2CF+3C)}{2}$	2	1	1
M:Sum C	8:2	2:1	$1\frac{1}{2}:1$
(H+A):(Hd+Ad)	14:3	10:3	-
FK+F+Fc%	60%	64:9%	-
(FM+m):(Fc+c+C')	6:2	3:1	-
Supplementary relationships (additionals being counted as $\frac{1}{2}$)			
M:FM	$8\frac{1}{2}:2$	2:2	$1\frac{1}{2}:2$
M:(FM+m)	$8\frac{1}{2}:6$	2:3	$1\frac{1}{2}:3$
(FK+Fc):F	$6\frac{1}{2}:24$	$\frac{1}{2}:12$	-
Achromatic: Chromatic	$4:3\frac{1}{2}$	-	-
Differentiated: Undifferentiated shading	$6\frac{1}{2}:0$	-	-
FC:(CF+C)	$1:2\frac{1}{2}$	$\frac{1}{2}:1$	-
Succession	Confused	None	-

The Rorschach scores are conventionally not standardized (other than by calculating percentages and ratios within the record). Where possible, appropriate comparative data for 11 year olds are given from Ames, Métraux and Walker's (1959) sample of children with above-average intelligence and largely with professional or semi-professional parental occupations. This sample seemed appropriate in Frank's case. Unfortunately, Ames *et al.* gave data slightly inconsistent between different tables and between tables and the text, presumably because different subsets of their sample were available for different analyses. Their data quoted in Table 12.1 should be regarded as approximate. When appropriate, data were converted to percentages of total responses. In addition, normative values were available for average 11 year olds for some main variables from Levitt and Truumaa's (1972) collation and analysis of published data. Again, their values were converted to percentages of the mean total responses where appropriate.

The test data are not interpreted here comprehensively; rather, data are discussed which bear on each aspect of Hudson's developmental theory of the convergent scientist. Similarly, interview and other evidence is presented only in so far as it is relevant to the issues.

Convergent intellectual abilities

Frank was in the top 1% for scholastic aptitude according to the Primary Mental Abilities Test, with very high scores on verbal, spatial and reasoning abilities.

His number subtest score was lower than the verbal score, but not exceptionally so in that about 8% of cases would give a verbal-numerical subtest difference as large as Frank's. In the manual it is stated that "The fluent, highly verbal person who has trouble with arithmetic is a common example" (Thurstone, 1958, p.28). Corresponding with the relatively low score on number ability was low interest in computational occupations on the Interests Guide. Frank explained his attitude to school mathematics

in his interview: "It's boring, especially in form L4 because we kept on doing the same mathematics. Especially mathematics; but now I'm teaching the teacher. I mean she knows some of it, but once she gave me a few extra points in the exam because of Pascal's Triangle. It was just a kind of complete-the-series thing. It said 1, 11, 121, 1331, 14541 - that series; and I knew it was Pascal's triangle." Frank was thus interested in the logic of mathematics but not in "boring" arithmetic.

Frank's school record confirmed his general academic ability, although it should be noted that divergent as well as convergent thinking might be involved. The last available report, for the term during which tests were given, showed him to be ranked 8th in the class of 30 pupils. The form teacher's report stated: "Frank has made very good progress. In English his work is flowering beautifully - mature and interesting. His Geography is good enough but not up to the standard of his other subjects. In Mathematics he shows good, logical thinking."

Slightly discrepant evidence was provided by Scale B of the High School Personality Questionnaire, on which Frank scored only slightly above average, rather than well above average. However, Scale B is admitted in the manual (Cattell and Cattell, 1969, p.28) to have "extreme brevity", being based on only ten Form A items, of which Frank was "correct" on eight.

High intellectual level was indicated by several Rorschach signs, such as the large number of responses, the very high proportion of responses to the whole blot (W), the high proportion of human movement determinants (M), and the wide variety of content (without the usual dominance of "animal" responses). The large number of responses may have been facilitated to some degree by the good rapport established during previous test sessions (*cf.* Levitt and Truumaa, 1972, p.22). Klopfer and Davidson (1962) recommended use of an average weighted form-level rating, for which Frank's score was 1.53, indicating "a superior level of intellectual capacity" (p.149).

Divergent/convergent bias

In contrast with scores for convergent abilities, Frank's divergent thinking scores were almost all near average on the Torrance Tests with *T* scores between 45 and 65. The exception was for figural elaboration, which gave a high *T* score of 77, and reflected Frank's meticulous attention to detail. Feldhusen, Treffinger, van Mondfrans and Ferris (1971, p.39) found that figural elaboration correlated consistently with school achievement, and commented that detailed drawings might often be required in school assignments. According to the manual, high figural elaboration reflects the ability to embroider ideas, is associated with keeness in observation, and may be obtained by "the compulsive elaborator" (Torrance, 1966, p.75). This interpretation fitted well with evidence of Frank's scientific activities, and did not contradict the general conclusion that Frank's relative convergent and divergent scores showed a fairly strong convergent bias. In confirmation of this conclusion, word fluency on the Primary Mental Abilities Test gave a lower percentile position than three of the four convergent subtests.

Further evidence of Frank's convergent bias was obtained in the interview. When asked, he said that he liked the Thurstone better than the Torrance tests. Asked what it was that appealed to him more about the former, he replied "It was so that I could tick or cross the one that I wanted to." He thus preferred the multiple-choice convergent tests to the open-ended divergent tasks.

On the other hand, there were some indications of traits associated with divergent thinking, such as the above average scores on Scale J of the High School Personality Questionnaire interpreted as "slightly individualistic", and Scale H "highly adventurous". The main feature of Frank's test performance indicating his potential for some forms of original thinking was his extremely high score for original responses on the Rorschach, most of which were quite appropriate to the stimulus (O^+). For example,

his three responses to Card I were a stuffed fox's head with a mirror providing a reflection, an entrance to a cave, and a cap. The high human movement determinants (*M*) also suggested "an intelligent, well-integrated individual, capable of creative experiences" (Klopfer and Davidson, 1962, p.134). Hudson (1966, p.107) commented on the originality which convergers may display: "Although convergers are defensive, it is a defensiveness which is not incompatible with wit and inventiveness ... defensiveness seems actually to cause originality, albeit originality of a special brand".

Most of Frank's "real life" creative activities were scientific or concerned with the study of the natural world (described below), and showed a close reliance on observation, and work of elaborate detail rather than carefree spontaneity. This point is illustrated by Plates 12.1 and 12.2, showing meticulous floral pictures executed at 6 and 10 years of age respectively. Frank was asked about his art work at school, and specifically how he set about it. His reply illustrates a convergent approach: "I write my name on the sheet of paper first, and it depends what I'm drawing. If I'm drawing flowers, I draw them from my head, but if I'm drawing a serious big flower, then I'd want to sit in front of a flower and look at it." Asked what gave him the idea of what to paint he replied, "Well, things I've seen before".

It thus seemed that Frank was capable of creative activities, but these took a controlled, convergent form. Several non-test indicators of creative potential listed by Torrance (1967a) were observed in Frank's activities, including going beyond assigned tasks, experimenting with objects, telling about his inventions, drawing elaborate pictures and using all his senses for observations.

Scientific interests and activities

Frank's most preferred occupational interest on the Guide was Scientific. His enthusiasm for science was conveyed in his interview. Asked how strong were his feelings about science when 4 or 5 years old, he replied "very

Plate 12.1. Flower drawn by Frank when aged 6 years

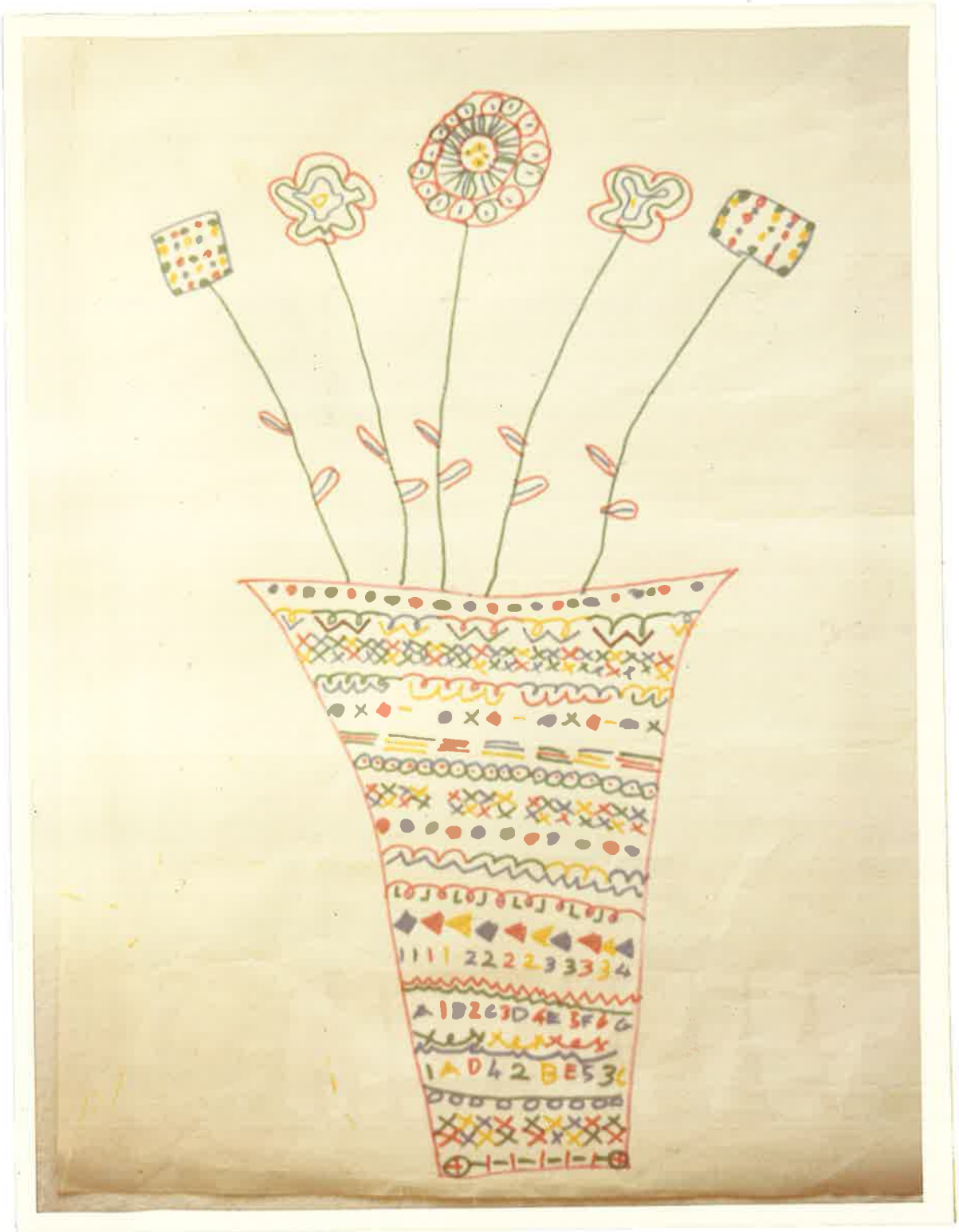


Plate 12.2. Flowers drawn by Frank when aged 10 years

strong". And when asked what it meant to him currently, he replied "Terribly more stronger. I mean it's everything, it's everything in my life". His mother reported: "He had the highest marks for ten years for his essay on 'Flower Collecting'; I asked him why he had not written about his hobby 'Science' and he immediately replied 'Well, Science is my life, not my hobby'". Three and a half years after the assessments, his mother wrote that "Frank is top for all science subjects, with 100% for Biology in the exams".

The content of his Rorschach responses reflected Frank's interest in the natural world, with relatively high proportions of objects (*Obj*), such as spinning top (Card II) and a cross section of a bronze-age container (Card IV); and a high proportion of Nature (*N*) responses, such as a little path leading down to the sea (Card III) and a cactus in the middle of a road (Card IV). Scientific interests even influenced his play activities: his first word in his first game of Scrabble (played between tests) was "neon".

Frank's scientific knowledge of a factual nature was sometimes startling. He watched Open-University television programmes on Chemistry, and made detailed comments on the chemical structures discussed. Indeed he had compiled a private note-book which he often carried with him, which he explained "had the table of inorganic acids and amino-acids. I'm fascinated with DNA, deoxyribonucleic acid. I like all science". He had read some of his father's books on physiology and anatomy from the age of four: "That was mostly the bones, but I read other physiology books".

Frank was given a broken transistor radio, and on the next visit the writer was shown how it had been used in an on-going experiment. With a second radio, Frank commented "I made a simple interferometer". He explained that it worked rather like a hologram in principle, and that "if I had more money I would get more advanced equipment".

Frank's mother was asked when his interest in science first showed itself. She thought at about 4 years of age, described his interest in his

father's books, and said that he seemed to understand the diagrams of internal organs and understood that these organs were inside himself. Also at the age of four, Frank was given a box which he called his "meter" and carried around. It had controls and a dial, and "was very precious to him". His interest in the meter is conveyed by Plate 12.5, a drawing completed when 6½ years old, which also illustrates the "obsessional" nature of the interest.

At the time of writing, seven years following the test sessions, Frank was taking "A level" examinations in Biology, Chemistry and Physics, and has applied to take a degree in Physiology at the University of Cambridge. His father reported that much of Frank's spare time is spent writing and executing computer programmes at his father's University.

Artistic interests and activities

Despite his strong scientific inclination, Frank also had artistic interests. In Hudson's (1968, p.72) words, Frank was "involved in a choice among selves that already exist inside him". Holland (1973, p.12) remarked that the pursuit of particular interests "leads to the development of more specialized competencies as well as to the neglect of other potential competencies". Frank's specialization had barely commenced; in particular, Frank had strong literary interests according to his school reports. With regard to music, Frank had been learning to play the violin since he was six, and had enjoyed attending concerts for children since the age of four, according to his mother. At six he was given a record of organ music, to which he enjoyed listening. By the age of 14 years, Frank had passed Grade V on the violin. (According to Frank, his father had played the saxaphone, mandoline and clarinet at various periods in Frank's childhood.)

Painting was a hobby also, and indeed Frank's father came from "a family of artists". Frank obtained unexpectedly high scores on both the Graves and the Barron-Welsh scales, scores typical of fine-arts students. It would seem therefore that Frank's early interest in science was *not* associated with a preference for simple stimuli, as expected from the results

described in chapters 8 and 10. From this point of view, Frank might be described as an "all-rounder", in Hudson's terminology, rather than an extremely convergent type. Nevertheless, Frank's art work was largely in a convergent style, and associated with his scientific interests. Plate 12.3 shows "maps" produced at 8 years of age (one of two similar drawings kept by his mother). The use of symmetrical shapes, the listing of chemical elements, geological forms and numbers, and the repeated patterns illustrate a converger's approach to art.

Indications of superego strength and control

There is evidence to support the notion that Frank had a highly developed superego and a high degree of self-control. In particular, scores on Scales C, G and Q3 of the High School Personality Questionnaire suggested emotional stability, superego strength and very high self-control.

The above-average score on the Ai3Q suggested "a defence mechanism mediated by the superego" according to the manual (Kline, 1971a, p.11), although it is important to note that the scale does not indicate obsessional *symptoms*. The long time taken to complete the Picture-Frustration test indicated "considerable inhibition and conscientiousness" (Rosenzweig *et al.*, 1948, p.143). Frank's final comment on completing that test was "I felt they were trying not to be angry". Also the trend towards intropunitive responses over the test suggested that the representation of aggression aroused a "feeling of guilt" (*op. cit.*, p.182). Similarly the four mildly negative responses to himself on the Family Relations Test indicated mild guilt feelings concerning anger.

On the other hand, the general response pattern on the Rosenzweig test was very near the average, all scores lying within one standard deviation of the mean. The main indicator of "superego defensiveness" (E + I) was very near the norm. The slightly above average extrapunitive score was mainly due to "e" responses, which implied "A solution for the frustrating situation is emphatically expected of someone else" (*op. cit.*, p.146);

Plate 12.3. "Maps" with codes drawn by Frank when aged 6 years

(The photograph has reduced the drawing to about 3/4 size)

behaviour of this kind might be reasonably effective for a bright child with professional parents.

The Family Relations Test showed no abnormal defences or inhibition. The strong jealously towards the nearest sibling was quite normal. Frank's self-control and conscientiousness did not generally interfere with normal inter-personal relationships. He was nevertheless very self-sufficient: "I'm solitary, if you like. I like walking by myself in the woods, and I run off."

The Rorschach supported the High School Personality Questionnaire in that there were some indications of inner tension and striving for high self-control. Tension, possibly arising from need for achievement, was indicated by three human movement determinants having poor accuracy ($\bar{M}$); some intrapsychic conflict was also suggested by the inanimate movement (*m*, *mF*) determinants. The frequent use of unusual detail (*Dd*) and white space (*S*) indicated "compulsive defensive style" according to an interpretation by Holt (1971, p.143). The very high *M*:(*FM* = *m*) ratio suggested a firm control of impulses. There were eight additional *dr* responses as well as four additional *dd* responses, suggesting "obsessional, meticulous or pedantic trends" (Klopfer and Davidson, 1962, p.132). Amongst the main *Dd* locations, six (of eight) involved rarely delineated areas, used to define "good forms", and these responses suggested "great perceptiveness" for detail (Klopfer and Davidson, 1962, p.132).

Meticulous concern for detail was evidenced to some degree in the interview records. For instance, after collecting flowers during a holiday trip, Frank's mother recalled: "He went into great detail. We bought him a very good book, and he learnt all the Latin names and all the family names (of the flowers). It took a lot of his time". Frank worried if his scientific experiments did not work well. He stated: "Some time ago I was trying to make a model of the solar system, with things so I could move the planets round on their wires, and I couldn't get it to work. I tried

and tried and tried". He was dissatisfied unless his work was perfect in his own eyes. For example, he "lost" one of his note-books because one diagram was crudely drawn: "It was just that the way I had drawn the planets in - I wished I had made - when I looked at it, I felt rather depressed".

One remark by Frank was particularly interesting in that it implied a direct connection between emotionality and the "calming" effect of scientific order. "Science gives me a lot of pleasure. And even when I really am in a state, and I've been taken to the university, and looked at something, like anything there, a computer or something, I usually calm down."

In some cases Frank's activities could be regarded as showing obsessional repetition. This is illustrated by the drawings in Plates 12.4 - 12.6 completed at ages 5, 6½ and 8 years respectively. Other drawings of a similar kind were produced. For a time when he was 9-10 years old, Frank became very concerned that his possessions should be well-ordered. According to his mother, "everything had its place ... And nothing had to be moved".

The question arises as to whether Frank's conscientiousness and concern for detail were debilitating, and whether his emotional control was a barrier to affectionate relationships. Several pieces of evidence indicated a "healthy" personality in these respects: fairly normal patterns were obtained for the Picture-Frustration and Family Relations tests; high emotional stability and average affectothymia, self-assurance, and ergic tension were found on the High School Personality Questionnaire; and *F%*, colour determinants, *FK + F + Fc*, *(FM + m):(Fc + c + C')*, and *FC:(CF + C)* values were within the normal range on the Rorschach. These features supported the interview impression that Frank was a well-adjusted child with normal affectional needs. His mother reported that "He seems to have quite a number of close friends. Some he's had from the first class". In so far as Hudson's developmental theory implies that a convergent interest in science is associated with debilitating inhibition, Frank's data did not support that aspect of the theory.

Plate 12.4. Drawing by Frank when aged 5 years, showing repetitive features

(The photograph has reduced the drawing to about 3/4 size, and only part of the original 50 x 110 cm drawing was included)

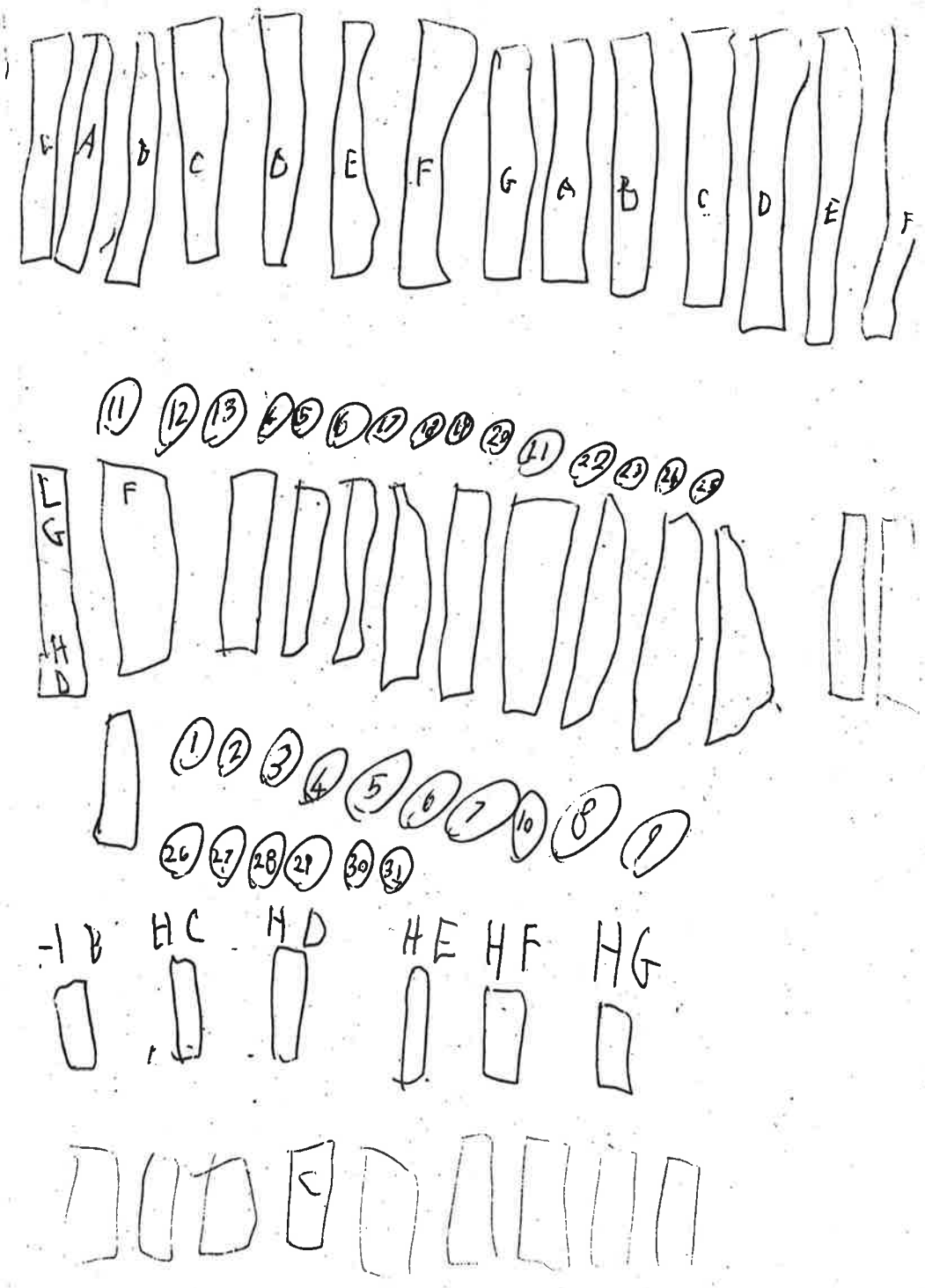


Plate 12.5. Technical drawing by

Frank when aged 6½ years, showing repetitive details

(The photograph has reduced the drawing to about 3/4 size. It was one of two similar sheets)

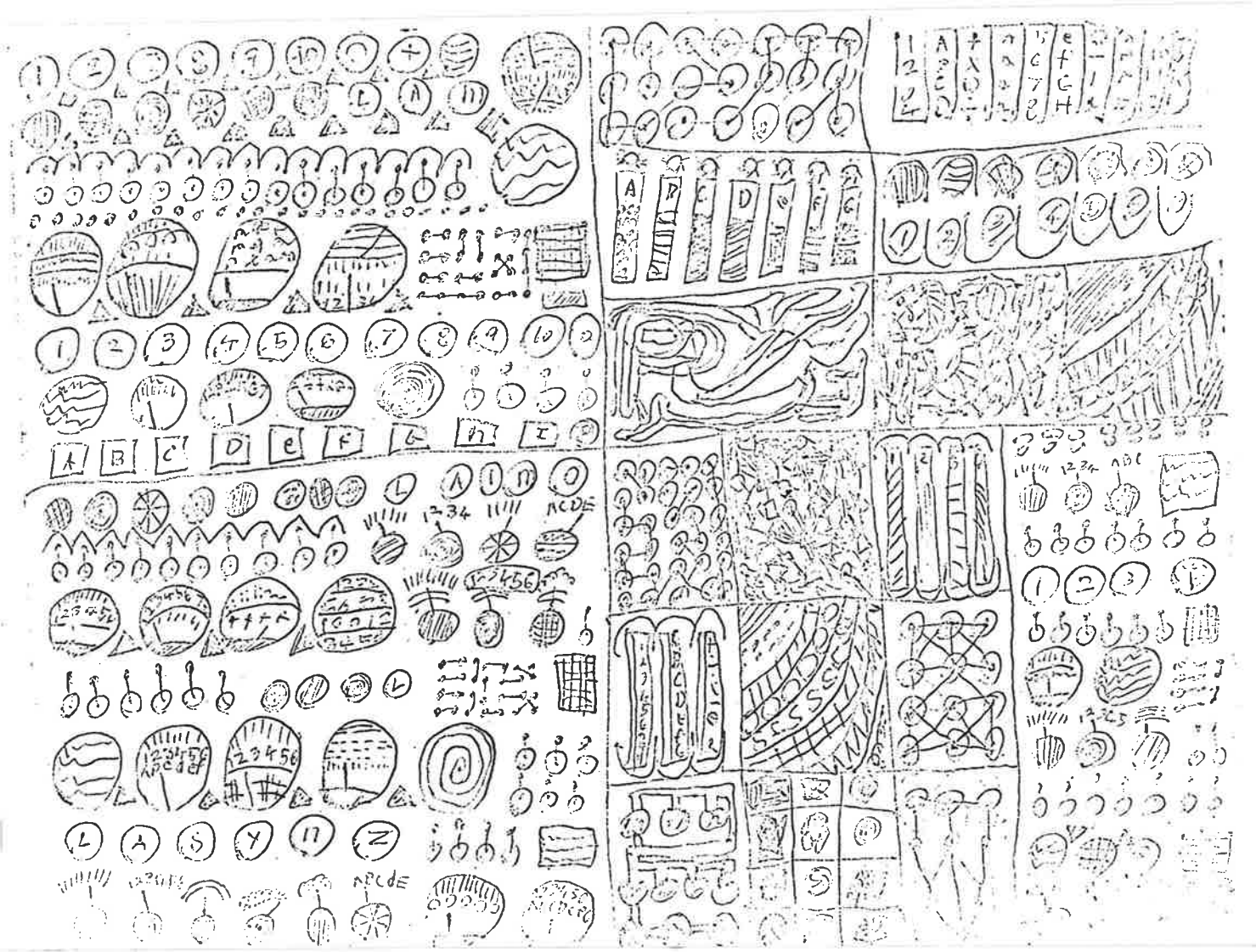


Plate 12.6. Scientific drawing by Frank when aged 8 years, showing repetition and various classifications

(The photograph has reduced the drawing to about 3/4 size)

Outbursts of emotion

Hudson (1968, pp.68-70) suggested that the emotionally controlled child might display occasional emotional outbursts, given an "authorized" opportunity. Frank displayed this kind of behaviour when visiting children were giving an informal "concert", according to a family friend's account. At first Frank showed disdain. Then a "play" was performed which involved clowning by a 12 year old. Frank reacted with embarrassed giggles but later, encouraged by adults, he joined in "circus acts". His enthusiasm grew until, as a "horse", he became rather rough with the smaller girls, and finally displayed his anger when the circus "pyramid" collapsed prematurely.

On another occasion, Frank was making a list of organic chemicals in his science note-book, which he explained was precious and must be written perfectly. He complained of a mistake, that there was not enough space, and then that his pen was not working properly. Fianlly, he lost his patience and exclaimed, "I must tear this page out and begin again". The five Rorschach responses concerned with fire or explosions suggested intense feelings, which in view of the generally high form levels were well controlled.

It should not be concluded that Frank's inner feelings were concerned predominantly with violence. Some of his occasional unconventional outbursts were associated with mischief and fun. Frank was asked what he thought of other children who were naughty in school. "Well, it's quite fun actually. I feel at the beginning ... I say to myself 'I wish they would be quiet'. And then when the teacher's out ... and there's misbehaving and things, well, I go along on the floor. It's awful, but I go along on my back, you see, pushing along ... I just go in the files of desks, so the teacher doesn't see." His mother reported that at school, between the ages of 5 and 8 years, "he did clown quite a lot". His school report at age 8 years showed that the teachers played their part in discouraging this "undesirable" activity: "Frank still behaves very childishly in class and I feel that if he settled down to work more seriously, his results would be a truer guide to his ability".

Parental discipline

According to their 16 P.F. Profiles, Frank's father and mother were alike in being composed, intelligent and aloof. However, they differed in many other respects, the mother being calm, dominant and enthusiastic, whereas the father was submissive, uncommunicative, shy, and sensitive, although also relaxed, confident and self-sufficient. It was clear from the interview material that Frank's mother played the major role with respect to discipline. This influenced Frank's feelings towards her as indicated by the Family Relations Test; for there was some ambivalence towards his mother, with mild negative feelings as well as strong positive involvement.

The ambivalence was understandably difficult for Frank to express in his interview. He was asked how he had felt when punished as a younger child: "I felt, I felt (pause) I wasn't angry, just felt a bit angry with myself... I did something bad, I can't remember what it was, mummy smacked me and I went away. She - I can't remember, but I know it was amusing. My daddy didn't smack me, no, he didn't. I still like my daddy because he doesn't get into a temper." Thus Frank's negative feelings towards his mother's punishment were not expressed directly, but by the implied contrast with his feelings towards his father. Frank recalled an occasion when "she gave us both a row, daddy and I", when they had been recording the violin and were late for dinner.

Frank's mother was quite concerned about discipline. At about the age of 18 months, she explained that "a German friend came to stay, and she said 'he's becoming very resistant'. And she thought I wasn't being strict enough with him." Frank's mother went on to say that she did not agree that Frank had been resistant to her, but later described various activities that she stopped, such as "destroying books ... and I didn't allow him to climb furniture." Later in the interview, Frank's mother admitted that "we felt that he was very disobedient," and said that on various occasions she had been "very cross". In the second interview, she said "I suppose

I was tense, and took it all so seriously" with reference to Frank's upbringing.

Conclusions

From the test, interview and behavioural data, a number of conclusions can be drawn concerning Frank's scientific interests and competencies, to illustrate Hudson's developmental theory.

Frank's scientific orientation began from early childhood with the encouragement of his father, himself a scientist. His drawings showed his fascination with the orderliness, systematic classifications and control systems afforded by science. Although Frank's mother used physical punishment only rarely, Frank's independent and adventurous character led to some conflicts, which were largely resolved by Frank's internalisation of parental demands in the normal way. Strong superego development, and its outward signs of conscientiousness and self-control, were supported by his parentally approved interest in science and nature.

Both teachers and parents encouraged a serious, convergent approach to learning, and conventional academic abilities thrived. Imagination and spontaneity became somewhat subdued, although Frank's independence and observational sensitivity were maintained. Frank's personality, at age 11 years, illustrated the association that can occur between scientific interests, convergent bias, and traits such as conscientiousness and meticulous concern for detail. However, in Frank's case there was no evidence that a scientific orientation had been inimical to literary, artistic or musical appreciation and competence. Nor was there any evidence that Frank's emotional inhibition hindered normal affectionate relationships or intellectual pursuits. It is stressed that the case-study illustrates aspects of Hudson's theory, but does not test it with scientific rigour.

CHAPTER 13

GENERAL IMPLICATIONS OF THE FINDINGS

This final chapter considers the findings of the thesis in relation to theoretical approaches outlined in the first chapter; and a model of personality development is tentatively proposed. Practical implications of the findings are discussed, followed by a brief indication of additional research which could be undertaken.

Theoretical overview

It was pointed out in chapter 1 that the four types of theoretical approach outlined therein are not necessarily incompatible. It is appropriate in this final chapter to review the empirical findings to determine the value and limitations of each approach.

Motivational concepts have been considered both with respect to aesthetic preferences and to divergent thinking. For instance, the concept of arousal, based on the analogy of energy flow through a system, is considered in relation to relaxed inspection and appreciation of visual designs, shapes and patterns, and is found to be unhelpful. Similarly, the concept of adaptation-level, which has been found useful when dealing with the effects of stimulus energy-level on perceived intensity, is misleading when applied to preferences for stimuli varying in complexity and in symmetry/asymmetry.

Nevertheless, rather loose motivational concepts have been used in describing phenomena associated with creativity generally, and these have implications for both divergent thinking and aesthetic preferences. In particular, the need for diverse, absorbing stimulation shared by visual artists and divergent thinkers is a theme investigated in several parts of the thesis (chapters 6 - 10). Although evidence disconfirming a general dimension of "openness to diverse stimulation" is reported in chapter 7, students of the arts and humanities display more catholic taste compared with students of the sciences both in the production of diverse ideas, and in

their pattern preferences (chapters 2, and 7 - 10). In particular, science students display in the words of Beswick (1971, p.158) a "tendency towards systematic integration of the cognitive map, that is, to replace disorder by order".

Further motivational theories stressing the role of interests and values in the organisation of behaviour have flourished during the last decade (*e.g.*, Rokeach, 1973; Holland, 1973). In particular, interest in the arts and humanities, with associated educational background, preferences and competencies, represents a broad orientation with implications for personality traits and cognitive styles. Moreover, artistic interests may develop "functional autonomy" (Allport, 1937) and provide motivation for a wide range of activities. Indeed, the characteristics of the artistically-oriented diverger in many respects suggest a high level of intrinsic motivation or curiosity (Maw, 1971), although this hypothesis has not been explored explicitly in the thesis.

A more specific motivational hypothesis which is examined in the thesis, is that a convergent scientist's need for order and predictability influences his interactions with others, attitudes, cognitive performance and preference for simple, symmetrical patterns. It is further suggested that some personality characteristics associated with the study of science may represent remote consequences arising from the introjection of parental control, and function as a mechanism of defence to avoid internal conflict and associated feelings of anxiety and guilt. However, there is little direct evidence to support this speculative interpretation, although it is illustrated by a case-study in chapter 12. This raises the issue of whether convergent traits involve pathological inhibition, but no evidence from the writer's investigations suggests that scientists or subjects with a convergent bias are handicapped by psychopathology to a greater extent than others. For instance, no significant correlation occurs between divergent fluency and neuroticism scores (chapter 7); science students are not particularly

emotionally activated (chapter 10); and a potential scientist's personality profile is generally normal despite indications of "obsessional" traits (chapter 12).

A second major approach, based on information theory, met with a rather mixed reception in the face of empirical analyses. As evident from chapters 2 and 3, responses to visual stimuli which vary in complexity in many cases conform to expectations derived from an informational viewpoint. However, the strong average preference found in chapters 2 - 4 for regular and symmetrical pattern amongst various groups cannot readily be accommodated within informational theory. For instance, the effects occur when pattern complexity is controlled by covariance analysis (chapter 4). These results suggest the operation of choice rather than an "informational imperative".

Despite such limitations to the informational approach, convergers and divergers, noncreative and creative persons, scientists and artists, can be regarded as differing in their preferred style of assessing both input and output information. Thus science students are less tolerant of complex, asymmetrical patterns and of unconventional ideas than arts students; and are more cautious in presenting responses to open-ended problems. Whilst modes of handling informational systems may differentiate between the converger and diverger (chapters 7 and 10), this does not imply that one mode is consistently more effective than another. As noted in chapter 6, both convergent thinking ability and divergent fluency correlate with educational achievement; similarly it is noted in chapter 9 that both scientific and artistic orientations are more associated with academic achievements, compared with "practical" orientations.

Pervading much of the discussion in Part C of the thesis is the notion of personal style, of individual differences amongst which a degree of consistency is apparent; and in several chapters some degree of consistency of individual and group differences in preference for complex visual stimuli and in divergent fluency is noted. When attempts are made to define personal

styles across the three areas of aesthetic preferences, divergent fluency and arts orientation, some consistency is found, but generally with correlations of a low order. Thus, it would be incorrect to label all those with a background in fine-arts as divergers with a liking for asymmetry. This uncertainty in the observed relationships is sharply demonstrated in chapter 10, in that fine-arts students fail to obtain high scores on divergent fluency or on the two art tests. Nevertheless, in several cases artistic interest is shown to be an aspect of personal choice having quite broadly-ranging implications for personality.

The final approach which succeeds in integrating some of the findings, relates to the influence of learning experiences. Although there is little evidence that length of education in arts or science is a critical variable (chapter 10, Study b), the fact that faculty (arts or science) and education in fine arts are characteristics usually related to both divergency and aesthetic preferences, shows that educational experiences are pertinent even if not causative. More direct evidence of the influence of learning experiences is provided in chapter 11, where it is shown that adult-education courses designed to stimulate the production and the assimilation of novel ideas have effects on students' divergent fluency, preferences and self-image.

Models of personality development

Is it possible to suggest a "model" which is sufficiently flexible to accommodate the loose interconnections described above? Holland's model of interests might at first sight appear to incorporate many of the findings and to set them into a general context. However, Holland's "types" are oversimplified and misleading in that they suggest firm, highly coherent and unchanging constellations of traits. Certainly students with scientific interests who are majoring in psychology do not fit Holland's stereotype for the scientific type (chapter 9). It seems necessary for a model of personal style to accommodate the idea of personal freedom to choose amongst

alternative possibilities.

Moreover, "Interpretative threads" are required to trace individual styles (Hudson, 1975); such threads are traced for an individual in chapter 12. The person is seen as an agent seeking interesting yet safe routes through life within the limits established by his culture and circumstances. The individual as an agent, rather than a victim of internal and external forces, is a theme of several current theorists (*e.g.*, Little, 1972b). Rychlak (1976, p.219) puts the humanistic view as follows: "The humanist believes that it is this facility to see open alternatives in all meaningful understandings which stamps human intelligence as fundamentally different from the efficient-cause 'thinking' of a machine." It is interesting that a contemporary behaviourist, who advocates the continued search for controlling contingencies, considers it appropriate for the individual to "behave spontaneously, and let the consequences follow" (Day, 1976, p.123). The term "spontaneously" implies that the individual has open to him alternative futures, which he may or may not reflect upon.

The individual may be seen as developing areas of specialisation which distinguish him (or her) from others. Initially, these are influenced by learning opportunities provided by family and friends, interacting with innate potentials. Gradually, satisfying areas of specialisation are discovered, whilst other areas are rejected or neglected. "Activities which are experienced as interesting are those in which the individual's capacity to appreciate, understand and control the environmental factors involved are more or less matched by the demands of the activity" (Closs, 1975, p.14). The individual's capacity for and mode of processing informational input, his areas of interest, competencies, attitudes and preferences tend to form a coherent pattern.

Such patterns may emerge during adolescence when many educational and career choice-points are faced. Those who continue their education to tertiary level, such as those who formed the majority of groups studied in

this thesis, may have difficult decisions to make as each searches for his "personal epistemology"; that is, "some personalized perspective that frees him from the obsessional hold of subjective realism, and permits him to feel and act in ways that allow a self to differentiate out from his own sea of contemplated alternatives" (Chandler, 1975, p.177).

Approaches to personality development of this kind, whilst they incorporate the possibility of coherent cognitive styles, are more flexible than accounts in terms of "types" and "traits". Haven (1965) makes this point in relation to creativity. He writes: "I am inclined to believe that creativity may not be a personality dimension at all in the general sense used by most investigators ... After completion of the present investigation, I would tend to agree with those investigators who feel that all individuals have creative potential in varying amounts ... (and) develop such inherent creative potential in various fields and using sundry media, as a result of past learning experiences" (p.752).

An analogy which is flexible enough to incorporate some of these views, is provided by Waddington's "canalization of development" model. Waddington (1961, p.94-98) described systems of development in the context of environmental stress and constraints, which give rise to modifications of behaviour (and bodily forms) to cope. In these terms, the developing individual is seen as traversing a canalized landscape. Entry into a canal leads towards others of even greater specialisation, although some are broad and some narrow. Some channels cut one off from whole areas of life's potential landscape, like the scientists described by Eiduson (1962) and noted in chapter 10.

An example of "channelling" into a style of life, partly under the influence of educational factors, is provided by Hammond's (1971) longitudinal study of Melbourne boys, tested from ten to twenty years of age. Those less interested and successful in school tend to enter manual occupations; their satisfactions centre round social and practical competencie

rather than intellectual or career achievements. Their lives are characterised by enjoyment (sports, girl-friends) and lack of moral constraints. Those tertiary students who have been described in this thesis, interested and educated in arts or science, can similarly be seen as channelled towards attitudes, competencies and activities related to their interests.

Practical implications

What are some of the practical issues raised by the research? One implication is that educational systems and teaching styles should attempt to cater for various styles of learning such as those exhibited by convergers and divergers. This should involve a consideration of teaching styles, as indicated by Yčas and Pascal's work (1974, referred to in chapter 7); and also methods of assessment, as indicated by Study c described in chapter 10.

More particularly, it would seem desirable to encourage original and divergent thinking within science courses (Poulton, 1963). Many recently devised science curricula include programmes of discovery through experimentation such as the Nuffield Foundation Science Teaching Project in Britain, and the Biological Sciences Curriculum Study (Klinckmann, 1970) in Australia. Indeed Jones (1972, p.61) states "The teaching of science has undergone a radical change over the last twenty years ... The emphasis is on the scientific process practised individually by children involving a significant proportion of problem-solving situations. The admission of a 'dignity of doubt' has moved the onus from the teacher to the pupil, and, not knowing what the outcome of an experiment will be, the child is very much in the role of the researcher." A recent text book on research in the behavioural sciences illustrates the new approach: on the frontispiece map of "The Island of Research", the one rule is "Do Not Block the Path of Inquiry" (Agnew and Pyke, 1978).

How may originality be encouraged? From the results reported in

chapter 11, many different methods of increasing skills and attitudes relevant to creativity can be effective. It seems likely that a varied approach, rather than concentration on any particular, simple technique like Maltzman's word-association method, is more effective.

Further research

Implications for additional research which might be completed on the thesis topics are evident. As often occurs in research, each experiment points the way to an even more comprehensive and informative design. For example, a difference between arts and science students was incidentally observed in preferences for Terwilliger patterns (chapter 2). This could have been followed up; it was not, because it was considered desirable to investigate individual differences using published aesthetic preference tests in the first instance. Furthermore, the findings with Terwilliger patterns suggest a follow-up experiment with an increased range of complexity values, to determine whether an asymptote would be reached with interest ratings and viewing time.

Later studies similarly introduced as many question marks as conclusions. For example, the anomalous finding (chapter 10) that fine-arts students obtained the *lowest* scores on two art tests requires further investigation. Were these students mainly interested in commercial art, rather than complex, original, individual work? This seems unlikely, but the nature of their art-appreciation courses is suggested as an important variable. To decide this issue, students from different types of fine-arts courses would need to be compared. Certainly the validity of the two tests, when used for selection purposes, is brought into question by the data. Another aspect of aesthetic preferences involved in several of the studies is preference for symmetry/asymmetry. Yet it must be admitted that different degrees of symmetry have not been investigated. Szilagyi and Baird's (1977) pioneer work in this field could be broadened by the comparison of fine-arts, design, and science students using their technique.

Finally, it is suggested in chapter 4 that young children like complex designs because they admire the draughtsmanship involved. Whilst this hypothesis is supported by the experimental results, it has not been directly tested. A study in this area might help to allay the mystery of the confused findings with children's aesthetic preferences.

The list of further studies which could arise from this phoenix is extensive. But for the purpose of the thesis, *num quid amplius?*

Appendix 1.1

Mean galvanic skin response to Berlyne's more complex (MC) and less complex (LC) patterns, extracted from two reports

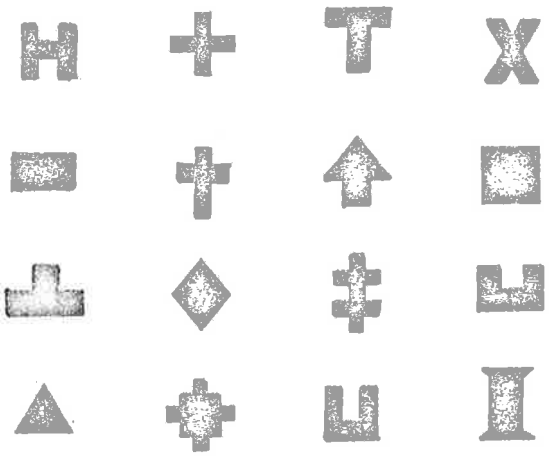
Reference	Berlyne, Craw, Salapatek, & Lewis, 1963			Berlyne & Lawrence, 1964	
Experiment	I	I	II	I	II
Group*	EM	NEM	EM	NEM	NEM
Measure	Frequency of GSR per 3 trials			Amplitude (mv)	Amplitude (Haggard index)
No. of Ss	40	40	40	84	60
Mean score:					
MC patterns	1.66	1.02	1.26	1.18	1.03
LC patterns	1.55	1.02	1.30	1.18	1.03
Significance	$p<.05$	N.S.	N.S.	N.S.	N.S.

*EM signifies "extrinsically motivated", and
NEM "not extrinsically motivated"

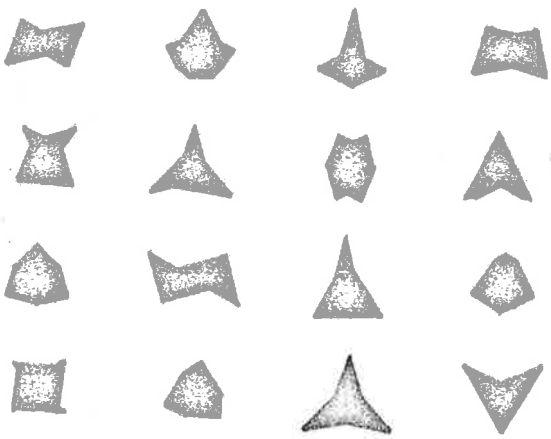
Appendix 2.1

Polygons with high positive and high negative loadings on a general factor (from Eysenck, 1968, Figures 5 and 6)

(a) Polygons with positive loadings



(b) Polygons with negative loadings



Appendix 2.2. Three random orders for patterns used in Chapter 2

(The patterns and their code numbers are given in Tables 2.9 and 2.10)

Serial position	Order i	ii	iii
	Pattern code number		
1	A16	S16	A 4
2	S10	A 2	S 3
3	S 5	S 8	A32
4	S 3	S14	A10
5	S16	A12	S 2
6	A 5	S 2	A14
7	S 2	A32	S 5
8	A 2	A 8	A 3
9	A23	A 4	S 4
10	A 4	S 4	S 6
11	A 3	A45	A 2
12	A64	A14	S14
13	S 8	A 3	A 5
14	A45	S10	S12
15	A 8	S12	A45
16	A12	A16	S10
17	A 6	A10	A12
18	S12	A64	S 8
19	A32	S 6	A 6
20	S14	A 6	A23
21	S 4	S 3	A64
22	A10	A23	S16
23	A14	S 5	A16
24	S 6	A 5	A 8

Appendix 2.3. Analysis of variance for responses to visual patterns of the Terwilliger type described in Chapter 2

(Each error term is tabulated immediately following the experimental effect to which it applies)

Group I: Pleasantness ratings

Source	Mean Square	df	F	p<
Symmetry	56444.08	1	24.45	.00001
Symmetry x Subjects	2308.64	59		
Pattern	5316.80	9	12.65	.00001
Pattern x Subjects	420.20	531		
Symmetry x Pattern	2390.24	9	5.09	.00001
* Symmetry x Pattern x Subjects	470.01	590		

Group II: Interest ratings

Source	Mean Square	df	F	p<
Symmetry	36036.82	1	17.55	.0001
Symmetry x Subjects	2053.39	65		
Pattern	19005.12	9	65.47	.00001
Pattern x Subjects	290.31	585		
Symmetry x Pattern	2501.55	9	5.78	.00001
* Symmetry x Pattern x Subjects	432.57	650		

* Because these analyses with the larger groups required a central memory greater than the normal limit of SPSS (CM=140000 octal words) even for the orthogonal, simplifed MANOVA method (Cohen and Burns, 1976, p.138) the design was slightly simplified by combining the Subjects term with the third-order interaction error term. This result is a slightly conservative test for the Symmetry x Pattern interaction.

Appendix 2.3 (Cont.).

Group III: Preference ratings

Source	Mean Squares	df	F	p<
Symmetry	4950.42	1	16.12	.01
Symmetry x Subjects	307.03	11		
Pattern	1792.22	9	4.82	.01
Pattern x Subjects	371.63	99		
Symmetry x Pattern	735.43	9	2.00	.05
Symmetry x Pattern x Subjects	367.61	99		
Subjects	5876.34	11		

Group III: Viewing times (seconds)

Source	Mean Squares	df	F	p<
Symmetry	83.07	1	6.59	.05
Symmetry x Subjects	12.61	11		
Pattern	34.62	9	2.20	.05
Pattern x Subjects	15.72	99		
Symmetry x Pattern	8.70	9	0.59	N.S.
Symmetry x Pattern x Subjects	14.81	99		
Subjects	685.27	11		

Appendix 3.1

Individual differences in tendency to choose more complex patterns for further viewing: correction of Berlyne's (1963) expected frequencies

The number of subjects was 80, each given 18 choices of a more complex or less complex pattern. Three sets of "null hypothesis" expected frequencies are given below, as follows:

E_1. These published expected frequencies were given in a "corrected" version by Berlyne (1963, p. 411).

E_2. Approximate expected frequencies were calculated by the writer using the Normal-approximation method (Ferguson, 1966, p. 102), and using the same probability (0.56) as used by Berlyne.

E_3. The exact expected frequencies were obtained using the correct overall probability value (0.55) and binomial tables (U.S.A. National Bureau of Standards, 1950).

Number of choices of more complex patterns	Expected (null hypothesis) distributions			Observed distrib.	Deviation
	Published	Corrected values			
		Approx.	Exact		
	(E_1)	(E_2)	(E_3)	(F)	(F - E_3)
0 - 7	23.04	9.35	10.24	27	+16.76
8	6.32	9.75	9.98	1	- 8.98
9	7.07	13.30	13.55	5	- 8.55
10	7.14	15.17	14.91	8	- 6.91
11	7.07	13.30	13.25	6	- 7.25
12	6.32	9.75	9.45	3	- 6.45
13 - 18	23.04	9.35	8.62	30	+21.38

The extreme cases are "grouped" so that expected frequencies are greater than five for the calculation of χ^2.

The deviations between observed and expected frequencies (F- E_3) are significant: $\chi^2 = 105.6$, df = 5, $p < .001$. The df value allows for the two parameters used to calculate expected frequencies (i.e. the total number of subjects and the probability of 0.55 estimated from the data).

Appendix 3.2

Calculation of overall evaluative judgement and GSR index using ranked data, for Berlyne's patterns over several studies

(a) Calculation of overall evaluative scores

To obtain "standard scores" from each study, the published mean response measures were ranked over the types of patterns. Since the three studies did not each involve all 16 pattern subsets, the rank values were multiplied by the fraction 16/k, where k was the number of subsets represented in the study. All "standard scores" were thus within the range 1 to 16. In all cases rank 16 was given to the highest evaluative score.

Pattern subset	Less/More complex	Standard Scores (i)	(ii)	(iii)	Overall mean score	Overall rank
A	LC	10.67	16.00	4.57	10.41	11
B	LC	8.67	6.40	8.00	7.69	6
C	LC	14.67	12.80	13.72	13.73	14
D	LC	16.00	8.00	8.00	10.67	12
E	LC	13.33	14.40	-	13.87	15
XA	LC	-	-	11.43	11.43	13
XB	LC	-	-	8.00	8.00	7
XC	LC	12.00	-	16.00	14.00	16
A	MC	4.00	3.20	5.72	4.30	5
B	MC	8.67	11.20	10.29	10.05	10
C	MC	6.67	9.60	12.57	9.61	9
D	MC	5.33	4.80	1.14	3.76	4
E	MC	1.33	1.60	-	1.47	1
XA	MC	-	-	3.43	3.43	3
XB	MC	-	-	2.29	2.29	2
XC	MC	2.67	-	14.86	8.76	8

(i) Berlyne, 1963, Expt. II, Pleasingness

(ii) Berlyne and Lawrence, 1964, Expt. II, Preference

(iii) Berlyne and Peckham, 1966, Ugly-Beautiful rating

Appendix 3.2 (continued)

(b) Calculation of overall GSR scores

To obtain "standard scores" from each study, the published mean response measures were ranked over the types of patterns. Since one available data set (Berlyne and Lawrence, 1964, Expt. II) involved only ten of the sixteen pattern-subsets, rank values for that set were multiplied by 1.6. All "standard scores" were thus within the range 1 to 16. In all cases rank 16 was given to the highest GSR.

Pattern subset	Less/More complex	Standard Scores (i)	(ii)	(iii)	(iv)	(v)	Overall mean score	Overall rank
A	LC	9.0	1.5	11.0	8.0	4.8	6.9	3
B	LC	4.5	13.5	14.5	3.0	12.8	9.7	11
C	LC	4.5	13.5	1.0	15.0	6.4	8.1	7
D	LC	1.5	7.0	11.0	13.0	11.2	8.7	9
E	LC	9.0	7.0	5.0	6.0	14.4	8.3	8
XA	LC	1.5	7.0	5.0	12.0	-	6.4	2
XB	LC	14.5	7.0	16.0	5.0	-	10.6	13.5
XC	LC	4.5	16.0	11.0	4.0	-	8.9	10
A	MC	12.5	7.0	5.0	9.5	1.6	7.1	6
B	MC	9.0	7.0	5.0	1.0	8.0	6.0	1
C	MC	9.0	13.5	5.0	16.0	9.6	10.6	13.5
D	MC	9.0	7.0	5.0	11.0	3.2	7.0	4.5
E	MC	16.0	7.0	14.5	2.0	16.0	11.1	16
XA	MC	4.5	13.5	11.0	14.0	-	10.7	15
XB	MC	14.5	1.5	5.0	7.0	-	7.0	4.5
XC	MC	12.5	7.0	11.0	9.5	-	10.0	12

(i) Berlyne, Craw, Salapatek and Lewis, 1963, Expt. I, EM Group

(ii) Berlyne, Craw, Salapatek and Lewis, 1963, Expt. I, NEM Group

(iii) Berlyne, Craw, Salapatek and Lewis, 1963, Expt. II

(iv) Berlyne and Lawrence, 1964, Expt. I

(v) Berlyne and Lawrence, 1964, Expt. II

(c) Spearman's Rho

Correlating the overall rank values for evaluative scores and the GSR from (a) and (b) above, Spearman's Rho was -o.307, $p > .05$ (NS).

Appendix 4.1

Instructions to judges for describing Welsh's figures to obtain the complexity measure used in Chapter 4 (with examples)

1. A brief description in note form is required, covering the main features of each figure, in such a way that a reproduction from the description would look essentially similar.

2. Describe by listing concepts, together with modifying terms; each piece of information being separated by a stroke (/). The score used will be the number of terms used for each figure.

3. Information which may need to be given includes:-
   (a) Form: e.g. any geometrical form (circle, pentagon, arc, segment, sine waves) any letter shape, any object of fairly standard shape (spring, waves). Modifying terms such as curving, symmetrical, repeated, horizontal, clockwise (of a spiral), inlets each end.
   (b) Outline: e.g. dots, dashes, roughly drawn, double line, thick line, no outline, scribble.
   (c) Size: relative size need be given only if it is an essential feature, e.g. same size, shorter, larger, the sides equal to the radius of the circle.
   (d) Relationships: e.g. overlapping, touching, between, outside, concentric, near to.
   (e) Position: this need be given only if a figure is not fairly central, e.g. towards the upper-left, around the edges, in a horizontal row, inclined (i.e. not horizontal or vertical); or if relative position is an important feature, e.g. below, evenly spaced, above and to the right. Any inclined feature need be specified more precisely only if necessary in relation to another, e.g. "inclined / but nearer to the horizontal than the first line/ ".

In general the position of a part counts as one term only for each part defined, however stated, except that inclination or relationship may count as additional terms.

(f) Number: this needs be stated only if more than one, e.g. "circles /4/ to the left/ and 3 / to the right". If the number is large and the exact value seems inessential, state "many".

(g) Filling: e.g. speckled, black, cross-hatched. The nature of the cross hatching may need to be specified further if it is a noticeable feature. "White" need be stated only if the outline itself is a white line or band.

(h) Background: this need be specified only if not plain white, e.g. "black background".

4. Define the whole figure or its parts in such a way as to minimise the number of concepts required. This is aided if the whole or main part is described by one "form" term; if concepts like "symmetrical", "another" "in groups of" etc are used; and if general features are stated before exceptions e.g. "a square / with corners missing /."

5. The denoting of a part already implied does not count as a separate term, e.g. "a square / but with left side curving / outward." ("Curving" counts as an extra idea, but "left side" is implied by "square").

6. Terms should be as specific as possible, to aid brevity and accuracy. "Complex", "intricate", "composed" etc. should be avoided.

7. If it is clear that the number of terms required would be 20 or more, simply score "20+"

8. Use abbreviations to assist speed of coding.

Examples of resulting descriptions

Welsh Item	Description	No. of verbal units	Other judge's score
27	Circle /	1	1
16	Squares / 4 / horizontal / thicker lower, right sides / evenly spaced /	5	5
196	Waves / 2 humps / almost horizontal / 6 / lower ones sloped more down to left / otherwise even / but lower 4/ closer together / on right /	9	10
126	Rectangles / 8 / long axes horizontal / on right side / longest 2nd from bottom / 2nd longest 5th from bottom / 3rd longest 7th from bottom / 4th longest 3rd from bottom / next two equal, 4th and 8th from bottom / containing many / horizontal / lines / along rectangles, / being closer together nearer the bottom /	15	15
127	Circles / 3 / in near vertical row / smaller one above / slight incline of row to top left / bottom circle has horns / two / sticking out below / middle has paths across / 2 / as rectangles / but blank in the circle itself. / Above circles / is a hat / with a large brim / and above each side / 3 / small / additional circles. / All the figure drawn roughly. /	20	20

Appendix 4.2

Welsh Figure Preference Test items included in analyses for Chapter 4, with their type, complexity and "liking"

The columns in the following pages give coded information about each figure included in the analyses under these column headings:

SYM

Symmetrical figures are coded 2.
Asymmetrical figures are coded 1.

REG

Smoothly drawn figures are coded 2.
Irregularly drawn figures are coded 1.

FIG

This column gives the number of the figure as specified in the Welsh Test booklet.

LKADULT

This column gives the percentage of Welsh's (1959) Sample B (adults) liking the figure.

LKCHILD

This column gives the percentage of Welsh's (1959) Sample C (children) liking the figure.

GEO

Geometrical figures are coded 2.
Other figures are coded 1.

COMP

This column gives the complexity score, ranging from 1 to 20, as defined in chapter 4. The score given is the mean of two judges' values, truncated to the integer value.

Appendix 4.2 (continued)

SYM	REG	FIG	LKADULT	LKCHILD	GEO	COMP
1.	2.	1.	80.	57.	2.	7.
1.	2.	2.	67.	56.	1.	10.
2.	2.	3.	63.	51.	1.	5.
2.	2.	4.	64.	46.	1.	7.
2.	2.	5.	53.	44.	1.	3.
2.	1.	6.	56.	82.	1.	18.
1.	2.	8.	55.	63.	1.	11.
2.	2.	9.	73.	72.	2.	6.
1.	2.	11.	53.	44.	1.	7.
1.	1.	12.	37.	49.	1.	13.
2.	1.	14.	13.	56.	1.	8.
1.	2.	15.	63.	49.	1.	20.
2.	2.	16.	74.	72.	2.	5.
2.	2.	19.	70.	62.	1.	3.
1.	1.	20.	25.	68.	1.	13.
1.	1.	21.	26.	40.	1.	7.
1.	2.	22.	62.	52.	1.	8.
1.	2.	23.	51.	59.	1.	20.
2.	2.	25.	43.	44.	1.	4.
1.	1.	26.	35.	32.	1.	8.
2.	2.	27.	73.	63.	2.	1.
2.	1.	30.	29.	56.	1.	7.
1.	1.	31.	17.	39.	1.	4.
2.	2.	34.	64.	46.	1.	7.
1.	1.	35.	33.	49.	1.	10.
2.	2.	36.	59.	56.	1.	6.
2.	2.	37.	73.	61.	1.	9.
2.	1.	38.	22.	49.	1.	4.
1.	1.	41.	23.	34.	1.	15.
2.	2.	42.	91.	79.	2.	8.
1.	1.	45.	19.	54.	1.	9.
2.	2.	48.	75.	66.	1.	5.
1.	2.	49.	78.	52.	1.	11.
2.	2.	50.	72.	56.	1.	5.
1.	1.	52.	33.	54.	1.	17.
2.	1.	53.	26.	52.	1.	6.
1.	1.	54.	21.	56.	1.	7.
1.	1.	55.	38.	56.	1.	20.
2.	2.	57.	49.	60.	1.	5.
2.	1.	61.	23.	50.	1.	4.
2.	2.	65.	69.	57.	1.	5.
1.	2.	67.	67.	70.	1.	10.
1.	2.	68.	50.	48.	1.	20.
1.	2.	69.	44.	48.	1.	8.
1.	2.	71.	48.	48.	1.	20.
2.	2.	73.	57.	72.	1.	6.
2.	2.	74.	81.	78.	2.	9.
2.	1.	75.	54.	67.	1.	5.
2.	1.	76.	11.	51.	1.	6.
2.	1.	78.	35.	68.	1.	8.
2.	1.	79.	11.	48.	1.	8.

Appendix 4.2 (continued)

SYM	REG	FIG	LKADULT	LKCHILD	GEO	COMP
2.	2.	80.	74.	49.	1.	8.
1.	1.	81.	32.	32.	1.	6.
2.	2.	82.	75.	74.	1.	5.
1.	1.	83.	32.	34.	1.	11.
2.	2.	89.	61.	54.	1.	4.
1.	1.	90.	20.	51.	1.	7.
1.	2.	92.	68.	61.	1.	18.
1.	1.	93.	33.	38.	1.	20.
2.	2.	94.	55.	61.	1.	3.
1.	2.	95.	77.	65.	1.	4.
1.	1.	96.	40.	54.	1.	20.
2.	2.	98.	71.	70.	2.	3.
2.	2.	101.	86.	65.	1.	14.
1.	1.	102.	23.	44.	1.	19.
2.	2.	104.	51.	45.	1.	4.
1.	1.	105.	76.	60.	1.	8.
1.	1.	108.	53.	50.	1.	20.
1.	1.	109.	27.	49.	1.	9.
2.	1.	110.	11.	59.	1.	8.
2.	2.	113.	65.	62.	1.	19.
2.	2.	114.	71.	70.	2.	3.
2.	2.	115.	63.	54.	1.	5.
2.	1.	116.	54.	49.	1.	4.
2.	1.	119.	27.	44.	1.	6.
2.	2.	120.	73.	61.	1.	9.
2.	1.	121.	21.	71.	1.	5.
2.	2.	122.	83.	80.	2.	5.
1.	2.	123.	41.	50.	1.	8.
1.	1.	124.	21.	29.	1.	17.
1.	2.	126.	46.	56.	1.	15.
1.	1.	127.	29.	51.	1.	20.
2.	2.	129.	42.	66.	1.	6.
1.	1.	130.	23.	35.	1.	20.
1.	1.	133.	6.	39.	1.	19.
2.	2.	134.	69.	66.	2.	4.
2.	2.	137.	69.	62.	2.	3.
2.	2.	138.	56.	48.	1.	6.
2.	2.	139.	71.	63.	2.	3.
1.	1.	141.	19.	38.	1.	20.
1.	1.	142.	47.	45.	1.	16.
1.	2.	143.	88.	68.	1.	15.
1.	2.	144.	56.	56.	1.	12.
1.	2.	145.	83.	57.	1.	18.
1.	1.	146.	56.	60.	1.	7.
2.	2.	147.	40.	50.	1.	4.
1.	2.	149.	59.	56.	1.	14.
1.	1.	150.	42.	46.	1.	18.
1.	2.	152.	59.	61.	1.	7.
2.	2.	153.	64.	48.	2.	5.
2.	2.	157.	63.	55.	1.	5.
1.	1.	158.	27.	59.	1.	10.

Appendix 4.2 (continued)

SYM	REG	FIG	LKADULT	LKCHILD	GEO	COMP
2.	2.	162.	65.	72.	1.	5.
2.	2.	163.	49.	68.	2.	5.
1.	1.	165.	26.	29.	1.	20.
2.	2.	166.	61.	61.	2.	4.
2.	2.	167.	71.	62.	2.	7.
1.	2.	168.	45.	52.	1.	20.
2.	2.	169.	80.	61.	2.	4.
1.	1.	170.	39.	54.	1.	12.
2.	2.	171.	72.	59.	2.	3.
1.	2.	172.	56.	49.	1.	15.
2.	2.	173.	50.	48.	1.	4.
1.	1.	174.	16.	50.	1.	20.
1.	2.	175.	75.	56.	1.	20.
1.	1.	176.	20.	50.	1.	6.
1.	1.	177.	25.	46.	1.	13.
1.	1.	179.	27.	56.	1.	12.
2.	2.	180.	67.	51.	1.	4.
1.	1.	181.	11.	44.	1.	12.
2.	2.	182.	58.	59.	1.	2.
2.	1.	183.	39.	54.	1.	4.
2.	1.	185.	30.	54.	1.	4.
1.	2.	187.	65.	54.	2.	7.
1.	1.	188.	17.	66.	1.	17.
1.	1.	190.	17.	52.	1.	17.
2.	1.	191.	22.	52.	1.	11.
1.	1.	194.	37.	55.	1.	20.
1.	2.	195.	54.	57.	1.	20.
1.	2.	196.	33.	49.	1.	10.
1.	1.	197.	29.	65.	1.	20.
1.	1.	198.	30.	49.	1.	20.
1.	2.	199.	48.	43.	2.	20.
2.	2.	200.	77.	57.	2.	8.
1.	2.	201.	59.	35.	1.	18.
1.	1.	202.	55.	50.	1.	14.
2.	1.	203.	16.	55.	1.	4.
2.	2.	204.	41.	54.	1.	5.
1.	2.	205.	79.	51.	1.	17.
1.	2.	206.	30.	39.	1.	12.
1.	1.	207.	59.	74.	1.	20.
2.	2.	208.	66.	72.	1.	8.
1.	2.	209.	44.	48.	1.	20.
2.	2.	211.	58.	57.	1.	2.
2.	2.	214.	65.	55.	1.	8.
1.	1.	215.	51.	46.	1.	12.
1.	2.	216.	57.	62.	1.	15.
2.	2.	217.	66.	72.	1.	7.
1.	2.	218.	70.	55.	1.	7.
2.	2.	221.	63.	56.	2.	4.
1.	2.	222.	27.	43.	1.	19.
2.	2.	223.	70.	72.	2.	5.
2.	1.	224.	21.	43.	1.	14.

Appendix 4.2 (continued)

SYM	REG	FIG	LKADULT	LKCHILD	GEO	COMP
2.	2.	225.	72.	65.	2.	3.
1.	1.	226.	18.	50.	1.	13.
1.	1.	227.	14.	40.	1.	13.
1.	1.	228.	40.	48.	1.	12.
1.	1.	229.	25.	56.	1.	17.
1.	1.	230.	29.	57.	1.	10.
1.	2.	231.	46.	48.	1.	18.
1.	2.	232.	74.	61.	1.	15.
2.	1.	234.	25.	41.	1.	18.
1.	2.	235.	64.	62.	1.	8.
1.	1.	236.	34.	35.	1.	11.
2.	2.	238.	64.	61.	1.	5.
1.	2.	239.	43.	61.	1.	12.
1.	1.	240.	35.	32.	1.	20.
1.	2.	242.	43.	54.	1.	20.
2.	1.	244.	65.	52.	1.	10.
2.	2.	246.	57.	60.	2.	7.
1.	1.	248.	31.	41.	1.	20.
2.	2.	249.	78.	65.	2.	2.
1.	2.	250.	71.	76.	2.	5.
2.	2.	251.	58.	56.	1.	12.
1.	2.	259.	66.	40.	1.	18.
1.	2.	261.	23.	48.	1.	8.
1.	1.	262.	31.	56.	1.	14.
2.	2.	263.	75.	50.	2.	6.
2.	1.	264.	44.	59.	1.	5.
1.	2.	265.	57.	55.	1.	8.
2.	1.	266.	57.	68.	1.	11.
2.	2.	267.	72.	54.	2.	3.
2.	2.	268.	63.	68.	1.	4.
1.	1.	269.	26.	38.	1.	6.
2.	2.	270.	68.	43.	1.	8.
2.	1.	271.	37.	34.	1.	7.
1.	1.	272.	22.	46.	1.	8.
2.	2.	274.	64.	52.	1.	4.
1.	2.	275.	66.	68.	2.	5.
2.	2.	276.	60.	38.	1.	3.
1.	2.	277.	70.	56.	2.	4.
2.	2.	278.	50.	50.	1.	2.
1.	2.	279.	65.	46.	1.	6.
1.	1.	280.	33.	52.	1.	9.
1.	2.	281.	48.	46.	1.	9.
2.	2.	282.	69.	60.	2.	1.
2.	2.	284.	59.	50.	1.	9.
2.	1.	285.	19.	51.	1.	4.
2.	2.	287.	59.	54.	1.	3.
2.	2.	288.	65.	54.	2.	3.
2.	2.	289.	61.	62.	1.	4.
1.	1.	290.	43.	66.	1.	20.
2.	2.	291.	77.	62.	2.	4.
1.	1.	292.	34.	44.	1.	13.
2.	2.	293.	43.	37.	1.	1.
1.	1.	294.	33.	38.	1.	18.
2.	2.	295.	69.	62.	2.	5.
2.	1.	296.	36.	52.	1.	15.
2.	2.	297.	75.	79.	2.	5.
2.	2.	298.	73.	68.	2.	6.
1.	2.	299.	45.	48.	1.	20.

Appendix 4.2 (continued)

SYM	REG	FIG	LKADULT	LKCHILD	GEO	COMP
2.	2.	300.	69.	63.	2.	4.
1.	1.	302.	27.	61.	1.	18.
1.	2.	303.	44.	44.	1.	16.
2.	2.	304.	90.	79.	2.	8.
2.	2.	350.	80.	65.	2.	9.
2.	2.	306.	78.	65.	2.	7.
1.	1.	307.	48.	62.	1.	15.
2.	2.	310.	87.	72.	2.	6.
2.	1.	311.	45.	55.	1.	13.
2.	2.	312.	63.	45.	1.	4.
1.	2.	313.	43.	62.	1.	9.
2.	1.	314.	19.	56.	1.	3.
2.	2.	316.	65.	55.	1.	3.
1.	1.	317.	20.	44.	1.	16.
2.	2.	318.	64.	45.	1.	6.
1.	2.	320.	58.	57.	1.	14.
1.	1.	322.	40.	33.	1.	13.
2.	2.	323.	63.	55.	1.	10.
2.	1.	326.	20.	49.	1.	5.
2.	2.	327.	77.	71.	2.	3.
2.	2.	329.	67.	55.	2.	6.
2.	2.	330.	32.	35.	1.	2.
2.	2.	331.	69.	76.	2.	4.
2.	2.	333.	53.	44.	1.	5.
2.	2.	335.	69.	60.	1.	5.
2.	2.	336.	69.	71.	1.	7.
2.	2.	337.	56.	46.	1.	8.
1.	2.	338.	61.	60.	1.	20.
2.	2.	339.	54.	59.	1.	2.
1.	1.	341.	43.	55.	1.	12.
2.	2.	342.	49.	54.	1.	11.
1.	1.	343.	21.	44.	1.	5.
2.	1.	346.	25.	50.	1.	4.
2.	2.	348.	61.	63.	2.	4.
2.	2.	350.	64.	56.	1.	6.
2.	2.	351.	59.	49.	1.	6.
2.	2.	352.	71.	62.	2.	3.
1.	1.	354.	46.	44.	1.	20.
2.	2.	355.	44.	40.	1.	5.
2.	1.	356.	19.	60.	1.	10.
1.	1.	357.	21.	37.	1.	20.
2.	1.	359.	37.	43.	1.	8.
1.	1.	360.	63.	66.	1.	19.
2.	1.	382.	30.	59.	1.	6.
1.	1.	383.	12.	29.	1.	18.
1.	1.	384.	59.	51.	1.	20.
2.	2.	386.	71.	66.	2.	4.
1.	1.	387.	10.	39.	1.	20.
2.	2.	388.	81.	70.	1.	4.
2.	1.	390.	25.	63.	1.	4.
1.	1.	391.	23.	34.	1.	9.
1.	2.	392.	46.	51.	1.	9.
1.	1.	394.	50.	54.	1.	20.
2.	2.	395.	67.	56.	1.	8.
1.	1.	396.	36.	24.	1.	17.
2.	1.	397.	81.	67.	1.	12.
2.	2.	398.	67.	66.	1.	10.
1.	1.	399.	35.	35.	1.	20.
2.	2.	400.	81.	67.	1.	15.

Appendix 4.3

Analysis of Welsh's figures with complexity as covariate

(The subset means corresponding with this analysis are given in Table 4.2)

Code	Source	Mean Square	df	F	p
	Complexity covariate	644.87	1	5.20	.02
R	Regularity	43123.88	1	347.58	.00001
S	Symmetry	4039.22	1	32.56	.00001
G	Geometrical figures (within Regularity Level 2)	7240.38	1	58.36	.00001
A	Age group	2635.65	1	21.24	.00001
	R by S	1.25	1	0.01	N.S.
	R by A	17165.75	1	138.36	.00001
	S by G	9.80	1	0.08	N.S.
	S by A	47.25	1	0.38	N.S.
	G by A G by A by S	62.55	1	0.50	N.S.
	R by S by A	821.10	1	6.62	.01
Error (within cells)		124.07	527		

(Note: Because of the small number of symmetrical, geometrical figures, it was not possible to estimate the "G by A by S" and "G by A" effects independently of other effects. These terms were therefore combined, and the sum of squares for that source was obtained as the residual).

APPENDIX 7.1

Scoring Guide for the Unusual Uses Test

Each correct different item scores 1, even if two are on the same line of the answer-sheet.

Responses which do not meet the instructions score zero. That is, responses which are very like the examples, or very like a previous response for that object, or are not a 'use', or do not involve an 'object' are not counted. Otherwise, all responses count 1, however bizarre.

Items which are "deleted" on the answer-sheet may nevertheless be scored, if legible.

Only 'problematic' examples are listed on the following pages.

First Object: KEY

Given common use: "to open a lock".

Given different use: "to lever things open".

The following are examples of inadequate responses. They are (a) too like the given examples, or (b) not a "use", or (c) not using key as an 'object'.

Score 0, unless accompanied by an adequate explanatory elaboration:

As a word	*Key phrase*	*Prise open*
Body	*Keystone cops*	*Put in envelope*
Break	*Key together*	*Put in pocket*
Collect dust	*Key to heart*	*Quay*
Destroy	*Key to knowledge*	*Remember*
Drop in tank	*Key to life*	*Remove lock*
Find	*Key to success*	*Secret*
Fingers	*Leave in house*	*Slide under door*
Flat	*Leave under mat*	*Subconscious mind*
Florida Key	*Loath*	*Take*
Force	*Lock inside car*	*Tense up*
Hang on hook	*Lose*	*Throw away*
Hate	*Maintain*	*Title*
Hide	*Monkey*	*Turn back*
Keep	*Nails*	*Unlatch*
Key colours	*Open*	*Unlock*
Keyed stonework	*Part of donkey*	*Use*
Keyed up	*Pick lock*	*Vital piece*
Key personnel	*Ply*	*Withdraw*

First Object: KEY

The following are examples of sets of responses which are not sufficiently different from others within the set. If two or more responses from the same set are given in the answer-sheet, only one of those responses is deemed adequate.

Score 1 only, for each of these types of response:

To secure; protect; keep safe.

To start or stop car; bus; truck; etc.

To shut door or lock; lock or close any door (but lock cell counts as a different set).

Lock cell; warders' "permission".

As piano key; piano accordian key; black and white keys.

As key in sheet music; musical use.

To solve puzzle; to solve problem; to answer question.

As key to code; key to map; key to diagram.

To open, unlock or loosen door; case; to open cupboard; open car door, gate, safe; gain entrace (but can or sardine tin opener counts as a different set).

To give to someone; to send to someone.

To demonstrate circle; demonstrate diameter; demonstrate radius.

To scratch mark; to scratch initials.

Symbol of trust; of freedom, of honesty; of maturity; of responsibility.

Wind up clock; toy car; etc.

Peter's symbol; symbol of key of kingdom; symbol of key to heaven.

Draw designs from; draw round.

Freedom, escape.

Draw letters, p, d, etc.

Weight; paperweight.

Pull in; pull out; push in; push out.

Press in pin; press fastener.

Fill in hole; fill in crack.

Screw; unscrew.

Sort; mix.

Second Object: SHIRT-BUTTON

Given common use: "to fasten a shirt".

Given different use: "to draw a circle".

The following are examples of inadequate responses. They are (a) too like the given examples, or (b) not a "use", or (c) not using shirt-button as an "object".

Score 0, unless accompanied by an adequate explanatory elaboration:

Alter
Attach to garment
Baby, swallowing
Break
Button-hole someone
Choke upon
Clean
Come off when one's late
Cotton
Cut in half
Dispose of
Disrupt washing machine
Fall
Fastening
Fund
Float it
Get caught in drawer
Get hooked up
Heat
Hide
In industry
Insert needle through
Light
Lose
Not sew
Nuisance
Pin
Pretend it's an aspro
Put in koala's ear
Put in wrong button-hole
Rip off
Ruin button-hole
Run over
Sew on
Snag one's stockings
Some people's eyes look like buttons
Undo
Vary
Wash
Word to translate
Zip

Second Object: SHIRT BUTTON

The following are examples of sets of responses which are not sufficiently different from others within the set. If two or more responses from the same set are given in the answer-sheet, only one of those responses is deemed adequate.

Score 1 only for each of these types of response:

To save; hoard; collect.

To cause concern; cause embarrassment.

To button trousers; use on children's clothes; button any other cloth garment; (but button shoes, or button pocket, or hold braces, count as a different set).

Decorate; emblazon; to decorate blouse; decorate dress, etc. (but different specified forms, e.g. to make "flower" decorations, count as a different set).

To fasten to key ring; watch chain; etc.

To unfasten shirt; trousers; etc.

Draw arc; ½ circle; ¼ circle.

Press to start; press to stop; press to switch on or over.

Substitute draughtsmen; substitute chessmen.

Open car; open cupboard; etc.

Used on a typewriter as press-button; key on an adding machine; push-button on camera; push-button on lift; etc.

Fasten canvas; fasten plastic.

Spin; roll.

Appendix 7.2

Scoring guide for the Similarities Test

Each correct different item scores 1, even if two are on the same line of the answer-sheet.

Responses which do not meet the instructions score zero. That is, responses which are very like the examples, or very like a previous response for that object, or are not a 'use', or do not involve an 'object' are not counted. Otherwise, all responses count 1, however bizarre.

Items which are "deleted" on the answer-sheet may nevertheless be scored, if legible.

Only 'problematic' examples are listed on the following pages.

First pair: MILK, MEAT

Given obvious similarity: *"food value"*

Given other similarity: *"government inspected"*

The following are examples of inadequate responses. They are (a) too like the given examples, or (b) not a "similarity", or (c) not factually correct.

Score 0, unless accompanied by an adequate explanatory elaboration:

Bones	*Less common in densely populated countries*	*Pasteurize*
Cake		*Rhyming slang for feet*
Colour	*Liquid*	
Don't burn	*Meat exported*	*Similar smell*
Food	*Milk produced by meat*	*Skin*
Goat hair	*Never fresh*	*Solid*
Home grown vegetables	*Paddock*	*Yoghurt*

First pair: MILK, MEAT

The following are examples of sets of responses which are not sufficiently different from others within the set. If two or more responses from the same set are given in the answer sheet, only one of those responses is deemed adequate.

Score 1 only, for each of these types of responses:

Derived from cow; from sheep; from goat; dairy herd; grass eating creatures; mammals; 4-footed animals; or animal origin.

Primary product; primary industry.

Exported; imported.

Cost money; economic value; selling power.

Can be of good quality; can be bad quality.

Need in childhood; need in adulthood; basics; necessities.

Both eaten by dogs; by any other animal.

Nourishing; health food; nutritious; beneficial.

Served hot; served cold.

Cannot fly; cannot be used for fuel; not green; any other negative.

In country; on farm; rural.

Infect; harmful bacteria; germs.

Contain atoms; molecules; fundamental particles.

Second - pair: CURTAIN, RUG

Given obvious similarity: *"household goods"*

Given other similarity: *"can be dry cleaned"*

The following are examples of inadequate responses. They are (a) too like the given examples, or (b) not a similarity, or (c) not factually correct.

Score 0, unless accompanied by an adequate explanatory elaboration:

Bounce	*Flying carpet*	*Perpendicular*
Can be chrome plated	*Furnishings*	*Rug more expensive*
Can be living	*Government inspected*	*Shield ground*
Covered by law	*Indoor goods*	*Thicker*
Drapery	*Lie on something*	*Writing material*
Float	*Musical*	

Second pair: CURTAIN, RUG

The following are examples of sets of responses which are not sufficiently different from others within the set. if two or more responses from the same set are given in the answer-sheet, only one of those responses is deemed adequate.

Score 1 only, for each of these types of responses:

Age; wear and tear; grow old; deteriorate.

Use in lounge; use in kitchen; use in bedroom; etc.

Can have borders; frilled edges.

Can be ugly; can be pretty.

Can be washed; can be laundered.

Can be wet; dry; damp; soaked.

Attacked by moths; attacked by other insects.

Can be square; oblong.

Bought; sold; purchased.

Could be used to make clothes; jacket; pants; etc (but "can be used to make belt or footwear" count separately).

Use in car; ship; caravan; tent; plane; office.

Sold in shops; stores; shopping centres.

Can be cheap; can be expensive; vary in price.

Can be light; can be heavy.

Muffle sounds; sound dampeners.

Can be complementary colours; matching colours; basic colours, etc.

Can be useful; useless; used.

Can cover floor; cover articles; etc.

Designed; evolved.

Can be dirty; clean; stained; etc.

Can be hand-made; manufactured.

Can be thick; thin.

Can be heavy; light.

Can be fluffy; smooth.

Made of same material; made of wool; of cotton.

Idea of thrift; economy.

Not a university; not a lake; any other negative.

Can be good; can be evil.

Can be admired; despised.

Not drastically important; can be done without.

Can be hard; can be soft.

Can be ripped; torn.

Appendix 7.3

Extended Scoring Guide for the Controlled Associations Test[1]

This scoring guide was compiled from test responses given by 50 male and 50 female first-year students at the University of Adelaide, having English as their native language.

Correct Responses

A word is scored correct if it can replace the given word in any context so as to convey an essentially similar meaning. In a few cases the context is noted in parentheses following the word in the guide. Minor spelling transformations of a correct response which do not alter the meaning are scored correct. Appropriate hyphenated words are also allowed. English, U.S.A., and Australian usages were considered.

Incorrect Responses

A word is scored incorrect if no context could be conceived by 3 or more judges that would allow the response word and the given word to convey a similar meaning. Phrases of two or more words are also scored as incorrect; however, if the phrase contains a word which alone is correct, then the redundant words are ignored, and the response is scored correct. Incorrect responses are mainly inappropriate associations of the given word, words with different or even opposite meanings, idiosyncratic neologisms, phrases, and foreign-language words.

[1] Test Fa-1 in the Kit of Reference Tests for Cognitive Factors edited by French, J.W. et al., Princeton, N.J.: Educational Testing Service, 1963.

CLEAR

Correct:

Absolute, abysmal, acquit, apparent, audible, azure, (e.g. sky).

Bare, bright, brilliant, brisk.

Carefree, certain, clarified, clean, cloudless, cogent, coherent, colourless, complete, comprehensible, concise, contrasted, crisp, crystal, crystal-like.

Decisive, defined, definite, demolish, detailed, devoid, diaphanous, discernible, disentangled, distinct, doubtless.

Easy, empty, even, evident, expedite, explicit.

Fine, forceful, free, fresh.

Glaring, (e.g. error), glassy, glossed, glossy, graphic, grasped.

Healthy.

Incisive, innocent, intelligible.

Legible, light, limpid, liquid, logical, lucid, luminous.

Marked, meaningful, miss (e.g. obstacle), move.

Neat (e.g. handwriting), net, noticeable.

Obvious, open, orderly, outright, outstanding, overt.

Pass, patent, pellucid, perceptive, perfect, permeable, perspective, perspicuous, plain, pointed, polished, positive, precise, pristine, projecting, (e.g. above the surface), pure.

Radiant, readable, remove, resonant, rid, ringing, rippleless.

Safe, see-through, self-explanatory, separate, sharp, sheer, shift, shimmery, shining, shiny, simple, smooth, spacious, spotless, stark, straight (e.g. win), straight-forward, sunny.

Tanned, thin (e.g. soup), tidy, translucent, transparent, treeless, trenchant, twinkling.

Unambiguous, unblemished, unblocked, unclouded, uncluttered, uncoloured, uncomplicated, understandable, understood, undisturbed (e.g. sequence), unencumbered, unfettered, unhindered, unimpeded, uninterrupted, unlined, unload, unmistakable, unmisted, unmixed, unobscured, unobstructed, unoccupied, unsubtle, untroubled.

Vacant, visible, visionary (Scientological usage), vivid.

Watery, well-defined, wipe.

Incorrect:

Brief, clarity, daylight, dogmatic, filmy, happy, insight, opaque, optical, peaceful, pearly, permissive, reasonable, shallow, take away.

DARK

Correct:

Abstruse, ambiguous, angry.

Bad, black, blackened, blackness, bleak, brooding, brunette.

Closed, clouded, cloudy, cold (e.g. colour), coloured (e.g. race), contemptible, corrupt, covered, cryptic.

Dangerous, darkling, deep, dense, depressing, dim, dingy, dirty, dismal, doubtful, dowdy, drab, dreary, dull, dungy, dusk, dusky.

Enclosed, eerie, enigmatic, equivocal, evil.

Fearsome, foggy, forbidding, forboding, formidable.

Gloomy, glum, grave, grey, grim.

Hazy, heavy (e.g. cloud), hidden, hopeless, horrible.

Ignorant, indistinct, inky.

Jet.

Lightless.

Misty, moonless, morbid, murky, mysterious, mystery.

Native, negro, negroid, night, noir, nubian,

Obscure, ominous, opaque, oppressive, overcast.

Perverse, pitch-black, pitchy.

Raven, reticent.

Sad, scowling, secrecy, serious, shade, shaded, shadow, shadowed shadowy, shady, sinister, smoky, sober, sombre, sooty, spooky, stormy, sunless, suntanned, surly, swarthy.

Tempestuous, threatening, thundery, troubled, twilight.

Unclear, uncoloured, undefined, underexposed, unenlightened, unfathomable, unilluminated, uninformed, unknown, unlighted, unlit.

Vague, void.

Incorrect:

Dank, depth, hell, not light, small, solid, tenubrous.

STRONG

Correct:

Able, active, ardent, athletic, authoritative, awesome, (e.g. wind).

Big, bold, brawny, brave, broad, bulky, buttressed.

Capable, clear (e.g. lead), coarse, (e.g. fishing line), cogent, cohesive, concentrated, convincing, (e.g. argument), courageous.

Decided, definite, dependable, developed, distinct, distraught, dogged, dominant, dominating, drastic, driving (e.g. wind), durable, dynamic.

Elastic (e.g. spring), emphatic, enduring, energetic, erroneous (guess), exhaustive.

Fearless, fierce, firm, fit, forceful, fort (archaic usage), fortified.

Granite, good (e.g. push), great.

Hale, hard, hardy, headstrong, healthy, hearty, heaving, heavy, heavily-built, hefty, herculean, heroic, high (e.g. odour), high-tensile huge, husky.

Immovable, impenetrable, imposing, impregnable, indestructible, indomitable, inflexible, intense, intoxicating, invigorating, iron.

Large (e.g. following), lashing, lithe, loud (e.g. beat), lusty.

Manifest (e.g. gain), manly, marked (e.g. accent), masculine, massive, masterful, mighty, muscle-bound, muscled, muscly, muscular.

Oaken, obnoxious, omnipotent, oppressive, overbearing, overpowering, overwhelming.

Passionate, persuasive, piercing (e.g. tone), poignant, potent, powerful, pronounced, pugnacious, pure, putrid (e.g. smell).

Rank, reinforced, relentless, reliable, repelling, repugnant, resilient, rich (e.g. imagery), rigid, robust.

Secure, severe, shocking, smelly (e.g. odour), solid, sound, stable, stalwart, staunch, steadfast, steely, stern, stoical, stocky, stout (e.g. beam), stubborn, sturdy, substantial, successful, superhuman, supporting.

Tenacious, tensile, thick, tight, tough, trustworthy, tyrannical (e.g. government).

Unafraid, unbeatable, unbendable, unbending, unbreakable, unmovable (e.g. views), unyielding, undiluted (e.g. wine), untearable, unweakened, upstanding.

Vehement, vice-like, vigorous, vile, virile, virtuous (e.g. drug, archaic usage).

Warm (e.g. greeting), well-built, well-developed, well-strengthened, wiry, worthy.

Young (e.g. warrior).

Zealous.

Incorrect:

Boisterous, compact, competent, decaying, demanding, forthright, grasping, handsome, impregn, intelligent, many meaningful, persistent, physical, reaching, righteous, silent, sinuous, stamina, steady, straight, strength, Tarzan, trim, useful, well, well-proportioned, well-shod, wilful. withstanding.

WILD

Correct:

Abandoned, aggravated, agitated, aggressive, angry, annoyed, aroused.

Bad-tempered, barbaric, beastly, blazing, blizzard, blustery, boisterous, brutal, bush.

Carefree, careless, confused, crazed, crazy, cross.

Dangerous, defiant, delinquent, desolate, different, disorderly, disrespectful, dissipated.

Eager, earthy, effervescent, enranged, enthusiastic, erratic, excitable, excited.

Far-fetched, ferocious, fierce, fiery, foolhardy, foolish, frantic, free, frenzied, frivolous, fuming, furious.

Groovy, gypsy.

Headstrong, hectic, hostile.

Ill-mannered, immoral, impatient, imprudent, incoherent, inconsiderate, indigenous, infuriated, insane, irate, irrational, irrepressible, irresponsible, irritated.

Lashing, livid, loose, lunatic.

Mad, maddened, mistaken (e.g. estimate).

Nasty, native, natural, non-domestic.

Outback, outlawed, outrageous, overgrown.

Pagan, passionate, precipitous, primitive, provoked.

Raging, rampant, rash, ravaging, razor-edged, rebellious, reckless, restless, riotous, ropeable, rough, roving, ruffled, ruthless.

Savage, snarling, stirred, stormy, strange, swinging.

Temperamental, tempestuous, terrible, terrific, terrifying, thoughtless, troublesome, tumultuous, turbulent.

Unbridled, unbroken, uncared-for, uncaring, unchecked, uncivilized, uncleared, uncontained, uncontrollable, uncontrolled, uncoordinated, uncultivated, uncultured, undisciplined, undomesticated, uneducated, unexplored, unhandled, uninhabited, uninhibited, unkept, unmanageable, unmindful, unopened, unprincipled, unrestrained, unrestricted, unruly, unselfconscious, unsociable, unsocialized, unstable, unstemmed, untamed untendered, unthinking, untidy, untilled, untouched, untrained, untrammelled, upset.

Vexed, vicious, violent, virgin.

War-like, waste, way-out, wide-eyed, windy (e.g. weather).

Incorrect:

Active, ancient, anxious, awful, banal, beast, blowing, charging, corrupt, dense, distant, escaped, exciting, fearless, hair-raising, independent, juvenile, loud, merry, off course, open spaces, strong, tempered, thick, vibrant, visionary, wiry.

Part 2

COMPANY

Correct:

Accessories, acquaintance, acquaintances, actors, affiliates, affiliates, aggregation, army, assembly, associates, association, audience.

Band, battalion, battery, board, body, brigade, brotherhood, bunch, business, bystanders.

Callers, camaraderie, circle, clan, class, clique, club, cohort, colleagues, collection, companions, companionship, comrades, comradeship, community, concern, congregation, contemporaries, convoy, cooperative, corporation, coterie, crew, crowd.

Division.

Emporium, enterprise, entourage, establishment.

Factory, federation, fellowship, firm flight, flock, followers, fraternity, friends, friendship.

Gang, gathering, group, guests, guild.

Helpers (e.g. Smith and Company).

Incorporation, institution, intimates.

Legion, line (of men).

Manufacturer, mates, mateship, meeting, members, mob, multitude

Order, organization, others.

Pack, pals, partner, partners, partnership, party, people, persons, platoon, presence, proprietary.

Regiment, relatives, repertory.

Set, society, support, syndicate.

Throng, togetherness, train, troop, troupe, trust.

Union.

Visitors.

Incorrect:

Accompany, act, atmosphere, attachment, committee, congenial, directorate, executives, friendly, industry, join, likeable management, many, neighbours, number, occupation, operation owners, sociable, solace, soldiers, some, surroundings, together, workers.

SHARP

Correct:

Abrupt, acid, acrid, accurate, acute, alert, angled, angry, angular, apical, artful, astute, attentive, awake, aware.

Beautiful, biting, bitter, bony, brief, bright, brilliant, brisk, brusque.

Caustic, cheating, clear, clear-cut, clever, cold, commanding, concise, contrasted, correct, crafty, critical, crisp, cross, cunning, curt, cutting, cynical.

Dazzling, decisive defined, definite, designing, detailed, direct, distinct.

Edged, exact, expert.

Fine, firm.

Gaudy, ground.

Handsome, harsh, high-pitched, hitting, honed, horny, hurtful (e.g. critic).

Impelling, impetuous, impressive, incisive, intelligent, intense (e.g. pain) irregular, ironic.

Jagged.

Keen, keen-edged, knife-edged, knife-like.

Lively.

Marked, mordant.

Narrow, nasty, needle-like.

Peaked, penetrating, perspicacious, piercing, piquant, pointed, pointy, precise, pricking, prickly, probing, promptly, protruding, punctual, pungent.

Quick, quick-witted.

Razor-edged, razor-like, rocky, rude, rugged.

Sarcastic, scathing, serrated, severe, shaped, sharpened, short, shrewd, shrill, sly, smart, spiked, spikey, splintered, staccato, stinging, strong, sudden.

Tapered, tart, thoughtless, thin, toothed, trenchant, tricky, true (e.g. observation).

Unadulterated, underhanded, unfriendly, untrustworthy.

Vigorous, vitriolic.

Wary, well-dressed, wily, witty.

Incorrect:

Abrade, arrow, blunt, busy, dangerous, dart, deadly, decrease, discipline, etch fatal, fixed, fresh, hurting, injurious, knife, knifed, lethal, no later, pain-causing, painful, pencil, perspective, pin, pure, razor, rigid, savoury, sliver, small, steel, sword, taciturn, voiceless.

TELL

Correct:

Acknowledge, acquaint, address, adjudge, admit, advise, announce, answer, appraise, articulate, ask, assert, asseverate, assure, aver, avow.

Beg, betray, blab, breathe.

Chatter, clarify, command, comment, communicate, confess, confide, confirm, convey, count, cry (e.g. out).

Decide, declare, delineate, demand, describe, dictate, direct, disclose, discover, discriminate, distinguish, divulge, dogmatize.

Educate, elaborate, enlighten, entreat, enumerate, enunciate, exclaim, explain, expose, express.

Gossip, guage.

Hint.

Illuminate, impart, indicate, inform, insinuate, insist, instruct, introduce, invite, invoke.

Know (e.g. whether it is true).

Lecture.

Mention, mouth, mumble.

Nag, narrate, notify, number.

Orate, order.

Pimp, portray, predict, prevail, proclaim, promulgate, prophesy, publish.

Realize, recognize, record, recount, refer, rehearse, relate, relay, release, remark, repeat, reply, report, request, respond, re-tell, reveal.

Say, shout, show, speak, spin, split, state, submit.

Teach, talk, tattle.

Uncover, understand (e.g. what is said), unfold, utter.

Verbalize, vocalize, voiced.

Warn, whisper, wish (e.g. "I wish you to do that"), write.

Yell.

Incorrect:

Account, administer, cash register, condense, console, converse, correspond, deliberate, digress, discuss, dit, envisage, illustrate, let know, loquate, make known, mark, notice, parlez, point out, recall, reminisce, told, usher, verbate, William (Tell).

Correct:

About-face, act, adjust, affect, aim, alter, alternately, apply aptitude, attack, avert, avoid.

Become, begin, beginning (e.g. century), bend, bent, betray, blunt, bout, by-pass.

Capsize, chance, change, channel, circle, circulate, circumnavigate, circumvent, close, convert, convolution. convulsion, corner, crane, crank, curb, curve.

Deed (e.g. good turn), deflect, dement, derange, deter, detour deviate, digress, direct, distract, divert, dodge, drive.

Eddy, edge (e.g. of speed), employ, evacuate.

Face, favour, fever, fit, flee, flick, flip, fold, fright.

Gift*, go (e.g. opportunity), guide, gyrate.

Illness, incline, intersection, invert.

Leaf (e.g. pages), lock (e.g. steering wheel), loop.

Manipulate, manoeuvre, meeting (e.g. roads), move (e.g. opportunity).

Navigate.

Obvert, opportunity, orientate, overturn.

Performance, pirouette, pivot, point (e.g. towards North), ponder, prejudice*, pull (e.g. the car round), put (e.g. put on the radio).

Re-aim, rebound, recoil, redirect, reel, reface, refer, reflect, rehash, re-locate, renounce, repel, repoint, re-position, resort, retreat, return, reverse, revert, revolt, revolution, revolve, roll, rotate, round.

Screw, set, sheer, shift, shot, shun, shunt, skirt, somersault sour, spell, spin, spiral, steer, surround, sway, swerve, swing, swirl, switch, swivel.

Talent*, tendency*, tilt, tip, tour, translate, trend, trick, trip, try, twirl, twist.

Unlock, upset.

Veer.

Walk, wheel, whip (round), whirl, wind, withdraw.

Yaw.

Incorrect:

Around, aversion, balance, choice, entrance, erase, falter, go about, go around, initiate, make aware, manage, negotiate punctual, renew, restore, retrace, slide, subject, whiz.

*e.g. aptitude for religious training.

Appendix 8.1

The Self-description Checklist scales: Means, Standard deviations and tests of significance for three studies

Notes: The three studies referred to in the Table are as follows.

Main study: The main correlational study reported in chapter 7.

Art study: The art test validity study reported in chapter 8.

Rigby's study: A study, supervised by the writer, and reported by Rigby (1975).

In the Art study and Rigby's study the revised instructions were used, which added the request "Tick about half the items if possible." The Table below shows that no significant effect of the revised instructions was found for Creative Independence or for Emotional Activation with respect to the means or standard deviations.

	Combined data	Main study	Art study	Rigby's study	Significance test*
	Total	University students	Mixed	Institute students	
N	406	100	95	211	
		CREATIVE INDEPENDENCE			
$\bar{X}$	10.48	10.52	10.82	10.31	$F = 0.87$, df = 2, 403, $p > .25$
SD	3.15	3.20	3.11	3.14	$\chi^2 = 0.05$, df = 2, $p > .95$
		EMOTIONAL ACTIVATION			
$\bar{X}$	8.72	9.00	9.18	8.38	$F = 2.52$, df = 2, 403, $p > .05$
SD	3.22	2.94	3.15	3.38	$\chi^2 = 2.59$, df = 2, $p > .25$

*One-way AOV was used to test the significance of differences amongst the three means. Bartlett's test was used for differences amongst the three SD values, applied to corresponding variances.

Bartlett's test was calculated using the "weighted mean of variances", according to the method given by Walker and Lev (1953, p.193). The square root of this statistic was used for the SD of the combined data.

APPENDIX 10.1

Explanation of the index of similarity between matriculation subjects based on their common candidature

The index of similarity, S_{ij}, is defined as follows:

$S_{ij} = (n_{ij} - e_{ij})$ / (Maximum possible magnitude of numerator).

The term n_{ij} represents the known number of cadidates who take both subjects i and j, as shown in Table 10.3. The term e_{ij} represents the chance expected number of candidates enrolled for both subjects if they were selected independently. It is estimated by the following binomial method which allows for subgroups of candidates taking various numbers of subjects (from 1 to 6) in the examination:

$e_{ij} = \Sigma (w.k.p_i.p_j)$ where summation is over the subgroups shown in the Table overleaf.

Terms are defined as follows:

w is the number of candidates in the subgroup.

k is the appropriate binomial coefficient.

p_i is the overall probability of an examination being for subject i.

p_j is the overall probability of an examination being for subject j.

The values p_i and p_j are estimates of probabilities on the null hypothesis condition that enrolment in any subject is not conditional on other subjects taken. The formula for e_{ij} is an approximation since it assumes "selection with replacement" (Diem, 1962, p. 147).

Subgroups of candidates for the 1977 matriculation examination

Number of subjects taken	Number of candidates in subgroup: w	Binomial coefficient k	Product w.k
6	106	15	1590
5	7647	10	76470
4	269	6	1614
3	181	3	543
2	631	1	631
1	825	0	0
Totals	9659		80848

Clearly the chance expectation of a candidate taking both subjects i and j depends on whether he takes six subjects or only two so that the expectation must allow for the subgroups tabulated. The above equation for e_{ij} is a weighted estimate over the six subgroups involved. Given the data tabulated, the equation may be specified further:

$$e_{ij} = 80848 \cdot p_i \cdot p_j \quad \text{- - - - - - - - - - - - - - - - - - - -(a)}$$

The probabilities p_i and p_j are estimated from the overall enrolments in each subject, n_i and n_j:

$$p_i = n_i/42577 \text{ and } p_j = n_j/42577 \text{ - - - - - - - - - - - - - - -(b)}$$

(since there were 42577 enrolments in total over all 37 subjects).

The values for n_i and n_j are given in Table 10.3 The value of e_{ij} may be specified in terms of these data by combining equations (a) and (b).

$$e_{ij} = 80848\ n_i \cdot n_j\ /\ 42577^2 = 22422\ n_i \cdot n_j .$$

Substitute inthe defining equation for S_{ij} :

$$S_{ij} = (n_{ij} - 22422\ n_i \cdot n_j) / \text{ Maximum possible magnitude of numerator).}$$

The maximum possible value of the numerator depends on whether the obtained joint candidature is greater or less than the chance expected value. That is, the denominator for the index depends on whether the numerator is positive or negative. If it is positive, the maximum value will occur when n_{ij} is a maximum; that is, equal to the smaller of n_i or n_j (the individual subject enrolments). However, if the index is negative, the maximum (negative) magnitude for the numerator occurs when n_{ij} is zero. Thus the working formulae used for calculating the index were as follows:

(i) If $n_{ij} \geqslant 22422\ n_i.n_j$,

$$S_{ij} = (n_{ij} - 22422\ n_i.n_j) \ / \ (\min [n_i, n_j] - 22422\ n_i.n_j)$$

(ii) If $n_{ij} < 22422\ n_i.n_j$,

$$S_{ij} = - (22422\ n_i.n_j - n_{ij}) \ / \ (22422\ n_i.n_j)$$

Calculations were undertaken using programs written by the writer for a Canola 1614P programmable calculator.

Appendix 10.2

Calculation of exact chance probability of a student selecting both objective questions on the third-year psychology examination papers considered in Study c, chapter 10 (Group iv)

The format of the arts and science papers were somewhat different, and the probability of a student answering both objective questions was calculated for arts and for science separately.

In the discussion below, the following terms are used:

N = The number of questions set on the examination paper.

X = The number of questions on the paper involving "objective" answers (= 2 in these cases).

x_1 = The number of "objective" questions selected (= 2 in the cases considered).

N_1 = The number of questions to be answered from the examination paper (= 4 in these cases).

Science faculty paper

The science paper contained five questions, and students were required to select four. Two questions numbered 1 and 3 on the paper, involved "objective" answers; but in the case of question 3, two alternative questions were provided, one being of the objective type, and the other of the essay type. That is, Question 3 was of the form "Either (a) (essay type) or (b) (objective type)."

The null hypothesis probability of both questions 1 and 3 being attempted, assuming all questions to be equally likely, may be calculated from the hypergeometric distribution (Diem, 1962, p.188):

$$P(x_1 | X, N, N_1) = \frac{N_1!(N-N_1)!(N-X)!}{N!x_1!(N_1-x_1)!(X-x_1)!(N-X-N_1+x_1)!}$$

With $x_1 = 2$, X=2, N=5, N_1=4:

P (probability of selecting both questions 1 and 3)

$$= \frac{4!\ 1!\ 2!\ 3!}{5!\ 2!\ 2!\ 0!\ 1!} = 0.6$$

Since (on the null hypothesis) only half the question 3 answers would be of the objective type (question 3b), the required chance probability of selecting both questions 1 and 3b is:

$$\underline{P}' = \tfrac{1}{2}\ (0.6) = 0.3$$

Arts faculty paper

The arts paper contained six questions, and students were required to select four. Two questions, numbered 2 and 6 on the paper, involved "objective" answers; these questions were identical to questions 1 and 3b on the science paper. On the arts paper, neither question 2 or 6 involved any "either/or" alternative.

The null hypothesis probability of both questions 2 and 6 on the arts paper being attempted, assuming all questions to be equally likely, may be calculated from the hypergeometric distribution, as described above.

With $x_1 = 2$, X=2, N=6, N_1=4:

P (probability of selecting both questions 2 and 6)

$$= \frac{4!\ 2!\ 2!\ 4!}{6!\ 2!\ 2!\ 0!\ 2!}$$

$$= 0.4$$

Calculation of χ^2

The probability values calculated above were used to obtain expected frequencies, for arts and for science subgroups, of students who selected both objective (i.e. convergent) questions. These expected frequencies were compared with observed frequencies, and χ^2 values calculated in the usual manner. The results are shown in Table 10.18.

Appendix 12.1

Modifications required for the administration of the Ai3Q questionnaire

Kline's "Easy-Reading" version of the Ai3Q was unsatisfactory in having no "norms", and having items unsuitable for young schoolchildren, such as "Do you smoke?" and "I think sex before marriage in many cases is a good thing". Therefore the original adult form was used despite its difficult vocabulary. To aid understanding, each question was read aloud. In addition, the writer said: "If you come to a question which is not clearly worded, so that it's hard to understand, tell me and I'll put the question in another way".

Alternative versions were prepared of five very difficult items. These alternatives were intended to convey a very similar meaning to the original versions, but using less abstract concepts. They were still difficult, but nevertheless comprehended by the testee, Frank.

Alternative wordings (used in the questionnaire given to Frank):

Q.11 Do you think envy of other people's wealth is at the root of the belief that everyone should be equal?

Q.14 Do you disagree with punishment by hitting with a cane or belt?

Q.23 Correct behaviour between men and women (such as a man kissing only his wife) is the important part of good behaviour. Do you agree?

Q.25 Is it sheep-like to follow the ways of fashion?

Q.27 Spiteful savagery is the motive of most rebels against authority. Do you agree?

Scoring

The questionnaire as modified gave a raw score of 22. The score based only on unaltered items (adjusted pro rata for the number of items) was 23. It was therefore decided that the modifications probably made little difference to the score obtained, and 22 was that used for interpretation.

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