



An Exploration of Unit Commander Decision-Making
in the Australian Army

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Abstract

In recent years, the adequacy of classical models to explain expert decision-making in environments involving time pressure, high stakes, uncertainty and dynamic conditions has been questioned. An alternative model to describe decision-making in these conditions is the recognition-primed decision-making (RPD) model (Klein, 1989). This model is descriptive and suggests that expert decision-makers learn to recognise typical situations and solutions and use these mental shortcuts to fill in gaps in their understanding and inform their decision-making. The model has been validated in many domains (Klein, 1999), but to date has not been applied in the Australian Army. Moreover, the model has been criticised because it largely ignores the influence of the wider context in dynamic decision-making. The aim of this research is to address these issues.

The setting has been the unit level of operations in the Australian Army. In particular, the focus is on the Commander, as s/he has the largest impact on the strategic direction of an operation. The approach combines a number of complementary data collection methods, drawing on both qualitative and quantitative data. The main methods of data collection include in-depth, semi-structured interviewing; Q-sort analysis; and observational research in the field. These are triangulated to increase validity. Computer simulation is also used to investigate its adequacy for further naturalistic decision-making (NDM) research.

The outcome is firstly a validation of the RPD model in the Australian Army and revision to include contextual variables perceived to impact on NDM. The effect of these contextual variables on RPD requires further research using naturalistic techniques. Computer simulation has been found to be an unsatisfactory technique to employ in this instance.

These are important outcomes as the Australian Army moves towards an era of Networked Centric Warfare where established structures for team work are being revised. Establishing a better understanding of contextual factors that impact on NDM enables policy

makers to take this knowledge into account when hypothesising about the effect that structural changes might have on business processes. Thus, having better defined models, and research techniques identified to achieve this, is a benefit.

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List of Acronyms

DM	Decision-making
NDM	Naturalistic decision-making
HQ	Headquarters
CO	Commanding Officer
OPSO	Operations Officer
RPD	Recognition primed decision-making (model)
SA	Situation awareness
SOP	Standard operating procedures
DSTO	Defence Science and Technology Organisation
COA	Course of action
NCW	Network centric warfare
SMM	Shared mental models

Author's Statement

This thesis contains no material that has been accepted for the award of any other degree or diploma at any university. To the best of my knowledge and belief it contains no material written or published by any other person except where due reference is made in the text. If accepted for the award of the degree I give consent for this thesis, when deposited in the University Library, to be made available for photocopying and loan.

Signed

Taryn Elliott

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CHAPTER 1. Overall Introduction

1.1 Current Issues Facing the Australian Army

This dissertation is guided by the challenges that the Australian Army is currently facing. Two major challenges facing the Army are the changing context of operations; and the need to incorporate new tools and technology. Thus, advances in technology, combined with incidents such as the Iraq War and September 11 terrorist attacks, highlight the need for a re-evaluation of our current understandings of war. The current climate negates many assumptions inherent in military doctrine. For example, the threat and enemy doctrine are often unknown, and there is no predetermined order of battle (Worley, 2001). In response to this current world climate, it has been predicted by specialists that future warfare will be network centric and asymmetric (Alberts, Garstka & Stein, 2000; Worley, 2001).

Network centric warfare (NCW) is a term developed to describe the way the Army will organise and fight in the *Information Age*. With increased capabilities in network technology, possibilities have been created for networking sensors, decision-makers, and shooters to achieve shared awareness, increased speed of command, and a faster tempo of operations (Alberts, Garstka & Stein, 2000). Essentially, there is better distribution of awareness and knowledge in the battlespace. This results in a greater potential for collaboration between different sections throughout the military, and hence the possibility to develop better shared perceptions of the situation (Alberts, Garstka & Stein, 2000).

Implications from these shifts are that there will be: possibility for increased knowledge transfer, greater potential for collaboration and shared perception, increased potential for the enemy to access crucial information, increasing tempo of operations, and possible demarcation between planning and execution. Overall, it seems that the shift will benefit the Australian Army. However, it is important to evaluate the impact that it might have in the context of current military operations.

To understand the most appropriate measures required for implementing change, the way in which the current system functions requires clarification. This is imperative for smooth transitions to newer, more technologically supported situations. One such system is the human decision-maker. To adapt current procedures to fit the new environment successfully, it is critical to understand the current decision-making process, and identify nuances that differ from current models and doctrine about decision-making.

Understanding the human process for decision-making in the Army environment then becomes crucial. Klein (2001) has written:

“... However, the technology can also become a source of problems. That is why it is so important to clarify the needs of leaders and decision-makers in distributed teams. Only by representing these cognitive requirements can we work with designers to support decision-making” (p. 292).

Therefore, it is our challenge, as scientists and system users, to work together to make the best possible system. This system should not only take into account the system requirements, but, more importantly, the environmental requirements and the human in the loop.

1.2 History of Decision-making Research and Thesis Context

Part of being human requires us to make decisions. These range from everyday decisions (such as deciding what to wear) to more specific, important decisions (such as choosing a partner or a career path). Despite the fact that our decisions can determine to a large extent the future state of events, the frequency of poor decision-making (leading to less than optimal outcomes) is common. Due to this important predictive nature of decision-making in our daily lives, it has been a widely researched topic in the field of psychology since the 1950s (e.g. Edwards, 1954; Janis & Mann, 1977). In particular, psychologists have been interested in modelling the human decision-making process. Two anticipated outcomes of this research have been development of methods for decision-making enhancement and

machines that could replicate human decision-making. However, throughout the history of decision-making research, the cognitive complexity and contextual variability of decision-making has remained an obstacle for the actualisation of these outcomes. To date, despite the production of a number of useful theories and models, researchers have still not found adequate explanations for all decision-making events.

Recently organisations such as the Army have become increasingly interested in understanding decision-making within their organisation. Traditional analytical models as explanations for decision-making in such environments have been criticised because of their reliance on assumptions that the human decision-making is governed by probabilistic outcomes. Research has found that humans do not always behave in this manner. Moreover, because of the complexity of this environment and the unique requirements placed upon decision-makers, it has generally been concluded that traditional decision-making models have not provided an adequate explanation of decision-making (Beach & Lipshitz, 1997).

The unique conditions under which this organisation typically operates incorporate the following:

- **High stakes** – The costs associated with poor decision-making are usually very high and can often be the difference between life and death.
- **Time pressure** – Decisions must be made quickly as time is critical.
- **Dynamicity** – This refers to the continual complexity of the environment. Usually a series of decisions are required, rather than a single moment of choice as described in traditional decision-making theory (Brehmer, 1990). In this environment, each decision made affects each consequent decision.
- **Uncertainty** – The quality of available information about a situation is often questionable. Moreover, there is often missing or incomplete information.

- **Distribution of tasks** – This is required because of the complexity of the situation. There is too much information for an individual decision-maker to cope with, so the decision task is distributed among several contributors.

Environments containing these conditions have been described as naturalistic environments by Omodei and Wearing (1995). This kind of environment is not unique to the Army; similar environmental demands will be required of many others including firefighters, workers in emergency medicine, and air traffic controllers.

Recent research has focused on understanding how decision-making differs within this context (e.g. Klein, Calderwood & Clinton-Cirocco, 1986). Researchers have termed the type of decision-making occurring in the Army, and other naturalistic environments, naturalistic decision-making (NDM; Zsombok, 1997). A new model, called the recognition-primed decision-making model (RPD; Klein, 1989) has been developed as a description of how expert decision-makers operate in an NDM environment. This model takes into account the short time frames, uncertainty, multiple goals, and high stakes associated with decision-making in many real world situations.

To date, the RPD model has been useful for describing decision-making in a number of naturalistic environments (Klein, 1999). However, there have also been some criticisms made of the model (e.g. Bryant, Webb, & McCann, 2003; Hall, 2000; Meso, Troutt & Rudnicka, 2002). Klein (1999)¹ himself has acknowledged that further research is necessary to consolidate and expand the model. The current thesis adopts the RPD as a baseline description of decision-making in naturalistic environments, with a vision to begin to fill some gaps in the RPD model that have been identified (which will be further discussed in Chapter 2). These include:

¹ Klein originally proposed the RPD model.

- RPD model is not validated in an Australian Army environment.
- RPD fails to define key features (such as experience).
- Contextual factors impacting on RPD process are not defined.
- Rigour of research on RPD needs to be confirmed and described.

Therefore, to create a more complete model of NDM, to assist in particular with future planning in the Australian Army, the above areas must be pursued.

1.3 Describing Emerging Research Aims

Firstly, to date the RPD model has not been tested in the context of the Australian Army. The current research will investigate the adequacy of the fit of RPD to this environment. If decision scenarios in the Australian Army are adequately explained by the model this will enable us to use it confidently in the development of decision aids and training protocol and policy formation. This will also validate its usefulness to inform future planning.

Secondly, the current research will attempt to better define expertise in the RPD model. While NDM is becoming an increasingly popular field, evidenced by the number of published books emerging on the area, there is still room for improved definition within the RPD model (Lipshitz, Klein, Orasanu & Salas, 2004b). One particularly problematic concept requiring further definition is expertise. Research suggests that experts use particular cognitive strategies and specialised domain knowledge in order to inform their decision-making. This gives them an advantage over their novice counterparts. However, research has failed to provide a clear explanation of what constitutes experience, and what kind of experience decision-makers tend to draw upon to facilitate their decision-making.

The definition of expert within the field of NDM is often problematic. NDM researchers often use regular decisions made by experts as benchmarks for comparison with

disasters such as the “Vincennes”² incident. This benchmarking allows the exploration of differences. The problem with using experts as points of reference, without having adequate definitions of expertise, is that they do not provide a standard or reliable measuring stick. It is known that the quality of decisions made by experts is variable. Thus, care needs to be taken to develop and provide better definitions for expertise within NDM.

Thirdly, the thesis will investigate the internal and external elements that impact on the decision-making process. To date there has been a lack of research focusing on what broader elements impact significantly on the NDM process, and in what ways this influence occurs (e.g. Whyte, 2001). Traditionally NDM research has defined the decision-making process as embedded within a context of high stakes, time pressure, dynamicity and uncertainty. However, because NDM research is still in its infancy, attention has not yet been paid to broader external and internal elements that may impact on the process. Recently some attention has been given to the impact of the context on NDM (Orasanu, Martin, & Davison, 2001). For example, it has been argued that emergency response scenarios can be looked at in terms of *task specific factors* and *situation specific factors* (Dunn, Lewandowsky & Kirsner, 2002). This research investigated whether these contextual elements impacted on communication behaviour in a naturalistic environment. They defined *task factors* as “intrinsic characteristics of emergency management that tend to remain relatively stable across different situations” (p. 720). Examples include: rate at which new information becomes available and perceived importance of coordinated activity. *Situation factors* were defined as “characteristics of the current situation that are novel, unique or unpredictable.” (p. 720; e.g. timing and nature of critical events, sudden equipment failures). Results from this

² The “Vincennes” incident occurred on July 3 1988 when the warship *US Vincennes* fired on Iran flight 655, thinking it was an enemy aircraft. Iran flight 655 was actually a commercial airliner and this decision resulted in the loss of many innocent lives. This tragic decision outcome has attracted a lot of subsequent analysis to determine where the decision-making processes may have gone wrong. For more information see Klein (1999).

suggested that context does impact on communication in a naturalistic environment. One could assume that this may also impact on subsequent decision-making. Moreover, Perrin, Barnett, Walrath and Grossman (2001) found that, depending on the order of the information that decision-makers are processing, they reach different conclusions. This is called the information order bias, and sees the marrying of NDM and the bias and heuristic paradigm. This work supports the notion that external context is an important consideration for NDM. Moreover, we have seen in traditional decision-making models that internal elements (such as emotion; Sayegh, Anthony & Perrewe, 2004) are beginning to attract more research attention and their impact on NDM cannot be ignored.

Following Dunn et al. (2002), Perrin et al. (2001) and Lawrence and Nohira (2002), this thesis addresses the internal and external elements impacting on NDM, particularly in the unit headquarters (HQ)³ environment. The influence that context has on a Commander's (CO's) decision-making processes is currently unclear. Yet, this understanding is particularly important if we are to adapt current procedures successfully to fit new environments. Moreover, to develop appropriate decision aids, the CO's decision-making processes must be examined in the context within which they occur (e.g. the potential impact of the environment, the team and the organisation in which s/he works should be explored). With the introduction of NCW, the importance of the individual's decision-making process and the social and informational network within which this resides become more apparent.

Finally, the use of appropriate rigour through research methodologies will be addressed in the thesis. NDM methodology has been criticised as soft (e.g. Yates, 2001). This criticism is based on the fact that many experiments have been field-based and/or qualitative.

³ This is the office of a military commander and his core staff from which orders are issued. This organisation will act as the centre of operations and administration at an operational level of the Australian Army (see Chapter 3 for further description).

The reason for the predominance of these types of methodologies has been their suitability for investigating the phenomenon of NDM *in situ*. Although there is a certain stereotype associated with these kinds of methodologies as being less rigorous and reliable, this stereotype is misguided. Standards of rigour attainable in a laboratory situation can rarely, if ever, be met for a field study. However, NDM researchers have been careful to use a number of appropriate methods available to check the reliability and validity of the data collected. Overall, rigour is about whether the methods used support the conclusions drawn. Thus, researchers should not measure NDM research according to controlled experimental research standards. Instead, measuring it against standards that have been set over many years of qualitative and field research is more sensible.

Care will be taken to structure the research adequately to achieve a good fit between the research question and methods used. Moreover, the rigour of the research will be ensured through establishing measures of reliability and validity. Finally, the appropriateness of research methods such as computer simulation in conducting future research will be explored. Such methods may provide more cost-effective means for exploration of NDM, but it is unknown to what extent these research tools are useful in exploring NDM. Addressing this matter will assist in the structuring of further research in the field.

1.4 Summary and Research Directions

The above research requirements are addressed in the current thesis. The focus is on NDM within the Australian Army. In particular, research has been conducted at the unit⁴ level, focusing on the decision-making of the Unit Commander (CO) within the context of the headquarter (HQ) team. Research here will be most useful for new policy formation.

⁴Unit- a battalion group. A hierarchical formation of approximately 700 soldiers and officers (see Chapter 3 for further description).

In summary, the research aims to:

- Provide validation for the RPD model within the context of the Australian Army.
- Better define NDM in terms of expertise as defined by the RPD model.
- Identify and describe the wider elements impacting on NDM.
- Develop and use a rigorous and replicable research methodology.
- Determine the extent of usefulness of computer simulation as a research tool for future exploration of NDM.

The outline for this thesis includes literature reviews on decision-making research (Chapter 2) and also relevant team work literature in relation to the Australian Army context (Chapter 3). Research methods and questions are addressed in detail in Chapter 4. Chapters 5-7 describe the research studies undertaken as a part of this thesis, with the conclusion in Chapter 8. There will be two outcomes. The first will be an enhanced understanding of decision-making at the unit level of the Australian Army and the elements impacting on this process. The second will be an enhanced understanding of appropriate research methods for further exploration of NDM.

CHAPTER 2. A Review of Decision-making Research

This chapter sets out the relevant background information required to begin to understand the field of decision-making research and how naturalistic decision-making (NDM) has developed from this. Current theories of NDM are first described; highlighting the critical nature of expertise within this field. Finally, criticisms of NDM are presented.

2.1 Theories of Decision-making

Decision-making has been defined by Yates (2001) as the process that leads to a commitment to an action, the aim of which is to produce satisfying outcomes. This provides the basis for the definition adopted in the current research, which will be further discussed in Chapter 4. Preceding NDM research, there has been a rich tradition of research into formulation of decision-making models. For the purpose of the current summary, this history will be described in terms of *prescriptive* and *descriptive* models of analytical decision-making. Following this, an explanation and critique of models within the field of NDM will be presented.

Edwards (1954) introduced the classical concept of prescriptive, analytical decision-making to the field of psychology. This theory can be used to investigate everyday decision-making processes. The theory suggests that people should collect and analyse information, eventually selecting an optimal solution from a range of alternatives. This should be done by evaluating the advantages and disadvantages of each possible outcome and then choosing the one most appropriate to achieve the desired outcome goal. This decision is regarded as optimal (McDaniel, 1993).

This field of decision-making research essentially investigates the quality of the decision made by comparing it with the outcome predicted by a normative statistical model. In doing so, this theory draws upon such methods as expected utility theory and Bayesian

analysis. Possible decision outcomes can be presented statistically as probability estimates for expected outcomes. Research in this field has relied on laboratory experiments and, instead of studying how people actually make decisions, “Classical” decision theory focuses on how the optimal decision should be reached. This approach has also examined how real life decision-making outcomes differ from the optimal solution (Brehmer, Jungermann, Lourens & Sevon, 1985).

However, Classical decision theory failed to describe many decision-making events adequately and, in response, decision research started to become more descriptive. A number of descriptive decision theories were proposed (Plous, 1993). A commonly cited example of a descriptive decision model is the rational choice model of decision-making (Janis & Mann, 1977). This model provides an analytical approach for understanding decision-making, based on the researchers’ observations. The seven process criteria specified by the rational choice model are:

1. A wide range of objectives is identified.
2. A broad spectrum of alternatives is produced.
3. The advantages and disadvantages of each alternative are assessed.
4. A search for new information relevant to each alternative is undertaken.
5. New information is incorporated into the analysis of the alternatives.
6. The advantages and disadvantages are revised.
7. Detailed provisions are made when implementing the chosen decision.

Janis and Mann (1977) argued that this model would be the only way that individuals under pressure could make good decisions. One pressure that was discussed by Janis and Mann (1977) was time pressure, which is of particular interest because it is a defining characteristic of NDM environments. In relation to time pressured situations, Janis and Mann

(1977) discussed how errors could occur due to people being in a “hypervigilant” state⁵. Hypervigilance was associated with a heightened level of emotion, and it was suggested that this high level of emotion may be sustained for minutes and even hours after the decision had been made. Janis and Mann (1977) indicated that people in a “hypervigilant state” become preoccupied with the losses that may occur due to their decision-making. They also suggested that in such conditions decision-makers are indiscriminately open to all information available, being unable to discriminate relevant from irrelevant. Unfortunately, this particular aspect of Janis and Mann’s (1977) discussion is not extensive, and does not consider the role of expertise as a mediator in such situations. Recent NDM researchers have also found that in time pressured situations experts are not indiscriminately open to all information, but are guided in their information search by cognitive schema, built up through their experience (Lipshitz & Shaul, 1997). This indicates that the level of experience possessed by many people in NDM situations is vital in understanding their decision-making process.

In sum, the rational choice model is useful in a number of ways. Firstly, it provides a useful description of some decision events. Moreover, the effect of context on decision-making has been highlighted. In particular, Janis and Mann (1977) have highlighted time pressure and emotion as potential influences on decision-making. However, although probabilistic theories have been successfully tested in the laboratory, they have failed to describe decision-making behaviour observed in the real world (Fishchoff, 1988; Simon, 1956). These models are based on a set of assumptions that decision-making is mechanistic, and based on probability; while evidence suggests that humans do not consistently use probability-based assumptions (Allias & Hagan, 1979; Beach, 1966; DuCharme, 1970; Edwards, 1968; Kahneman & Tversky, 1973; Savage, 1954). More recently, it has been argued that this approach to decision-making has weaknesses when applied to real-life

⁵ This was described as an aroused psychological state triggered by time pressure (Janis & Mann, 1977).

decision-making in environments that exhibit high stakes, uncertainty, time pressure and dynamic conditions (Beach & Lipshitz, 1997; Klein, 1999; Salas, Bowers & Cannon Bowers, 1995). One obvious problem within the above described environment, that is not catered for in this model, is that the time frames in real life situations may be very short, and hence evaluation of pros and cons associated with a variety of options is often not possible. In fact, recent research by Klein, Calderwood and Clinton-Cirocco (1986) has found that on average firefighters only focus on one or two options before making decisions. Also, in such environments the quality of information is usually ambiguous and there may be inadequate time to search for new information relevant to possible alternatives to incorporate into the evaluation. Instead it has been suggested that the past experience of the decision-maker and the ability to interpret information is vital (Klein, 1999).

Another school of decision-making research based on describing biases and heuristics observed in the laboratory began to emerge in response to criticisms of early analytical models to describe decision-making (Plous, 1993). These theories attempt to describe the heuristics that human decision-makers tend to use in order to reduce cognitive load. A summary of some popular theories is provided in Table 1.

Other decision biases and heuristics include: primacy and recency effects, cognitive dissonance and the law of numbers. For a summary of these theories, see Plous (1993).

Table 1. Description of decision theories based on heuristics.

Decision Theory	Description
Satisficing (Simon, 1956)	To choose a decision option that satisfies your most important needs. Not necessarily the optimal path.
Prospect theory (Kahneman & Tversky, 1979)	To evaluate alternatives in relation to a reference point. Within this theory it has been found that in relation to that point, perceived losses are weighted more strongly than gains.
The certainty effect (Allias, 1953)	Where alternatives reduce potential risks by the same amount, the alternative that reduces risk to zero is favoured.
Pseudocertainty (Tversky & Kahneman, 1981)	When an alternative appears to have reduced the risk to zero it is more popular.
Regret theory (Bell, 1982; Dunning & Parpal, 1989; Loomes & Sugden, 1982)	This rests on two assumptions; firstly, that many people experience regret and rejoicing; and secondly that we take this into account when we make a decision. Therefore, similar to prospect theory, we try and minimise losses (regret). This, however, does not hold for all decision cases.
Multi-attribute choice (Einhorn & Hogarth, 1981)	Where the alternative attributes are weighted and one attribute can be traded off for another more important one.
Non-compensatory strategies (Hogarth, 1987)	Similar to multi-attribute choice but choices are made beforehand on the value of the attributes, and trade offs do not occur.
The more important dimension (Slovic, 1975)	When people are faced with an equal choice they will choose the alternative that rates highest on the “most important dimension”.

Cannon-Bowers, Salas and Pruitt (1996) argue that the research upon which the heuristic and bias paradigm has been based has been too sterile to generalise to real world settings. However, a range of evidence suggests that biases might help to explain some decision-making in real world environments (e.g. naturalistic environments). For example, in the classic book, on *The Psychology of Military Incompetence*, Dixon (1976) discussed how some of these biases (such as cognitive dissonance) may be used to explain what he described as failures of the military. In addition, research has found some inconclusive evidence of biases in naturalistic conditions. For example Entin, Serfaty and Forester (1989) found a recency bias in judgements of military intelligence analysts of conflicting information presented over time. However, research by Tolcott, Marvin and Lehner (1989) produced conflicting findings that military intelligence analysts displayed a primacy bias and confirmation bias (subsequent information that confirmed their initial hypothesis was overemphasised and other contradictory information discounted). To explain these conflicting results, the effect sizes in these studies have been small and the observed effect might have been influenced by the less experienced participants in the samples (Perrin, Barnett, Walrath & Grossman, 2001). To support this statement, Alderman, Tolcott and Bresnick (1993), in a study of US Army air defence operators, found that biases based on the order in which information was presented were less pronounced in officers (experts) than enlisted men (novices). However, when a similar study was done using experts doing a more realistic task, the strength of the effect of information order (recency bias) was increased substantially.

The problem with this finding was that it could be explained in two ways:

1. Judgement bias can occur in naturalistic settings.
2. Experts are using a pattern matching technique to make decisions (as described by NDM researcher Klein, 1999).

Perrin, Barnett, Walrath and Grossman (2001) drew on these previous studies to determine which of these two explanations best fit, but results were inconclusive.

Thus, to date there has been no unequivocal evidence that judgement biases explain decision-making in naturalistic settings. Overall, these biases and heuristic theories have offered some valuable explanations for observable phenomena, but each has fallen short of providing an inclusive theory for decision-making applicable to naturalistic situations (where there are often multiple goals, uncertainty, and time pressure). However, research indicates that their impact on decision-making in naturalistic environments should be further explored.

In summary, the history of analytical decision-making and biases and heuristics has been useful in shaping our understanding of the cognitive processes that drive decision-making in many contexts. The main criticisms that NDM researchers have aired are:

1. **Time pressure-** It has been suggested that needing to evaluate such a large number of alternatives in a short period of time is impractical in naturalistic situations (Kaempf & Militello, 1993). In fact, usually only one option is considered (Klein, Calderwood & McGregor, 1989).
2. **Dynamic environment-** Because of the dynamic environment, continual evaluation and judgement of the environment is required, in contrast to a single moment of choice assumed by these models.
3. **Context-** Contextual elements impacting on decisions have been touched on by previous researchers, but need further clarification (e.g. how does the context impact on decision-making?).
4. **Expertise-** Naturalistic environments usually require expert decision-makers, whose experience facilitates their decision-making. These facts are not adequately accounted for in analytical decision theories.

5. **External validity-** Ebbensen and Konecni (1980) have argued that the external validity of decision-making research that relies on laboratory experiments (such as many of the analytical decision-making models) is minimal. It may be that biases found in the laboratory are simply caused by participants not understanding the task (Fischhoff, 1988). Conclusive evidence of these biases occurring in real world decision-makers, still needs to be achieved.

Thus, in naturalistic circumstances, there are grounds for querying the adequacy of analytical decision-making models. In particular, these theories still require extension in order to describe decision-making adequately in a military context.

2.2 Emergence of NDM Theory and Decision Models

In response to the inadequacy of analytical decision-making theories or simple heuristics and biases to explain decision-making in NDM environments, researchers shifted focus to developing descriptive models catering for the unique aspects of this environment. Decision-making within these real world naturalistic environments has been described as “naturalistic decision-making” (NDM; Cannon-Bowers, Salas & Pruitt, 1996). Zsombok (1997) defined NDM as:

...how experienced people, working as individuals or groups in dynamic, uncertain, and often fast paced environments, identify and assess their situation, make decisions and take actions whose consequences are meaningful to them and to the larger organisation in which they operate (p. 5).

In other words, NDM research investigates how people use experience to make decisions in naturalistic environments (e.g. under time pressure, shifting conditions, with unclear goals, degraded information and within team interactions). Consistent with this definition, research has aimed to identify appropriate models of decision-making for

application to this context. Theories that have been put forward include: image theory (Beach & Mitchell, 1987) and the RPD model (Klein, 1989).

Image theory is an example of a descriptive model of decision-making that has been posited as a potential NDM theory. It has been applied successfully in some real world settings (auditing decisions; Beach & Fredrickson, 1987; cited in Beach & Mitchell, 1987). In contrast to traditional decision models that tend to isolate information as the only determinant for decision-making, image theory posits that other elements should be considered. It focuses on an individual's values and goals in combination with current information. In this model, the role of previous experience is important in decision-making.

Image theory holds that the decision-maker should possess three “decision-related images”, which act to constrain the decisions that can be made. These images are described as:

- **Value image** - This image contains the decision-maker's principles; his/her assumptions about how things should be. When participating in a group the decision-maker can participate effectively by using the organisation's values when making decisions (Beach, Smith, Lundell & Mitchell, 1988).
- **Trajectory image** - This image contains the goals of the decision-maker or the larger organisation within which s/he functions (thus all decision-makers are using the same set of values).
- **Strategic image** - This image contains the strategies and plans that have been adopted to accomplish the goals. Each plan is abstract; a sequence of potential activities to work towards eventual goal attainment. Potential plans tend to come from past experience.

Along with these images, a decision-maker will have goals that will represent the desired outcome. A combination of the goals and the values is required for the production of a

plan. During the decision-making process it is suggested that a compatibility test occurs in the decision-maker's mind to examine the goodness-of-fit between the potential goals and plans, and the values. Decision-making therefore requires accepting or rejecting goals and plans according to suitability and then profitability.

Because goals and plans are linked in memory, it is often the case that once a goal has been identified, an immediate plan of action can be applied. The link between goal and action is called a "policy", and the process is referred to as "framing the decision". It involves probing memory with information from the current situation. If there is a similar contextual memory to the current situation, the situation is recognised, and an appropriate course of action already stored can be modified and executed. A major part of the decision-making process is monitoring the courses of action that have been decided upon.

It has been suggested by Beach, Smith, Lundell, and Mitchell, (1988) that this theory could be applied to decision-making in naturalistic environments. A number of studies have validated parts of this theory. For example, laboratory research has supported the ideas of compatibility and profitability tests during decision-making (Nicholas-Hoppe & Beach, 1987; Payne, 1976). Also, Dunegan (1995) has shown that when perceptions of a project's current and target images were more similar, decision-makers tended to continue with that project. Finally, the model has been applied in real world situations such as organisational decision-making, decision-making for married couples and also auditing decisions (Beach & Fredrickson, 1987, cited in Beach & Mitchell, 1987; Beach & Morrison, 1987; Mitchell, Rediker & Beach, 1986). Thus, there has been some support for this theory, but further research is required in order to fully validate the theory and to test empirically its adequacy to describe decision-making in naturalistic environments. Moreover, the model does not describe the effects that context (e.g. emotion, time pressure) may have on the decision-making process.

A more often cited model of decision-making, developed from observations in naturalistic environments, is the RPD model (Klein et al., 1986). The model was based on interviews and observations of fire ground commanders working in difficult and challenging circumstances (Klein et al., 1986). It was anticipated that, under complex circumstances, involving time pressures, the Commanders would make limited comparisons between possible outcomes. However, the early research revealed that they were making no comparisons at all. In fact, 80% of decisions made in this task were made in less than one minute. From this, Klein et al. (1986) identified the following issues:

- The Commanders drew on their previous experience to recognise a typical action to take.
- They did not have to find an optimal solution, merely a workable one.
- Once they had arrived at a suitable course of action, they would mentally simulate it first, to check that it would work.

Consequently, Klein (1989) developed the RPD model. The model posits that experienced decision-makers:

- Usually consider a workable option and do not need to generate a large set of alternatives.
- Generate and evaluate options one at a time, instead of comparing the advantages and disadvantages of all options.
- Evaluate an option by imagining the outcome, and by finding ways to avoid problems that may arise from its implementation.
- Focus on assessing the situation and looking for familiar cues.
- Emphasise acting quickly and not sustaining analysis.

The RPD model describes how experts make decisions without comparing outcomes (see Figure 1). The decision-maker initially assesses the situation, looking for familiar patterns or prototypes (Phase 1: Developing Situation Awareness). By recognising similarities between the current situation and those stored as previous experiences in memory, the decision-maker is able to know which goals make sense, what relevant cues to expect, and what action should be appropriate (Phase 2: Recognition). A series of options is then generated. The first solution may not be optimal, but it will usually be workable (Phase 3: Option Generation). The adequacy of the option is then determined by mentally simulating the possible outcomes (Phase 4: Mental Simulation). If the simulation is successful, finally a decision is made (Phase 5: Decision).

There are several similarities with image theory. Firstly, RPD also asserts that options are assessed sequentially in order to generate a solution. Moreover, options considered are based on developing an understanding of the environment based on the experience of the decision-maker. Both models show that action can be taken quickly. This is important in crisis management (Klein, 1997).

Advantages that the RPD model holds over image theory are that it has been applied to various NDM settings and accepted by a number of research groups as providing a viable description of cognitive processes underlying NDM (Kaempf, Klein, Thordsen, & Wolf, 1996; Mosier, 1991; Pascual & Henderson, 1997). The RPD model has been found to describe decision-making in domains such as fireground command, wildland fire incident command teams, US Army armoured division personnel (Klein, 1989), battle planning (Thordsen, Galushka, Young & Klein, 1987), critical care nursing (Crandall & Calderwood, 1989), and chess tournament play (Calderwood, Klein & Crandall, 1988). This theory has also been applied as widely as multidisciplinary assessment of disability (Bartolo, Dockrell & Lunt, 2001). Moreover, concepts embedded within the model, such as situation awareness, have been defined and explored by a number of prominent researchers.

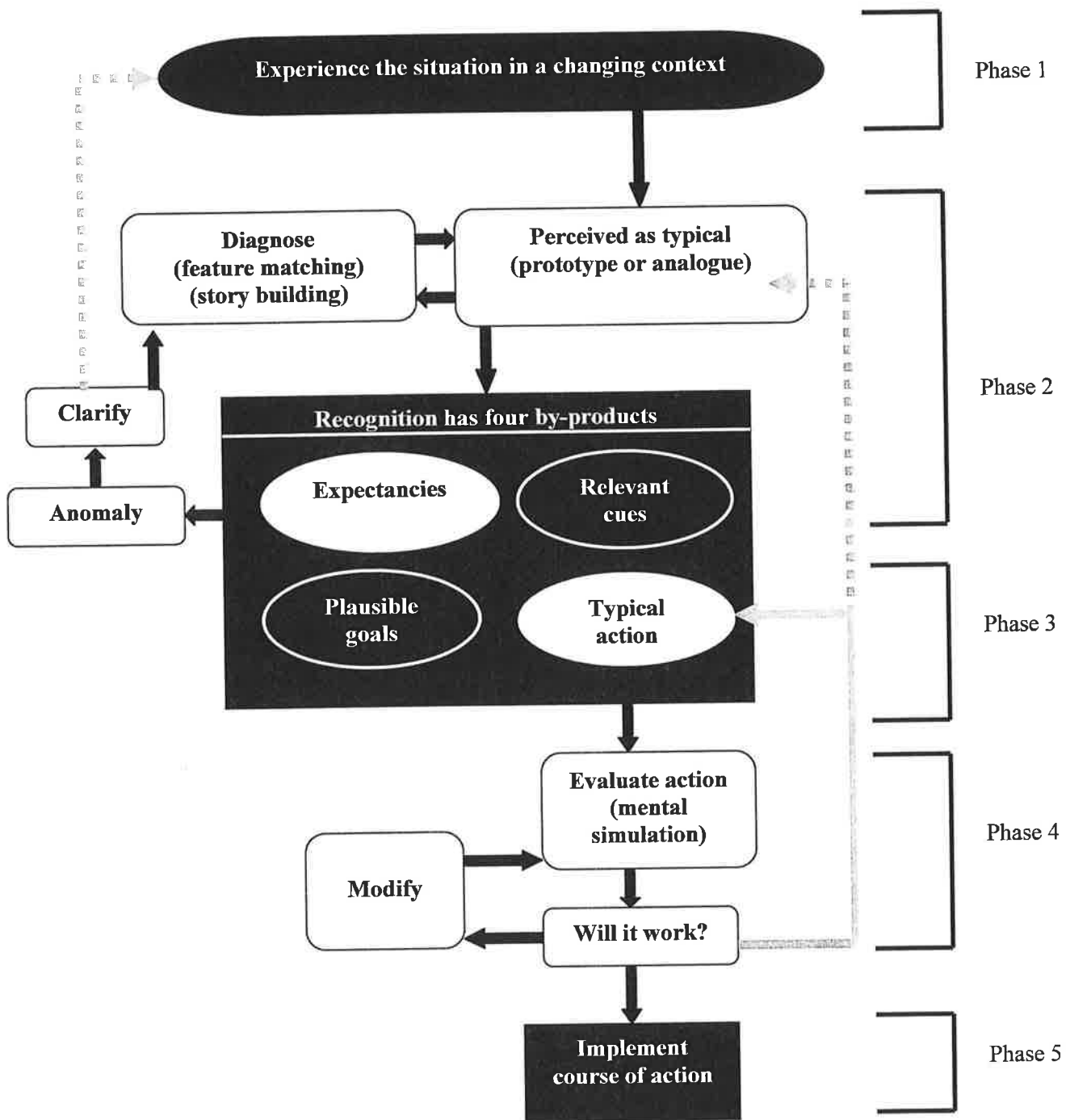


Figure 1. The basic RPD model (adapted from Klein, 1999).

Klein (1999) has noted that there are boundaries for the applicability of the RPD model. These are that the decision-maker has a reasonable level of experience, that there is

time pressure and uncertainty/ ill defined goals. Klein (1999) argues that it is less likely to occur in situations with highly combinatorial problems or where justification is required.

Since its conception, the RPD model has been built upon to incorporate more descriptive theory to better define the NDM process. Notably work has been done on incorporating schema and mental models into the RPD, modelling situation awareness and describing cognitive-perceptual mechanisms used by expert decision-makers.

Lipshitz and Shaul (1997) recommended an extension to the RPD model by arguing that it oversimplified the processes occurring in NDM, and required the inclusion of schema and mental models. This criticism followed the failure of the model to provide adequate explanations of their research finding (Lipshitz & Shaul, 1997).

The study done by Lipshitz and Shaul (1997) focused on the differences between experts and novices in decision-making in a sea-combat simulation.

This study found that:

- Experts collect more information on the situation before they make a decision because they know what questions to ask.
- Experts engage in a more efficient information search because they know what information to keep track of.
- Experts read the situation more accurately because they are able to identify the difference between relevant and surplus information.
- Experts make fewer bad decisions related to reading the situation correctly.
- Experts communicated more frequently and elaborately with friendly units.
- Experts are more likely to consider other people's perspectives when making their decisions.

Lipshitz and Shaul (1997) found that Klein's (1989) RPD model accounted for most of these observations. However, it could not account for experts collecting more information than novices on the situation before they make a decision. As described, the RPD model specifies those conditions under which a decision-maker would collect additional information. These are: when the decision-maker does not recognise the situation (thus cannot establish goals); if expectancies are violated; or the expert's mentally simulated course of action fails.

If Lipshitz and Shaul (1997) are correct, however, and experts always collect more information than novices, it could be inferred that, in comparison with novices, experts require more information to identify goals; experts' expectations are more likely to be violated; and experts engage in mental simulation more often. According to Klein's (1989) RPD model, the third implication is accurate and empirically supported (Calderwood et al., 1987). The first two inferences contradict the idea of experts being efficient decision-makers.

In light of this, Lipshitz and Shaul (1997) suggested that, in order for the RPD model to more adequately explain these findings, it should be modified to include schema and mental models. Schema would be incorporated into the situation assessment phase (phase 1) and mental models would inform the recognition and option generation phase (phase 2 and 3) and mental simulation phase (phase 4). This would account for experts collecting more information, and conducting more effective searching. Each of the phases will now be explored in detail.

Phase 1 of the RPD model is development of situation awareness (SA). Situation assessment is the process by which a decision-maker gathers information pertaining to the current decision problem. It often results in recognition of a situation from past experience. Klein (1999) argued that in real world situations it is uncommon to be making decisions in a static environment. Thus, in contrast with the singular moments of choice, as described in analytical decision-making models, NDM often requires a series of interdependent decisions. Therefore, instead of relying on static information, the decision-maker must constantly

monitor the changing environment to inform his/her decision-making. This will be changing spontaneously, as well as changing because of each decision made. Thus, NDM requires continual situation assessment. Continual assessment produces SA.

Endsley's (1995) definition of SA is "the perception of elements in the environment within a volume of time and space, the comprehension of their meaning and projection of their status into the near future" (p. 97). This definition is useful because it divides the concept into three levels:

- **Level 1**- Perceiving cues in the environment.
- **Level 2** - Integrating these perceptual cues and comprehending their meaning and significance.
- **Level 3**- Projecting from current events and anticipating future events.

In order to facilitate rapid judgement, Lipshitz and Shaul (1997) proposed that the expert's stored schema⁶ is retrieved from memory. A schema helps determine what we attend to, what we perceive, what can be filtered out, what we remember and infer, what information is missing and where it can be found (Augoustinos & Walker, 1995). This allows experts to process relevant information more quickly, and not to experience cognitive overload. Due to their ability to filter information, experts are able to take into account more relevant information than novices (Federico, 1995; Hutton & Klein, 1999). Less expert decision-makers may experience cognitive overload more rapidly because they attend to all information and do not filter out irrelevant aspects (Randel, Pugh, & Reed, 1996). Another advantage associated with the use of expert schema to guide information search is the ability to group important information into "meaningful chunks". The classic study by DeGroot

⁶ A schema is described by Vaughan and Hogg (1995, p.31) as "a cognitive structure that represents knowledge about a concept or type of stimulus, including its attributes and the relations among those attributes."

(1965/1978), later replicated by Chase and Simon (1973), compared the performance of chess masters and novices. The researchers were interested in isolating elements that separate an expert from a novice. They found that experts and novices did not differ significantly on memory abilities, depth of planning or other similar areas. Instead, the difference was that the expert players could look at the entire complex chess display and condense it into “meaningful chunks”, whereas the novices tried to understand the whole display (Means, Salas, Crandall & Jacobs, 1993, p. 310).

Therefore, the inclusion of schema in a description of NDM explains why experts may seek more information, but because their information seeking is guided, actions can still be taken quickly. This is important in crisis management (Klein, 1997). It may also explain why decision-making can seem intuitive to the decision-maker.

Situation assessment results in a mental representation of the problem at hand. Essentially it is a “hypothetical construct, which refers to the operator’s ideas about a system and what it is controlling” (Mogford, 1990, p. 4). Following this, the mental model forms the lense through which the decision-maker views the problem. It helps to shape future goal building, and determine expectations formed (Wickens, 1984). It acts as a mental representation of the perceived situation, and facilitates consequent pattern matching, judgements and decisions.

Phase 2 of the RPD is recognition of the situation. Continual schema-guided situation assessment enables the expert to recognise familiar patterns. Understanding how it is stored in memory assists to explain how previous experience can be used to trigger recognition of the situation. A cognitive model, proposed by Noble (1993), represents how previously solved problems are stored in memory. These are termed “reference problems”. Each reference problem can be broken down into three constituent features (See Table 2).

This model therefore identifies three levels of abstraction in memory. Using this model, previously experienced problems can be compared, at conceptually different levels of memory, with the current problem.

Table 2. A description of the features described in Noble’s (1993) model of how experience is stored in memory.

Question Answered	Memory Features	Description of Feature
What?	Objective features	This aspect of the memory characterizes the problem and its objectives. It is concerned with concrete features (specific observable events or objects).
How?	Action / abstract features	These identify the steps that are involved in solving the problem. These are abstract features that help generalise the problem type and solution method.
Where?	Environmental features	These comprise cues that were present in the past problem scenario. These are environmental cues that may indicate a similar or related problem.

During situation assessment reference problems are selected because the expert is able to match patterns in the current situation with those stored in memory. It is assumed that experts will have a large store of patterns to match. For example, Simon & Gilmarin (1973) estimated that chess masters store 10,000-100,000 patterns in their memory. Thus, the likelihood of a match in this instance would be high. Further evidence for the use of stored expert knowledge for NDM was presented by Sohn and Doane (2005). They found that

variation in level of expertise impacts on the type of memory relied upon for the production of SA. For novices, spatial working memory capacity is most predictive of good SA. In contrast, for experts, a combination of both long term memory capacity and working memory are most predictive of good SA (Sohn & Doane, 2005).

The method by which experts are able to draw upon the action/ abstract level of previous experience is advantageous (Noble, 1993). It has been found that experts will categorise and match stored cases by similar inferences and principles (Level 2-action / abstract features), where novices will organise representations around surface features (Level 1-objective features; Chi, Feltovich & Glaser, 1981). An example of experts drawing on abstract knowledge to inform decision-making was shown by Chi, Hutchinson and Robin (1988), who studied children who were dinosaur experts and novices. These children were presented with a series of dinosaur pictures and asked to identify whether the picture being viewed was a dinosaur. Novices failed to judge typicality. Klein and Hoffman (1993) also argued that “expertise is a function of the knowledge base itself, and that as people develop richer knowledge bases they are able to represent problems in more powerful ways”(p. 208).

Evidence of pattern matching in real world NDM has been produced by Kaempf, Klein, Thorsden and Wolf (1996), who worked with military officers and found that, when establishing SA, 87% of participants used a pattern matching strategy. This is where the decision-maker sees the situation as familiar, and arrives at situation awareness through a series of recognised cues. Moreover, recent research by O’Hare and Wiggins (2004) provides further evidence about the use of recall of previous cases to build into SA generation in NDM. This reliance on past cases increases with age. Pattern matching leads to generating a typical course of action (Klein, 1999).

Phase 3 of the RPD is option generation. Noble (1993) proposed that when previous reference problems match current mental models, the “problem solutions associated with those in memory become candidate actions” (p. 305). This is in accordance with NDM being

proceduralised; meaning that decision-making is directly linked to action and the conditions of its applicability (Means et al., 1993; Rasmussen, 1983). This cognitive model allows recognition-based solutions of new problems that resemble but are not necessarily identical to those previously experienced (Cohen, Freeman, & Wolf, 1996).

A number of studies have suggested that previously stored cases are linked with generated decision-making options in the RPD. Studies that support these assumptions include George, Kaempf, Klein, Thorsden and Wolf (1996), who found that military officers who had an awareness of the situation were able to recognise actions appropriate for the current situation from published procedures, and past experiences. Also, Lipshitz (1989) found that Israeli army officers seemed to make decisions by matching situations to an associated action. Means et al. (1993) have also confirmed that the nature of a person's experience, and consequently the patterns recognised, affects the decisions made.

However, sometimes, a decision-maker is forced to make a decision on the basis of incomplete information. In such circumstances, the abstract level of memory facilitates decision-making. Noble (1993) concluded that in such instances cognition may involve the use of sophisticated information processing on general world knowledge. In support, Kaempf, Klein, Thorsden and Wolf (1996) found that in their study 12% of participants used story generation. Thus, when the environment does not provide enough information to be recognised as familiar, the decision-maker constructs a story to explain the information and to arrive at greater SA.

Phase 4 of the RPD model is mental simulation of the option to test its adequacy. Once an option is considered, experts will use their existing mental model to mentally simulate the anticipated outcome from the chosen option. They explore the option at a deep level, looking for pitfalls and opportunities. Mental models based on good SA also allow decision-makers to project the environment's status into the future (Artman, 1998; Brehmer, 1990). Both experts and novices may have this cognitive strategy available, but experts can

use it more effectively because of their superior knowledge base and perceptual advantage. They are able to categorise problems, according to their large repertoire of knowledge-based schema, and then apply basic problem solving techniques. Mental simulation is depicted in a model adapted from Endsley (1995) in Figure 2.

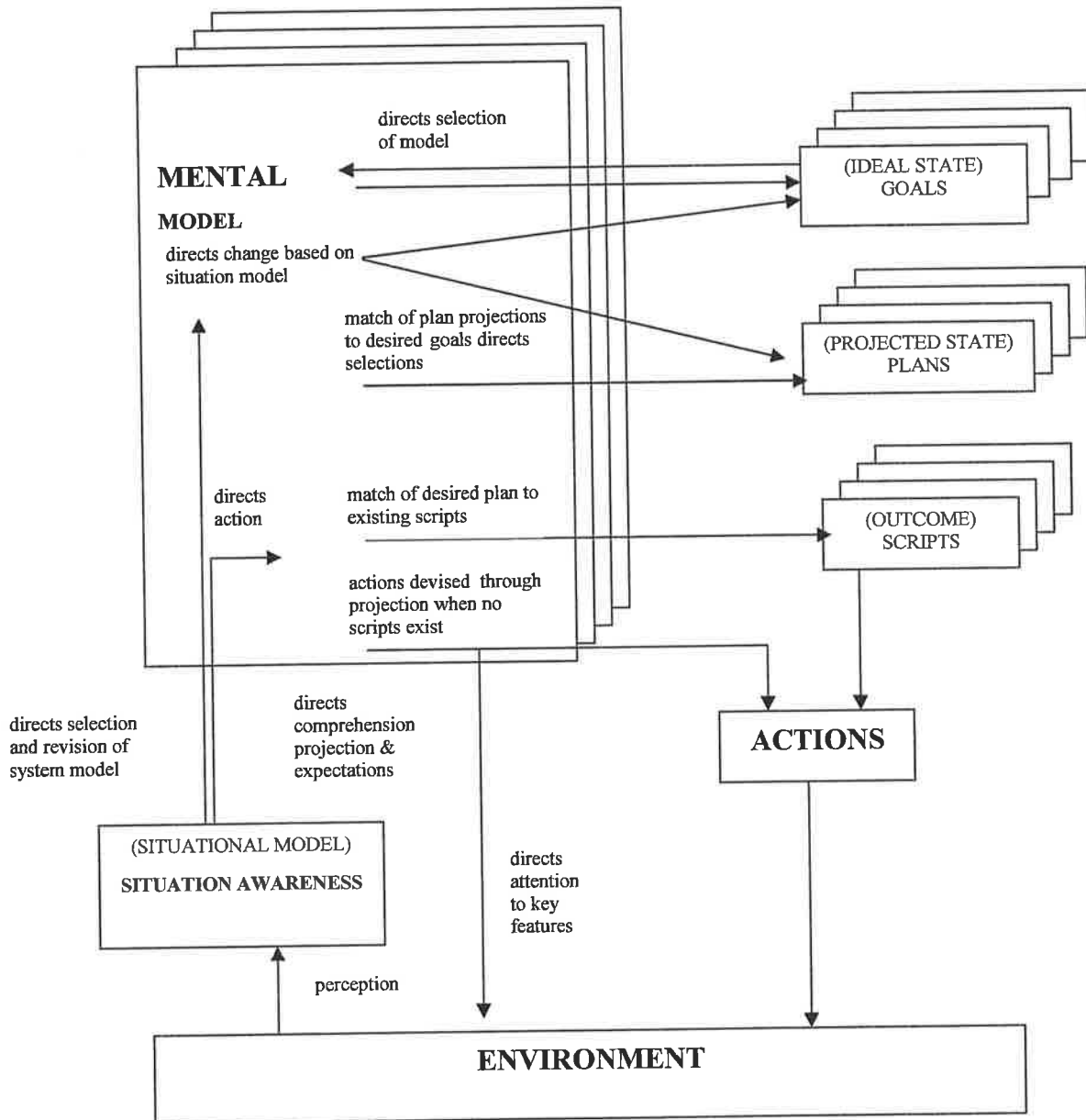


Figure 2. Relationship of goals and mental models. The role of mental models in processing current situational information (adapted from Endsley, 1995).

Figure 3 represents a revised model incorporating both Endsley's (1995) ideas on SA and Lipshitz and Shaul's (1997) contributions of schema and mental models. The inclusion of these ideas offers a more detailed explanation of how an expert analyses the situation, and recognises and evaluates a course of action.

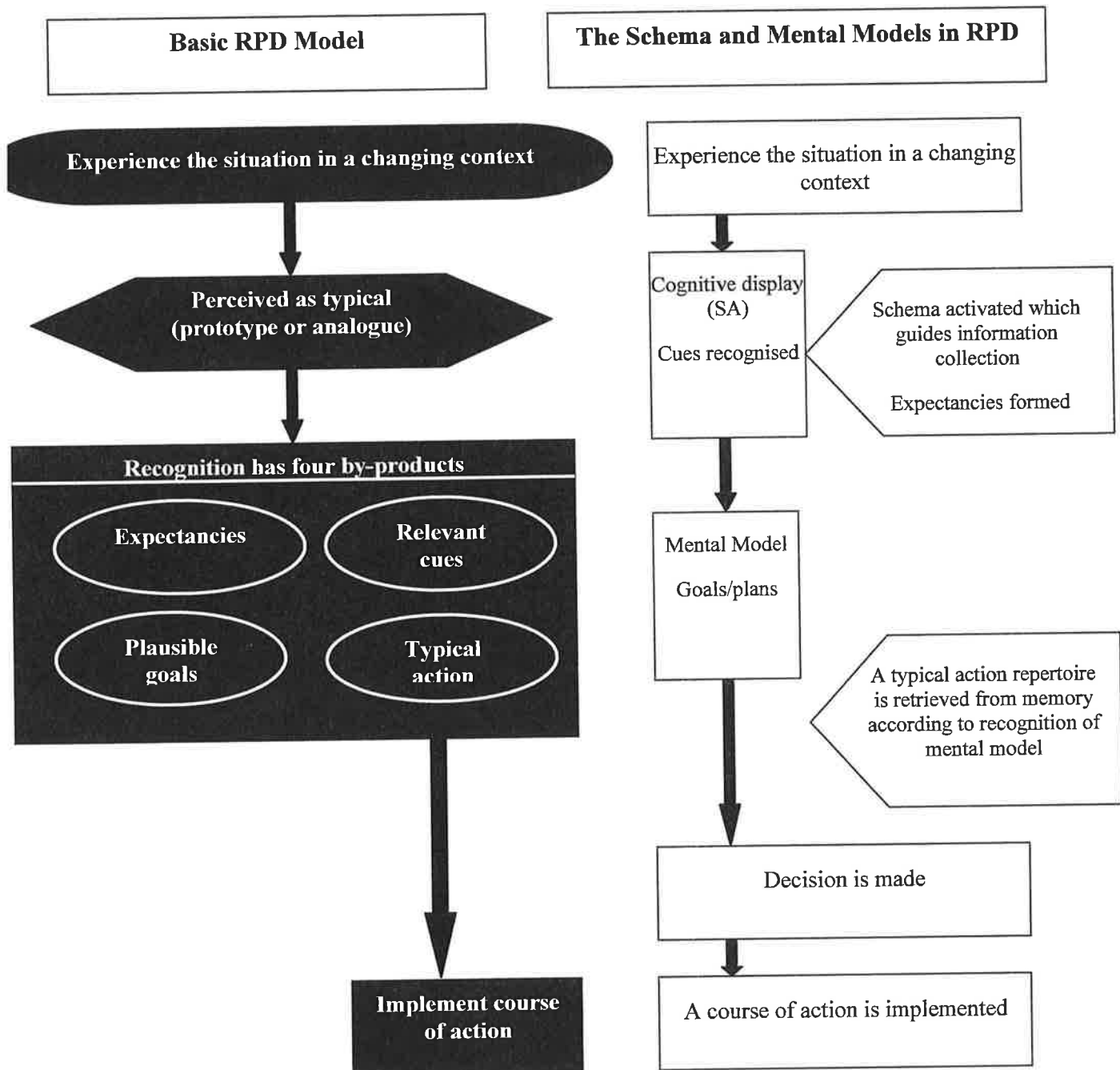


Figure 3. Proposed adaptation of the RPD model.

Thus far the combination of RPD, SA and schema and mental models has provided a good theoretical description of the processes believed to be employed by naturalistic decision-makers, but validating this experimentally has proven difficult. Although it is arguable that at present they offer the best available explanation of NDM behaviour, these models still require further elaboration and validation across contexts.

2.3 The Role of Expertise in Decision-making

A list of common themes of expertise from Glaser and Chi (1988; cited in Hutton & Klein, 1999) are:

- Expertise is domain specific.
- Experts see patterns.
- Experts are faster and make fewer errors.
- Experts have superior memory in their domain (environmental cues are an aid to recall).
- Experts see and represent a problem at a deeper level.
- Experts spend more time trying to understand a problem but have a more efficient path to solving it.
- Experts have strong self-monitoring skills.
- Experts have refined perceptual abilities.

Experience has been recognised as playing an extremely important role in decision-making (Bedard & Chi, 1992). For example, in a summary of the great military blunders throughout history, David (1997) noted that a “typical handicap seems to be a lack of command experience. Naivety tends to promote vacillation and overcaution, resulting in lost opportunities and ultimately disaster” (p. 1). In this case, David (1997) suggests that the

application of expert knowledge to NDM is the element determining whether the decision outcome is successful. In reality the relationship may not be quite as clear. It is likely that external elements also mediate decision outcomes (Woods, Johannesen, Cook, & Sarter, 1993). However, it has been shown repeatedly that experts tend to have different perceptual and cognitive mechanisms in comparison with novices, which facilitate their decision-making (e.g. Klein & Hoffman, 1993; Randel, Pugh & Reed, 1996; Wiggins, Stevens, Howard, Henley & O'Hare, 2002).

There has been debate in the literature over whether experts actually use different, more refined higher-level skills (such as methods of problem solving), or whether the expert/novice distinction is based on different ways of seeing the world. Means and Gott (1988) suggested that expert and less expert decision-makers apply the same rules but to a different context. Beach and Lipshitz (1997) extended this idea by stating that decision-making events require decision-makers to use their existing knowledge of the context to facilitate both their situation assessment and subsequent decision-making. According to the RPD model, it seems that both perceptual and higher order cognitive skills distinguish expert decision-makers from novices. These skills include: information representation, attending to relevant information, chunking, knowledge base, pattern matching, and cognitive strategies.

Thus, there has been a range of skills associated with expert decision-making performance, and these have been successfully incorporated into the RPD model. It is important that further research is done in order to produce an adequate definition for expertise that can be applied in the future development of expert training systems.

2.4 Criticisms of NDM

To date there have been a number of criticisms of NDM. These were summarised in the introductory chapter and are discussed further in this section. These include:

1. NDM does not adequately define “expert” (e.g. Bazerman, 2001; Halvor Teigen, 2001).

Despite experience being central to the RPD model, a consensus has not been reached regarding the most adequate definition for expertise (Shanteau, 1992). Definitions have varied from study to study (Shanteau, 1992). Many studies use hours of experience as an indicator (Klein & Calderwood, 1986; Klein et al., 1986). A repertoire of 10 years experience is generally accepted to qualify a person as an expert (Klein & Calderwood, 1986). However, it is not only length of experience that is important; quality of experience should also be considered. For example, Klein et al. (1986) found that, for firefighters, 10 years on-the-job experience in an environment with infrequent skill practice was not as valuable for skill development as one year in a decaying inner city with frequent requirement for skill practice. Shanteau (1992) suggested that in order to define expertise we need to procure the assistance of those in the field to identify people who have the necessary skills and abilities to perform at the highest level within their specialised domain. However, this method is flawed in that it also does not define specific criteria and is reliant on subjective judgement. Nonetheless, by collecting consensus among judges this improves the reliability of the judgement.

Because of the difficulty in accurately defining expertise, research has tended to focus on comparison of experts and novices in decision-making. Thus, an understanding of expertise is typically mediated by novice performance. A step in the right direction has been taken by Weiss and Shanteau (2003) who published a paper explaining a method derived for the empirical assessment of expertise. This measurement takes into account: ability to discriminate various stimuli in the domain; and consistent treatment of similar stimuli.

The ratio produced using these two criteria is then compared with ratios derived from other identified experts within the domain to determine a relative level of expertise. However, this ratio still relies on a number of untested assumptions and although we can measure the relative expertise of one person compared to another we still rely on subjective assessment of

an expert to use as our benchmark. Thus, establishing expertise still requires further extension.

2. The impact of the external context of NDM needs attention (e.g. Whyte, 2001).

To date there has been a lack of research focusing on whether the context of NDM impacts significantly on the process, and in what ways it might do so. Endsley (1995) developed a model of SA in dynamic decision-making (see Figure 4). This model can be viewed as additive to the previously discussed RPD model.

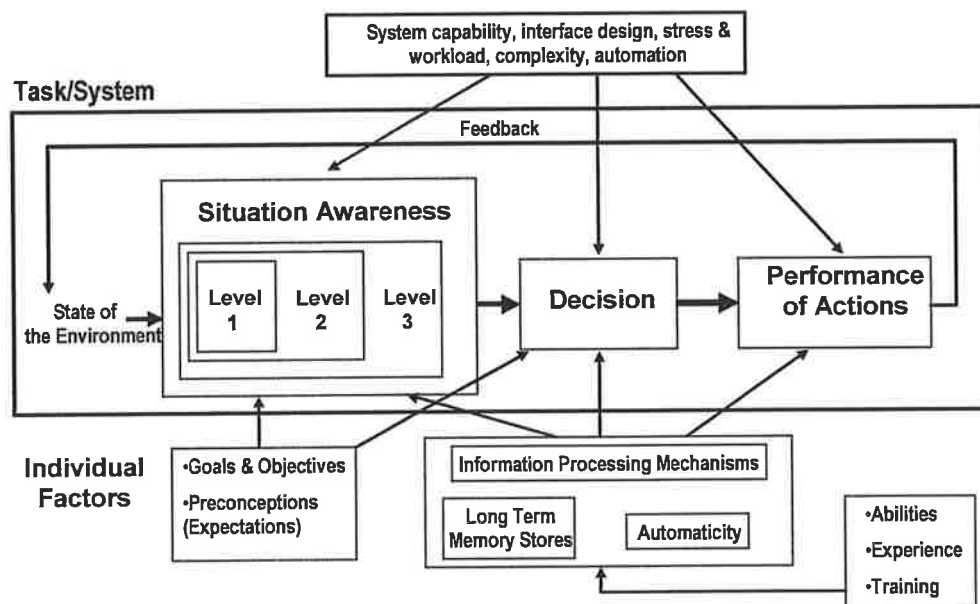


Figure 4. Model of SA in dynamic decision-making (adapted from Endsley, 1995).

According to this model, SA is distinct from decision-making and performance. We can infer from this that a high level of SA does not guarantee a high quality decision or performance. An advantage of this model is that it represents that all three stages of the process can be influenced by individual elements such as innate abilities, experience, training, fatigue, and task elements such as workload, stress, and complexity. To date, researchers are still establishing how variation in the context may impact on establishing SA.

To date, there has been limited research identifying elements impacting on NDM. Montgomery, Lipshitz and Brehmer (2005) confirm that “it is surprising that not many ‘full blown’ NDM studies have been conducted attempting to grasp the complex web of elements shaping decision-making in field settings” (p. 10).

However, in the broader realm of decision-making research there have been some elements that have received research attention. Research has shown that good judgement and rational thought are largely dependant on emotional signalling (Bechara, 2004; Hockey, Maule, Clough & Bdzola, 2000). Particularly relevant is research by Sayegh, Anthony and Perrewe (2004), who emphasised the important role emotion can play in managerial decision-making under stress. However, whether this impact is context specific is still largely speculative and further research is required. Janis and Mann (1977) also touched on the role of emotion in decision-making. Research in the field of neuropsychology suggests that emotions may play a profound role in complex decision-making (Bechara, Damasio, Damasio & Anderson, 1994; Manes et al., 2002). It has been suggested that the brain’s emotional centres actually receive signals before they reach the cognitive centres of the brain. The emotional centres will process input more quickly and tag this with emotional responses. Following this, the stimuli are transported to the cognitive centre where they will be processed more logically. Thus, emotion seems to be inextricably linked with decision-making.

Recently there have also been suggestions that personality can impact on decision-making (Lauriola & Levin, 2001; Lauriola, Russo, Lucidi, Violani & Levin, 2004). Finally, it has been suggested that fatigue can affect the amount of information one takes into consideration when making a decision, because the brain seeks to minimise cognitive processing. Consequently, research has linked increased fatigue with increased levels of risk taking in decisions (Hockey, Maule, Clough & Bdzola, 2000). Although the influence of these

elements is beginning to be recognised, they have not yet been discussed in the NDM literature.

This understanding is particularly important if we are successfully adapting current procedures to fit new environments. In so doing, the current research should build on existing models of NDM and identify any nuances that may differ from current models and doctrine. As we have seen in previous decision models, contextual elements (such as emotion) are beginning to attract more research attention, and their impact on NDM cannot be ignored. This needs to be addressed.

3. NDM methodology has been criticised as soft (e.g. Yates, 2001).

Similar to arguments presented in Chapter 1, this criticism is based on the fact that many experiments have been field-based and/or qualitative. It is important for researchers to design rigorous studies and explore which methods are most appropriate for the further investigation of NDM.

4. NDM is not really decision-making (e.g. Clemen, 2001; Kerstholt & Ayton, 2001).

Researchers have voiced their concern that the process that NDM researchers explore is conceptually different from those explored by other decision-making. One criticism has been that in NDM it has been argued that if the decision-maker already knows what course of action is appropriate, and is not deciding between alternatives then this is not a decision. Thus, it is important to understand that both the behavioural decision theorists and researchers from the judgement and decision-making background (BDT/JDM) are investigating a different commodity when compared with NDM researchers. There are some similarities and overlap, but comparing results across theories should be viewed with caution.

These criticisms notwithstanding, the RPD model has provided a good theoretical platform for the further exploration of NDM. Because it is in its infancy there are multiple

opportunities still for future research, definition and clarification of the model and its key contributing elements.

Overall, the topic of NDM is an important concept for researchers concerned with decision-making in the Australian Army. This chapter has presented the relevant background information required to begin to understand the field of NDM, how expertise is understood within this field, and what criticisms of NDM require immediate research and follow up. Research in the current thesis will be based at the unit level of operations where a CO is embedded in a HQs team. Therefore, the next chapter will step back from the individual to look instead at the wider team and organisational context within which unit level COs are immersed. A description of the structure and function of the Australian Army will also be provided.

CHAPTER 3. Positioning the Research in the Australian Army Context

This thesis focuses on the Australian Army and, in doing so, aims to discover useful information to inform future business processes⁷. This chapter has three sections. The first section describes the structure and context of the Australian Army. In particular, the structure and existing business processes at the unit level will be described (the level of analysis in the current research). Other important contextual information such as differences between sections of the Australian Army (e.g. regiments), the role of doctrine and the changing climate within the Army will also be discussed. Understanding this is important to inform the design and interpretation of the research. This section also describes teamwork theories relevant to the current research. This is necessary because the research focus is at the unit level (where the CO makes decisions within a team HQ). The second section presents a description of the overall research methodology and justification of the philosophical stance of the current research. The final section presents a phase by phase description of the research methods used in the current thesis.

3.1 An Overview of the Structure and Context of the Australian Army

The Australian Army operates as a hierarchical organisation (see Figure 5). Soldiers are usually promoted through the ranks as a reward for good performance. Their promotion also rests on other elements including: the amount of time spent in rank; merit (ie. are they deserving of the promotion); and whether there are places available to be promoted into.

⁷ Business processes in the unit HQ are defined as those processes that are commonly used/ repeated across regiments in the Australian Army in order to achieve goals. Within a unit HQ, an example of a business process is the military appreciation process (for planning).

Generally, higher ranked officers will have had more experience than their subordinates, although this is not always the case.

There are two streams of Army personnel. Most are General Service Commissions (GSO). These personnel work their way through the ranks and are able to carry out a broad set of duties and commands. The second stream of personnel is Special Service Commissions (SSO). If a civilian enters the Army with tertiary qualifications they will be made an SSO. This stream limits officers to perform only in their specialist area. An SSO may qualify as a GSO but completing a number of specialist courses is first required. Therefore, no GSO rank equivalence is given for existing university based qualifications.

The organisational structure of the Australian Army has developed over time to support the Army's requirement to be able to operate in extreme circumstances involving high levels of stress and uncertainty. The structure creates an environment in which both stress and workload should be shared. For example, a soldier on the ground would not be expected to have an overall, operational understanding of the current situation. Instead, each soldier will operate within his/her area of responsibility by following orders and making lower-level tactical decisions. Higher level COs have access to the broader situational information and make strategic or operational decisions.

The current research is set at the unit level. A unit is typically made up of a number of companies, a headquarters (HQ) and support elements (see Figure 5). The unit HQ controls the operations of the formation and it is here that operational decision-making occurs. Across regiments the composition of a unit HQ can vary. However, typically unit HQ consists of a CO and a team of supporting officers. The CO commands all elements of the unit, including attachments. Doctrine dictates that the CO has direct contact and close relationship with subordinate commanders. Each support officer in unit HQ has a different role within the team.

These roles are typically organised into the following functional groups: Command Group, Operations Group, Administrative Group, Other Attachments⁸.

All members of the unit HQ are typically in the same location. The HQ may or may not be mobile. The main function of the unit HQ team is to provide the CO with the resources required to run the unit and any supporting arms or services that may be allocated to it.

There are three reasons why the unit level has been chosen as the focus for the current research. Firstly, the unit level is the lowest level that exhibits the type of organisation described above. Thus, in terms of the numbers of officers involved in the HQ it is the smallest and easiest to observe reliably. Secondly, at a more practical level, access to staff for research participation is more likely because there are a greater number of unit HQs in Australia compared with Brigade and higher HQs. This improved the researcher's chances of collecting data.

Thirdly, with the introduction of Network Centric Warfare (NCW) the effects on the higher headquarters (HQ) of the Australian Army are predicted to be substantial. At these higher levels, decision-making is complex (operational or strategic), team embedded and technology-aided. Thus, there are a number of elements potentially impacting on the decision-making that could be changed. There have been recent discussions about changing the nature of unit HQ to fit with the emergence of NCW. In this regard it has been suggested that the unit HQ team and the CO do not need to be positioned in the same location. Possibilities arise for unit HQ to remain in Australia, while a detached HQ element is deployed overseas. This geographical distribution will dramatically change the context in which the CO is making

⁸ In most cases regiments will operate in combination with other arms. In this case, there will normally be representatives from the supporting arms located in the unit HQ to provide a point of contact to the CO for their area of support.

decisions (for example informal social networks). Currently, research is being carried out by the Defence Science and Technology Organisation (DSTO) on the effects of a distributed HQ on performance. This means that the unit HQ team could be split and located in two different locations. To date, researchers are still uncertain of the total effects of this shift. It seems important first to establish the elements that are currently impacting on the process in order to determine the best way to facilitate the shift.

There are a number of differences across groups within the Australian Army that are also important to understand when structuring research in this context. These differences influence some of the business processes undertaken by the officers. The divisions that are important to consider in the current research are those between the regiments and between regular and reserve Army personnel.

Within the Army there are different regiments established to perform different functions. For example, there is a regiment that operates armoured vehicles, an infantry regiment and an air defence regiment (among others). A regiment would typically exist as a unit level organisation. Because of the different functions of the regiments they operate according to different Standard Operating Procedures (SOPs). Anecdotal evidence suggests that there are also specific cultures associated with the different regiments. Thus, regimental affiliation would have an impact on experience, behaviour and attitudes.

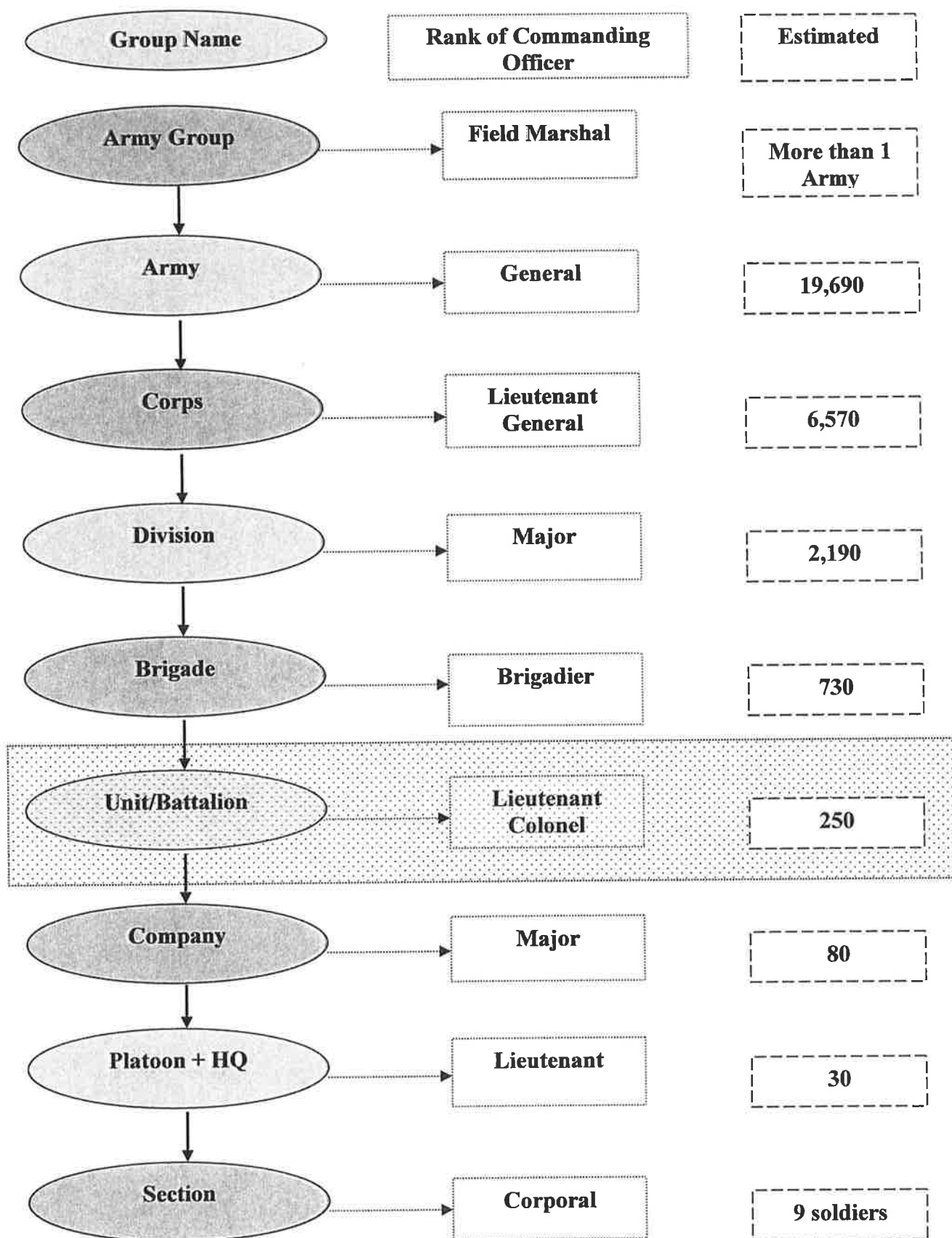


Figure 5. A simplified representation of the hierarchy in the Australian Army (level of current research highlighted above).

The second significant area of difference across personnel is their status as full-time or part-time officers. The Australian Army consists both of Regular (full-time) personnel and also Reserve (part-time) personnel.⁹ In terms of their function and role in an operation, a Reserve CO would be expected to perform the same function as the equivalent Regular CO. However, the time spent training is often less. Thus, although it is understood that Reserve and Regular officers should be comparable in terms of function, the varying time commitment affects the relative quantity of experience held by the officers. Also, anecdotal evidence suggests there is an assumed stereotype that Reserve soldiers and officers are less skilled.

Both of these differences need to be taken into consideration during structure and analysis of research. Overall, both the difference between regiments and between Regular and Reserve Army personnel impact on the potential for generalisation of any concept derived through research. Thus, in designing research it is important to sample across these boundaries. In doing so, similarities and differences can be discovered.

The Australian Army doctrine provides a level of constraint on decision-making within the organisation and thus is also important to consider in the current research. Because the Army operates in a complex environment, where decisions need to be made quickly, it is important that members have a shared understanding of the mechanics of different types of tasks. In order to ensure this, the Australian Army has published a large body of doctrine and many specific SOPs. Soldiers and officers are expected to operate by these. They automate many of the procedures that are frequently carried out. Consequently, any discussion about decision-making in the military must take this element into account, because doctrine provides a certain constraint on the decision-making process.

⁹ This is similar in other fields, where there are both part-time and full-time experts who function at various intervals (e.g. the Country Fire Service vs the fire brigade, army reservists vs full-time army, part-time vs full-time doctors, and first aid staff.).

Particularly relevant to the current research is The Australian Army Planning Doctrine. As has been described in Chapter 2, decision-making includes the process used to arrive at a decision-point. The Australian Army Planning Doctrine is consistent with NDM theory, suggesting that planning should also be considered as part of this process and not separated from decision-making. At a unit level, planning is performed according to doctrine that has been introduced in the last 10 years. Planning is documented as being CO led and staff driven. Overall, the CO has ultimate control but can decide how much or how little input s/he needs to give to the planning.

A simple task analysis of the process begins with the unit CO receiving an intent statement from his/her superior, and making sense of this in terms of his/her mission at a unit level. The unit CO will then issue his/her own intent to the HQ team. The next stage is to analyse the mission and develop suitable courses for action. The level of involvement that the CO has during these stages can vary depending on the operational conditions. During these stages the mission will be defined by the setting of realistic goals and information is gathered on the current situation. Next, potential courses of action are developed and analysed according to their feasibility. The distinction between these stages is often blurred because the planning process is iterative by nature. The last stage is the actual decision-making. This is handled by the CO. Typically this will be communicated through briefings with the HQ staff.

Understanding the planning doctrine can help to ascertain to what extent the CO is operating according to these guidelines. Importantly, we can also ascertain how COs may offer their own experience and interpretation to the planning doctrine.

Another issue important to understand within the current context of the Australian Army is the changing climate; with changes in available assisting technology and personnel response requirements. The Australian Army is immersed in the technology age and the organisation must take advantage of cutting edge technology to maintain a competitive edge. Thus, soldiers and officers must be able to incorporate the use of technology into their

workplaces. Therefore the Army currently faces increasing challenges to maintain best practice business operations whilst adapting to new technology and new types of response situations.

In addition to the ability to incorporate new technologies, today soldiers and officers must also be flexible and broadly skilled because they are required to be ready and equipped to respond to a myriad of emergency situations. For example, in recent years we have seen the Australian Army take part in operations ranging from peacekeeping in Bougainville to terrorist response in Afghanistan and Iraq. Recent events in the USA have demonstrated the potential role of the Army in disaster management after the destruction caused by Hurricane Katrina (2005), a role that the Australian Army has filled on many occasions, such as assisting to control the devastating Canberra fires (January, 2003).

Chapter 2 outlined NDM theory at the individual level. However, in many naturalistic environments, such as the unit HQ, the complexity and multi-dimensional nature of the task means that a single person cannot generate effective solutions (Cooke, Salas, Cannon-Bowers & Stout, 2000). In such situations a team of decision-makers is required in order to handle these complex tasks. This may result in superior decisions according to Hall (2000).

In the current research focusing on the unit level CO, we are investigating the decision-making of an individual who is immersed within a team context. Within the unit HQ team the CO is ultimately responsible for the decisions made, but doctrine states that the HQ team functions in a support role for that decision-making process. Thus, before describing the research design it is important to consider how the effect of being immersed within a team may impact on the CO's decision-making.

This section will explain some of the theoretical background on teamwork, particularly in application to a unit HQ team. "Team" will be defined and an overview of team research and theories will be presented. The discussion will then focus on the stages of team

decision-making: inputs, processes and outputs of decision-making. Finally, important concepts such as transactive memory will be discussed with reference to unit HQ. Overall, this section will identify a number of ways in which the team may exert influence in unit HQ CO's NDM.

In order to review the literature effectively, one needs first to make sense of the distinction between the concepts of *team* and *group*. Distinguishing between these has become quite a contentious issue within psychology. Some authors have argued that they should be separate concepts (e.g. Orasanu & Salas, 1993) and others have argued they should not (e.g. Sundstrom, Meuse & Futrell, 1990). Generally it is thought that to satisfy the definition of *team*, there is the requirement for cooperative action, interaction and interdependency of team members in achieving a mutual goal (Annett, Cunningham & Mathias-Jones, 2000; Morgan, Glickman, Woodard, Blaiwes & Salas, 1986). However, many definitions of group (e.g. Johnson & Johnson, 1987¹⁰) have also included these concepts of interdependency. Thus, these do not offer an adequate distinction between the concepts.

In order to distinguish between these concepts better, Orasanu and Salas (1993) suggested that it is necessary to focus on the degree of differentiation of roles and the effect of this on the degree of interdependence. They reported that teams require highly differentiated roles. In comparison, group members are more homogenous and interchangeable. Thus, because of the differentiation in roles, teams do have a higher degree of interdependence in comparison with groups. This is reflected in the Australian Army unit HQ teams where each team member has a set role and responsibility for different areas of operations. In addition,

¹⁰ Johnson and Johnson (1987) defined a group as “two or more individuals in face-to-face interaction, each aware of his or her group membership, each aware of the others who belong to the group and each aware of their positive interdependence as they strive to achieve mutual goals” (p. 8).

teams also tend to have a history and a future, where groups will often be formed and disbanded to achieve a specific short-term task.

Paris, Salas and Cannon-Bowers (2000) and Klimoski (2003a) have provided well-researched summaries of characteristics that have been observed in teams. Table 3 provides a summary of the main points.

Table 3. A summary of some defining properties of teams from Paris, Salas and Cannon-Bowers (2000) and Klimoski (2003a).

Defining Properties of Teams	
More than one member but less than 15	Intensive communication
Multiple sources of information	Adaptive strategies to respond to change
Complex task interdependencies	Mutual influence
Co-ordination amongst members	Social identity ¹¹ (belonging)
Common and valued goals	Task relevant knowledge
Specialised member roles/responsibilities	

¹¹ Social identity can be found across different regiments in the Australian Army.

The Australian Army unit HQ team satisfies all of the criteria in Table 3. From the above summary it seems fair to conclude that a *team* is a kind of a *group* (but the reverse need not be true). Because the unit HQ team satisfies the criteria to be labelled as a team, it is useful to draw from both group and team research to understand theories better that might govern its functioning and responses. Based on this understanding we can now explore the teamwork and group literature and interpret it in context.

Sundstrom (1999) suggested that teams could be categorised into six distinct types. These are represented in Figure 6. Each type of team operates in unique conditions, and has different requirements. Army teams have been classified as action/performing teams.

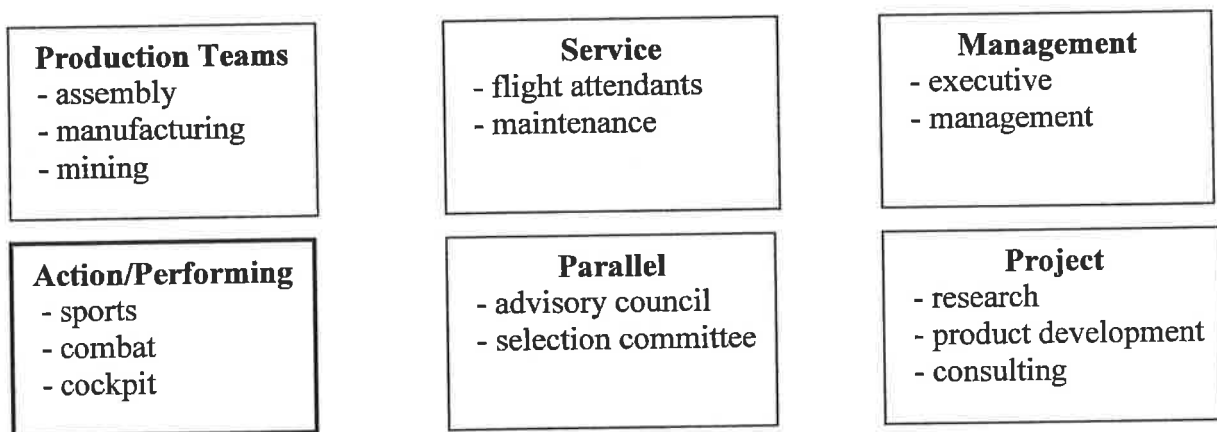


Figure 6. Taxonomy of teams (Sundstrom, 1999).

Since the 1950s, team research has regularly evolved. There are eight categories into which theories of teamwork have developed over the last half-century. These are: social-psychological approach, socio-technical approach, ecological approach, human resource approach, technological approach, lifestyle approach, functional (taxonomic) approach, and the integrative approach (for a summary see Paris et al., 2000). It can be argued that decision-making at a unit level occurs in a complex social environment. For example, the CO operates

within a team of officers in a HQ situation (this may be in a tent or similar). The team are often operating in extreme environments, with time pressure and high stakes. There are vast amounts of information often fed into the HQ via different forms of technology, from varying sections of the Army. They are also regularly required to interact with other outside organisations (such as United Nations), and across different cultures. From this brief description of the environment in which a unit CO operates, it is apparent that there is a level of social and contextual complexity that needs to be explored in order to understand adequately the intricacies of the elements impacting on the decision-making process. Because of the interest in the context of decision-making, a particularly useful approach for the current research is the social psychological approach¹². According to Bannon (2001), the trend for research in the field of human factors is currently shifting from a traditional cognitivist approach to a more social view. This provides further support for the direction of the current research.

In the study of teams, the focus is usually on team performance. Team performance can be better understood by reducing team behaviour into three distinct phases: input, process and output. Researchers are interested in identifying ways of maximising the usefulness of output. Therefore, attention is paid to identifying inputs and process factors that affect this.

Input factors can exist even before a team forms and they determine its potential to succeed (Mathieu, Heffner, Goodwin, Salas & Cannon-Bowers, 2000). Both internal and external elements have been identified as input factors (e.g. Morgeson, Aiman-Smith & Campion, 1997 [Appendix I]; Meister, 1985). A summary of the various levels of input

¹² Social psychology can be defined as: “The scientific investigation of how the thoughts, feelings and behaviours of individuals are influenced by the actual, imagined or implied presence of others” (Vaughan & Hogg, 1995, p. 2). Social psychological studies pay attention to the context and attempt not to leave “ecological gaps” (ie. Omission of real world factors and the addition of new elements of the testing environment that may not be present in the real world [Thomas & Kellogg, 1989]).

factors is shown in Figure 7; individual level factors, group level factors and environmental factors (from Driskell, Hogan & Salas, 1987; Mathieu et al. 2000).

Individual level factors contribute to taskwork, which refers to the knowledge, skills and attitudes required to perform individual tasks (Cannon-Bowers, Tannenbaum, Salas & Volpe, 1995; Salas & Cannon-Bowers, 2000). This includes demographic variables such as sex and personality (Salas, Bowers & Cannon-Bowers, 1995). This refers to the individual's capability to perform their own role within the team (e.g. CO makes decisions). There is a need for research on the impact of taskwork factors on decision-making at the unit level in the Australian Army. The previous chapter identified some variables (such as fatigue) that have been identified in the literature as impacting at this level

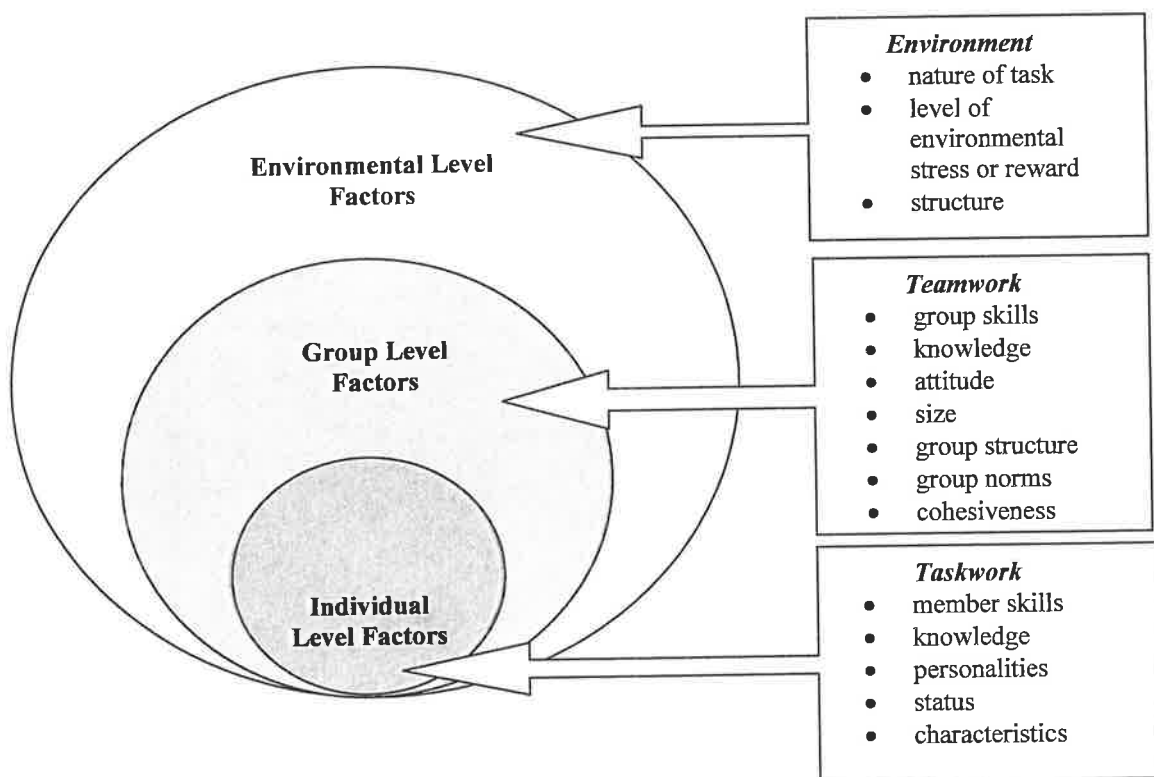


Figure 7. A pictorial representation of the various levels of input factors in teams, based on Driskell, Hogan and Salas (1987).

In addition to *taskwork*, in a team situation *teamwork* skills are also important to determine a successful outcome (Morgan et al., 1986). *Teamwork* skills refer to an

individual's ability to work within a team (e.g. the CO drawing appropriately on the knowledge and skills of his/her HQ staff). There are a number of findings drawn from research on groups¹³ that describe factors that enhance *teamwork* skills. For example, some basic social properties that are found in most groups of people working together over a period of time are: cohesiveness, social identity and norms (Vaughan & Hogg, 1995; Appendix II). Transactive memory is an important social property that assists to co-ordinate group knowledge. This is of utmost importance within the unit HQ where it is expected that specialised knowledge will be distributed amongst personnel and drawn upon appropriately to inform CO decision-making. The term transactive memory relates to a theory developed by Wegner, Erber and Raymond (1991). This theory seems to have been inspired by earlier theories regarding group mind (Durkheim, 1898). The theory of transactive memory suggests that groups develop a shared system for encoding knowledge, where each individual is only responsible for part of what the group needs to know. Thus, people are able to supplement their own memory capacity by using people around them as a repository for knowledge; dividing the cognitive labour within the group (Cordery, McDonald & Mitchell, 2003). It is suggested that groups develop certain "patterns" for structuring and processing information (Wegner, 1987, 1995). Each member understands who is responsible for each memory domain and this mechanism allows for groups to remember more information than the best individual in that group (Clark & Stephenson, 1989). A graphic representation of the types of knowledge stored via transactive memory is shown in Table 4. Carley (2003) reported that transactive memory improves both the speed and accuracy of team performance.

¹³ As stated, a team can be viewed as a type of group and thus some group findings can be generalised.

Table 4. A representation of the types of knowledge stored via transactive memory (adapted from Carley, 2003).

	People	Knowledge	Tasks
People Relation	Social knowledge <i>who knows who</i>	Knowledge network <i>who knows what</i>	Assignment network <i>who does what</i>
Knowledge Relation		Information network <i>what informs what</i>	Needs network <i>what knowledge is needed to do what</i>
Task Relation			Procedure Network <i>what tasks must be done before what</i>

The effectiveness of transactive memory is dependant on the length of time that a team has been working together for. It would be expected that transactive memory would be a social process used within a HQ team in the Australian Army, but evidence is sparse. Both *taskwork* and *teamwork* are equally important in determining a good performance outcome. A documented example of this has been provided by Orasanu (1990) who found that, when put under pressure, less effective teams tend to maintain *taskwork* but neglect *teamwork*, whereas more efficient teams uphold both.

The third input factor identified was the *environment* or context. *Environmental factors* are those outside of the individuals and team that have a bearing on decision-making outcomes. Some examples include: the organisation, the type of terrain and the weather. Similarly to individual level decision-making, there has not been adequate research attention given to the influence of the environment/ context on team decision-making. It is expected

that *taskwork teamwork* and environmental level factors will be identified in the current dissertation as impacting on NDM within the unit level HQ.

The second stage of team performance requires process factors to mediate outcomes. Process factors are established through the interactions between each of the input factors and team processes. They lead to a performance outcome. A number of team processes occur simultaneously. For example: team orientation, team leadership, monitoring, feedback, backup behaviour, coordination and communication¹⁴ (Dickson & McIntyre, 1997; Dickson, McIntyre, Ruggeberg, Yanshefski, Hamill & Vick, 1992), supporting behaviour, decision-making and assertiveness are all process factors (Prince & Salas, 1993; Smith-Jentsch, Johnston & Payne, 1998). Arguably one of the most important process factors, that is easily observable for research purposes, is communication. Communication allows team members to establish a shared awareness of the current situation (shared mental models; SMM), draw on the knowledge held by other team members (transactive memory) and to subsequently coordinate their actions. Communication is particularly important during the initial planning and decision-making phase in unit HQ because it has been found that teams that engage in effective planning before a mission (task) develop a better shared understanding of the situation than those that do not (Stout, Cannon-Bowers & Salas, 1990) and perform better under periods of increased workload (Stout, Cannon-Bowers, Salas & Milanovich, 2000). Good communication can depend on the amount of experience the team has had together, with teams who have more experience demonstrating more implicit communication (Swaine & Mills, 2001). In line with this, Stout et al. (2000) found that effective teams tend to provide information in advance and without prompting. In sum, more effective communication leads to better outcomes, while poor communication leads to suboptimal outcomes (e.g. Billings &

¹⁴ A meta-analysis by Dickinson, McIntyre, Ruggeberg, Yanshefski, Hamill and Vick (1992) describes these processes as contributing to a seven factor model of teamwork.

Reynard, 1981, found that 80% of aviation errors could be attributed to poor team communication). Communication provides an easily observable and important process behaviour for investigation within the unit headquarters. It is anticipated that information transmitted via communication in unit HQ will assist to validate elements identified to impact on decision-making.

In summary, due to current challenges facing the Australian Army, focus is placed on the unit level CO decision-making. This means that the environment for the research is a naturalistic team environment, but with final decision-making responsibility lying with the individual CO. The actual and theoretical context for this research has been described, including a review of relevant teamwork theories, whereby generic inputs and processes for decision-making have been identified. The description of both individual and team decision-making achieved in Chapter 2 and 3 was important to inform the research methodology. This methodology is detailed in the next section.

3.2 The Research Methodology Overview

This section provides a description of the methodology chosen to investigate NDM at a unit HQ level in the Australian Army. The methods have been structured so as to develop a framework¹⁵ that will extract highly descriptive information spanning various levels of enquiry with a high level of external validity. The research design is consistent with the context of the project, as described above

The overarching research questions are:

- How does decision-making occur at the unit level in the Australian Army?
 - Is the RPD a valid model to describe decision-making for unit HQ?

¹⁵ The fundamental structure of methods within which interpretation of data is based.

- What elements impact on NDM in unit HQ?
- What is the relative importance of these elements?
- Is a microworld simulation a useful tool to explore NDM for application to the Australian Army?

To answer these questions, the design of the experimental framework reflected the: paucity of research on the contextual determinants of NDM, the environmental complexity (Zsombok, 1997) and the constraints on design and data collection within the context of the Australian Army.

The paucity of research on the topic meant that preliminary descriptive data would be important. Although the literature outlined in Chapter 2 has provided some insight into NDM, most research has been concerned more with the internal cognitive mechanisms by which decisions are made, rather than the contextual elements impacting on decision-making. Moreover, while there have been numerous descriptive studies on NDM drawing on the American military and other organisations, there have been few such studies in Australia. Thus, an initial exploratory and descriptive approach is entirely appropriate for the current research.

The complexity of the environment also impacts on the consideration of the appropriateness of research methods. Because of this complexity it is difficult for researchers to apply results in practical situations that were formulated under laboratory conditions. Thus, researchers have generally adopted a more applied approach to the study of how people make decisions in naturalistic environments. Most studies of NDM have been either conducted in the field, or validated in the field. For example, a leading researcher in the field of NDM, Gary Klein, has approached the topic by using techniques such as interviews and fieldwork. Lipshitz (2005) agreed that for NDM research “observation is an ideal method inasmuch as it allows researchers to study their subject matter *in situ*” (p. 375). These methods allow

researchers to gain a more realistic understanding of how decision-making is occurring in the real world and what the contextual elements are that will affect any model of decision-making employed in real world conditions. Therefore, similar methods have been incorporated here.

However, despite the advantages of *in situ* research that these methodologies offer, they are often questioned by researchers who favour experimental methods. Such debates constitute a substantial proportion of the published literature within NDM. In 2004, issue 14 of the *Journal of Behavioural Decision-making* contained a number of articles that debated the usefulness of the NDM approach. A concern of some authors was the frequent use “soft” science research techniques in the field of NDM (Caverni, 2004; Klayman, 2004; LeBoeuf & Shafir, 2004; Mann, 2004; Roelofsma, 2004; Whyte, 2004). Techniques criticised as “soft science” techniques included interviewing and field studies. The concern of experimental decision researchers was that insufficient rigorous control could be achieved using such techniques. In this issue, Lipshitz, Klein, Orasanu and Salas (2004b) rebutted this view, stating that we should be focusing on identifying the best methods to discover the required information. At present NDM is still building a profile of what NDM decision-making events actually look like. At this stage, exploratory, *in situ* experimental methods are useful. However, attention to scientific rigour within these methods should also be maintained.

The first NDM volume (Klein, 1993b) was published over a decade ago, and since this time there has been constant effort to establish NDM research as rigorous and scientific. Perhaps because of this continuing debate between the researchers from the two schools of decision-making, the rigour associated with many methodologies used within the field of NDM is of a high standard, compared with some other fields of research that rely predominantly on qualitative research techniques. For example, checksheets are useful

inclusions that improve rigour¹⁶. Reliability measurement has been extended beyond inter-rater reliability (Neuendorf, 2002) to include consideration of the influence that the researcher can have on the outcome. Data collection and interpretation need to be transparent and plausible (Lipshitz, 2005). Researchers like Klein have employed excellent methods of validity and reliability to their research and these will be drawn upon in the current research.

A final consideration when designing the current research was the constraints imposed by the structure and guidelines within the Australian Army. These issues can be grouped into the following categories:

1. Formal approval chains.
2. Lack of control over selection criteria for:
 - i) regimental membership and
 - ii) type and quality of experience.
3. Lack of control over exercise attendance.

Satisfying formal approval chains is a necessary prerequisite to conducting any research in this area. Due to increasing demands on military officers' time, there are limitations on accessibility to suitable participants. As might be anticipated within a military setting, research is generally given secondary importance compared with the hectic and sometimes unpredictable day-to-day job demands. Within the Australian Defence Force (ADF) a procedure has been put in place whereby accessing military participants requires adherence to formal approval chains within the organisation. These chains ensure the perceived value of the research to the Army in general and they evaluate research priority

¹⁶ Weike (1968) supported that the use of checksheets, which require only a judgement of whether something is present or absent minimise recorder bias. Moreover, Gellert (1955) emphasised that, the fewer the categories, the easier to manage and define well.

within the scope of tasks being undertaken in the ADF. In addition, research generally should not intrude significantly on the participant's time.

Moreover, it is difficult to specify particular selection criteria for participants. There are a limited number of unit HQ teams within Australia (approximately 50) and excluding participants from research conducted within this pool would be difficult. However, this means that research participants will be diverse in regards to their skills (regimental membership) and experience (type and quality). Some officers may have had experience serving in different overseas operations, both with the Australian Army and possibly other organisations like the United Nations. Others may never have experienced an operation and have updated their experience through practical training. Moreover, in recent years the diversity of military operations has ranged from anti-terrorist security operations at the Sydney Olympics, to peacekeeping in Bosnia and Afghanistan, to war in Iraq. Because the types of experience are so broad, it is not possible to compare or generalise experience between officers. Ultimately, this means that an understanding of expertise at higher levels of command in the Australian Army must remain problematical. Instead, as a measure of control, diversity of participants' roles needs to be taken into account when analyzing data.

Finally, due to the training system in the Australian Army, there is a distinct lack of control over timing and location of the research. Research must fit with the Australian Army's existing training and evaluation agenda. Thus, methods must be flexible. For example, observational field research has to be organised to fit conveniently with pre-existing military exercises. Thus, there can be little control over such things as the regiment observed, type of exercise or length of mission.

These issues were all considered in the design of the current research and a research plan has been organised within the four phases outlined in Table 5. This allowed smaller attainable goals to be set for each phase. This research framework has allowed a detailed examination of the hierarchically layered research questions described earlier. Overall, the

methods chosen have provided rich, descriptive data appropriate for NDM, they did not require large numbers of participants for data collection and they were sufficiently flexible to align with existing Army programs.

The validity of the research was an important consideration, particularly in light of recent criticisms of NDM research techniques. Cook and Campbell (1979) defined validity as the "best available approximation to the truth or falsity of a given inference, proposition or conclusion." (p. 33). Types of validity important in research are:

1. **Internal Validity:** Ensuring that independent variables are controlled within a study.
2. **Face Validity:** The practice of confirming that what is being measured produces results that at face value indicate the research topic. This is especially important in creating coding categories for data.
3. **Content Validity:** The extent to which the measures used actually represent the full scope of the concept being investigated.
4. **Construct Validity:** The "extent to which a measure is related to other measures in a way consistent with hypotheses derived from theory" (Neuendorf, 2002, p. 117).
5. **External Validity:** The extent to which the results can be generalised into the real world (Campbell & Stanley, 1963). It is often referred to as "generalisability".

Table 5. A description of the phases to guide research in the current project.

Phase	Purpose	Aim	Method
1	Exploration & grounding	To explore the validity of the RPD model for application to unit HQ. To identify and explore elements perceived to impact on the process.	Interviews
2	Expansion & confirmation	To determine relative importance of these elements.	Q-sort
3	Validation	To provide field validation for results generated during previous phases.	Field study
4	Microworld exploration	To determine the usefulness of microworld research for application to Army unit HQ.	Microworld experiment

These types of validity, excluding external validity, will be addressed in discussion of the particular methods chosen in subsequent sections. However, external validity can be most effectively addressed within the overall design of the method. Two methods by which this can be improved are: using multiple methods to collect data on the same phenomenon (triangulation) and choosing research methods that complement one another. Both of these measures have been employed in the current design.

Firstly, validity was achieved by using triangulation of research methods. Triangulation is the practice of increasing the validity of data by checking multiple sources. The underlying idea is, the more evidence one can compile, the smaller the doubt surrounding

the answer (Patton, 2002). This practice derives from the field of sociology and requires using at least three empirical indicators to investigate any particular complex theoretical concept (Denzin, 1970). Initially, the idea was borrowed from the area of navigation, where a position can be 'fixed' by using different kinds of measures (for example, a compass, sextant, radio bearings; Porter, 1994).

The current study integrated different research methods so as to triangulate the data (see Figure 8). Each method was used to gather data on unit level CO decision-making. Overlap and agreement within these data sets were accepted as confirming validity from any one particular phase. This use of various methods is also in line with the suggestion made by NDM researchers Lipshitz, Klein, Orasanu and Salas (2004a) that different research approaches should be used to counteract the weaknesses of any one method.

In addition to using multiple methods, overall validity of the research was improved by using complementary methods. Hofstede (2001) has discussed research methods as falling into one of four quadrants (see Table 6). Each quadrant by itself tends to lack sufficient validity but, by using methods from different quadrants, validity can be improved. The current research was planned to span all four quadrants, so that triangulation should provide a well-rounded approach to the research topic.

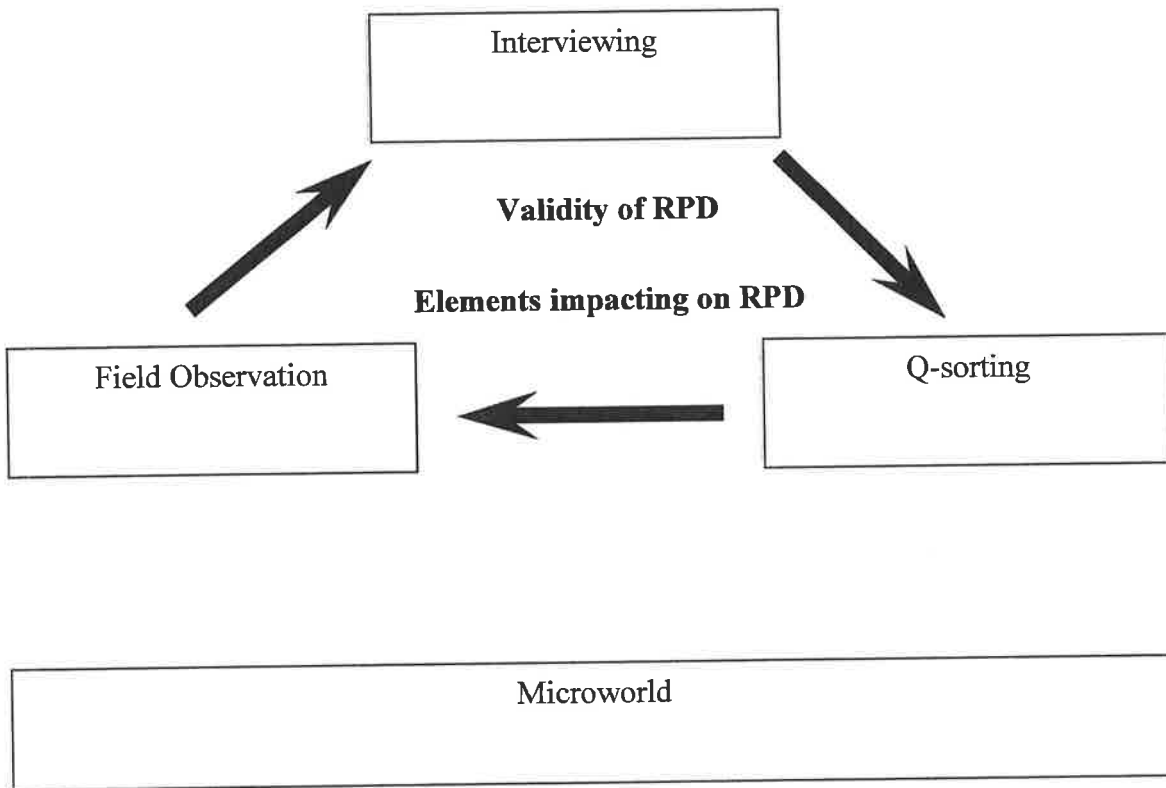


Figure 8. Increasing validity of the current research by using triangulated methods.

Table 6. Four strategies for collecting data (Hofstede, 2001).

	Provoked	Natural
Words	Interviews Questionnaires Projective Tests	Content analysis of speeches Discussions Documents
Deeds	Laboratory Experiments Field Experiments	Direct Observation Use of Available Descriptive Statistics

Note. The techniques used in the current investigation have been highlighted in bold.

The philosophical basis to the current research is important to understand. The research framework here uses both quantitative and qualitative research methods. In the literature on qualitative research there has been confusion regarding the potential of qualitative research for the generation of useful theories (Cutcliffe & McKenna, 1999). In particular, the reliability and validity of qualitative research have been called into question (Madill, Jordan & Shirley, 2000). This problem seems to have stemmed from inadequate definitions of the epistemological stances taken by qualitative researchers when reporting their studies.

Traditional survey and experimental research in psychology has generally originated from a realist framework. Thus, stating an epistemological approach in the reporting of results is generally not required. However, qualitative research can be conducted under different philosophical frameworks. These can be broken down into three main approaches: realist (natural science), contextual constructionist (human science) and radical constructionist (poststructuralism; Henwood & Pidgeon, 1994; Parker, 1994). Thus, because of the inclusion of qualitative methods, it was deemed important to address the philosophical stance at the outset of this research.

Each philosophical approach has differing core beliefs and consequent stances on reliability and validity of data. Hence different methods are generally employed in order to maintain the credibility of the results. These epistemological approaches are briefly outlined in Table 7.

The epistemological assumptions adopted by the researcher impact on the measures used to understand the validity and reliability of the results. Thus, according to Madill et al. (2000), "...qualitative researchers have a responsibility to make their epistemological position clear, conduct their research in a manner consistent with that position and present their findings in a way that allows them to be evaluated appropriately." (p.17). The current research

has been approached from a critical realist perspective and throughout, the research measures appropriate to this standpoint were used to add credibility to the current research.

In sum, the research framework described above was adopted to provide rich, descriptive data, in response to the proposed research questions. The methods are not dependant on large numbers of participants and are sufficiently flexible to fit in with pre-existing plans of the Australian Army. A high level of validity was planned as discussed in terms of triangulation and the choice of complementary methods. By satisfying all of these requirements it was anticipated that the research framework would provide results with applicability to the development of new doctrine in response to NCW, improving command support systems, and developing new training methodologies in the Australian Army. They would also be useful to validate the existence of NDM within the Australian Army.

The next section describes the methods associated with each phase of the research and how rigour has been maintained throughout.

3.3 A Phase by Phase Description of the Research Methods

This section describes each phase in the current research, discussing aims, participant population and research method chosen. Detailed justification for the methods will be given and other issues associated with data collection highlighted. The requirements for rich descriptive data, small participant numbers and flexibility have been addressed in the selection of appropriate research methods.

Table 7. A description of validity in qualitative research across epistemologies.

Framework	Core Belief	Stance on Reliability & Validity	Types of Checks
Realist	<p><u>Naïve</u> - the world is largely knowable. It is how it appears.</p> <p><u>Scientific</u> - Although fallible the scientific method can capture true representations of the world.</p> <p><u>Critical</u> - way we perceive facts, particularly in the social world depends upon our beliefs and expectations (Bunge, 1993). This admits an inherent subjectivity in the production of knowledge.</p>	<p>In the realist framework ideas of reliability and validity can be used with only small adaptations because we are working under the assumption that things will be the same again and again.</p>	<p>Triangulation (Denzin, 1970)</p> <p>Member checking Auditing the procedure (Creswell & Miller, 2000)</p> <p>Inter-rater reliability (Neuendorf, 2002)</p>
Contextual constructionist	<p>A contextualist framework implies the assumption that all knowledge is local, provisional and situation dependant (Jaeger & Rosnow, 1988).</p>	<p>Terms for validity are distinct from those used in realist paradigm (credibility, transferability, confirmability, etc.) Truth will vary according to contextual elements. Thus the depth of research and description is important.</p>	<p>Disconfirming evidence Prolonged engagement in the field Thick, rich description (Creswell & Miller, 2000)</p>
Radical constructionist	<p>A radical constructionist framework implies the assumption that meaning is generated by individuals and groups, thus there is no one true reality (Lincoln & Guba, 1985).</p>	<p>Validity is questioned, as there is thought to be no one true reality. In order to have a credible interpretation the stance of the researcher must be adequately identified.</p>	<p>Researcher reflexivity Collaboration Peer debriefing (Creswell & Miller, 2000)</p>

3.3.1 Phase 1: Interview method background and justification

The first phase explored the concept of NDM within an Australian Army unit environment. Aims were to search for evidence of RPD in the Australian Army and to identify elements perceived to impact on unit level CO decision-making. The population of participants being drawn upon were unit level COs in the Australian Army. Because this pool is already limited, other strict selection criteria were not enforced (see Chapter 4 for more information). Background information was collected.

A number of studies in the literature looking at elements impacting on decision-making processes have begun with an interview approach to generate a list of possible elements for further testing (Laurence & Elliott, 2004; Verville & Halington, 2002). Moreover, interviews have also been a popular method within the field of NDM. Thus, the use of semi-structured interviews appeared to provide a particularly useful way to begin data collection.

People are interviewed in order to discover information not directly observable (Patton, 2002). By interviewing, the researcher attempts to extract knowledge about another person's experiences. The assumption therefore is that the perspective of others is meaningful, knowable and able to be made explicit (Patton, 2002).

The interview has a number of advantages. These include: it can provide information richness, information is extracted in a guided manner (this focus on the topic achieves efficiency), time taken can be controlled, a small number of participants can create meaningful data and standardization across participants is possible. Interviews allow researchers a certain level of control over the situation, while still allowing a more free exchange of information than that found in most laboratory style studies (Rossman & Rallis, 1998). A final advantage is that, while offering depth of qualitative analysis, interviewing also offers the potential for a quantitative analysis.

However, interviewing, like many other research techniques, also has typical flaws. These are: the researcher can have an impact on what is said, the context influences what information the participant volunteers, the variability of responses can generate a problem of inference when reporting results; and the most common criticism is that the verbal account given may not equate to the actual behaviour.

Like any research technique, to obtain the best results possible, certain control measures need to be applied in order to minimise bias. Similar to controlling variables in a laboratory environment, interview researchers incorporate a number of checks and balances to ensure that the data obtained is as valid and reliable as possible. Objectivity has been achieved in the interview phase by structuring the research in a particular way. Firstly, care was taken in structuring the interview questions in order to minimise typical biases found in many interview research designs (e.g. interviewer effects and pre-determined responses). In the current design, clear, open-ended, non-dichotomous questions framed in the language of the participants were used. Also, specific opportunities were presented where participants could bring up any other points they thought were relevant to the discussion. This allowed the data extracted to extend beyond the preconceived structure of the interview.

Secondly, the context (including the physical environment in which the interview occurs, and the relationship established between the interviewer and the participant) may have an impact on the information elicited (Wengraph, 2001). These two elements were taken into account in the current research. In most cases, each interview was conducted in the participant's work office. It is suggested that this is an environment in which the participants would feel comfortable, and also allows for minimal time away from work. The researcher also aimed to develop a good rapport with each of the participants in order to facilitate information transfer.

A third criticism of interviews is that they can result in variable data. This has been addressed in both the structuring of the interview and the interpretations made from the data.

A semi-structured interview technique was chosen, which allows for a level of standardization across participants, but also the opportunity for further exploration of topics identified as important by the participant (Patton, 2002). Further, this structure was taken into account in the analysis and interpretation of the interviews.

Finally, the most common criticism is that the interview account may not equate to the actual behaviour. This criticism has been addressed in two ways in the current design. Firstly, this was addressed by incorporating triangulation¹⁷ with observational methods into the overall design. Validation through observational methods was appropriate because the focus of the research is not purely on the internal cognitions of the CO, but also on the system within which s/he is immersed (Reason, 1990). By placing the focus here a more observable system was created. Thus, behavioural validation of most interview data was possible.

Secondly, the validity of the interview account has been improved by employing interview methods designed to extract information through the interview process that is as true to life as possible. Basically the premise is that usually people do not verbalize their actual behaviour; instead they focus on judgements, comments, generalities or a description of the circumstances (Vermersch, 1994, cited in Light, 1999). These things are subjective. In order to create a more objective approach, a participant can be immersed within a situation in order to construct an understanding of that past experience. Several techniques have been developed based on this premise. Early examples of immersion interviewing techniques are the critical incident technique (CIT; Flanagan, 1954) and Vermersch's (1994, cited in Light, 1999) explication interview technique. They draw on a set of procedures used to collect observations of human behaviour, by immersing a participant in their previous experience (Norman, Redfern, Tomalin & Oliver, 1992). A limitation of these techniques is the accuracy

¹⁷ Triangulation is the practice of increasing the validity of data by checking multiple sources (Denzin, 1970; see Chapter 3).

of human memory (Loftus, 1980). However, when used in combination with other techniques they provide good sources of data. A more recent example of an interviewing technique that immerses participants in their past experience, that has been tailored for use in emergency situations, is the critical decision method (CDM; Klein, Calderwood, & MacGregor, 1989). CDM is a form of cognitive task analysis that attempts to break down complex cognitive tasks into simpler constituent parts. It is a retrospective interview strategy that aims to discover the decision-maker's understanding during the course of a critical incident. Critical incidents¹⁸ are drawn upon because they are a rich form of data, often exploring them in terms of successful and unsuccessful practices in a particular organisation (Norman et al., 1992). The unique contribution of CDM is that cognitive probes used are developed from the RPD model and used to examine the critical incident carefully in more detail (O'Hare, Wiggins, Williams & Wong, 1998). This pre-designed set of cognitive probes is applied to actual non-routine events. The focus on non-routine events is because they are the richest data source about the capabilities of a highly skilled person and by placing the focus here, efficiency is achieved.

Klein et al. (1989, p. 464) suggested that three criteria met by the CDM that emphasise its utility are:

1. It addresses the basis of expert decision-making performance as described by the RPD model.
2. It is applicable under field conditions.
3. It has applied value (in terms of training, system design, or development).

The basic format of CDM is a sweeping interview process, where the participant is guided while recounting the selected incident. The procedure used in CDM begins by asking

¹⁸ Flanagan's (1954) definition of critical incident is an incident in which the purpose or intent of the act is clear to the observer and the consequences are definite (cited in Norman, Redfern, Tomalin & Oliver, 1992).

the participant to bring to mind an incident in which his/her expertise made a difference to the outcome. This incident is then freely recalled in detail. Following this, the researcher aids the participant to construct a time-line in order to establish the precise sequence of events. The incident is then considered in more detail by using specialised cognitive probes. The emphasis is on 'perceptually based cues that are difficult or unnatural for people to articulate' (Klein et al. 1989, p. 465). These cues are thought to provide a basis for understanding the concept of *pattern matching*, which is central to the RPD model.

The final step is to use a series of "what if" questions. These are used to clarify ideas and to provide points of comparison for analysis. However, because they do not require the expert to be directly immersed in experience (instead they encourage the projection of a possible alternative outcome) this section deviates from typical immersion interviewing techniques. The findings from these questions should be viewed with caution, and drawn back to the participant's experience as much as possible.

Previous studies using the CDM have found that it produces high inter-rater reliability in the order of 81-100% (Calderwood, Crandall & Klein, 1987; Taynor, Crandall & Wiggins, 1987). The comparative validity of CDM was examined by (Klein, 1996). Two groups of highly experienced Fire Commanders were involved in the study. Each Commander was shown the same simulated scenarios. The first group were asked to "think aloud" and the second group were interviewed using principles of CDM. This study found that Commander's vocalizations during the CDM condition included far more situation assessments and evaluations of cues and goals.

From the above research, it was decided that CDM was a suitable method for extracting more autonomous knowledge. Moreover, recent research by O'Hare and Wiggins (2004) has supported the underlying assumption of CDM, that expert knowledge can be organised around case-based reasoning and stories. However, as yet, no test has been

achieved to assess the external validity of information extracted using the CDM. Therefore, an important measure is to check findings derived from the method with field observations.

The CDM technique is appropriate to the current research question because:

- It provides a rich source of data that identifies a critical decision point.
- Theoretically it provides more objective outcomes because it immerses participants within their experiences and evokes event specific descriptions.
- The context can be probed by establishing a sequence of events surrounding the decision point.
- It is appropriate for use with unit COs, because it has been developed particularly for use in emergency situations, by drawing on understandings gained from the RPD model.

Content analysis of interview data aimed to identify the validity of the RPD model and the elements perceived to be of importance in decision-making. These elements were then integrated into the next phase to determine their relative importance. A more detailed discussion of the interviewing approach taken in the current project can be found in Chapter 4.

3.3.2 Phase 2: Q-sort method background and justification

The aim of phase 2 was to confirm and organise in a meaningful way the results from the interviews. In essence, the interviews (phase 1) aimed to extract from the COs a range of elements perceived to influence their decision-making. A Q-sort (phase 2) then allowed for these elements to be taken to a larger sample of COs and Operations Officers (OPSOs¹⁹), to

¹⁹ Operations officers work closely with COs at the unit level and hence have a good understanding of the CO decision-making process. They were included in the population pool to increase potential numbers of respondents.

look for variability of responses and confirmation or disconfirmation of the importance of the elements identified. The Q-sort also explored similarities and differences in the overall perception of these elements between individual COs.

The Q-sort method can be used to examine, in detail, people's opinions on a particular matter. It requires participants to arrange a number of statements (chosen by the researcher) along a continuum from *strongly agree* to *strongly disagree*. Once the sorting of statements has been completed, the data are factor analysed to reveal the opinions held within the group under investigation. Data are analysed by correlating each Q-sort (participant) with the others. This analysis indicates how similar or different the Q-sorts are. Participants who significantly correlate on any given factor are assumed to share a common view (possibly based on similar experiences). More generally, correlations between participants determine clusters, which are a group of Q-sorts that resemble each other. A factor analysis of the data then clusters people who ranked these things in a similar position. The factors extracted from the factor analysis represent participants' points of view. Finally, the strength of association between a particular point of view, and any given factor is established by calculating factor scores. These are essentially weighted z scores of the factor. They represent the "loading" that a statement has on each particular factor. These scores help to establish the important contributing "points of view" to each factor, thereby aiding in factor definition. The Q-sort thus combines both quantitative and qualitative methods, in order to generate theories (Stephenson, 1953).

The Q-sort technique is not typically a well understood method within psychology and the following section is necessary to discuss Q-methodology and its outcomes, the advantages of applying this method to the current research and finally points of misconception and common criticisms, with reference to the current design.

The steps typically involved in Q-methodology are detailed in Figure 9, which depicts the main stages involved in the method (Figure 9; adapted from Amin, 2000). Because of the use of factor analysis to interpret results in Q-methodology, the results it produces are often

confused with typical factor analytic research. However, a good illustration of the different results generated by Q-methodology and a typical factor analytic study was illustrated by Brown (1972, 1980). He used the human body as a subject for scrutiny. Twenty-five bodily objective measurements (arm length, thigh width, foot length, etc.) were collected for a sample of 20 people. A typical R factor analysis resulted in a segmentation of body parts across eight factors, with shoulder width, arm length, width of palm and foot length (among others) significant in one factor, chest and waist width in another factor etc. Factor analysis (R) breaks whole things into related parts. If this same data matrix was transposed and re-factored, it creates a single factor accounting for 99% variance in the results. This reflects that people are fairly much the same. In sum, R-analysis is based on objective measurements (For example a person's shoulder width is x centimeters long and this holds true whether correlating traits or persons).

In order to perform a successful Q-sort, a matrix of subjective data (opinions) must be generated (Stephenson, 1953). In this case, the same 20 individuals were asked to assess the same body parts in terms of their "significance for me." From this, different saliencies relative to the body parts were revealed in the resulting Q factors. For example, the first factor, placed emphasis on eyes, head, and mouth, which received the highest factor scores.

For both the objective and subjective data analysis, an artist was asked to draw an impression based on the data. The result is shown in Figure 10.

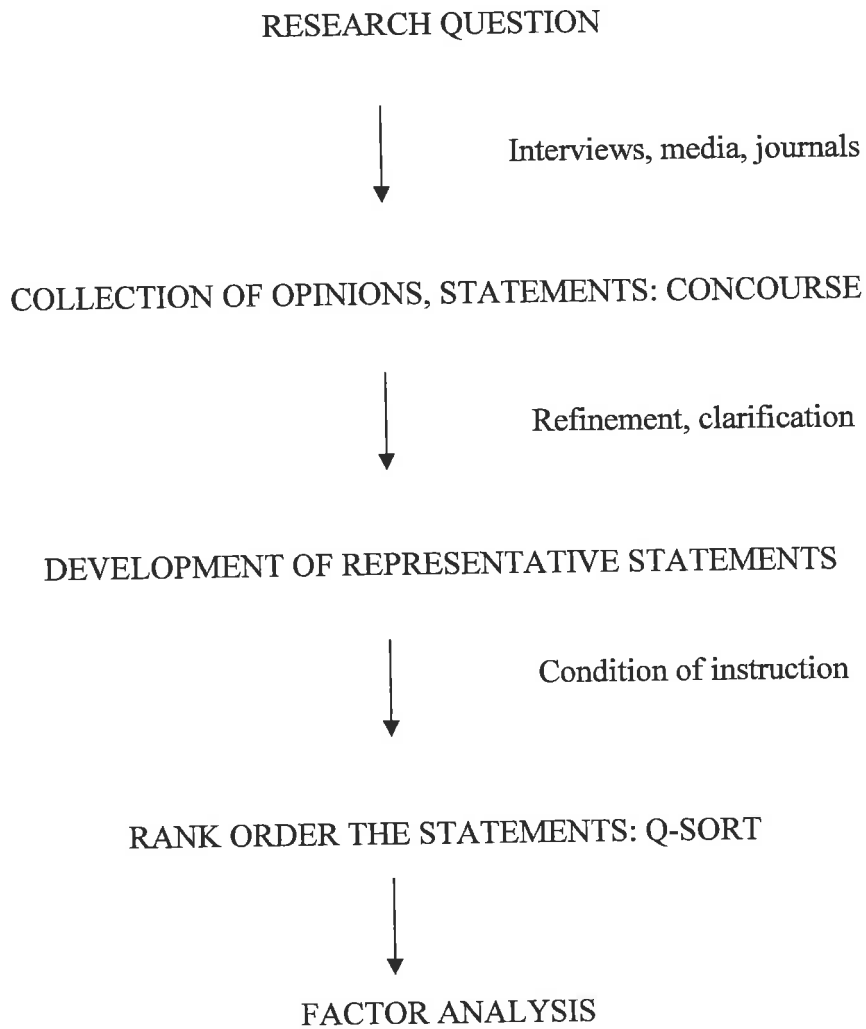


Figure 9. A step-by-step description of Q-methodology.

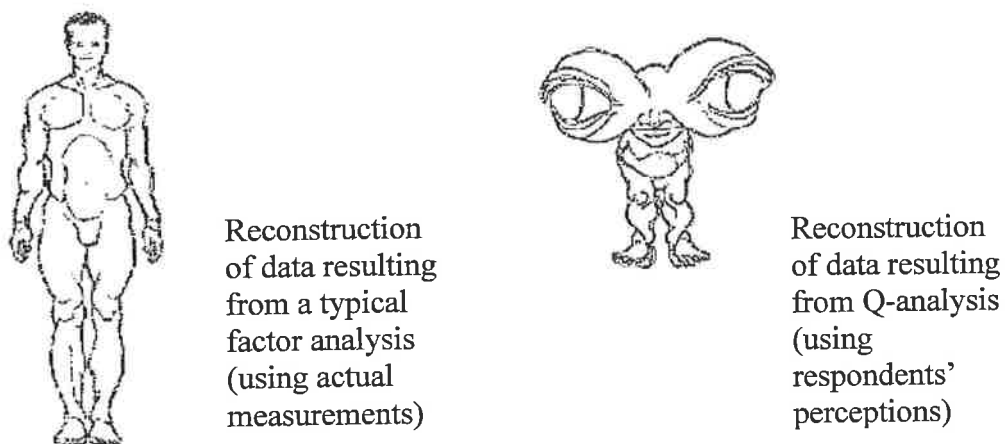


Figure 10. A comparison of pictorial representations of data from an analysis of objective and subjective data (adapted from Brown, 1972, 1980).

Q-methodology was chosen for this stage for a number of reasons. Firstly, it forces the comparative ranking of a large number of opinions. This was useful in order to gain an understanding of how the elements identified in the interviews compared with each other in terms of their importance. It is argued that the resultant arrangement of statements provides data on participants' internal frames of reference²⁰, which are used to guide decision-making (Sexton, Snyder, Wadsworth, Jardine & Ernest, 1998).

Secondly, there was a desire to search for similarities in opinion across participants. Anecdotal evidence suggested that unit level COs are all experts, but because of their unique previous experience they tended to view things in different ways. Therefore, it was necessary to find a method that could ascertain whether elements impacting on unit level decision-making were seen in a similar way by most participants, or whether there were distinct groups within the sample. The statistical analysis used in Q-methodology allowed for this. Unlike the analysis of many surveys, Q-methodology does not assume that all individuals tested hold one homogeneous opinion (Kitzinger, 1999; Mrtek, Tafesse & Wigger, 1996). Instead, it caters for the assumption that people's opinions may differ and it is important not only to find averages but the broader spectrum (Brown, 1980; cited in McKeown & Thomas, 1988). It determines what is statistically different about the participants' frames of reference and identifies individuals who may view things in a similar way (Lipgar, 1999; Sexton et al., 1998).

Thirdly, Q-methodology was appropriate because, to date, there has been scarce research on describing the array of elements impacting on unit level decision-making. Q-methodology has been recognised as useful for in-depth exploration of unknown areas for their identity, interrelations and functioning (Kerlinger, 1973). The purpose of Q-

²⁰ Internal frames of reference include such things as: experiences, opinions, ideas, beliefs and perspectives (Kitzinger, 1999).

methodology is to gain scientific understanding before prediction and control (Lipgar, 1999). Although there is no great potential for generalisation, it provides a solid basis to be followed with other methods to enhance prediction (Amin, 2000).

Fourthly, Q-methodology was appropriate because it allowed the researcher to gain an understanding of the decision-making task from the viewpoint of the CO and other experts who work within the unit HQ decision-making team. This was possible because Q-methodology allows experimental control to be given mainly to the participants. This is done by aiming to understand the participant's own definitions of a concept rather than giving him/her a definition and trying to understand responses in light of that (Kitzinger, 1987). Thus, in Q-methodology, generation of a research hypothesis is not always necessary because the respondents' viewpoint is being explored and not the researchers²¹. This viewpoint is obviously important when considering the design of command support systems (CSS), because the success of CSS is undoubtedly linked with their ease of use, and the desire of the end user (the Commander or other HQ staff) to make use of them.

Fifthly, because Q-methodology relinquishes experimental control to the participants, rather than conforming to the hypothetico-deductive model, it avoids many flaws inherent in other research methods. These include: response bias from surveys, missing responses, social desirability of response and interviewer bias. In Q-methodology, Stainton-Rogers (1991) points out that "A factor cannot emerge unless participants sort items in ways to enable it to do so." (p.130). For example, with other techniques (such as interviews) the researcher has to make some kind of a judgement about which views are most important to the interviewee. However, in Q-methodology, these are given to the researcher directly by the placement of these items at the extremes of the scale (Kitzinger, 1999).

²¹ Stephenson (1953) questioned the prominent hypothetico-deductive paradigm of the time. Instead, he believed that researchers still needed to have curiosity about research material.

Finally, Q-methodology combines both qualitative²² and quantitative techniques. An advantage of qualitative data is that they permit an in-depth, context bound analysis of data. A disadvantage is that such data cannot always be amenable to quantification. Data resulting from a Q-sort, however, are amenable to statistical analysis. It is the Q-sorting that initially prepares the structure of subjectivity (i.e. the factors that emerge are due to the Q-sorting operations of the participants (Stephenson, 1977). Following this, the statistical processes render the structure apparent through mathematical representation. This allows a description of the data to be achieved that would be missed without numerical treatment.

There is a common misconception regarding Q-methodology that must be clarified. According to Amin (2000) between the conception of the Q-sort method and the year 2000, 4000 articles on the Q-method have appeared in scientific journals. These appeared predominantly in the social sciences (Amin, 2000). A survey by Brown (1968) found that Q-sort is used across disciplines including psychology, education, nursing, sociology, political science and communication science. Considering the length of its existence this is not a large number of publications. However, the author believes that the sparse Q-methodology literature is related to both lack of knowledge of the technique and misconceptions about the methodology.

The most common misconception seems to be that Q-methodology has an underlying post-positivist philosophy. In order to evaluate this claim critically, the researcher has found it useful to explore the method in its historical context (see Appendix III). In sum Q-sort can be used within a positivist framework in order to explore COs' internal frames of reference. In particular, it will provide a description of the comparative importance of elements perceived

²² Strauss and Corbin (1998) distinguished between qualitative and quantitative research by offering the following definition. "By the term *qualitative research* we mean any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification" (p. 17).

to influence decision-making across a group of unit COs. This method typically does not require a large number of participants and it can be administered via email so that participants can complete the task in their own time. A specific description of this phase of research will be given in Chapter 8.

3.3.3 Phase 3: Field observation method background and justification

Phase 3 of this research aimed to provide external validation of results extracted during previous phases. In essence, this field research involved taking the data generated from the interviews and Q-sort and looking for corroborative evidence in the field. The pool of participants again was the unit level COs in the Australian Army. Actual participation relied on acceptance to attend scheduled field exercises.

Observational analysis is a useful tool for gaining insight into how the observed group behave within their natural setting. It reduces the element of artificiality introduced in many laboratory studies, but maintains objectivity because behaviour is observable and can undergo reliability testing. In addition, the use of field research does not require large participant numbers and in this case was flexible enough to fit in with existing exercises scheduled for training in the Australian Army. Thus, there was minimal disruption of the participants.

Patton (2002) argued that there are six main strengths of observational research. These are:

1. Observation allows a better understanding of the context within which behaviour occurs.
2. Firsthand experience allows researchers to be more inductive in their observations and analysis, not basing these entirely on prior understandings.
3. The researcher has the opportunity to see things that might regularly escape the consciousness of the participants (all social systems involve routines that can become unconsciously acted).

4. A researcher may learn things participants are unwilling to talk about.
5. Observing goes beyond the selective perceptions of others.
6. Observation allows the researcher to achieve personal knowledge and experience of the situation of interest.

Thus, observational field research offers strengths that do not exist in previous methods used. It is expected to offer a deeper understanding of previous findings, enriching and validating interview and Q-sort data.

Observational techniques are used in a variety of established methodologies. Examples of these are: ethnography, grounded theory, and animal behaviour. All rely on observation as a means of data collection and field notes are typically collected across all methodologies. However, techniques differ in their unit of analysis, the role of the observer and often in their underlying philosophies.

The unit of analysis in ethnography is normally focused on studying cultures. Thus, group level data are generally collected. Animal behaviour research can be focused on the individual or group level, depending on the research interest. Grounded theory is not generally used to study groups or individuals, but instead can be used to develop a theory about any phenomenon and is most appropriate in the case of the current research. The current method focuses on the CO in particular, and how s/he interacts with the team in order to make decisions.

The role of the observer in ethnography involves active participation of the researcher, whereas grounded theory and animal behaviour tend generally to be unobtrusive methods. In order to remain as objective as possible, the current research positions the researcher as an unobtrusive observer. It was deemed important to learn as much as possible about the “group” being observed before commencing observation. This was done through communication with military personnel and reading existing doctrine.

The underlying research philosophies are where the major differences can be found in different observation methods. Animal behaviour is firmly grounded in a realist framework. From this point of view the world is largely knowable and, although fallible, the scientific method can capture true representations of the world (Madill et al., 2000). However, the way in which we perceive facts can depend upon our beliefs and expectations, and this must be taken into account in reporting (Bunge, 1993). Both ethnographic and grounded theory research have been used across philosophies (i.e. realist, contextualist²³ or radical constructionist²⁴ frameworks). This impacts on the way in which the data are analysed and reported. The current research takes a critical realist approach to knowledge, because this is in line with the view taken across the thesis as a whole.

A number of other factors needed to be decided upon in observational research that affects the nature of the data collected. These were: whether research methods are triangulated in the field setting; the length of observations; the most appropriate sources of data.

Triangulation of methods within the field adds to the depth and objectivity of the interpretation (e.g. a combination of behavioural data, and short interview data). However, short interviews can be intrusive on normal behaviours in an observational study. The researcher needs to be aware of this, and approach the participants at times convenient to them. This was considered in the current study.

The length of observations is not always under the control of the researcher. Traditional ethnographic research could involve the researcher in the field for a minimum of six months. For the current research, the researcher was given access to short training

²³ A contextualist framework implies the assumption that all knowledge is local, provisional and situation dependant (Jaeger & Rosnow, 1988).

²⁴ A radical constructionist framework implies the assumption that meaning is generated by individuals and groups, thus there is no one true reality (Lincoln & Guba, 2000).

exercises. Therefore, observation time depended on the length of the exercise. This led to the necessity to evaluate whether the amount of time allocated was long enough to answer the research question. As a basis for further research, the observations in this study were deemed sufficient. However, in order to determine the significance of the results longer observations would be necessary.

The most appropriate source of data also needs to be chosen. There is a vast array of possible sources of data. These include: the program setting; human/social environment; activities undertaken; informal interactions; language and communication and observing what does not happen (e.g. there may be a distinct lack of communication between two people that one would expect to communicate and this may guide the researcher to question why this might be). It is important to choose which of these are most appropriate for the research topic, because it is difficult to collect them all without missing crucial pieces of information from each.

For the purpose of the current study the pieces of information considered to be most relevant were the setting, the social environment and the types of communications used. By observing the setting, an understanding of the environment in which previous research findings are embedded is gained by the researcher. Understanding the social environment is important in order to monitor effectively and interpret communications. Finally, communication is thought to be a medium by which the “team mind”²⁵ is observable to an outsider for analysis. Thus, observing these variables provides a good basis for testing the current study’s hypotheses.

²⁵ See Klein, G.A. & Thorsden, M.L. (1990). *A cognitive model of team decision-making*, Klein associates, Yellow Springs: OH.

Data collection in observational research is generally done in two phases; the mapping phase and the data collection phase. During the mapping phase preliminary data are collected. This provides a chance for familiarisation with the environment. Notes can be collected on physical layout of the environment and the types of activities exhibited (Ratcliff, 2001). This phase allows for the generation of checksheets listing typical behaviours of interest that can be used for later data collection. Following this, the main data collection stage begins. For the research reported here, notes will be taken at this stage. These will include:

- **Behavioural frequency counts-** based on mapping out observations, and related to prediction accuracy. These will be made on behavioural frequency count sheets.
- **Notes**
 - **Field Notes--**A running account of what happens or transcriptions of video or audiotapes. It is important to be thorough in taking field notes, particularly at the earliest phases of research. As much as possible, the observer should try to get the whole picture of what is happening.
 - **Personal Notes--**Personal reactions, how the observer was feeling, self-reflection, memories, and impressions. This is similar to a diary, so the observer can later see possible personal influences on the data, and identify the effects of personal events on the data collection and analysis.
 - **Methodology Notes--**Description of methods used, reasons for using those methods, ideas for possible changes in methodology. These are used for keeping track of changes and rationale for changes.
 - **Theoretical Notes--** Emergent trends, hypotheses. This can also include guesses and hunches to follow up in later research. Note taking is also

used to describe changes made to emergent categories and hypotheses, and the reasons why those changes were made.

In field research it is important to include practices within the research design that maintain high reliability and validity. Patton (1990) stated that “validity and reliability of the qualitative data depend to a great extent on the methodological skill, sensitivity, and integrity of the researcher” (p. 11). Therefore, the responsibility lies with the researcher to develop a sound experimental framework and provide strong evidence for their claims. Two main considerations must be made in order to address this issue.

Past criticisms of observational research have hinged on the fact that the researcher is an active participant in data collection and interpretation. However, scientific results are ideally independent from the person who produces them (Breuer, Mruck & Roth, 2002). In field research complete independence is not possible. Hence, researcher bias²⁶ is a potential problem. This element of subjectivity is controlled by using inter-coder reliability checks.

Secondly, scientific results are ideally generated without influence from the experimenter. However, in observational research it is necessary for the observer to be close enough to the participants to make accurate observations. However, by doing this, there is an added possibility that the observer may influence the behaviour of participants. Previous research has found that if participants know they are being studied, they perform differently based on this knowledge (Hawthorne Effect; Mayo, 1933). This is another possible limitation that must be considered. In an attempt to control for this effect, an unobtrusive stance has been adopted. The observers were dressed in military attire (similar to the participants so as to blend in) and were positioned in discreet locations where accurate observations were still possible. Thus, it was expected that the observers blended with the environment so that the

²⁶ A number of human biases have been suggested as affecting our judgements (Kahneman, Slovic & Tversky 1982; Plous, 1993).

participant could act as if the observers were not present. Moreover, it is not unusual in the Australian Army for observers (unknown to the exercise participants) to be present during exercises. This presence can be for a number of reasons and is an accepted part of training operations.

The observational data and short interviews were analysed using content analysis. A more specific description of this phase will be given in Chapter 6.

3.3.4 Phase 4: Microworld simulation method background and justification

The aim of the final phase of the research was to determine whether microworld simulation is a useful tool to further investigate NDM in the Australian Army (taking results from previous phases into consideration). Because the final phase of the current research investigated NDM on a computer simulation, a population of non-military volunteers were adequate. It has been suggested that NDM results generated on Networked Fire Chief (*NFC*) should be transferable across domains (Omodei et al., 1998; Omodei, McLennan, Elliott, Wearing & Clancy, 2005). Moreover, previous research has found that military experience offers no advantage on a computer microworld (e.g. Chapman, Nettelbeck, Mills & Welsh, 2006). These volunteers could then be trained. This made participant recruitment more achievable. The selection criterion was that the participants were computer-literate university students. The assumption was made that IQ is relatively consistent amongst participants.

Manipulating variables within a controlled environment can produce clear ideas of relationships between variables and causality. Considerable decision-making research has been based in the laboratory but, because of the environmental complexity inherent in NDM, laboratory research has not been commonly used in this field. However, with the recent advent of information technology, embedded testing within computer games has become a viable option. This has been seen by many researchers as an appropriate medium within which to examine basic cognitive rules or constructs believed to be associated with NDM

(Ackerman & Kanfer, 1993; Brehmer & Dörner, 1993; Funke, 1991; Omodei & Wearing, 1995; Weaver, Bowers, Salas & Cannon-Bowers, 1995).

Existing technology has made a number of different types of simulation possible with today's level of technology (see Table 8). Attendance at Army exercises is similar to "simulated /standardized actors" but lacks the associated control. From a practical viewpoint, although high fidelity simulation is by definition the closest to real life, it is also extremely expensive and resource intensive to set up. Following this, the most popular form of simulation used for NDM research has been computer simulation using tools called microworlds.

A microworld is where "we select the important characteristics of the real system and create a small and well controlled simulation system with these characteristics" (Granlund, 1998, p. 91). The advantage of computer simulation research is that it allows researchers to set a relevant complexity level in a controlled research environment. A microworld generates an on-screen environment that the user needs to interact with in order to produce a good outcome (e.g. fight fires in a forest to save land from burning and people from being killed).

Microworlds do not attempt to mirror everything that occurs in an equivalent real world context. Instead, they are tools used to investigate theories (Chapman, Mills, Kardos, Stothard & Williams, 2002). They focus on the essential psychological features of the decision-making environment (e.g. generating stress, dynamic conditions), but often disregard surface features (e.g. landscape features). Thus, they incorporate the same sorts of variables that would be involved in a real world NDM situation, such as uncertainty, complexity, and feedback loops. These variables that are exhibited in microworlds have been found to be similar across domains encompassed within the NDM theory; such as oil rigs, emergency rooms, fire fighting, military operations (Salas & Klein, 2001).

Table 8. Description of different types of simulation available.

Type of Simulation	Tool	Description	Capabilities
Low fidelity	Models or mannequins	<i>Practice simple physical moves or procedures</i>	Procedural skills (e.g. CPR)
	Screen based computer simulators	<i>Computer programs designed to train/ assess knowledge and decision-making.</i>	Knowledge Decision-making
High Fidelity	Simulated/ standardised actors and settings	<i>Actors trained to role play in a realistic but controlled setting</i>	Procedural skills (some) Communication skills Knowledge Decision-making
	Virtual Reality	<i>Computer driven, life-sized virtual reality scenarios constructed to represent scenarios as true to life as possible.</i>	Procedural skills Communication skills Knowledge Decision-making Team skills

Although it is a low fidelity simulation, a microworld is cost efficient and can require no more resources than a computer in a room. Using this medium is an attractive alternative to field research because there are often limitations in participant accessibility and appropriate research exercises. However, before turning to simulation as a medium for research, it must be understood what types of research questions can sensibly be answered in research using microworlds.

Several NDM-style simulations are available. For example, Lewandowsky and Kirsner (2000) used a computer generated bush fire prediction task to investigate the effect of context on decision-making. Other studies have been conducted by Artman (1998/1999) that also used a similar fire fighting simulation to test the effectiveness of different communication

networks. In Australia, a similar fire fighting simulation called *Networked Fire Chief* (NFC) has been used to investigate such things as management structures, communication styles, and tool usage (Chapman, 2000; Wearing & Omodei, 1998; Omodei, McLennan, Elliott, Wearing, & Clancy, 2005).

Nonetheless, there is some uncertainty about the usefulness of microworlds to provide meaningful answers for application to the real world environment (e.g. Chapman, Nettelbeck, Mills & Welsh, 2006). The current phase will therefore investigate whether microworlds can replicate important variables associated with decision-making in a real-world Australian Army environment. Data are captured using behavioural checksheets, questionnaires and interviews. A full description of the method will be presented in Chapter 7.

3.4 Overall Strength of the Methodology

In sum, the research was divided into four phases. The research techniques applied to each phase have been described, with particular attention to the aims, population pools and standards of rigour including reliability and validity. This methodology is one of the strengths of the current research because it incorporates good standards throughout. This high standard is essential to NDM research, where in a recent NDM volume Montgomery, Lipshitz and Brehmer (2005) assert that “The challenge of demonstrating that NDM methodologies can produce general testable models, in addition to valuable insights on how decisions are actually made, looms as large today as it was a decade ago” (p. 10).

In the current methodology the researcher has ensured that all available and reasonable methods for establishing reliability and validity were employed. The author has addressed common methodological criticisms that have been voiced in the past in structuring the current project. Moreover, the method of triangulation was employed. This has meant that no assumptions were made that any one method can reveal more than it was designed for.

CHAPTER 4. Using Critical Decision Method to Explore Unit CO Decision-making

4.1 Introduction

As the Australian Army moves towards Network Centric Warfare (NCW), it becomes increasingly important for us to understand, in detail, how decisions are made at a unit level and what elements impact on decision-making. This phase of the research aimed to investigate these issues by generating a description for decision-making at a unit level in the Australian Army. An interview method was chosen to extract contextually sensitive results. Interviews attempted to:

1. Search for evidence of RPD in unit level decision-making.
2. Identify and describe the elements perceived to impact on unit CO decision-making.

The anticipated outcome from this phase was to establish a broader understanding of decision-making in unit HQ than that currently existing²⁷. This is important because, in order to make reasonable suggestions about how to facilitate this process, one must have a sound understanding of how decision-making occurs and what elements may have a significant impact on the outcome. Existing research has not validated the RPD model in an Australian unit HQ environment or provided an account of elements perceived to impact on unit level decision-making in an Australian context.

The current chapter first defines the topic of research and then describes the method employed. A summary of evidence found for RPD in the unit HQ of the Australian Army is

²⁷ See Chapter 2 for descriptions of existing models (such as the RPD model).

presented. Finally, elements impacting on unit level decision-making are identified, described and explored.

4.1.1 Searching for evidence of recognition primed decision-making (RPD)

The first aim of this chapter, to search for evidence of the RPD at a unit level in the Australian Army, was achieved in three main ways. Firstly, the number of options considered for each decision was investigated. In previous work Klein, Calderwood and Clinton-Cirocco (1986) compared a number of decision points²⁸ to ascertain how many options were considered in the decision-making process. The assumption was that, to support NDM, only one or two options would be considered, but to support traditional decision models a number of alternatives should be considered. Klein et al. (1986) research provided the initial impetus to pursue the development of an alternative model for decision-making (RPD). Therefore, similar evidence was sought in the current research. It was hypothesised that in most decisions described only one or two options would be considered.

The second area explored to support the validity of RPD as a descriptive model for unit level decision-making was the reliance on experience to feed into the decision-making process. The RPD model describes a process by which previous experience allows for recognition of current scenarios and appropriate option generation often occurs automatically in response to this. Thus, a second check for the suitability of the RPD model in the Australian Army was to code novel²⁹ and previously experienced³⁰ situations across all

²⁸ A point at which a decision has been made.

²⁹ Novel situations were coded as those situations different from anything experienced before.

³⁰ Previously experienced situation were coded as those situations where previous experience could be drawn upon to make a decision.

decision points. It was hypothesized that in the majority of decisions described, previous experience will be used to guide the decision-making process.

Thirdly, elements identified in the interviews as impacting on decision-making was analysed in terms of their relevance to and support the RPD model. It was hypothesized that there will be elements identified that support the existence of RPD within the unit HQ environment.

4.1.2 Identifying elements impacting on unit decision-making

The second aim of the research was to determine and explore the array of elements perceived to impact on unit decision-making. This is an exploratory aim as to date there has been no research to identify this array of elements impacting on decision-making at a unit level in the Australian Army. This is becoming increasingly important as we move towards NCW. As we prepare for possible transitions to the distribution and processes within the unit HQ we need to determine which elements are currently impacting on decision-making so that we are able to model how these may be effected by any future changes. Elements identified will be explored in terms of how they may impact on the Army's transition to NCW.

4.1.3 Defining key terms in the current research

For the purpose of this research it is important to define what is meant by the words "expert" and "decision-making" within the military context. Previous research has used a variety of definitions to explain these terms. The definitions used in the current research are explained below.

Despite the frequency with which the term decision-making has been used in the literature³¹, there has been no consistent definition. In particular, determining where the decision-making event begins and finishes has been contentious.

Yates (2001) defined decision-making as “the process of solving a particular type of problem, and arriving at a good decision” (p. 17). In this sense, Yates (2001) referred to a decision as “the commitment to an action whose aim is producing satisfying outcomes” (p. 17). This definition is useful because it includes both the process and the event. Klein (1999, 2001) has argued that, in order to attempt to improve decision-making effectiveness in the military, it is the process leading to decision that is most important for researchers to understand and not only the “moment of choice”. Klein’s (1989) RPD model makes explicit the process of NDM as requiring cognitive functions such as: sense-making, situation awareness (SA), problem detection, planning, replanning and mental simulation. Thus, to investigate the adequacy of this model the focus must be on the process. Moreover, elements that impact on the outcome are likely to impact at different points throughout the process.

Deriving a specific definition for the beginning and the end of the decision-making process is also necessary. It could be argued that decision-making begins when the decision-maker becomes aware that a decision needs to be made. It follows that the end of the decision-making process would be when a decision has been made, typically reflected by an action being implemented. This is how decision events are defined in the current chapter.

One limitation of Yates (2001) definition is its reference to “arriving at a good decision” (p. 17). It should be noted that decision-making does not always result in a decision that would be deemed as “good”, as evidenced many times in military history (David, 1997). If the eventual aim is to improve decision-making, we need to understand why some decisions

³¹ A search on 2.10.06 in PsychInfo under the keyword “decision-making” revealed a total of 27, 304 published works.

result in good outcomes and some in poor outcomes (Edwards, Kiss, Majone, & Toda, 1984). Therefore, the current research explores both decisions with good outcomes and those with poor outcomes. A decision with a good outcome is defined as *one where the outcome matched the decision-maker's previous expectations*. A decision with a poor outcome is defined as *one where the outcome did not match the decision-maker's previous expectations*. It is suggested that, by comparing these decision scenarios, a better understanding can be achieved about the effect that various elements may have on the quality of the decision.

A further clarification that needs to be made when conducting research with the Australian Army is the level of decision-making being investigated. Because the current research is specific to the unit level, decision-making needs to be defined in terms of the level of planning detail involved in the process. Overall, Army decisions tend to be viewed as operational, tactical, or strategic. Under which of these categories the decision falls, depends on the objectives for that decision. It can also usually be predicted by the location in the hierarchical organisation at which the decision is located. Generally these decisions would also differ in the time frames available. Thus, the type of decision-making needs to be defined according to these levels, in order to make reasonable comparisons between decisions. The current research will focus on operational³² decision-making occurring at a unit level in the Australian Army.

Moreover, Krulak (1999) proposed that two qualitatively different types of decision-making occur within operational settings. Planning decisions are pre-emptive in nature and typically occur when the enemy has not been engaged. Warfighting decisions in contrast are where the enemy has been engaged and are therefore responsive in nature. The time frames

³² The operational level of war is concerned with the planning and conduct of campaigns. It is at this level that military strategy is implemented, by assigning missions, tasks and resources to tactical operations.

associated with each type of decision are generally different; planning typically requires longer time frames.

Despite qualitative differences, it can be argued that there are many similar conditions associated with both types of decision-making. Both planning and warfighting decisions are often made with uncertain information, high stakes and in a team environment. Moreover, although planning decisions would typically require longer periods of time and are usually more complex, both types cannot be delayed. It is a well-documented observation that, during both planning and warfighting, the longer a decision is delayed the more opportunities may be missed (e.g. Sun Tzu, 1994 [trans]; Krulak, 1999). This has been demonstrated throughout history where battles have been lost, not only as a result of poor decisions, but also due to a leader's failure to make a timely decision (David, 1997). Therefore, it must be noted that, despite some differences between planning and warfighting decisions, both occur under time-pressured conditions. Thus, although it is possible to distinguish between these different decision-making events, both occur in similar naturalistic environments with similar constraints. It is therefore sensible to assume that many similar elements will impact both types of decisions; and the current research has drawn on both types of decision-making.

In sum, decision-making is here defined as the process by which unit COs make decisions. This process begins at the point where the CO is conscious that a decision must be made and continues until a plan has been implemented. Both planning and warfighting decisions have been examined because it is likely that these are influenced by a similar range of elements. However, the type of decision-making described has been documented and taken into consideration in the analysis of the data. The criteria set for defining the decision-making process in the current study are consistent with NDM theory in terms of the environment (Omodei & Wearing, 1995) and focus on process rather than event (Klein, 1999, Klein, 2001).

The second term requiring definition is expertise. NDM researchers accept that experts are useful for the investigation of decision-making because they will typically have a large

repertoire of good decisions and poor decisions upon which to draw for analysis. However, agreeing on a suitable definition of an expert has proved problematic for researchers (Shanteau, 1992). The debate here centres on the issue of the quality and quantity of experience required.

Quantity of experience was used by Klein, Calderwood and Clinton-Cirocco (1986) to define expertise. In this case, a repertoire of 10 years experience was chosen as the minimum requirement. However, Klein et al. (1986) suggested that relying solely on quantity of experience as a definitive element left a large margin for variability. In fact, they found that amongst firefighters, one year stationed in a decaying inner city, where the firefighter was required to use their “expert skills” frequently, was more valuable for skill development than 10 years in a less busy area. This finding therefore illustrated that the issue of the quality of expertise is also important. Quality refers to the frequency at which the experts have the opportunity to put their skills into practice, engaging in further experiential learning. In most NDM domains, experts (e.g. firefighters, military personnel, paramedics and other emergency workers) are not constantly required to use their skills and the frequency with which they use their skills varies. In addition, many of these professions also have both full-time and part-time workers. Therefore, the variable frequency of skill use between professions and within professions is an issue. Among these professions it is likely that military personnel use their “expert skills” least frequently and with more variability. Thus, applying a standard definition to the quality of expertise is important, in order to maintain control of variability within the sample. A definition for ‘quality’ could be a measure of the frequency of experience over a given time frame. However, this still neglects the inclusion of the type of experience. For example, questions arise such as; was the experience novel? Did the experience result in learning? Deriving answers to these questions is problematic. In most cases this information will comprise self-report data and hence is subject to bias. Weiss and Shanteau (2003) have recently suggested that expertise should be viewed as a skill that takes into account both

discrimination (good evaluative judgement) and consistency. They have suggested a simple equation using both of these criteria to calculate a relative score of expertise on a particular task.³³ Based on this score they have proposed that relative ratings of expertise can be calculated, by comparing this score with that of other experts performing the same task. Although promising, this method of assessing expertise still has flaws. Firstly, domain knowledge is not taken into account and this means that, although a candidate may show high consistency of discrimination, this may be based on incorrect knowledge and assumptions. Moreover, the index is relative to others' performance on the task. No baseline norms for expertise exist and thus we can still only judge experts as scoring significantly better than other candidates on the same task. Thus, we still need a better definition of expertise on which to base the interpretation of the scale.

Consideration of these issues has led to the development of specific criteria for the selection of experts in the current study. Firstly, as suggested by Klein, et al. (1986), one selection criterion was that the participants had 10 years or more experience in the military. In regard to the quality of their experience, further control was considered to be too limiting. This is because the potential participant pool was already limited, due to the specialised nature of the work (ie. unit Commanders) and also because the inclusion of both full-time and part-time military experts was intended. Instead, as a measure of control, descriptive information on participants' experience was collected and this was considered as a possible predictive variable. For example, locations, organisations and types of participants' previous experience were recorded. It was anticipated that this definition would be sufficiently broad not to limit the availability of suitable participants, while also allowing for exploration of the potential influence of differences in quality of experience.

To recapitulate, the aims of the current study were to:

³³ The Cochran-Weiss-Shanteau Index = Discrimination / Inconsistency.

- Further explore validity of RPD in the Australian Army context.
- Identify and explore elements perceived to impact on unit level decision-making.

4.2 Method

4.2.1 Participants

Purposeful sampling was employed (Patton, 1990). The researcher sought experienced unit COs who were available to participate. Thus, typical cases were selected and then studied in depth. The request for participants was put through the required channels at the Defence Science and Technology Organisation (DSTO) and an appropriate sample was obtained.

The 12 participants were key decision-makers in the Australian Army; unit level Commanders and Brigade Majors (six reserve officers, six full-time officers). Due to the in-depth nature of the interviews, this sample was deemed adequate for exploration and discussion.

Participants were from a cross section of regiments in the Australian Army. All participants were male³⁴. Ages ranged from 35-48 years, with a mean age of 39 years. A description of participants' experience and other relevant demographic information is presented in Table 9 and Table 10. The selection criterion for participants was that they had a minimum of 10 years experience in the Australian Army.

³⁴ This is typical of the majority of unit COs. NDM theory would not predict that responses from female unit COs would differ significantly from the current sample.

Table 9. Demographic information from participants in the interview phase.

	Mean	SD	Minimum	Maximum
All Officers (N=12)				
Age (years)	39.42	3.40	35.00	48.00
Years of experience in the Army	19.17	1.95	15.00	22.00
Number of postings	5.42	3.65	1.00	11.00
Full-time Officers (N=6)				
Age	37.50	1.76	35.00	40.00
Years of experience in the Army	18.33	2.34	15.00	21.00
Number of postings	7.33	3.14	4.00	11.00
Part-time Officers (N=6)				
Age	41.33	3.67	37.00	48.00
Years of experience in the Army	13.50	1.50	19.00	22.00
Number of postings	3.50	3.27	1.00	9.00

Table 10. Description of participants' experience in the interview phase.

	All Officers (N=12)		Full-time Officers (N=6)		Part-time Officers (N=6)		
	Frequency	Percent	Frequency	Percent	Frequency	Percent	
Frequency of job related training	Every day	3	25.0%	2	33.3%	1	16.7%
	Weekly	8	66.7%	4	66.7%	4	66.7%
	Monthly	1	8.3%	0	0.0%	1	16.7%
Frequency of combat training	Weekly	3	25.0%	0	0.0%	0	0.0%
	Monthly	4	33.3%	3	50.0%	1	16.7%
	Every 6 months	1	8.3%	3	50.0%	1	16.7%
	Yearly	4	33.3%	0	0.0%	4	66.7%
Frequency of operational experience	Yearly	0	0.0%	0	0.0%	2	33.3%
	More than yearly	7	58.3%	5	83.3%	4	66.7%
	Never	5	41.7%	1	16.7%	2	33.3%
	No	11	91.7%	5	83.3%	6	100.0%
Involved in other NDM organisation	Yes	1	8.3%	1	16.7%	0	0.0%
	Mean	7.00		7.17		6.83	
Time since last combat training (days)	Standard deviation	4.63		5.78		3.71	
	Min / Max	0.00 / 14.00		0.00 / 14.00		3.00 / 14.00	
Time since last operational experience (years)	Mean	5.01		3.82		8.00	
	Standard deviation	3.81		3.88		1.41	
	Min/ Max	0.08 / 9.00		0.08 / 8.00		7.00 / 9.00	

4.2.2 Materials

The participant information sheet detailed the background for the current research and informed COs of their role and time commitment (see Appendix IV). It also outlined ethical considerations and provided contact numbers for the responsible investigator if further information was required. A consent form was attached (see Appendix V).

The demographic questionnaire required participants to answer nine questions regarding their age, rank and other elements, to build a description of their experience (see Appendix VI). The researcher used the interview script during the interviews to maintain a standardised open-ended structure (see Appendix VII). This script was based on the principles of CDM and separated the interview into the four main sections³⁵, listing appropriate questions for each section. Interview prompting sheets (cue cards) were also used for each participant. These were supplementary to the interview script and helped to define concepts and focus the participants on the questions (see Appendix VIII). Participants were also supplied with a sketchpad and pen to assist with illustrating concepts. A Sony mini disk recorder (MZ-R90) was used to record the interviews for later transcription.

4.2.3 Procedure

Participants were initially phoned to arrange an appropriate time for the interview and the information sheet and demographic questionnaire were sent to them via email. In an attached letter the participants were instructed to consider, from their experience at unit level, a decision event that resulted in a good outcome³⁶ and one that resulted in a poor outcome³⁷. Interviews were scheduled at a time convenient for the participants. Because participants were

³⁵ The four parts of CDM are incident recall, time-lining, progressive deepening and *what if?* questions. These are described in Chapter 3.

³⁶ A good outcome was defined as one where their expectations matched up with the decision outcome.

³⁷ A poor outcome was defined as one where their expectations did not match up with the decision outcome.

located around the country, holding the interviews in a common location was impossible. Thus, interviews were typically held in the participant's office. Upon arrival, introductions were made and the completed demographic questionnaire was collected. Following this, each interview began with a standard introduction from the interviewer (see Appendix VII). This introduction reaffirmed the purpose of the research and defined the structure of the interview. Any questions the participant had were answered at this point.

Following this, the formal interview process began. As described in Chapter 3, the basic format of CDM is a sweeping interview process, where the participant was guided in recounting the selected incident. There were four information sweeps: incident selection and recall, time line identification, progressive deepening and what if? This process was done with each participant for both a decision with a good outcome and a decision with a poor outcome. At the end of the interview all participants were asked if they had any further comments. Throughout the interviews participants were encouraged to draw timelines on a sketchpad provided. This was then used to facilitate further exploration of the decision scenario throughout the interview. All interviews were recorded, lasted approximately 3 hours and were later transcribed for analysis.

4.2.4 Method of analysis

Choosing an appropriate coding method and ensuring a valid interpretation of meaning are both issues in qualitative research. This research used a method of inductive analysis; drawing upon ideas from grounded theory and content analysis. The process used to code the data began in an exploratory way. Data were initially broken down into discreet parts and substantive codes. Codes were then grouped into descriptive categories. The method for producing codes involved constant comparative analysis, adapted from grounded theory. As a result of these further comparisons between categories, they were further collapsed into higher order categories. Comparisons of similarities and differences between codes were made continuously throughout this process. An effort was made not to allow preconceived

categories to limit the story that the data presented (Ihde, 1977). This allowed for depth, openness and detail in the analysis. This method of coding was considered the most appropriate in the current research as it revealed, from the perspective of military decision-makers, the elements impacting on unit level decision-making.

All coding was done using the QSR computer program NVivo version 2[®]. As the final coding hierarchy was established, a code book listing definitions for all codes was also created. This book was modified as codes were developed or dropped (See Appendix IX). From the final higher order categories identified through the comparative coding process, a quantitative content analysis³⁸ was performed.

In order to reduce bias the researcher attempted to adopt a neutral stance, to understand the data as these were presented and not how she anticipated them to be. This required that final interpretation was postponed until all data were collected (Ihde, 1977). Inter-rater reliability checks were used in the current research, acknowledging that if something is true, then more than one person should observe it. A reliability check calculated the degree of agreement between two observers about interview coding (the researcher and a trained associate). The extent to which the two observers agreed indicated the reliability of the interpretation of the data.

³⁸ Content analysis is defined as "... a summarising, quantitative analysis of messages that relies on the scientific method (including attention to objectivity, intersubjectivity, a priori design, reliability, validity, generalisability, replicability and hypothesis testing) and is not limited to the types of variables that may be measured or the context in which the messages are created or presented." (Neuendorf, 2002, p. 10).

4.3 Results and Discussion

4.3.1 Presentation of results

The results will be presented in three sections: reliability analysis, evidence for RPD in unit HQ and identification and exploration of elements perceived to be impacting on decision-making. In the final section, as well as a quantitative presentation of data, the meaning of categories is illustrated by the use of direct quotations. Direct quotations assist to illustrate the meaning behind the coding. Patton (1990) argued, "...direct quotations are a basic source of raw data in qualitative inquiry, revealing respondent's depth of emotion, the ways they have organised their world, their thoughts about what is happening, their experiences and their basic perceptions"(p. 24).

4.3.2 Reliability and validity

It has been generally accepted that high reliability falls between 0.75 to 0.8 (Elliss, 1994), and 0.70 is a good cut off score for reliability analysis (Neuendorf, 2002; Riffe, Lacy & Fico, 1998). Anything falling below this mark should be questioned. For the current analysis a reliability check was performed using 10% of the data (Wimmer & Dominick, 1997). Percent agreement (PA) was calculated for the high and medium level coding categories. Codes were then excluded if a high inter-rater reliability was not achieved or they were mentioned in fewer than three interviews.

Overall, five codes were excluded. *Stress*, *Morals* and *Age* were excluded because they appeared in too few interviews. *Comradery* and *Politics* were excluded because they received low inter-rater reliability (where $R < 0.70$). The final overall inter-rater reliability was calculated as 0.93. This was considered a high level for reliability analysis (Neuendorf, 2002; Riffe, Lacy & Fico, 1998; for a summary of reliability calculated for each code see Appendix X).

4.3.3 Evidence of RPD in the Australian Army

The first aim of this chapter was to look for evidence of RPD in the Australian Army unit HQ. To achieve this, the accuracy of two basic assumptions was tested. The first assumption was that only one or two options are usually considered in RPD. The second assumption was that experience would be fed into the majority of decisions to facilitate recognition and problem solution (as this is an integral part of the RPD). The third way in which evidence for RPD was sought was through an analysis of the elements identified as impacting on decision-making in unit level HQ. During this analysis further support for the RPD was sought.

The outcome of the exploration of the number of decision options considered supported the RPD model. The current interview research yielded 24 decision points (12 deemed as having a good outcome, 12 deemed as having a poor outcome). Table 11 shows how many options were considered at each of these identified decision points. As can be seen from Table 11 in almost 80% of the decisions made only one or two options were considered. From those where three options were considered it is unclear whether this was done only as a matter of procedure (e.g. doctrine dictated that they should).

Table 11. Comparing the number of options considered during decision-making.

Number of options considered	1	2	3	missing
Number of decision points	9	10	3	2
Percent of all decision points	37.50%	41.67%	12.50%	8.33%

A number of the transcripts indicated that, although the decision-makers considered up to three options, they had already known that one of those options would be best. For example, one CO said:

We did three, because- I remember it because the book said you should at least do three so - we said well we actually know what course of action we're going to do because the Brigadier has given us fairly firm guidance on that. (P5-poor, Section 0, 1.1)

Although this conclusion has been based on only 24 decision points, the finding that the substantial majority of decision points indicated that the solution was clear on the basis of evaluating 1 or 2 options, strongly supports RPD in the Australian Army unit HQ.

The second area explored to support the validity of RPD was the reliance on experience in decision-making. This was achieved by coding novel³⁹ and previously experienced⁴⁰ situations across the 24 decision points. This task was difficult because, despite certain novelties within some situations (mainly current situational information), participants always drew on some form of previous experience in order to make a decision. Thus, 100% of instances were considered to be conducive to experience-based decision-making. In further support of the reliance on previous experience, one of the elements identified as impacting on decision-making was experience. This was the most commonly discussed element within the interviews and will be described further in section 4.3.4.

³⁹ Novel situations were coded as those situations different from anything experienced before.

⁴⁰ Previously experienced situation were coded as those situations where previous experience could be drawn upon to make a decision.

Finally, a number of the elements identified supported the idea of RPD in unit HQ. A summary is shown in Table 12. The way in which each of these elements specifically supported the existence of the RPD in unit HQ will be discussed in section 4.3.4.

Table 12. Summary of elements supporting existence of RPD in unit HQ.

	Supports RPD		Disconfirms RPD		Supports RPD		Disconfirms RPD	
Personal								
Fatigue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Perspective	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Emotion	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Flexibility/contingency	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Personality	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Experience	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
IQ	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Instinct	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reputation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Team								
Diffuse responsibility	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Communication	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Team personalities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Team emotion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Team morale	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Trust	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Organisational								
Diffuse responsibility	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Organisational (continued)								
Organisational communication	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
....Higher management	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
....Intelligence	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
....Subordinates	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
....Other regiments	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Organisational constraints:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Resources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Army culture	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Situational								
Visual support (Computer or other)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Spatial position	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Culture	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Outside organisational influence	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Environmental influence	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Context of operations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Time of day	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Timing	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lead up activities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

4.4 Detailed discussion of elements identified

The second aim of this chapter was to identify and describe the elements perceived to impact on decision-making. Outcomes are presented in this section. Firstly, the number of interviews that included coding for each of the elements was documented. This provided a quantitative measure of the number of participants who suggested that this element had impacted on their decision-making. Following this codes frequently discussed (appearing in over 50% of transcripts) were qualitatively analysed. This resulted in a description of their meaning illustrated with direct quotations. Those codes identified as supporting the RPD model are also discussed to describe why they indicate RPD is occurring in unit HQ. In addition, codes that were seen to be directly relevant to changes arising due to NCW are also highlighted.

The analysis of interviews focused on elements perceived to influence unit level CO decision-making. From this analysis 33 elements were identified as perceived influences. Their relative frequencies of expression throughout the interviews are shown in Figure 11. Definitions for each element can be found in the interview code book (see Appendix IX). These 33 elements identified fell into four broad categories: *Personal, Team, Organisational and Situational*.

Table 13. Definitions of the four broad categories found in the current analysis.

Category	Defining Statement
Organisational	<p>Any influence within the organisational structure* of the Army exterior to the unit HQ team.</p> <p>*Organisational structure - a structure through which individuals cooperate systematically to conduct business.</p>
Personal	<p>Any influence on decision-making done, made, performed or originating from within a person. This can be a situationally mediated characteristic, or a stable personal characteristic.</p>
Team	<p>Any influence within or created by the immediate unit HQ team.</p>
Situational	<p>Any influence external to the Army organisation, arising from the current situation*.</p> <p>*The combination of circumstances at a given moment; a state of affairs</p>

Definitions for each of these categories are described in Table 13. When these 33 elements were grouped into higher-level categories, we see that all categories were mentioned with high frequency in the majority of transcripts (see Figure 12). *Personal*, *Situational* and *Team* categories were referred to in the largest number of transcripts. Elements within the *Organisational* category were mentioned in fewer transcripts. However, to compare at a different level, if we examine the percentage of the total coded text that each of the categories accounts for, the differences in frequency of expression are clearer. This analysis differentiates more clearly the differing amounts of discussion centring around each of the categories. Viewing the data in this way, the most frequently referred to category, *Personal*,

accounts for almost half of the coded text, with lower frequency of expression for the remaining categories; *Situational*, *Team* and *Organisational*.

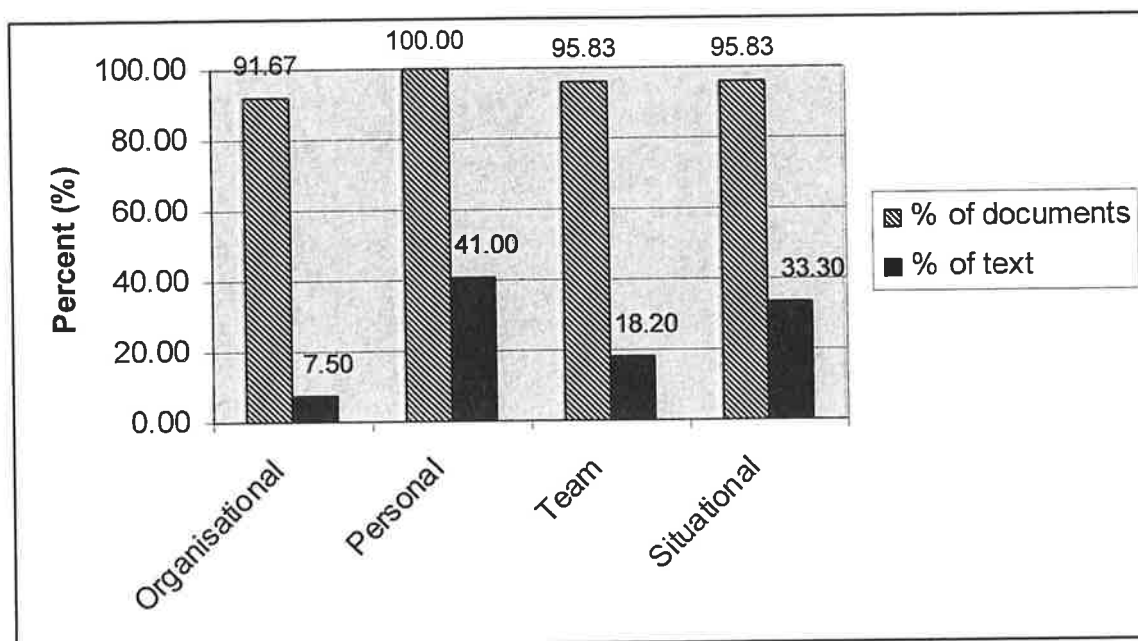


Figure 12. The percentage of transcripts showing each of the high level categories identified as influencing unit decision-making.

Each of the high level categories is comprised of a number of lower level elements. In the following sections they will be explored in detail to determine what the COs were referring to under each of these broad categories. A particular value of this research lies in this deeper level of description and discussion of how these elements are relevant in the current context of the Australian Army.

4.3.5 Analysis of elements across good and poor decision scenarios

As mentioned in the method section, both good and poor decision scenarios were explored in the interviews. This was done with the intention of exploring whether the impact of certain elements tended to predict either good or poor outcomes. This was not generally

found. Most often the same elements would be coded as impacting on decisions deemed to have had good and poor outcomes. An example of this is shown by comparing the coding for *Fatigue* across transcripts describing both good and poor decision scenarios (see Table 14). Fatigue was mentioned as an influence by only six of the 12 COs. The table shows that fatigue was mentioned as an element perceived to influence decision-making in both good and poor decision scenarios.

Table 14. Fatigue as an example of an element loading across COs and across good and poor decision scenarios.

CO Transcript ID #		Fatigue Mentioned as an Influence?	
		Good decision scenario	Poor decision scenario
F1	Full-time	YES	
F2	Full-time		YES
F3	Full-time	YES	YES
F4	Full-time	YES	YES
P2	Part-time	YES	
P5	Part-time		YES

It could be that elements affect decision-making outcomes differently depending on the CO involved. However, according to two of the participants, fatigue had been an influential element in both good and poor decision scenarios. Alternatively, it could be that the interactions between different elements predict good or poor decision outcomes. Further research would be required to explore the accuracy of these suppositions.

In some cases an element did seem to be associated predominantly with one particular type of outcome (either poor or good). In these cases this will be discussed within the description of that element.

4.3.6 Personal elements

All of the interviews contained coding for the *Personal* category. Sub-codes positioned under this category are as shown in Figure 13. These elements can be considered in terms of:

1. those relatively stable elements that would not tend to change during an operation (e.g. flexibility, personality, experience etc); and
2. those elements that tend to be mediated by the environment (e.g. fatigue, perspective, emotion etc.).

The second group of elements could therefore change substantially during the course of an operation (see Figure 14). Within the *Personal* category support for the RPD model is discussed in terms of the use of experience in decision-making, flexibility and also perspective. Other elements identified neither confirm nor disconfirm the RPD model. Instead they provide us with a better understanding of the current decision process for future planning and training for NCW.

Within the *Personal* category, *Experience* was the most frequently mentioned element (95.83%). In fact, this was the most frequently mentioned element out of all of the categories. This is consistent with the RPD model, which is dependant on the experience of the decision-maker to feed into the decision-making process.

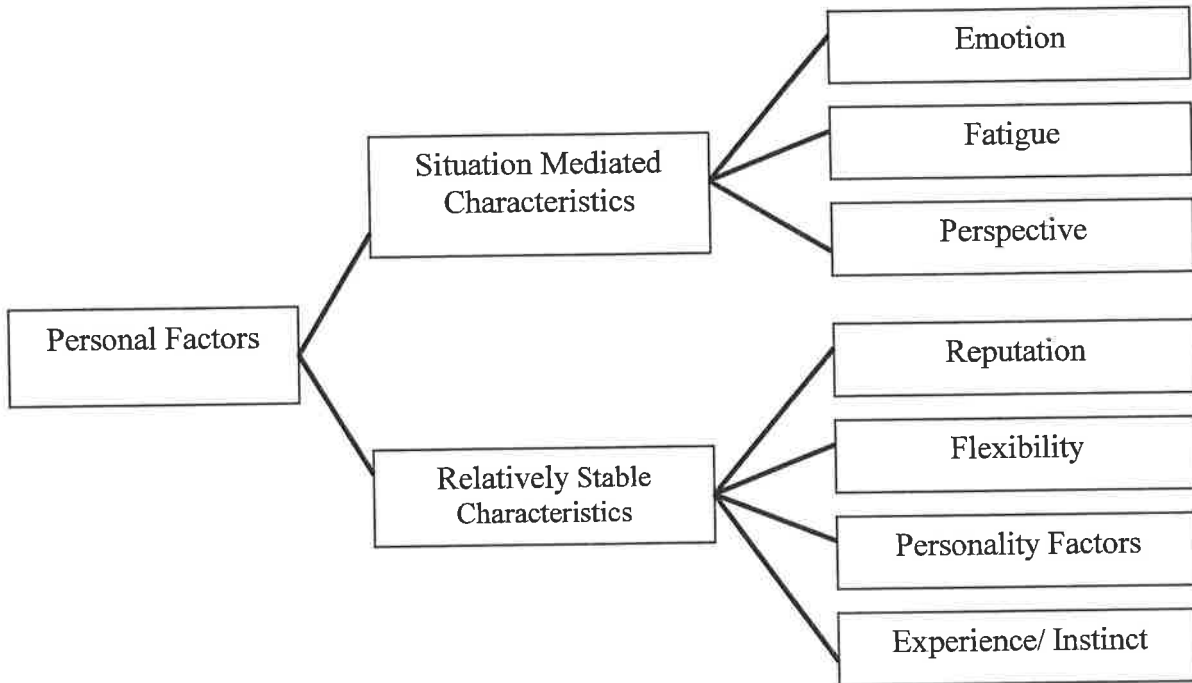


Figure 13. Modelling Personal elements.

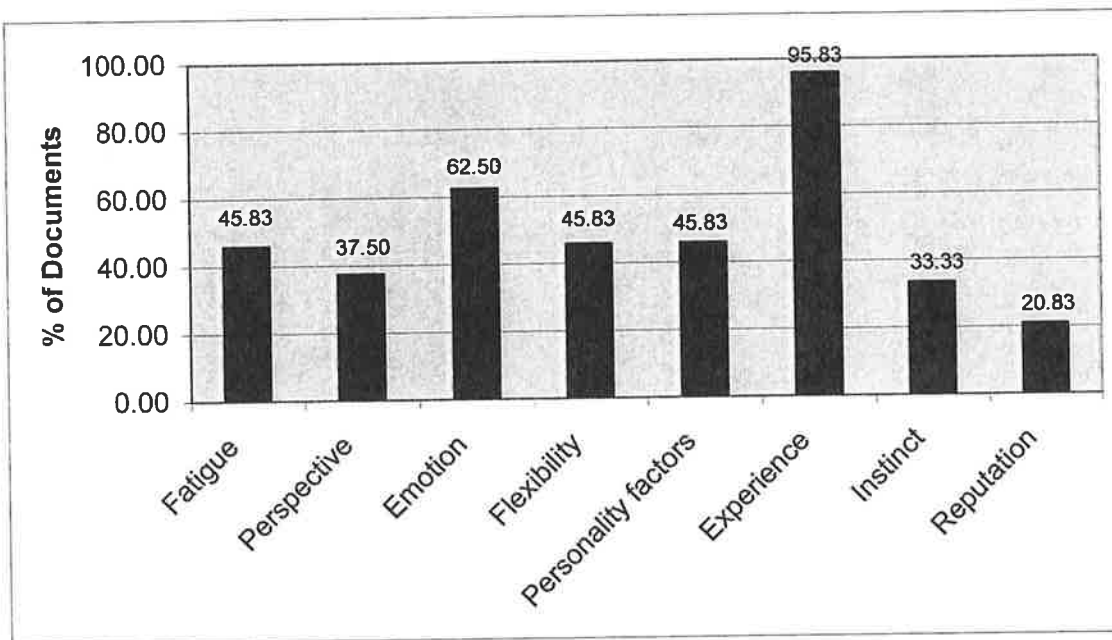


Figure 14. Description of the coding frequencies of sub-codes positioned under the Personal category.

Experience was seen as operating in three main ways, as can be seen in Table 15 . The RPD model supports the notion of experience being used as a template for current decision-making, enabling assumptions, suitable option generation and thus automation. These mechanisms are in line with the RPD model which holds that one draws on experience in order to make time-effective, appropriate decisions.

Another interview theme that arose was that a lack of experience resulted in poor decisions. This is illustrated below:

And sometimes those decisions are really bad because they are lacking experience as well. And a lack of ... base knowledge. You know that point about base knowledge. Yeah they've got nothing. Therefore they make the decision and you go "where did that come from?" (F3-Poor, Passage 7 of 9, Section 1.1, Para 269).

Table 15. Themes coded in *Experience*.

Theme	Example Quotes from Transcripts
Experience automates decision-making (instinct)	<i>I think the overriding reason was that it was an activity that had been foreseen. It was anticipated and we had practiced for it and people just fell into their positions to do it. (F6-Good, Passage 5 of 5, Section 1.1, Para 234)</i>
Experience enables assumptions	<i>How do you make an assumption? Umm I think in many ways it's experiential. Umm from what you have gone through. (F5-Good, Passage 5 of 7, Section 1.1, Para 481)</i>
Experience provides a template match for decision-making	<i>Yeah, in many ways I think [experience is like a mental shortcut] it is yeah. (.) We know that whenever this happens, this happens. You get your old soldier stories coming- "Look sir, it doesn't matter what the book says we know this happens because it goes this way every single time. And ah (.) so (.) You tend to get a bit of that stuff as well. (P4-Good, Passage 13 of 18, Section 0, Para 364)</i>

Again, this is in line with assumptions about the experience feeding into decision-making, as suggested in the RPD model. Without an adequate experience base, recognition cannot occur and thus decision-making becomes much more analytic as described in earlier decision-making models. To date, research has failed to define what type of experience is being drawn upon most commonly. Thematic analysis of the current transcripts revealed a number of different types of experience that were drawn upon when making decisions.

Experience was talked about as originating from the following sources:

- Actual operational experience (as a CO);
- Actual operational experience (as soldier or lower rank);
- Experience derived from training;
- Experience outside the military (everyday learning / knowledge);

- Experience drawn from others stories etc.;
- Experience derived from books (drawing on history, etc).

As would be expected, not all experience draws upon personal practical experience.

For example, one participant commented about how he decided to use a particular course of action:

So using the Mr Milosovich model out of the former Yugoslavia where he essentially led them a merry dance by hiding tanks in haystacks and mixing military vehicles in with ,uh, you know, farmers convoys and the like” (F2-Good, Passage 1 of 8, Section 1.1, Para 21).

Similarly, not all experience drawn upon was derived from the military. One CO commented about a solution to a problem as described below:

People say “Oh this radio doesn’t work”. Well they say “If you piss on the ground and the antenna of the anchor you’ll get another 100 kilometres range out of it.” [Why? Cause that gives you. Its not written in the book anywhere. They just know by camping experience that provides the conductance to the Earth to extend the range. (P2_Good, Passage 3 of 3, Section 1.2, Para 590)

Another CO commented that one’s previous cultural and ethical experience is also relevant to decision-making:

I mean the other thing about experience is that it comes from your cultural and ethical base and, you know try. Apply your cultural and ethical base to all the problems in East Timor, all the problems in Afghanistan and Iraq and Iran and its just futile (F3-Good, Passage 5 of 5, Section 1.1, Para 410)

In order to better inform training strategies, researchers need to determine to what extent these different types of experience contribute to unit level decision-making.

Understanding how experience through military training, combined with life experience, impacts on the quality of CO decision-making, will assist to inform both policy and training.

The other element in the *Personal* category that was mentioned in over half of the interviews was *Emotion* (62.5%). In all cases, quotes from the interviews suggested that decision-making was skewed by emotion. For example:

Emotional issues, you know personal faults, fickle faults, moral faults hhh will affect, you know, of course they affect decision-making. (F3-Bad, Passage 2 of 3, Section 1.1, Para 151)

Emotion took over. Umm (4) It had to be done quickly- I mean she was dying And I think that's where you make the biggest mistakes. (F1-Bad, Passage 6 of 8, Section 1.1, Para 63)

There were interactions between *Emotion* and *Fatigue* in the coding. *Fatigue* was mentioned in 45.83% of the interviews. *Fatigue* was often associated with emotion-based decision-making. Thus, when fatigued, rather than being able to control emotional responses, they would often occur unchecked. Some quotes that illustrate this point are:

Yep. Absolutely. Ohh I think that's-that's- from my command point that's very much the case.. Ahh I know my decision-making will be affected by um the amount of sleep I've had. Ahh and then my ahh general feelings about how things were running. So frustration will negatively affect my decision-making process. (P3-Good, Passage 1 of 2, Section 0, Para 596).

So those sort of physical things I guess start to have an effect on your emotions. Umm lack of sleep, you're doing extended sort of hours, umm then again everybody goes through it whether you're out patrolling around the scrub or you're driving trucks or you're a doctor working excessive hours trying to deal with all the battle casualties, all the surgery that goes on. All

that sort of stuff, so there's a whole bunch of different things that might happen there too, and are potentially risky as well. (P4-Poor, Passage 4 of 4, Section 1, Para 236).

The influence of emotion on decision-making is of particular concern in light of the fact that recent research shows that fatigue impacts on decision-making (Hockey, Maule, Clough & Bdzola, 2000). However, it is promising to note that planning to minimise fatigue was also mentioned by the participants as being an element that should be considered.

You also need to think about rest. You know how do you find a place for your guys to cool off, and sleep, so that they can continue for week after week after week doing this stuff? (P4-Good, Passage 1, Section 0, Para 218).

This awareness will be necessary to keep emotional decision responses made by fatigued COs under check. Emotion and fatigue have not to date been specifically discussed in terms of their impact on the RPD model, or their potential interaction with other elements.

Flexibility (45.83%) was discussed in terms of the importance of ensuring plans are flexible and contingencies are available. For example:

So you never have complete information, so all you can do is say, well (1) ok (1) looking at the nature of operations and what your expectation is, this is what I recommend you take err and we'll play it by ear from there to see how we go, and if we need to supplement it or do something else, then we'll do that later on (P4-Good, Passage 2 of 3, Section 0, Para 548).

The idea of flexibility is consistent with RPD because decision options are evaluated sequentially and if they are not adequate other options are considered. It is interesting that this was coded in less than half of the interviews because it is an important part of the current training and is a documented requirement of the MAP. Analysis found that flexibility was more often mentioned in decisions with good outcomes (7 transcripts) compared with those

with poor outcomes (4 transcripts). This indicates that flexibility may predict good decision-making.

Personality (45.83%) was discussed in terms of either the process or outcome of decision-making varying across personality types:

Umm depending on what their roles are I suppose. I suppose it's a strategy, but I think it's a personality trait- that affects the sort of strategy you approach. (P6-Good, Passage 3 of 4, Section 1.1, Para 370)

The impact of an individual's personality has not been explored to date in relation to the RPD. However, an increased awareness of how this interaction actually works would be useful to better structure teams so that differing personalities complement each other and cover each other's biases. In particular, if a HQ was distributed in NCW, a knowledge of appropriate grouping of personalities would be useful.

4.3.7 Team elements

The interviews contained 95.83% coding for the *Team* category. The six elements listed under the *Team* category can be categorised into three groups: *Team Status*, *Team Mechanisms* and *Team Relationships* (as shown in Figure 15). Sub-codes positioned under this category are shown in Figure 16.

Team elements are not addressed within a particular part of the RPD model because it has been used predominantly at an individual level. However, some of the elements identified within this category provide evidence of the COs development of SA originating from the team in which he/ she is immersed. This development of SA supports the notion of RPD in unit HQ.

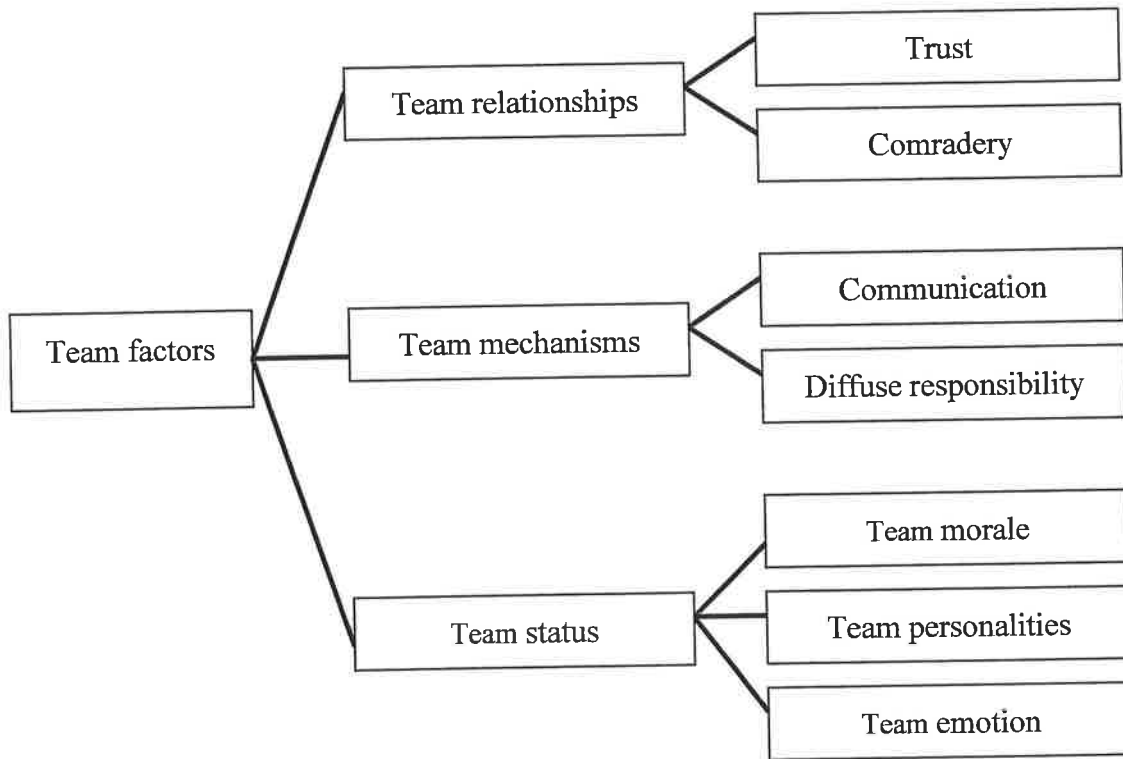


Figure 15. Modelling Team elements.

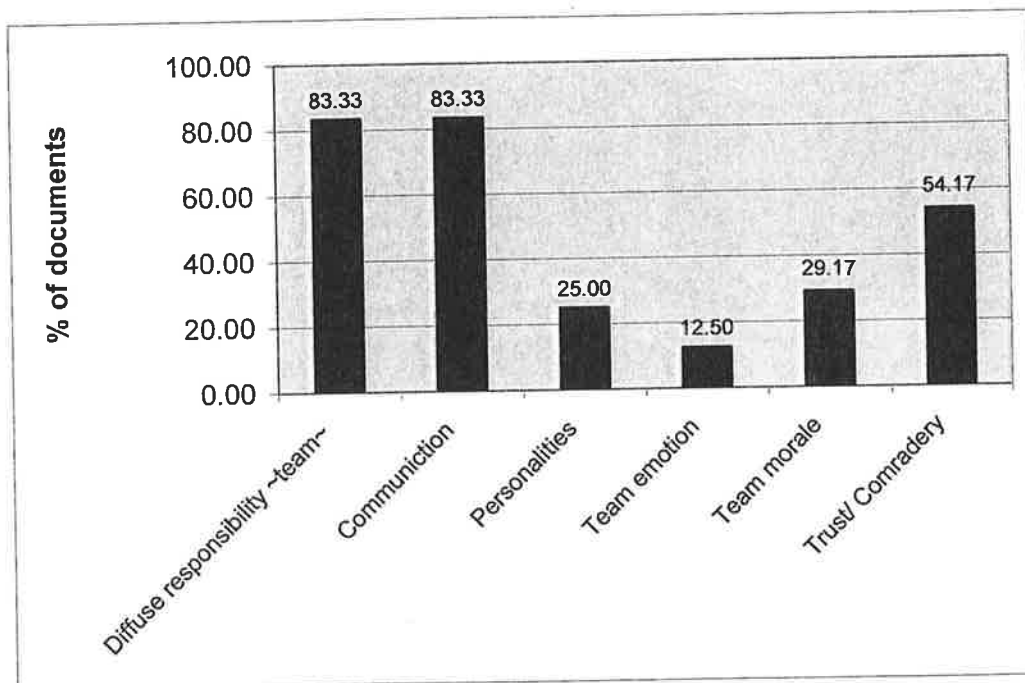


Figure 16. Description of the coding frequencies of sub-codes positioned under the Team category.

From all of the sub-codes incorporated into the Team category, Diffuse responsibility within the team and Communication were mentioned substantially more frequently than the other codes. Both codes confirm the importance of the team contributing to both SA and actual decision-making. The other elements that fell under this category were mentioned far less frequently.

Diffuse responsibility/Team (83.33%) contains coding that indicates the team members influence each others' perceptions and that individuals are responsible for different parts of the decision-making process. Three specific areas identified in the interviews were: drawing on the knowledge of other team members, filtering information through others and working to another's agenda/ risk level. Thus, decision-making is decentralised, supporting the concept that the members of the team play a critical role in CO decision-making (see Table 16). Within the first theme, drawing on each others knowledge, two common topics were discussed. These were *Plan evaluation* and *Important judgements*. Important judgements most often described determination of important information. This is dependant on the knowledge of the decision-maker. As identified in the interviews, judgements and evaluations of the plan were often discussed at a team level.

Um through umm..this [determining the exact bits of information] was all done by ah LO's and- and officers under my command.... (F1-Good, Passage 1 of 5, Section 1.1, Para 161, 426 chars).

His plan (the Commander) would be rigorously checked by the staff, and dumb plans would be eliminated. You'd go back and say "sir hey, hang on" (F2-Bad, Passage 1 of 3, Section 1.1, Para 79, 739 chars).

I've got 4 Captains but only 1 Senior, so the experiential. So in my headquarters I should have experienced captains and understand deeply what the units do. [So. They can do their own problem solving. If you don't know

what a tank regiment does how can you make decisions about them Um that's a problem across Army at the moment, um (2) We can't act on all the things we need to ahh decide and act on. There's just not enough resources and assets.] (F3-bad, Passage 3 of 4, Section 1.1, Para 143, 449 chars).

Coding for team *Communication* (83.33%) was strongly related to *Diffuse responsibility*. It was grouped into the following themes: asking for information, knowledge and opinion; receiving information, knowledge and opinion and giving orders and other general comments. Information, knowledge and opinion correspond to the three levels of SA as identified by Endsley (1995). These are: Perception (Level 1; information) which is the perception of raw situational elements, Comprehension (Level 2; knowledge) which is integrating information sensibly and Projection: (Level 3; opinion) which is the extrapolation of future status and actions based on current elements. The finding that the team seem to be contributing to all levels of SA provides support for the RPD model, but also highlighted the importance of the team feeding into this SA development process in the unit HQ. An example of this is illustrated in the quote below:

We could say" look, what exactly can these engineer resources do for me in terms of crossing a river or in terms of umm umm laying mine fields or putting in place obstacles or the like", so it was good to be able to (.) umm ask people who had that specific to core experience (P1-Good, Passage 4 of 4, Section 0, Para 168, 715 chars.)

Table 16. Themes coded in *Diffuse Responsibility*.

Theme	Example Quotes from Transcripts
Drawing on each other's knowledge	<p><i>And in this case here um the kind of areas where I wasn't proactive, was picked up by my CMA guy, my military affairs guy who was saying, "Have you told (?) you want to get the civilian police involved?" Cause in Timor there's police "Yes, they'll need to know about it" [So there's a proactive kind of culture there as well, and people feed into you as well for things that you just simply overlook, when you focus on the casualties.] (P6-Good, Passage 1 of 1, Section 1.1, Para 330)</i></p> <p><i>In my headquarters I should have experienced captains that understand deeply what the units do. [So. They can do their own problem solving. If you don't know what a tank regiment does how can you make decisions about them (F3-Bad, Passage 1 of 2, Section 1.1, Para 143)</i></p>
Filtered information through others	<p><i>Their job [the team] is to present facts as they are and to ahh give as much information to that commander as possible.....(F1-Good, Passage 3 of 4, Section 1.1, Para 319)</i></p>
Working to another's agenda/risk level	<p><i>I make the plan, I ameliorate the risks, and I explain the risks. And the commanding officer made the decision to go. I mean in that job. (F1-Good, Passage 3 of 4, Section 1.1, Para 319)</i></p>

All evidence indicates that the CO is also drawing on the team's experience to assist in decision-making. Therefore, whilst the final decision event is centralised with the CO, the decision-making process (as described in the RPD model) is decentralised and occurs across the HQ team.

Other themes that were highlighted within this element were:

1. Intelligence officer received a substantial amount of communication.
2. Problems associated with team members "not telling it as it is".
3. Importance of voice communication.

The final sub-code under the *Team* category that was mentioned in more than half of the interviews was *Trust* (54.17%). Themes emerging within this code are shown in Table 17.

Table 17. Themes coded in *Trust*.

Theme	Example Quotes from Transcripts
Selecting those you trust to implement plans	<i>And also the experience .hhh. If we were dealing with exceptionally well-trained units that had been in the field for months and months and months and were really hot umm ((tsk)) it would have been ok, but they weren't. Their experience training levels were relatively low. So the safety factors were playing significantly on my mind. (F3-Bad, Passage 4 of 7, Section 1.1, Para 79)</i>
Accepting information and advice only from those you trust	<i>Umm (2) but what I'll do a lot is sit down with someone I trust umm who's judgement I trust, and say "look we're doing this. Can you see any problems?". And they'll tell you what's going on. (F3-Good, Passage 5 of 6, Section 1.1, Para 426).</i>

High levels of trust tended to be associated with better decision outcomes. The important role of trust in the unit HQ team has important implications if with the introduction of NCW, unit HQ became distributed. The question would arise as to whether the lack of face-to-face contact would impact on these levels of trust.

4.3.8 Situational elements

Interviews contained coding for 95.83% the *Situational* category. The nine elements listed under the *Situational* category were organised into three groups: *Immediate Environment*, *Temporal Influences* and *Wider Environment* (as shown in Figure 17). Within the *Situational* category there are a number of elements that were mentioned in over half of the interviews. Sub-codes positioned under this category were as shown in Figure 21.

Situational elements are not described specifically within the RPD model. However, in

general Situational elements were discussed in terms of assisting to build up an appropriate SA and this notion supports RPD within the unit HQ. To better understand and predict decision-making outcomes (at least in the Australian Army) a specific description of the array of Situational elements impacting on the process needs to be generated

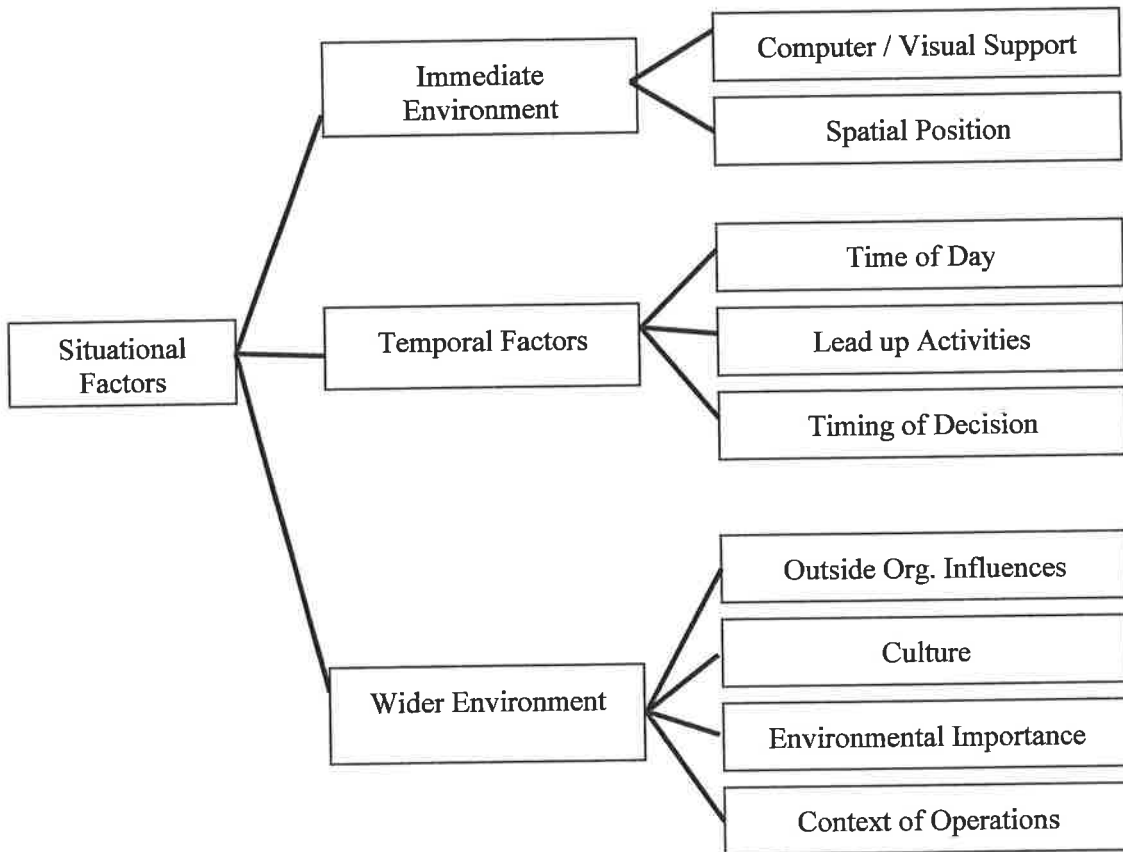


Figure 17. Modelling Situational elements.

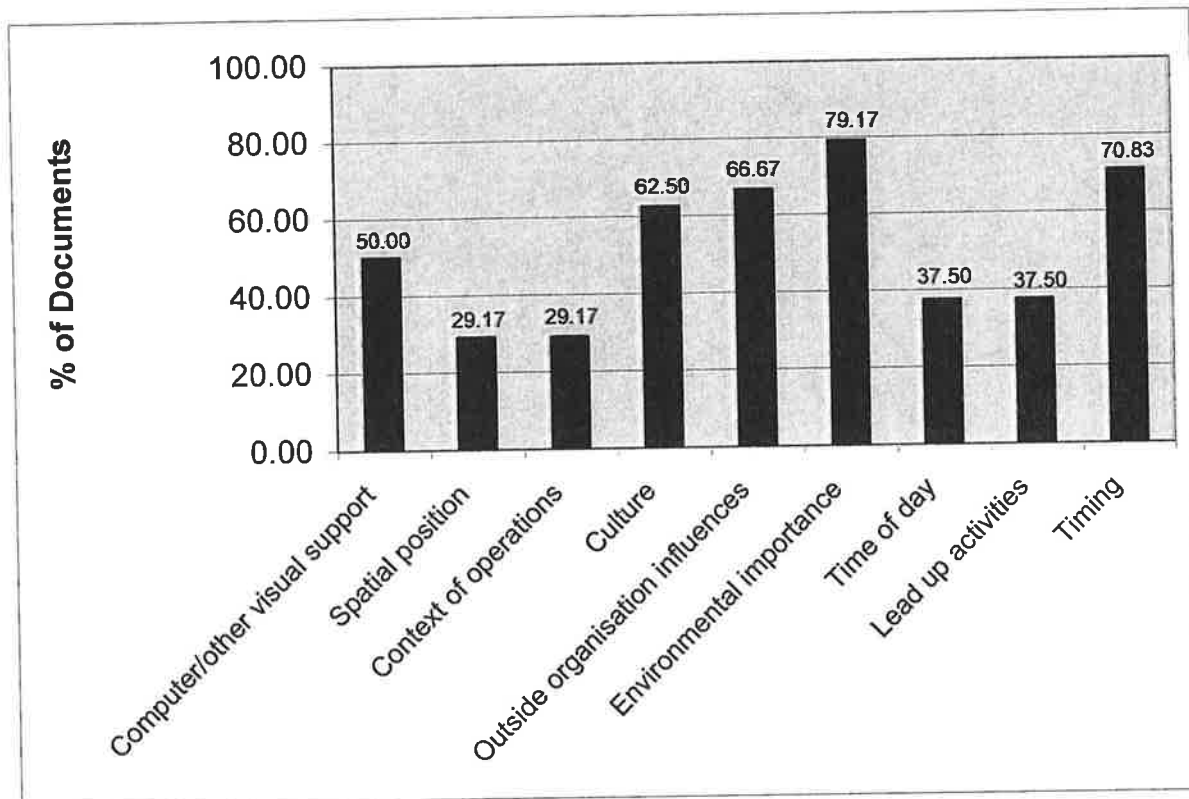


Figure 18. Description of the coding frequencies of sub-codes positioned under the Situational category.

The importance of the environment was the most frequently mentioned element in this category (79.17%). Typically, the COs emphasised that SA of the environment is important for decision-making. For example, one participant said:

I know that without that kind of information on enemy locations, you are never going to make good decisions. You really need to have a clear understanding of what is going on around you. I think you boffins call it situation awareness (P1-Bad, Passage 5 of 5, Section 1.1, Para 110).

This is in line with the importance of SA in the RPD model. COs also talked about how the environment can best be used in their decision-making. For example one participant said:

And you might say to yourself based on your knowledge- yep this is an ideal area for a company sized position. Or this is an ideal area to put anti armour resources, because that's the sort of threat that you're anticipating (P1-Good, Passage 3 of 3, Section 0, Para 201).

Timing was also mentioned frequently (70.83%). This was discussed in terms of needing to know when the decision has to be made. One of the defining characteristics of NDM environments is time pressure, meaning that decision-making cannot often be delayed. Because COs are operating in a dynamic environment and typically maneuvering against an enemy, the decision-making must not only be suitable for the environment and context of operations but must also be suitably located in time. The actual timing of the decision and also the timing allocated to the execution are both integral in decision-making (see Table 18).

Table 18. Themes coded in *Timing*.

Theme	Example Quotes from Transcripts
Timing of the decision	<i>The first decision is- I make is how much time have I got prior to making the decision. And that then drives my decision-making process. (F3-Good, Passage 3 of 4, Section 1.1, Para 370)</i>
Timing allocated to the execution	<i>And in terms of getting your timing right it's not just your decision, because you are a part of some bigger plan. (P4-Poor, Passage 6 of 6, Section 1, Para 131)</i>

Outside organisational influences were also frequently talked about in the interviews (66.67%). The influences identified were: the UN, the Australian government, the aid community, the media and other Defence organisations (e.g. Navy, Airforce). An example from the interviews is:

Yeah, because the UN has a very difficult set of agendas (4). And I'm not thinking about the military side of the house so much. It could be the local UN refugee organisation it could be just that UN political organisation which is in country with you, and umm I'm thinking Cambodia, or Bosnia, Rwanda probably, (2) where they are there for a specific thing, which is to manage through the transition say from umm dictatorship to democracy or something] [Therefore, they have the agenda which probably doesn't want to see the military interfering so much, and don't recognise that the military has something to offer. And so you have to know that your military operations are going to be inhibited by them, you know. I think that's another sort of thing. I think- I don't know whether you'd call that cultural per se, but it's just organisational stuff. That you need to build into your- into your (decision?) (P4-Good, Passage 1 of 3, Section 0, Para 428).

Culture was mentioned in 62.5% of the interviews. COs were interacting with people from a different culture in three different ways: culture in war, culture in peacekeeping and cultural mix within teams (see Table 19).

The predominant themes in each of these different types of cultural relationships were:

- When dealing with a different culture, it is important to understand and consider cultural nuances in decision-making.
- Cultural differences can lead to misunderstandings if they are not adequately understood.

In essence, these themes indicate the importance of understanding other cultures in military operations. This understanding is important both in terms of the wider situation but also in terms of the team within which the COs are working.

4.3.9 Organisational elements

Interviews contained 91.67% of coding for the *Organisational* category. Sub-codes positioned under this category are shown in Figure 19 (compared with previous topics there is a much more even spread across the elements identified; see Figure 20).

Organisational communication was mentioned most frequently (83.33%) under this category. This is similar to the *Team category* where *Team communication* was mentioned most frequently. Interestingly, the number of transcripts that highlighted organisational communication (83.33%) as impacting on decision-making was the same as the number that highlighted team communication (83.33%). However, the concept of trust, which was mentioned under the *Team category*, was not mentioned in the organisational context. This could imply that different relationships/ understandings lie between people at an organisational level, as compared with those possessed within a team (who are usually in close proximity and engaging in face-to-face communication).

Organisational elements are not specifically mentioned within the RPD model. However, it is likely that they would be considered in decision-making as a part of an officer's knowledge and experience and used to guide suitable option generation.

Table 19. Themes coded in *Culture*.

Theme	Example Quotes from Transcripts
Culture in war	<i>Umm very ahhh, what's the word umm (tsk) aww clicky geographically. I mean the demographics are that if you weren't from that area nobody gave a toss about you, and these people weren't from that area. So you know if they blew up in a minefield it wasn't a big deal. (Breaths) (F1-Good, Passage 6 of 14, Section 1.1, Para 79)</i>
Culture in peacekeeping	<i>They were there to keep the peace, but they were just upsetting the Somalians because they-they lacked that vital piece of cultural information. That's the- that's the one example I draw to whenever we're doing cultural training around here. We need to understand all the nuances, because that effects what size force you're going to have to go in- in the end, and how well that force is going to be received, or how badly that force is going to be received (4). (F4-Bad Passage 2 of 4, Section 1.1, Para 188)</i>
Culture mix within a team	<i>And the relationships within the team. And that plays a big factor. I suppose when you've got a UN force. For example when the guys come back from Timor in the hospital And their relationships with the Egyptians was interesting. They just couldn't work with one another. Their attitude to life, the way they treated women- Especially the nursing staff, who were over 50% women, was completely different (P6-Bad, Passage 4 of 7, Section 1.1, Para 141).</i>

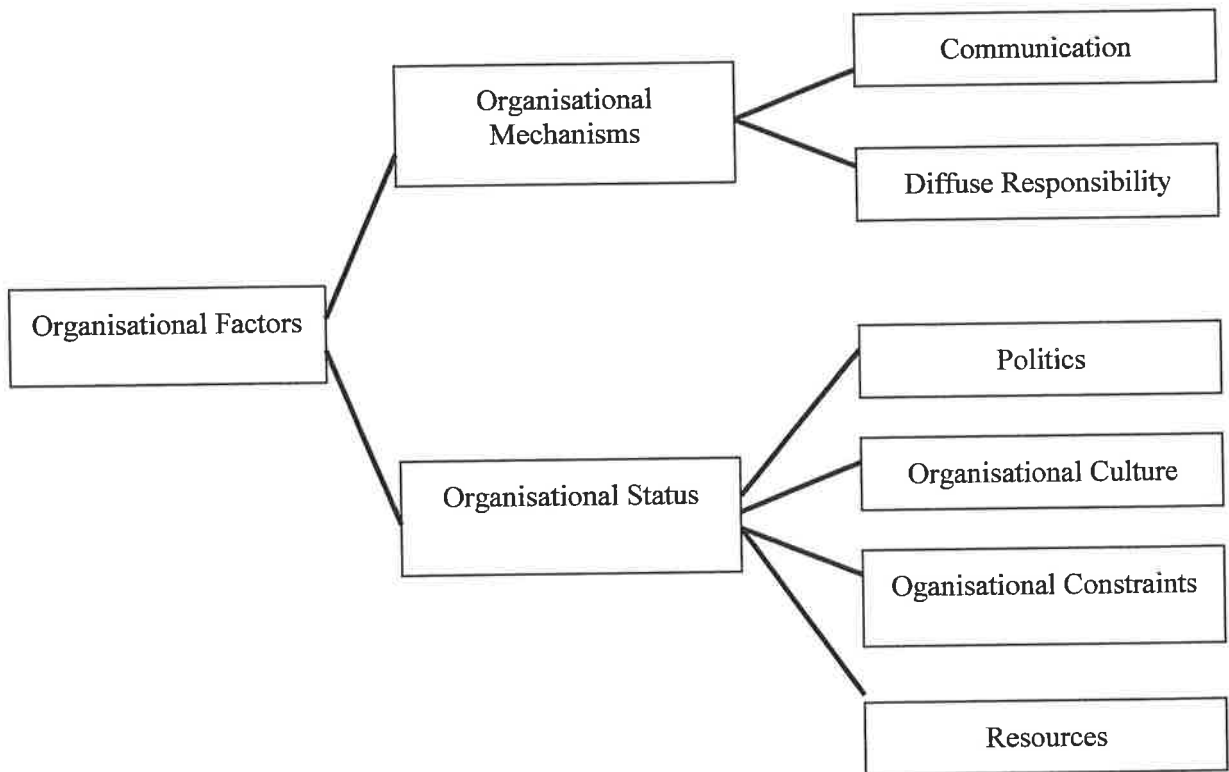


Figure 19. Modelling Organisational elements.

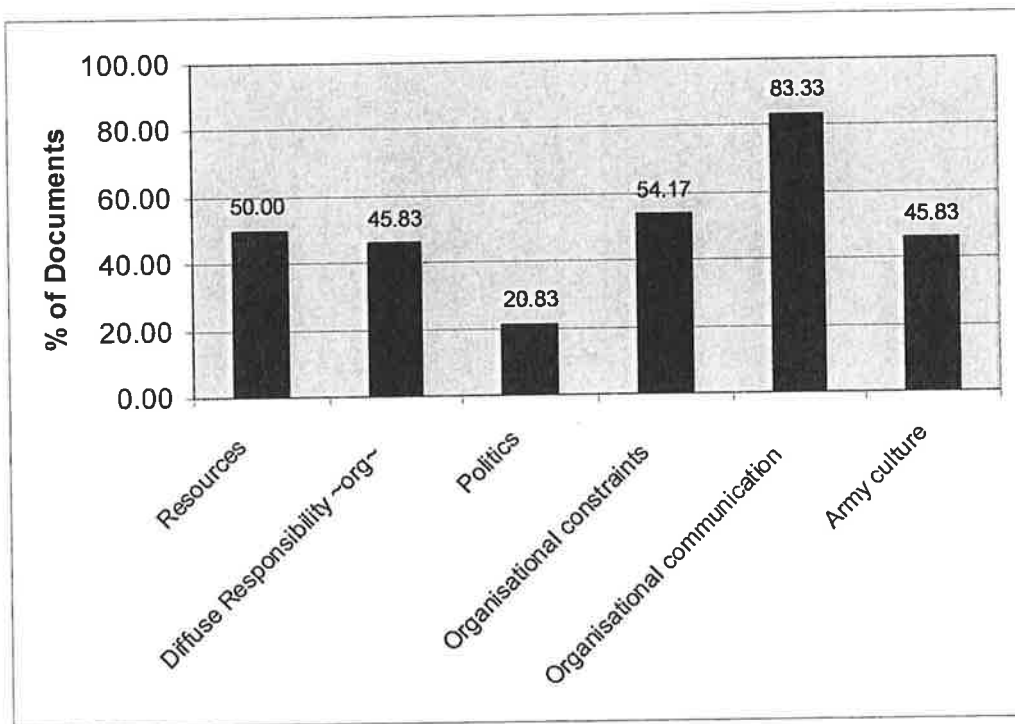


Figure 20. Description of the coding frequencies of sub-codes positioned under the Organisational category.

Organisational communication was talked about in the following ways:

- Receiving information from subordinates/ other regiments/ RAAF;
- Receiving advice/ opinion given by superior (higher HQ);
- Giving orders;
- Giving information to higher headquarters.

Thus, similar to *Team Communication*, the CO is both receiving and giving information and orders. Figure 21 shows the relative number of transcripts that mentioned *Organisational Communication* across different groups within the organisation. The distribution is quite equal across these groups.

Also, two themes that were found in the analysis were

- Emotion of other sections transmitted via verbal communication.
- Coordination is achieved via communication.

Organisational constraints were mentioned in 54.17% of the interviews. There were a number of constraints that were mentioned in the interviews and these are shown in Table 20.

Resources were mentioned in 50% of the interviews. There were a number of ways in which resources were considered. These are shown in Table 21.

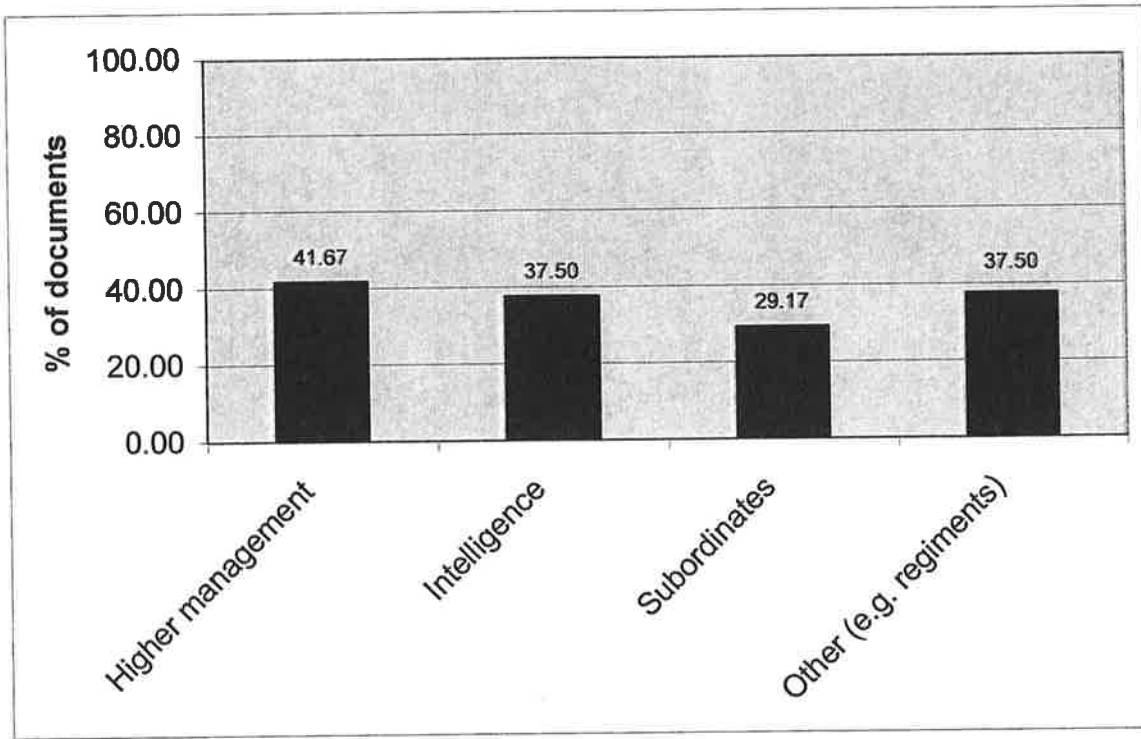


Figure 21. A description of the common groups engaging in Organisational Communication with the unit CO.

Table 20. Themes coded in *Organisational Constraints*.

Theme	Example Quotes from Transcripts
Complying with orders/ intent	<i>... you also had in the directive control aspect a sense of what your higher commander and 2 up intended to do, which is very important because your solutions always needed to be contextual in terms of your forces at the grand picture... (P1-Good, Passage 1 of 2, Section 0, Para 181)</i>
Other priorities taking precedence	<i>... in the Brigade here, prior to us going on the exercise we were in the middle of an Army wide establishment review. That is, a team was coming around to decide how many people we would have, how many tanks we have, how many everything, right down to individual rifles, night vision goggles. The whole nine yards. .hhh. Now, in terms of importance, that was far more important than this exercise. Because ultimately we were talking about the shape of how our units would be in years to come..... (F2-Good, Passage 1 of 3, Section 1.1, Para 69)</i>
Honour/ respect from others	<i>Ah I think just going back to what I said earlier. One of the things that put-that certainly put pressure on me and and- and its hard to describe but I had calls from previous CO's of this unit before we went on exercise saying you know "X this is important. If you screw this up you're toast." (F2-Good, Passage 2 of 3, Section 1.1, Para 163)</i>
Army doctrine	<i>To go through, to make sure your decisions are within the bounds of policy, and policy is pretty dynamic. So I'd say that's another ah factor in decision-making that I have found in the last sort of 3 months. (P3-Poor, Passage 2 of 2, Section 0, Para 15)</i>
Drills and procedures	<i>The Chief says we should run on drills and procedures. I've got a bit of a fundamental disagreement with that at our level, because I don't think many times we'll be in standard situations. (F3-Poor, Passage 2 of 2, Section 1.1, Para 172)</i>

Table 21. Themes coded in *Resources*.

Theme	Example Quotes from Transcripts
The resources available determine the decision possibilities	<i>We can't act on all the things we need to ahh decide and act on. There's just not enough resources and assets.] (F3-Bad, Passage 1 of 3, Section 1.1, Para 143)</i>
The way in which the resources can be used determines decision possibilities	<i>The information I needed was: what time would the aircraft be available to start moving people out from Shoal water Bay back to Townsville? How long would it take the Brigade elements to drive to the airfield, and assemble at the airfield? (F4-Good, Passage 1 of 1, Section 1.1, Para 145)</i>
Best way to incorporate multiple resources	<i>Who do you allocate to the job- do I take the blokes that are way over there and haul them across there, while keeping a firm base there? Or do I pack their bits and pieces out - throw them over there and then gradually work them back. (P4-Good, Passage 1 of 14, Section 0, Para 22)</i>

The way in which resources were discussed had a large degree of overlap with *Organisational constraints*. COs had to make their decisions to be effective given the limited available resources. Examples of evidence from the interviews where this happened were:

Because they get to this step and they're struggling because they haven't got the assets, and they come up with huge risky plans, and you come up with holes everywhere. (F1-good, Passage 4 of 4, Section 1.1, Para 373, 168 chars).

We can't act on all the things we need to ahh decide and act on. There's just not enough resources and assets.] (F3-poor, Passage 1 of 3, Section 1.1, Para 143, 111 chars).

Oh .hh one of the key things for bad decisions actually. Army is a classic at this is .hh lack of resources to implement a decisions, you know, this some

stupid management matrix about decision execution about, .hh you know, conceptualisation, resourcing, planning something like that and I can't remember Everyone knows what they want to do got their bloody planned but haven't got their resources to bloody do it so .hh you know. I just see some of the rubbish that comes out of our higher headquarters and "we're gonna do this!" "Yeah right so you want me to do that as well as everything else I'm doing at the moment "Yeah, yeah it will be great "So why don't you give me another person" (F3-Poor, Passage 2 of 3, Section 1.1, Para 176, 1037 chars).

In light of this it is suggested that it is sensible to view resources as a type of organisational constraint. However, based on the large portion of coding identifying the impact of resources, they should be regarded as a particularly important organisational constraint.

Diffuse responsibility / organisational was mentioned in 45.83% of the interviews. There were a number of themes that were mentioned in the interviews and these are shown in Table 22. Similar to the discussion on the comparisons between organisational and team communication, *Diffuse responsibility/ Organisation* corresponds with *Diffuse responsibility~ Team*, but was not mentioned as frequently. This infers a higher level of team collaboration and decision sharing, rather than at an organisational level.

Army culture was mentioned in 45.83% of the interviews. There were a number of themes that were mentioned in the interviews and these are shown in Table 23. Interestingly, in line with management psychology literature, an understanding of the organisational culture within which one is immersed is important in structuring one's behaviour and responses appropriately.

Table 22. Themes coded in *Diffuse Responsibility / Organisation*.

Theme	Example Quotes from Transcripts
Rely on information from subordinates	<i>But the geographic picture that I'd established in my own mind was built up to me by umm subordinate officers who I trusted, and they'd come back and I'd ask them bits of information, and that would build my mind picture of the place. I rely as a commander- me that is- on my picture of it, and building that, and I try and build it, and if I could I guess if you could get my mind to sort of project it, I guess that I could create a fairly good geographic model of how it was going to go on and where things were going to be and where threats were and everything like that. (F1-Good, Passage 1 of 3, Section 1.1, Para 303)</i>
Higher levels in organisation have responsibility for decision-making (risk set here)	<i>But you can go on provided you've articulated the risks that you're not taking them- your Senior Commander is. And I guess as you get higher, that's John Howard. While he's prepared to take it in the butt you go onto the next step. Happy in the knowledge that someone else is wearing this can. That's what the process is about, and you know, it is a good process, we use it. (F1-Good, Passage 2 of 3, Section 1.1, Para 373)</i>
Providing opinion and knowledge to higher HQ	<i>That said, not all of this is my doing. Umm so in terms of decision-making I guess in a Brigade like this there are different people responsible for different pieces of this. .hh ah so I guess my- my input is about convincing Brigadier Roche where uh where I think he can, you know, where he needs to accept risk. (F2-Good, Passage 1 of 2, Section 1.1, Para 49)</i>
Sharing task responsibility across regiments	<i>So any player within the area of operations is going to have an impact on the final plan. I think we're very confident in the military now that we can't make plans exclusive of other people that are going to be there. I think we're getting better at being more inclusive, with all the key players. (P3 Good, Passage 3 of 3, Section 0, Paras 523)</i>
Commander gives intent	<i>Generally If I'm getting information through various sources, I guess what I'm getting through here is filtered stuff, cause its all coming from higher and higher and higher headquarters again, 2 or 3 levels further on. (P4-Good, Passage 5 of 12, Section 0, Para 298).</i>

Table 21. Themes coded in *Diffuse Responsibility / Organisation* (continued).

Theme	Example Quotes from Transcripts
Generate intent for subordinates	<i>Level in terms of decisions where- decisions you make, what you don't want to be doing is making a decision for a subordinate. (P3-Good, Passage 1 of 3, Section 0, Para 239)</i>
Feedback of knowledge/ opinion above	<i>Oh yeah, yeah. (3) Again because Generals have a habit of asking well, what about this? What about that? If you haven't thought it through properly then potentially you've made a mistake and just really you haven't done the work that the general expects of you, cause his plans might change too, and if you've also thought through a couple of other ways of doing business, if he does change his mind then he might also have something that you can latch onto at a later stage, cause you've thought through some other ways of doing business. (P4-Good, Passage 12 of 12, Section 0, Para 584)</i>
Give direct orders below	<i>Being a sort of I guess its more of directive control ummm. Well in order to get here do this- do that. But you're trying to think to tell everybody what to do, and they should hopefully run with the initiative and run from there. That's the sort of things that I've found I shouldn't be doing this. The Corporal running this section should be doing this but I am. He didn't know what to do so OK let's push on so I was doing the same for him. "You need to make your way through the wire." (P6-Good, Passage 4 of 4, Section 1.1, Para 166)</i>

Table 23. Themes coded in *Army Culture*.

Theme	Example Quotes from Transcripts
The way things tend to happen/ Underlying assumption	<i>Nah I don't think so. Gosh you've got more internal cultural problems than you've got external cultural problems. Like the culture of the infantry battalion which is look forward, go, and kill type thing and I'm not interested in where the force (is coming from) as long as they're here. [You (.) For a logistician that's very frustrating, but you've got to know that's the way it is so- so I guess that's an example where culture is pretty important.... (P4-Good, Passage 2 of 2, Section 0, Para 404)</i>
Attitude	<i>You know the initial plans easy, anyone can make the initial plan, but after the enemy got there before you what are you going to do about it? How do you respond, and they and they've automated the process so they can review it, so they can play it back .hh um now we- we have been slow to adopt that methodology and I think there's cultural reasons cause we- we don't want to fail. (F2-Bad, Passage 1 of 2, Section 1.1, Para 111)</i>

4.3.10 Conclusion

To summarise, this chapter had two aims. They were:

1. Search for evidence of RPD in unit level decision-making.
2. Identify and describe the elements perceived to impact on command decision-making

In response to the first aim, the RPD model is supported as a valid explanation for decision-making in the Australian Army unit HQ environment. The finding that almost 80% of the time only one or two options were considered in decision-making, along with the finding that out of 24 decision points, none was approached without reference to previous experience, provides strong support for this. Moreover, a number of elements identified in the interviews supported various parts of the RPD model (see Table 12). Firstly, the process of establishing SA was supported by a number of elements identified in the interviews.

Establishing SA was supported by the existence and descriptions of the *Situational category*. Also within the *Team* and *Organisational categories* communication coding showed that the team and the wider organisation were actually contributing information, knowledge and opinion into SA. This equates to contributions at all three levels of SA as described by Endsley (1995). In addition, perspective was also discussed as a potential impact on understanding of the current situation (SA). Secondly, the role of experience in decision automation, as described in the RPD, was supported. In fact, experience was the most frequently discussed element overall. It was described to facilitate recognition of situations and automate option generation and decision-making. This is exactly the role of experience in the RPD. Finally, the role of mental simulation, as discussed in the RPD, received some support in discussions of flexibility in decision-making.

In response to the second aim, a number of elements perceived to impact on decision-making were identified and described. At a macro level, four broad categories of elements that were perceived to influence decision-making were extracted. These categories were: *Personal, Situational, Team* and *Organisational*. These match the levels of elements identified as contributing to team processes discussed by Driskell, Hogan and Salas (1987). These were taskwork, teamwork and environmental factors. The current research adds the *Organisational category* to this model. Thus, the elements impacting on decision-making at unit HQ need to be considered across each of these four categories.

A number of personal elements were identified as impacting on decision-making. Many have not been explored before in relation to decision-making in the Australian Army. Of importance to assist to better define experience in the RPD model were the descriptions of the various types of experience that were being drawn upon in the decisions analysed here. To date there has been no published research describing what types of experience feed into the RPD model. However, it appears that the types of experience used in these instances may subtly differ from one CO to another. Current results raise the questions of how COs adapt

and apply their experience in various situations and whether the scenario can be used to predict what types of experience are most useful.

The critical importance of the roles of both the team and the organisation in decision-making has been confirmed. Overall, communication at both levels was mentioned frequently. Communication at a team level showed input at all levels of the COs SA (Endsley, 1995). Interestingly, the concept of trust was not mentioned at an organisational level, suggesting that communication from the team level may be more salient compared with that impacting at the organisational level. The ability to engage in face-to-face communication at a team level may also contribute to this establishment of trust. This would have implications for NCW because members of the HQ team may be separated from each other. It is uncertain to date whether this would impact significantly on the levels of trust held between team members, or on the level of importance placed on team communication and diffuse decision-making responsibility. However it is clear is that omitting either team or organisational elements from a model of decision-making in unit HQ would provide a less than adequate account of decision-making.

A number of situational elements were also raised by interviewees that are not specifically described in the RPD model. This provides a summary of important elements that impact on SA formation at this level in the Australian Army. One particularly under explored area is the effect of culture, within the team or across the operation. Sparse literature exists on many of these identified situational topics and they need to be explored further in terms of their impact on decision-making, because they could have substantial effects on the decision outcome.

The importance of further exploring how individual COs' perceptions of elements that influence decision-making may subtly differ was highlighted. This need stems from the spread of coding for individual elements across COs and also across good and poor decision points. This will be further researched in Chapter 5.

There are a number of possible limitations in the current research. Firstly, the sample size was small and the method typically not generalisable. The small sample size reflects the small number of unit level COs available within Australia the intensive nature of the method chosen. Therefore, this was unavoidable. However, validity of results will be investigated using triangulation in Chapters 5 and 6. Secondly, the way in which novel situations were here defined may have been problematic, because it is difficult to achieve a situation that is truly novel. Most Army officers require 15 years or more experience in the Army to achieve the level of unit CO. This was certainly so for the 12 participants in the current study, for whom the average length of experience in the Army was 19.17 years. After such a long time it would be expected that the Officers would have accumulated very substantial experience, so that it is unlikely that any could be confronted by an entirely novel situation. Future research may therefore need to consider instead the degree of novelty associated with specific situations. This could be recorded using specific criteria set by the researcher, or a self-report score. Situation novelty could then be compared with types of experience drawn upon, in order to generate laws governing this type of behaviour.

This chapter provided validation for the RPD in unit HQ of the Australian Army. It has also identified and described the array of elements that are perceived to impact on unit level CO decision-making. However, the relative importance of each of these elements has not been identified. Using the frequency of expression of elements within interviews is not an adequate method to identify their relative importance. An analysis forcing comparisons between these important concepts will be reported in the next chapter.

Finally, it will be important to also consider the external validity of the outcomes from this stage of the research. Behaviours need to be observed in a real world environment before the validity of interview data can be accepted. This issue will be further addressed in Chapter 6.

CHAPTER 5. Analysing the Relative Importance of Elements Perceived to Impact on Decision-making:

A Q-sort Study

5.1 Introduction

This chapter reports the Q-sort phase of the current research. This phase aimed to organise perceptions reported by the unit CO about elements impacting on their decision-making, ranked according to element importance. This was done using a Q-sort which requires participants to rank a number of statements along a continuum. This method permitted elements previously identified in the interviews to be defined and prioritised by the participants.

5.2 Method

5.2.1 Participants

Twenty six participants completed the Q-sort task. This number fell short of McKeown and Thomas' (1988) suggested sample size of 30-50 individuals, but was considered reasonable, especially because there were only 60 potential participants available in Australia (ie. a 43% response rate was achieved). Participants were not randomly selected but chosen according to their position. Participants in the current phase were unit COs (n=16) and unit Operation Officers (OPSO; n=10). Accounts by OPSOs' about unit level decision-making were included because there are only a few unit level COs in Australia. OPSOs were deemed suitable for participation because their role requires similarly high levels of knowledge relevant to unit-level decision-making compared with what is required of a unit level CO. An OPSO is in charge of monitoring and maintaining information about current operations for the CO. An OPSO therefore works closely with the CO and would usually have

one of the most complete levels of situation awareness (SA) in the unit HQ team. In addition, OPSOs are usually intimately involved in the decision-making process. Thus, their role is complementary in many respects with that of the CO. All participants were male⁴¹. Ages ranged from 26-51 years, with a mean age of 37.31 years (SD=6.55). This is similar to the group interviewed in the previous chapter where the mean age was 39.42 years (SD=3.40). Participants were from 9 Brigade, 7 Brigade, 1 Brigade and 3 Brigade. Sixteen participants were part-time officers and 10 worked full-time. A description of participants' experience and other relevant demographic information is presented in Table 24 and Table 25.

5.2.2 The current concourse and selection of Q-sort items

The Q-sort focusing on 'elements perceived to impact on unit level Command decision-making' was developed from coding the 24 interview transcripts discussed in Chapter 4. Structured sampling was used to identify key elements for inclusion in the Q-sort. Sixty Q-sort statements were developed in total⁴². These statements encapsulated the most frequently mentioned elements perceived to influence unit level CO decision-making. In line with the analysis presented in Chapter 4, elements were drawn equally from each of the four main categories discussed: *Personal*, *Team*, *Situational* and *Organisational* (see Table 26).

⁴¹ This is typical of the majority of unit COs. NDM theory would not predict that responses from female unit COs would differ significantly from the current sample.

⁴² It has been suggested that at least 60 statements must be used to ensure statistical stability and reliability (Kerlinger, 1973).

Table 24. Demographic information and experience of participants in Q-sort study.

	All Officers (N=26)				Full-Time Officers (N=10)				Part-Time Officers (N=16)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Age	37.3	6.52	26.00	51.00	34.8	6.00	26.00	41.00	38.87	6.51	27.00	51.00
Years of experience in the Army	17.61	7.22	2.00	33.00	17.5	5.42	9.00	24.00	17.69	8.31	2.00	33.00
Number of postings	7.42	4.29	1.00	15.00	8.29	4.23	4.00	13.00	6.92	4.42	1.00	15.00

Table 25. Description of participants' NDM experience in Q-sort study.

	All Officers (N= 26)		Full-Time Officers (N= 10)		Part-Time Officers (N= 16)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Frequency of Job Related Training						
Every day	5.00	19.23%	2.00	20.00%	3.00	18.80%
Weekly	3.00	11.54%	2.00	20.00%	1.00	6.25%
Monthly	8.00	30.80%	4.00	40.00%	4.00	25.00%
Every 6 Months	6.00	23.10%	0.00	0.00%	6.00	37.50%
Yearly	4.00	15.40%	2.00	20.00%	2.00	12.50%
Frequency of Combat Training						
Weekly	5.00	19.23%	2.00	20.00%	3.00	18.75%
Monthly	13.00	50.00%	7.00	70.00%	6.00	37.50%
Every 6 Months	6.00	23.10%	1.00	10.00%	5.00	31.25%
Yearly	2.00	7.70%	0.00	0.00%	2.00	12.50%
Operational Experience (any)	19.00	73.08%	8.00	80.00%	11.00	68.75%
Involved in Other NDM Organisation						
No	21.00	80.80%	7.00	70.00%	14.00	87.50%
Yes	5.00	19.23%	3.00	30.00%	2.00	12.50%

Table 26. A summary of topics covered by statements in the Q-sort.

Category	Element (from interview coding)	Quote Topic (for Q-sort)
Personal	<i>Experience</i>	<i>Experience</i>
	<i>Emotion</i>	<i>Emotion</i>
	<i>Fatigue</i>	<i>Fatigue</i>
	<i>Personality</i>	<i>Personality</i>
	<i>Perspective</i>	<i>Perspective</i>
Team	<i>Trust</i>	<i>Trust</i>
	<i>Diffuse responsibility/ communication</i>	<i>Information</i>
		<i>Judgements (knowledge)</i>
		<i>Plan evaluation (opinion)</i>
		<i>Decision responsibility</i>
Situational	<i>Environmental influences</i>	<i>Environmental influences</i>
	<i>Decision aids</i>	<i>Decision aids</i>
	<i>Outside org influences</i>	<i>Outside org influences</i>
	<i>Culture</i>	<i>Culture</i>
	<i>Timing</i>	<i>Timing</i>
Organisational	<i>Diffuse responsibility/ communication</i>	<i>Higher management</i>
		<i>Subordinates</i>
		<i>Intelligence</i>
	<i>Organisational constraints/Resources</i>	<i>Organisational constraints</i>
	<i>Army culture</i>	<i>Army culture</i>

Generally statements have been based on the most frequently mentioned elements identified under each of the four categories that were determined from the analysis of interviews. However, there are two occasions where this rule was not followed. One element that has been discussed frequently in interviews, but was not included in the Q-design, was

Resources (*Organisational*). As mentioned in the previous chapter it was decided that, for the Q-sort process, resources would be grouped with other organisational constraints. This was reasonable because of the overlap between the elements within the interviews. In addition, under the element of *Diffuse Responsibility / Communication* the four topics that were chosen to incorporate into the Q-sort were *Information, Important judgements Plan evaluation* and *Decision responsibility*. These were included because they contributed to a large proportion of interview coding.

Therefore, for clarity in explanation in Table 26, a third column has been added that describes the topics that are being discussed under each element extracted from the previous interview chapter. These topics have then been the basis for the development of the Q-sort statements. In most cases these are the same as the elements identified in the interviews. Only in the cases where it was deemed important to explore different topics within the element have the topics been broken down further. Therefore, in the analysis section of the current chapter reference will be made to the topics which describe the content of the statements in the Q-sort.

5.2.3 Defining the purpose and structure of the Q-statements

Interview findings suggested that a number of elements were perceived to impact on decision-making. However, no clear priority of elements was revealed. Conversion of these elements into representative Q-statements allows them to be comparatively ranked. The way in which participants arrange the statements along a pre-defined scale delineates elements perceived to have a greater impact on decision-making. Q-sort also determines whether this perception varies between different groups of COs. Given the interview data, it was expected that elements under the *Personal* category would generally be ranked as being more influential, followed by elements under the categories of *Team, Situational* and finally *Organisational*. This ordering is based on how frequently each of the categories were discussed during the interviews.

Beyond the ranking of the elements, the Q-sort study also aimed to derive a better understanding of where these elements impacted on the decision process. Thus, the Q-sort also gave opportunity for participants to decide whether they perceived the various elements to impact directly on the CO or the wider team. Participants were also given the option that elements did not impact at all on decision-making. This final option was added as a measure of control, to create a balanced design (i.e. avoiding the assumption that the larger group of COs sampled in the Q-sort study perceived all elements identified in the interviews to impact on decision-making). Therefore, 60 statements were created. Each statement focused on one of the topics (influencing elements) shown in Table 26 and one of the points of influence illustrated in the top row of Table 27.

Table 27. Representation of Fisherian balanced experimental sampling used in the current study.

	Commander	Team (Diffuse)	None
Organisational (5 elements)	A (5 statements)	B (5 statements)	C (5 statements)
Personal (5 elements)	D (5 statements)	E (5 statements)	F (5 statements)
Team (5 elements)	G (5 statements)	H (5 statements)	I (5 statements)
Situational (5 elements)	J (5 statements)	K (5 statements)	L (5 statements)

5.2.4 Constructing the statements

Each of the statements included in the Q-sort was constructed to represent the way in which the elements identified in the interviews were commonly talked about. To do this, all Q

statements were based on a number of direct quotations from the interview transcripts. For example, the impact of higher management on the decision-making process was a topic for Q-sort statements. This was developed, based on a number of direct quotes extracted from the interviews. For example:

“And umm it’s reality that external pressures interfere with your decision-making process. This is because higher headquarters demand to know things”
(Document F3-Good, Passage 1 section 1.23, Para 301).

“...Obviously someone sitting at the top of your organisation hierarchy has delivered orders to their subordinates. They’re then broken down and amplified changed and explained.. I think we’re sitting at a level below that”
(Document P2-Poor, Passage 1 of 3, section 1.2, Para 223).

“We’re functioning as part of the bigger organisation and other parts of the organisation are feeding information in and that gets fed to you at your level, but it also gets fed down to you from people above as well” (Document P2-Poor, Passage 2 of 3, section 1.3, Para 551).

“I had Brigadier X above me who just wouldn’t leave me alone. I think in the end I told him the plan 20 or 30 times, but he- at the end of the day you sort of think why did he want to do that? Well, cause he’s the national commander of this country. If it goes wrong he’s going to get it yeah” (F1-Poor, Passage 1 of 1, Section, 1.1, Para 402).

The topic (higher management) was then described in three Q-sort statements. Each statement describing one of the three different points of influence. The Q-statements read as follows:

1. I feel that the restrictions set by higher management influence me greatly throughout decision-making. (A)

50. I feel that the restrictions set by higher management influence the command team greatly throughout decision-making. (B)

39. Restrictions set by higher management do not greatly influence decision-making. (C)

Other examples are the statements that focus on the impact of *Experience* on decision-making:

16. It is important to feed my experience into the decisions made. (D)

5. It is important to feed the collective experience of my command team into the decisions made. (E)

54. Experience is not important for decision-making. (F)

These statements were also based on direct quotes extracted from the interviews. For example:

“I think the reason- I think the overriding reason was that it was an activity that had been foreseen. It was anticipated and we had practiced for it and people just fell into their positions” (F6-Good, Passage 5 of 5, Section 1.23, Para 234).

“How do you make an assumption? Umm I think in many ways it’s experiential. Umm from what you have gone through” (F5-Good, Passage 5 of 7, Section 1.1, Para 481).

“I- I don’t have some journal I’ve maintained over the years, so if I’m confronted with a decision I don’t go back and ‘Oh yeah. I can recall on this,’ you know ‘exercise or operation, where we had this and had these consequences’. It tends to be a much more reactive process. So being confronted with a decision, that’s normally a sufficient prompt to recall if

you've been in a similar or related situation previously". (P2-Bad, Passage 2 of 2, Section 1.1, Para 304).

"Yeah, in many ways I think [experience is like a mental shortcut]. It is yeah. (.) We know that whenever this happens, this happens. You get your old soldier stories coming- 'Look sir, it doesn't matter what the book says we know this happens because it goes this way every single time' " (P4-Good, Passage 13 of 18, Section 0, Para 364).

The statements were designed to read easily and unambiguously. Moreover, as much as possible, they were based on the style of language used by the COs during interviews. They were also constructed to be sufficiently general to cover the range of different interview excerpts from which they were originally derived. This was because the aim of the Q-sort was to demonstrate the perceived relative importance of the elements identified in previous interviews. Thus, because the elements were broad, it was important to develop generalised statements. In the end, two sets of corresponding statements were created. One set was phrased appropriately for COs and the other was phrased appropriately for OPSOs (see Appendices XI and XII).

5.2.5 Design and administration of the Q-sort

Because participants were spread around Australia, it was difficult to administer the Q-sort face-to-face, as would be done in an ideal situation. However, the availability of suitable computer software allowed for the construction of a simple computer-based program that could be used to complete the Q-sort. This program was designed to exhibit the same cognitive requirements as a traditional paper-based Q-sort (organisation of statements along a scale and ability to review and rearrange statements in order to generate the most accurate pattern of opinions). The computer program satisfied ethical requirements, such as informed consent and freedom to withdraw at any point. The program was developed so that it could be

emailed to the available participants around Australia. A standard email text was designed to be sent with the program (see Appendix XIII).

The program consisted of a number of steps (screens). These were: (1) Study information, (2) Consent form, (3) Demographic questionnaire, (4) Q-sort instructions and (5) Q-sort program. Participants could move between each of the steps by using the computer mouse to click on buttons labelled “forward” or “backward”.

The first screen explained the nature and purpose of the research as well as ethical rights and responsibilities (see Appendix XIV). The second screen displayed the consent form (see Appendix XV). At this screen participants also had the option of terminating their participation by clicking on the “I decline” button. If participants wished to continue with the study they were asked to highlight the “I accept” button, before proceeding. By clicking on the “I accept” button, participants proceeded to a screen displaying a demographic information questionnaire (see Appendix XVI). Once completed, participants could click on the “finished” button, which automatically saved the demographic data and presented the fourth screen. The fourth screen displayed instructions on how to complete the Q-sort (see Appendix XVII). To enable participants to print the instructions for reference during the Q-sort task, a print option was provided. The final page contained the Q-sort task (see Appendix XVIII). The statements to be sorted were available for perusal by the participant at the bottom of the screen in a *scroll down* list. At the top of the screen were several columns marked with numbers ranging from -5 to +5. Statements from the *scroll down* list could be dragged into each of these columns indicating a participant’s comparative level of agreement with that statement. The number of statements able to be dropped into each column was pre-programmed into the computer and if a participant tried to allocate more than this number a message would appear on the screen informing them that:

"That list can only contain a maximum of n statements!"

Participants could also move statements out of columns if they changed their minds. Once participants were satisfied with the arrangement of the statements, they clicked on the “finish/send” button. The completed Q-sort was saved by the computer and automatically sent electronically to the researcher for analysis.

5.2.6 Procedure

After potential participants had been identified they were sent an email explaining the purpose and nature of the study and requesting participation. The executable file containing the Q-sort program described in section 5.2.5 was attached to this email and could be opened by the participant if s/he was interested. Once the executable file was opened it proceeded through (1) Study information, (2) Consent form, (3) Demographic questionnaire, (4) Q-sort instructions and (5) Q-sort program. When the researcher received results these were entered into a spreadsheet for analysis.

A number of mechanisms were put in place to ensure the best response rate possible (Porter, 2004). These were drawn from the literature reporting on non-response to surveys. Following Dillman (2000), multiple contacts were made with each of the potential participants who were sent the Q-sort task; including multiple emails and also telephone follow up⁴³. Other aspects considered in the design were: minimising task length, describing the salience of the task to the audience, ensuring confidentiality, framing the research as a request for help, mentioning sponsorship of the research by DSTO and the University of Adelaide and setting deadlines for responses. These mechanisms have all been suggested to improve response rates (Porter, 2004).

⁴³ Reminder notes have been found to increase response rates by 3.5-8% (Dillman, Clark & Sinclair, 1995; Fox, Crask & Kim, 1988).

5.3 Results

5.3.1 Overall analysis

PQ Method 2.11⁴⁴ was used to analyse the data (Schmolck & Atkinson, 2002). The analysis began by correlating each participant's Q-sort with every other participant's Q-sort. Thus, a 26 x 26 correlation matrix was created (see Appendix XXI). Correlations indicated the extent to which pairs of Q-sorts resembled or were different from each other (Kitzinger, 1987).

Factor analysis (principal components) was then used to search for groups of Q-sorts that had resulted in similar patterns of organisation. Analysis resulted in one main factor, which was rotated to provide a clear account of factors perceived to impact on unit level decision-making. Two other divisions between the remaining sorts also emerged. A second group of three similar sorts all submitted by OPSOs emerged. This group was not recognised as a factor because in Q-method factors need to be well-defined (meaning that at least four or five sorts need to be substantially loaded on a factor; Reid, 1999). The final sort was an outlier that was dissimilar to both Factor 1 and Group 2.

The small number of sorts contributing to both Group 2 and the outlier indicates that they were minority opinions and less reliable than the emerging factor. Despite this, we know that they represent an opinion held by at least some members of the Australian Army and thus warrant a brief discussion. Further work would need to be done to understand the extent to which these opinions feature across the Australian Army.

⁴⁴ PQMethod was adapted, revised and is maintained by Peter Schmolck. The Fortran code, on which it is based, was originally written for the mainframe by John Atkinson under the guidance of Steven Brown at Kent State University.

Factor loadings for each participant are shown in Table 28. Factor arrays for the accounts of factors impacting on unit level decision-making are given in Table 29. Detailed discussions of the main Factor 1, Group 2 and the outlier are presented in the discussion section.

Table 28. Factor loadings for the accounts of elements impacting on unit level decision-making.

Q-sorter No.	ID	Factor 1	Group 2	Outlier 3
1	RCO_6	0.8520	-0.0804	-0.0882
2	RCO_7	0.7536	0.0063	0.1043
3	RCO_8	0.8629	0.0138	0.1111
4	RCO_9	0.8748	-0.0723	0.1545
5	RCO_12	0.8484	-0.0485	-0.0265
6	RCO_16	0.8561	-0.0455	0.0270
7	RCO_17	0.8999	-0.2026	-0.0716
8	RCO_19	0.6771	-0.2338	-0.1721
9	RCO_22	0.8982	-0.2042	-0.0590
10	CO_1	0.8894	-0.2041	-0.0645
11	CO_2	0.7781	-0.1062	-0.0214
12	CO_3	0.8570	0.0001	-0.0042
13	CO_4	0.7781	-0.1062	-0.0214
14	CO_5	0.8810	-0.0750	0.1669
15	CO_16	0.8701	-0.0948	-0.1024
16	ROP_2	0.7024	-0.1235	-0.2303
17	ROP_3	0.7081	0.0952	0.2988
18	ROP_5	0.7622	0.0121	-0.0514
19	ROP_9	0.7066	0.0984	0.2791
20	ROP_10	0.7651	-0.1208	-0.0721
21	OP_17	0.8099	-0.0414	-0.1224
22	ROP_4	0.6862	-0.1427	-0.2250
23	ROP_6	0.6314	0.7470	0.0399
24	ROP_7	0.6255	0.7541	0.0103
25	OP_6	0.6564	0.7203	0.0468
26	CO_7	0.0990	-0.3767	0.7453

Note: Boxed loadings indicate those sorts loading on each factor/ group.

Table 29. Factor arrays for the account of elements impacting on unit level decision-making.

Q-sort item	Factor 1	Group 2	Outlier 3	Q-sort item	Factor 1	Group 2	Outlier 3
1	+3	+3	-3	31	-1	-3	-2
2	+4	+3	+5	32	+1	+3	-2
3	-5	-5	+1	33	-3	-3	0
4	+5	+1	+4	34	0	0	0
5	+4	+4	+4	35	+1	+1	-2
6	-3	-3	-2	36	-3	-1	-1
7	-5	-1	+5	37	-1	-3	+3
8	+5	+4	+3	38	-1	+2	-3
9	-5	+5	0	39	-2	-2	-2
10	+2	+2	-4	40	-1	-4	0
11	+1	+1	0	41	+2	+2	-1
12	-2	-4	-3	42	-4	+3	-5
13	+4	+2	+5	43	+2	-1	+1
14	+3	+5	-5	44	+1	+5	-1
15	-1	+1	-1	45	-3	-5	+2
16	+5	+1	+5	46	+1	-2	-1
17	+3	+2	+4	47	0	-1	+3
18	-5	0	+2	48	-1	-2	+2
19	+4	+4	-4	49	0	-1	0
20	+3	+2	-1	50	+1	+3	+4
21	-5	-4	0	51	-2	-4	+1
22	+2	-1	-4	52	+2	+4	-4
23	+1	-1	+2	53	0	0	-2
24	-2	0	+1	54	-3	-5	-2
25	+3	-2	-5	55	-2	-2	-1
26	0	+1	0	56	-1	0	+3
27	-4	-2	-3	57	-4	0	-3
28	+2	+1	+5	58	0	+5	-3
29	0	0	+3	59	0	0	+1
30	-4	-5	+1	60	-2	-3	+2

5.3.2 Factor 1

As indicated in Table 28, 22 participants defined this factor. All sorts that loaded highly in Group 2 also loaded substantially high on Factor 1, reflecting the similarity between Factor 1 and Group 2. Overall, Factor 1 represented how the majority of those surveyed

understood NDM in unit HQ. The way in which each of the elements were rated by those who loaded strongly on this factor will be discussed for *Personal*, *Team*, *Organisational* and *Situational* categories.

Overall, topics under the *Personal* category were regarded as comparatively most important when making decisions. Four of the five topics received an extreme rating (either greater than +4 or less than -4). All of the statements falling under this Factor are shown in Table 30 and will be discussed individually.

Similar to the emphasis given to *Experience* in the interviews, this was also highlighted as an important topic in the Q-sort. Participants did not agree that experience had no influence (-3). Both the CO's experience (+5) and the experience of the HQ team (+4) were rated highly. This finding supports the NDM assumption that experience drives decision-making. The almost equal importance placed on the CO's experience and the experience of the team reinforces the importance of drawing of the team's knowledge and experience during decision-making.

The second topic under the *Personal* category, which also loaded highly in the Q-sorts, was *Personality*. Participants did not agree that personality had no effect on decision-making (-4). The personality of the CO (+5) was seen as being substantially more influential on decision-making when compared with the personalities of the team (0). This implies that personality is much more influential in parts of the process controlled by the CO (i.e. setting the intent and making the final decision). To date, there has not been conclusive research linking personality to NDM. Thus, for personality to be weighted with such high importance in comparison with the other factors presents a gap in our understanding of unit level decision-making. The inclusion of this factor in the theory should produce a model with better predictability than currently exists.

Table 30. Summary of how each statement in the *Personal* category was rated under Factor 1.

Statement	Influence	Rank
Experience		
It is important to feed my experience into the decisions made.	(CO)	+5
It is important to feed the collective experience of my command team into the decisions made.	(Diffuse)	+4
Experience is not important for decision-making.	(None)	-3
Personality		
My character traits affect decision-making, fundamentally.	(CO)	+5
Character traits do not have an effect on decision-making.	(None)	-4
The character traits of my command team are all important predictors for the eventual decision outcome.	(Diffuse)	0
Fatigue		
Fatigue does not influence decision-making.	(None)	-4
If my command team are fatigued, that will negatively affect the decision-making.	(Diffuse)	+2
If I am fatigued, this can slow down the whole decision process, and lead to untimely decisions.	(CO)	+2

Table 30. Summary of how each statement in the *Personal* category was rated under Factor 1 (continued).

Statement	Influence	Rank
Perspective		
Perspective does not influence decision-making.	(None)	-5
My command team determines the perspective from which the current situation is viewed.	(Diffuse)	0
I solely determine the perspective from which the current situation is viewed.	(CO)	-1
Emotion		
I sometimes find myself being influenced by my emotion when making decisions.	(CO)	+2
My command team's emotions can influence decision-making.	(Diffuse)	+3
Emotion does not influence decision-making.	(None)	-3

Note: 'Influence' refers to where the element is perceived to impact on decision-making. For example, is the experience of the CO (CO) or the team (diffuse) more important for decision-making or is experience not important at all (none).

The third topic under the *Personal* category that was ranked positively was *Fatigue*. Participants did not agree that fatigue had no impact on decision-making (-4). According to the Q-sort structure under Factor 1, both the fatigue of the CO (+2) and the team (+2) were seen to be of equal importance in decision-making. Fatigue has also attracted only sparse research in the Australian Army (Hochwald, 2001). However, world-wide it is often incorporated into military models of decision-making and it has been suggested that cognitive fatigue impacts on decision performance (Luscombe & Mitchard, 2003). Research outside the military has linked increased fatigue with increased levels of risk taking in decisions (Hockey, Maule, Clough & Bdzola, 2000). Moreover, in the healthcare field research suggests that lower levels of fatigue improves alertness, mood and performance (Howard et al., 2003).

The fourth topic under the *Personal* category was *Perspective*. Participants indicated by their sorts that they strongly disagreed that perspective had no effect on decision-making (-5). However, the actual level of importance was rated lower than that of the previous topics under the *Personal* category. The importance of the perspective of the team (-1) was ranked slightly lower than the importance of the perspective of the CO (0). Thus, it was difficult to decide whether the perspective of the CO or the team was deemed to be more influential on decision-making. The impact of perspective fits with NDM theory, because perspective would be associated with development of SA. Thus, it would affect a critical component of the RPD process. To date the impact of perspective on SA formation has not been explored and this issue warrants further research.

The final topic under the *Personal* category was *Emotion*. This did not rate as strongly as a potential influence on decision-making. Although none of the Q-statements on emotion were rated on extreme ends of the scale, there was substantial variation between the rankings of the three possible statements. Participants did not agree that emotion did not impact on decision-making (-3). The CO was ranked to be less influenced by emotion (+2) when compared with the team (+3). Although only a small difference in ranking, this may have

occurred for two reasons. Firstly, during the information gathering process the CO should be able to distance himself/ herself from the problem, leaving it the hands of the team. The CO is then presented with the facts to make the final decision, which should be objective, impartial and unemotional. Secondly, usually the CO has acquired more decision-making experience than a team member and thus s/he has learnt to be more impartial in decision-making. As mentioned in Chapter 2, recent research indicates that emotion does play a part in decision-making (e.g. Sayegh, Anthon & Perrewew, 2004). However, the influence may be either unconscious or ignored by the decision-maker.

Overall, the *Team* category was also regarded by raters as comparatively important when making decisions. Four of the five topics within the *Team* category scored an extreme rating (either greater than +4 or less than -4). All of the statements falling under this Factor are shown in Table 31 and will be discussed together.

As identified in the interviews, at both HQ team level, information, knowledge and opinions were regarded as highly influential. These three types of communication contribute to the three levels of SA, as defined by Endsley (1995). Level 1, the lowest level of SA, involves perceiving cues from the environment (information). Participants did not agree that information did not impact on decision-making (-4). Information was investigated in terms of information being transmitted to the team (+5) and information being transmitted to the CO (+4). Both were considered very important, with information for the team given a slightly higher priority. This may be because, in order for the team to deliver the most useful information to the COs, they must first be appropriately directed by the CO. Otherwise information search would be inefficient. The importance of the COs transmission of clear intent is also reflected in doctrine.

Level 2 of SA involves integrating perceptual cues and comprehending their meaning and significance (knowledge). Knowledge was described in the Q-sort in terms of judgements made on information. Raters strongly disagreed with statements proposing that judgements

did not impact on decision-making (-5). Both CO judgements (+1) and team judgements (+2) were given similar importance in decision-making, with team rating slightly higher. This outcome indicates that the team is important in the decision-making process. This is indicative of the role of the team, whereby team members make judgements on information relevance, even before presenting this to the CO.

Level 3 of SA involves projecting from current events and anticipating future events (opinion). Opinion was described in the Q-sort in terms of evaluating a plan. Raters strongly rejected the proposition that evaluating a plan was not important for decision-making (-5). Evaluating a plan in combination with the wider team was perceived as important (+3), rather than relying on CO to do it without team assistance (+1). However, the comparative rating for the CO doing it alone was still relatively high. All three types of *Diffuse responsibility/communication* feed into SA and were all ranked as quite important in the decision-making process. Information was the only type of communication where transmission from the CO to the team is most important. In the case of judgements and evaluations transmission from the team and CO were more important.

Two other topics in the *Team* category included in the Q-sort were *Trust* and *Decision responsibility* (see Table 31). These statements also aimed to learn more about the diffuse nature of decision-making. Because *Trust* was talked about predominantly at the team level during the interviews, the Q-statements described trust at a team level. Participants disagreed that trust is not important in decision-making (-3). Overall the rankings indicated that the CO trusts his team mates to supply information they deem to be important (+1) and does not rely only on him/herself (-2). Although *Trust* seems to be important in decision-making, evidenced by previous research and interview findings, in comparison with other Q-sort concepts it ranked as less important. It could be argued that *Trust* is linked with other factors associated with diffuse decision-making, such as sharing information and knowledge. For example, one would infer from the fact that the CO is drawing upon information, knowledge and opinion of

his team that he trusts team member's knowledge and judgement at a certain level. It may be that trust is so common in the Army that it is not often unavailable during decision-making. This would then result in a lower rating because it is generally not an important influence to consider because it is not variable.

The final team topic explored the location of *Decision responsibility*. Participants did not agree that knowing the location of decision responsibility is not important (-3). Despite the above emphasis on the importance of diffuse mechanisms for decision-making, in the end the responsibility still lies predominantly with the CO (+5). The idea that responsibility was shared with the team was generally not accepted (-1). Thus, it is important to understand that the final point where a decision is made rests with the CO, but the processes leading to this point are shared with the team, as evidenced by the topics described.

Overall, topics under the *Organisational* category were regarded as comparatively less important when making decisions. As shown in Table 32, only three topics in this category scored extreme scores (either greater than +4 or less than -4). At an organisational level, communication from subordinates and Intelligence were investigated. Participants did not agree that feedback from subordinates does not influence decision-making (-2). Feedback from subordinates to both the team (+4) and the CO (+4) was indicated as equally important. Participants also strongly disagreed that information gathered by Intelligence was not important for decision-making (-5). The ranking indicated that COs and OPSOs believe that the COs own interpretation (+3) of the information is more important than the team's interpretation (-1). In addition participants did not agree that information from Intelligence does not influence decision-making (-5). The interpretation of the information from Intelligence was ranked by participants to be more valuable from the CO (+3) compared with the interpretation by Intelligence (-1). Thus, the communication input from the wider organisation was perceived as important, but interpretation of that information is perceived most valuable if it comes from the CO.

Table 31. Summary of how each statement in the *Team* category was rated under Factor 1.

No.	Statement	Influence	Rank
Team Communication (Information sharing)			
8.	If I communicate my intent well to the command team, then the decision outcome is usually good.	(Diffuse)	+5
19.	The most important aspect of communication is feeding situational information to me to inform decision-making.	(CO)	+4
57.	Good communication of information is not crucial for good decision-making.	(None)	-4
Team Communication (Judgements - knowledge)			
21.	Judgements are not necessary for decision-making.	(None)	-5
32.	I tend to rely on the judgements generated by my command team during decision-making.	(Diffuse)	+1
43.	My own judgements are most important during decision-making.	(CO)	+2
Team Communication (Evaluating a plan - opinion)			
9.	Evaluating a plan is not important.	(None)	-5
20.	I like to seek support from my command team when evaluating a plan by consulting them before making a decision.	(Diffuse)	+3
29.	I am usually confident in my own ability to evaluate a plan and do not need to consult with my command team before making a decision.	(CO)	-1

Table 31. Summary of how each statement in the *Team* category was rated under Factor 1 (continued).

No.	Statement	Influence	Rank
Trust			
55.	I only trust myself to deem what information is important.	(CO)	-2
44.	I am happy to trust my command team to supply information that they deem to be important.	(Diffuse)	+1
33.	Trust is not important for decision-making.	(None)	-3
Responsibility for the Decision			
7.	In the end all responsibility lies with me for the decision made.	(CO)	+5
45.	It is not important to determine where responsibility for the decision lies.	(None)	-3
56.	In the end my command team and I share responsibility for the decisions made.	(Diffuse)	-1

Two other topics discussed under the *Organisational* category were *Organisational culture* and *Organisational constraints* (see Table 32). These topics also indicated a diffuse decision-making process. Participants strongly disagreed that *Organisational culture* was not important for decision-making (-5). Results also indicated that it is the CO (0) rather than the team (-4) who must consider the organisational culture when making a decision. It is likely that organisational culture is something that is not consciously considered when making a decision but rather is an unconscious influence. This assumption is in line with theory suggesting that workers are not often explicitly aware of organisational culture; but this culture still informs the way things are done in the organisation (Buchanan & Hubzynco, 2000). In other words, organisational culture likely effects decision-making by military COs, but at a subconscious level.

Organisational constraints were discussed frequently in the interviews. Things such as resources, drills, procedures and doctrine would fall under this element. In comparison with other elements participants only slightly disagreed that organisational constraints have no influence on decision-making (-1). This was not as expected in light of interview coding, because *Organisational constraints* were the second most frequently mentioned element. It may be that these constraints are so engrained in the Australian Army's way of functioning that they come automatically to mind during decision-making and do not require conscious consideration. All of the statements under the *Team* and *Organisational* categories indicate that decision-making at the unit level HQ is a diffuse process. Communication and information sharing (both at the team and organisational levels) tended to be allocated a high importance by participants loading on Factor 1. These emphasised both the importance of communicating with the team/ organisation and hearing from the team/ organisation. Moreover, topics such as team trust and organisational culture indicated other ways in which the team and organisation can impact on the decision-making process.

Table 32. Summary of how each statement in the *Organisational* category was rated under Factor 1.

No.	Statement	Influence	Rank
Organisational Communication (Subordinates - knowledge and opinion)			
13.	I take feedback from subordinates into account when making decisions.	(CO)	+4
3.	The command team takes feedback from subordinates into account when making decisions.	(Diffuse)	+4
51.	Decision-making is not influenced by feedback from subordinates.	(None)	-2
Organisational Communication (Intelligence - knowledge and opinion)			
4.	Information gathered by intelligence is not important in decision-making.	(None)	-5
25.	Although information gathered by intelligence is important, I believe that my own interpretation of that information is most important.	(CO)	+3
14.	The role of the intelligence officer is critical in providing his/her interpretation of information gathered to aid in decision-making.	(Diffuse)	-1

Table 32. Summary of how each statement in the *Organisational* category was rated under Factor 1 (continued).

No.	Statement	Influence	Rank
Organisational Culture			
27.	"Organisational culture" does not affect decision- making.	(None)	-5
38.	During decision-making it is predominantly my command team who need to consider the impacts that different "organisational cultures" throughout the Army might have on decision-making.	(Diffuse)	-4
49.	During decision-making it is predominantly me who needs to consider the impacts that different "organisational cultures" throughout the Army might have on decision-making.	(CO)	0
Organisational Constraints			
37.	During decision-making it is predominantly me who needs to take into account that we are part of a larger organisation (e.g. doctrine, resources).	(CO)	-1
26.	During decision-making it is predominantly my command team who need to take into account that we are functioning as part of a bigger organisation (e.g. doctrine, resources).	(Diffuse)	0
15.	Despite the fact that we are part of a larger organisation, I feel that decisions are not constrained by this (e.g. doctrine, resources).	(None)	-1

Topics under the *Situational* category were regarded as being less important than those topics already discussed. Despite these topics being frequently mentioned during the interviews, Q-sorts loading under Factor 1 tended to rank them more centrally on the distribution. For all of the topics under the *Situational* category most of the ratings were no more extreme than +2 to -2 (see Table 33). The only rating tending towards the edge of the scale was for environmental influences. Participants did not agree that environmental context did not impact on decision-making (-3). Out of all topics under the *Situational* category, environmental context was also the most frequently mentioned element in the interviews. It should be noted that the external environment is central to SA, but here was ranked as comparatively less important when compared with topics of a *Personal*, *Team* or *Organisational* nature. The above finding suggests a general perception that, although these topics under the *Situational* category have been discussed as important during the interviews, they were less important in comparison with the other topics that have been identified. The other topics under the *Situational* category were outside organisational influences, culture, time pressure and decision aids. In all cases (except decision aids) participants did not agree that these topics did not impact on decision-making. In addition, in the case of environmental context and culture, the location of influence was ranked the same across both team and CO. For decision aids, both CO and team ranked lower than no influence.

Table 33. Summary of how each statement in the *Situational* category was rated under Factor 1.

No.	Statement	Influence	Rank
Environmental			
58.	The external environment in which I am operating influences me most during decision-making.	(CO)	0
47.	The external environment in which we are operating influences my command team most during decision-making.	(Diffuse)	0
36.	The external environment has no influence on decision-making.	(None)	-3
Outside organisational influences			
10.	I can feel pressured by groups external to the Army (such as aid organisations or other government organisations) to make certain decisions.	(CO)	2
59.	I believe that my command team can feel pressured to make certain decisions by groups external to the Army (such as aid organisations or other government organisations).	(Diffuse)	0
48.	Groups external to the Army (such as aid organisations or other government organisations) do not impact on decision-making.	(None)	-1

Table 33. Summary of how each statement in the *Situational* category was rated under Factor 1 (continued).

No.	Statement	Influence	Rank
Culture			
46.	If we are dealing with different cultural groups, it is most important that I take this into account when making decisions.	(CO)	1
35	If we are dealing with different cultural groups, it is most important that the command team takes this into account when making decisions.	(Diffuse)	1
24	Dealing with different cultural groups does not affect decision-making.	(None)	-2
Time pressure			
22.	Most pressure caused by time limitations is felt by me during decision-making.	(CO)	2
11.	The time pressure associated with decision-making is mainly experienced by my command team.	(Diffuse)	1
60.	Pressure does not influence decision-making.	(None)	-2
Decision aids			
34.	I believe that the information provided by decision aids impacts predominantly on me during decision-making.	(CO)	0
23.	Information from decision aids impacts mostly on my command team during decision-making.	(Diffuse)	1
12.	Decision aids do not impact on decision-making.	(None)	2

Table 34. Differences in ranking found in Group 2 emphasising the diffuse nature of decision-making.

No.	Statement	Influence	Group 2 Rank	Factor 1 Rank
Team / Diffuse				
44.	I am happy to trust my command team to supply information that they deem to be important.	(CO)	5	1
Personal / Diffuse				
5.	It is important to feed the collective experience of my command team.	(Diffuse)	4	4
40.	I solely determine the perspective from which the current situation is viewed.	(CO)	-4	-1
Organisational / Diffuse				
14.	The role of the intelligence officer is critical in providing his/her interpretation of information gathered to aid in decision-making.	(Diffuse)	5	-1
3.	Information gathered by intelligence is not important in decision-making	(None)	-5	-5

Table 35. Differences in ranking found in Group 2 emphasising the control of the CO on information handling.

No.	Statement	Influence	Group 2 Rank	Factor 1 Rank
Team/ CO localised				
19.	The most important aspect of communication is feeding situational information to the CO.	(CO)	4	4
8.	If I communicate my intent well to the command team, then the decision-making outcome should be positive.	(Diffuse)	4	5

5.3.3 Group two

Three of the remaining sorts, not loading on Factor 1, could be grouped together in terms of similar rankings. These have been labelled as Group 2 and will be briefly discussed, with focus on how they differed from Factor 1. Group 2 opinions were similar to Factor 1, except for weightings given to a few statements. The main difference lay in the increased emphasis on the importance of the HQ team and larger organisation in decision-making apparent in Group 2 (see Table 34). In particular, high rankings were given to trusting the HQ team to deem what information is important (+5) and relying on the interpretation of information given by Intelligence (+5). However, there was still a belief about the importance of some CO contributions (particularly in information handling; see Table 35).

All of these rankings need to be viewed in the context of who the sorts belonged to that loaded on Group 2. All sorts loading on this group were done by Operations Officers (OPSO M=37.00, SD=12.49 years), who were a similar age to those loading on Factor 1 (M=37.27, SD=6.00 years). However, compared with those on Factor 1 (M=16.5, SD=7.89 years) these officers had slightly more experience on average (M=18.00, SD=8.66 years). It would follow that because of their greater experience, the COs with whom they were working may have been willing to place a higher level of trust in them, as compared with a less experienced OPSO. This would lead to the perception that decision-making is more team driven.

An unexpected ranking arising from this group was:

- Evaluating a plan is not important. 5 (*Factor 1 = -5*)

A perception that evaluation of a plan is not important is not expected, because doctrine dictates that any decision about a course of action should be evaluated by wargaming in order to determine its feasibility. A possible explanation could be that, although plan evaluation was done, the evaluation does not often change the decision because it has been

based on the extensive experience of the COs good decisions are mostly made. This is in line with research by Klein, Wolf, Militello and Zsombok (1995) who found that skilled decision-makers usually come up with a good course of action on their first attempt

5.3.4 Describing the outlier Q-sort

The final Q-sort did not load significantly on Factor 1 or Group 2. The sort was done by a LTCOL, with 20 years full-time experience. The main difference between this sort and the others was the high importance given to the impact of emotion on decision-making (see Table 36).

Table 36. Differences in ranking found in the outlier emphasising the impact of emotion on decision-making.

No	Statement	Influence	Outlier Rank	Factor 1 Rank
Emotion				
28.	I sometimes find myself being influenced by my emotion when making-decisions.	(CO)	5	2
17.	My command team's emotions can influence decision-making	(Diffuse)	4	3

We know that the participant whose sort became the outlier had had very recent operational experience (in contrast to many other participants). It could be suggested that this COs recent operational experience may have elicited more emotional responses, compared with recent training experienced by other COs.

The other unexpected topic that differed dramatically from Factor 1 and Group 2 was:

- In the end all responsibility lies with me for the decisions made. -5
(Factor 1 = 5)

This is an unusual outcome because doctrinally responsibility lies with the CO.

Therefore, a high positive ranking (e.g. +5) would have been expected. Because this particular frame of reference was only given by one participant it should not be taken as a typical frame of reference in the Australian Army. This participant is likely to have had particular experiences that led him to hold the above unique attitudes (e.g. recent operational experience).

5.4 Summary and Conclusions

From the 26 participants who took part in the Q-sort, one main Factor (Factor 1) was identified (upon which 22 of the sorts loaded). One other group (Group 2) was identified on which three sorts loaded. This left the final sort as an outlier. Group 2 and the outlier have both been explored as case studies, but will not be taken as typical views held in the Australian Army. The fact that 85% of the sorts loaded on Factor 1 suggests the conclusion that this Factor very likely represents a typical way in which the elements identified in the interviews are perceived to impact on decision-making at a unit command level in the Australian Army. Factor 1 allows us to understand how the topics included in the sort were perceived in relation to each other, as well as where these topics exerted influences (e.g. CO, team or not at all).

5.4.1 Validity of interviews

Within Factor 1, in all cases, participants ranked those statements that described the topics as influencing decision-making, higher than the statements that described the topic as having no influence at all. This result supports the conclusion that these topics extracted from

the interviews were perceived by the larger group of COs as having an impact on NDM in unit HQ.

5.4.2 Layering of importance

Given the frequency of the various topics within the interview data, it would be expected that topics under the *Personal* category would generally be ranked higher, followed by topics under the *Team*, *Situational* and finally *Organisational* categories. However, this order of importance was not held during the Q-sort analysis.

From the comparative ranking in Factor 1, it is obvious that overall, topics under the *Personal* category (such as experience and personality) were regarded as being most important in decision-making. Similar to previous interview findings, those participants who ranked high on Factor 1 put forward the importance of: *Fatigue*, *Experience*, *Perspective*, and *Personality*. The only topic in the *Personal* category that did not rate as extremely important was *Emotion*. As discussed, this may have been due to the lack of actual or recent operational experience possessed by a number of the participants. All of those who identified this element in the interviews described it as being based in an operational experience. Secondly, emotional responses and decision-making would not be encouraged in the military.

Following the *Personal* category, the importance of topics under the *Team and Organisational* categories were next most highly ranked. These topics both described the diffuse mechanisms present in the Army environment. These statements mainly focused on the “Army’s way of doing things”. This is most likely due to the structure of the organisation, which has come about in response to operational requirements. Such a structure relies on transmission of information, knowledge and opinion to assist in the task of highly complex decision-making. Moreover, as an artefact of this structure and purpose, elements such as trust and organisational culture are created often to facilitate decision-making.

Finally, topics under the *Situational* category, while identified as important in the interviews, have been placed as comparatively less important when compared with elements internal to the Army framework. This layering of importance is illustrated in Figure 22.

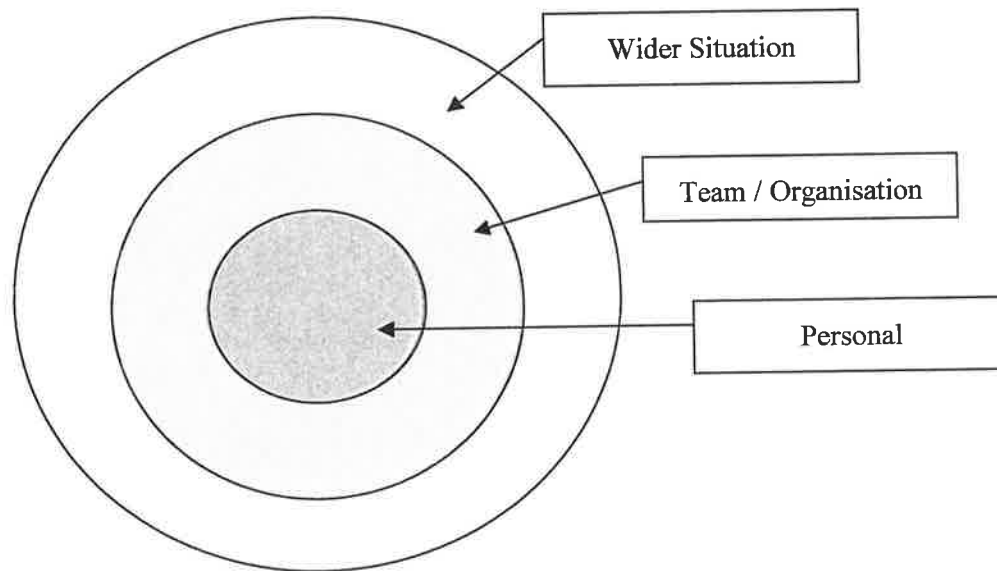


Figure 22. Illustrative concept of layers of importance in decision-making.

It is noted that the most important elements according to this interpretation were those closest to “self” (e.g. personality) and the least important elements were those furthest away from “self” (external environment). This identified layering is in accordance with the theories described in Chapter 2 that suggested that the elements impacting on teamwork were individual level, group level and finally environmental factors (see Driskell et al., 1987; Mathieu et al., 2000).

5.4.3 Diffuse or Commander-centred decision-making

Overall, the account of elements impacting on decision-making presented in Factor 1 has emphasised that although the ultimate responsibility for decision-making rests with the CO, communication both at a team level and an organisational level is perceived to be highly

important. The contribution of the team is apparent, in terms of their sharing of information, knowledge and opinion. Moreover, across all topics (n=20) 55% of the time the influence of the topic on the team was perceived as equal to or greater than that on the CO. This strongly supports the importance of the role of the team within unit HQ decision-making.

5.4.4 Implications for NDM

In the most part, the way in which items were ranked was compatible with our understanding of NDM theory. For example, the findings that (i) experience was held as an extremely important element and (ii) the implied importance of SA for decision-making, are congruent with NDM theory. Building SA was indirectly supported through communication of information, knowledge and opinion and also environmental context. However, the arrangement of some statements have presented immediate challenges to the completeness of the theory. Thus, for example, the importance attributed to topics under the *Personal* category (such as *Personality*) and the diffuse nature of the decision-making process are currently not incorporated into NDM theory.

5.4.5 Limitations

A limitation in this research was the low response rate in the Q-sort task. Despite this the response rate was considered reasonable, given the nature of the participants' job, which includes overseas missions and intensive training that could influence willingness and availability to fill in surveys. All practical measures of increasing likelihood of response rate were employed. Moreover, the outcome, where 85% of the respondents ranked the items in a similar way, indicates strong support that this is a commonly held view within the Australian Army.

5.4.6 Conclusion

Thus, the results from this research present implications for NDM theory that require additions to the existing models. However, due to the subjective nature of these results, before

attempting to incorporate these findings into NDM theory, triangulation of results will be completed. An observational field study will be used to validate the existence of observable elements within the unit level HQ. Some elements will not be directly observable (such as personality and emotion). However, the crux of the argument for diffuse level decision-making at a team and organisational level, which is that the CO is not only drawing level 1 SA from the team and organisation within which he works, but s/he is also drawing level 2 and level 3, can be observed by monitoring unit HQ communication. This will be reported in the next chapter.

CHAPTER 6. Using Field Research to Investigate

External Validity

6.1 Introduction

This chapter expands on research reported in previous chapters that identified and prioritized a number of contextual elements perceived to influence unit level decision-making. One important element identified was the perceived impact of the unit HQ team on the COs decision-making. In order to provide field validation to this finding, the current chapter focuses on the social context within which the CO operates during unit level decision-making. In doing so, it investigates whether the HQ team is substantially impacting on the CO's decision-making. This was done by investigating the quantities of information transmitted by the unit HQ team to the CO, at each of the three levels of situation awareness (SA; as explained by Endsley, 1995).

Operationalising the theory behind the current research is first described, followed by a description of the method. Results are discussed in comparison with those generated from previous interview and Q-sort data. Requirements for further research will be presented.

6.1.1 The current study

Interview and Q-sort data have indicated that decision-making is not an isolated process. In the current study, field observation was used to examine the general hypothesis that the CO does rely⁴⁵ on his/her HQ team to make decisions. This was investigated by using behavioural frequency data, observational notes and interviews.

⁴⁵ In this case the word "rely" has been used to imply being dependant for support, help, or supply.

In order to operationalise the hypothesis, an understanding of the fundamentals of the decision process is required (for a more detailed discussion of this see Chapter 2). In short, the decision process is dependant on situation awareness (SA). According to Endsley (1995) SA is comprised of three levels.

- **Perception:** Perception of raw situational elements (Level 1).
- **Comprehension:** Information integration (Level 2).
- **Projection:** Extrapolation of future status and actions based on current elements (Level 3).

To conclude that the HQ team is critically impacting on the decision process it would require evidence that the HQ team is contributing to each of these levels of the CO's SA. It has been suggested in the previous chapter from Q-sort outcomes that the information, knowledge and opinion communicated by the team were all impacting on CO decision-making. However, the phase of the research reported here provides external validation to this finding. These three levels are captured in the current observational data by identifying communication of current situational information (Level 1), knowledge (Level 2) and opinion (Level 3). Thus, the specific hypotheses tested were:

- The HQ team's contributions of information for decision-making will be higher than zero.
- The HQ team's contributions of knowledge for decision-making will be higher than zero.
- The HQ team's contributions of opinions for decision-making will be higher than zero.

It is also important to determine whether the CO is actively seeking from the HQ team contributions relevant to his/her SA, or whether staff are freely volunteering information. This will determine where the control for SA formation lies. The hypotheses tested were:

- The HQ team's contributions of information for decision-making will be higher than the CO's requests for information.
- The HQ team's contributions of knowledge for decision-making will be higher than the CO's requests for knowledge.
- The HQ team's contributions of opinions for decision-making will be higher than the CO's requests for opinions.

Other behaviours, such as the team identifying problems and the CO checking his reasoning with a team member, would also indicate mechanisms present within the team that also potentially impact on the eventual decision outcome. These types of communication were also monitored.

To establish the wider effects of the organisation on decision-making, it is also necessary to understand the nature of the CO's interaction with subordinates (sub-unit level). The effects of any decision made at a unit level are filtered through the various levels and "value" is added by subordinates, usually before an outcome is achieved. Thus, the subordinates' knowledge and opinions would most likely be added to the details of the plan formation occurring within Company HQ. In regards to current situational information, it would be expected that this would be passed from subordinate HQ. Therefore, their input into the CO's decision-making at this level of SA (perception) would also be predicted to impact on the decision made. Thus, communication between the subordinates and the CO was monitored to provide a better descriptive understanding of the wider impact of the organisation.

6.2 Method

6.2.1 Exercises attended

Purposeful sampling was employed in the current research. This method selects “information rich cases” and studies them in depth (Patton, 1990). The researcher requested attendance to Command Post Exercises (CPX) involving participants who had taken part in the previous interview and Q-sort study. Requests to attend the exercises were put through the appropriate networks at the DSTO and permission was given to attend the following exercises (see Table 37).

Table 37. Description of unit HQ exercises attended during field research.

LOCATION	EXERCISE TITLE	PURPOSE	WHEN
Adelaide	Forem Express	Exploratory	Feb 2002
Darwin	1 AR CPX	Data Collection	May 2002
Townsville	Exercise Silicon Brolga (1RAR)	Data Collection	August 2002

Each of the exercises provided a unique set of circumstances. The first exercise was used to create suitable behavioural coding categories. The following two were used for data collection. Forum Express was a Reserve officer exercise. Both 1AR CPX and Exercise Silicon Brolga were Regular personnel exercises. At these exercises, typically, data would be recorded over a period of 3-5 days. Excluding initial observations at each exercise to achieve familiarity with the key players and communications, a total of 17 hours of behavioural data

(across exercises) contributed to the final analysis. Remaining time in the field was spent conducting short interviews, or writing field notes.

6.2.2 Nature of the exercise

In recent years, we have witnessed operations ranging from peacekeeping in Timor, to war in Iraq. Thus, there is obvious diversity in modern military requirements. Despite the obvious differences between Timor and Iraq, both situations also exhibit common features; for example, time pressure, high stakes, dynamic conditions and uncertainty. Both exercises included these same conditions and thus were typical representations of a naturalistic environment. The two exercises differed in the type of mission being practised. Exercise Silicon Brolga (Townsville) was based on a rescue of foreign nationals from a fictional country, whereas 1AR CPX (Darwin) was a war-fighting scenario. Thus, the tempo of operations observed in Exercise Silicon Brolga was slower. Moreover, this exercise was scripted whereas 1AR CPX had an officer controlling the responses of the enemy force (unscripted). This should not have affected the reactions of the unit HQ team because, during both exercises, the unit HQ was receiving information and guidance from the Brigade.

It was concluded that both exercises represented different scenarios in which our Army may find itself in the future and both were therefore useful for analysis. By sampling both types of exercises, the analysis of results was expected to produce a better overall description of the laws of communication in unit HQ, rather than a more limited account that held for only a specific context of operations within the Australian Army (which would be limited in application due to the increasing diversity of military operations).

It was concluded that despite surface differences, the two exercises observed bore enough similarity to be classed as typical modern military exercises. However, data from each exercise were analysed separately, to explore variation due to the type of exercise.

6.2.3 Exercise set-up

The setups for the HQ in both of the Exercises observed were substantially different. The researcher noted that the HQ used in 1 AR CPX (Darwin) was decentralised and compartmentalised in nature (see Figure 23). The 1 AR CPX HQ consisted of a tent set up between five vehicles. Each vehicle provided a space for a specific cell within the HQ team to work. On the other hand, the set up at Exercise Silicon Brolga (Townsville) was in a fixed room. Tables were arranged in a circular fashion and maps and other visual aids were located around the room (see Figure 24). This allowed all team members to see all other team members. Maps were easily accessible and it was noted by the researcher that staff would browse over these regularly, possibly in order to build their SA. All team members were also facing computer support systems.

6.2.4 Materials

An information sheet was designed to explain the nature of the research to those being observed. It informed the participants of their role and time commitment. It also outlined other ethical considerations, such as freedom to withdraw at any time. The researcher's contact details were also provided in case participants required further information (see Appendix XXII).

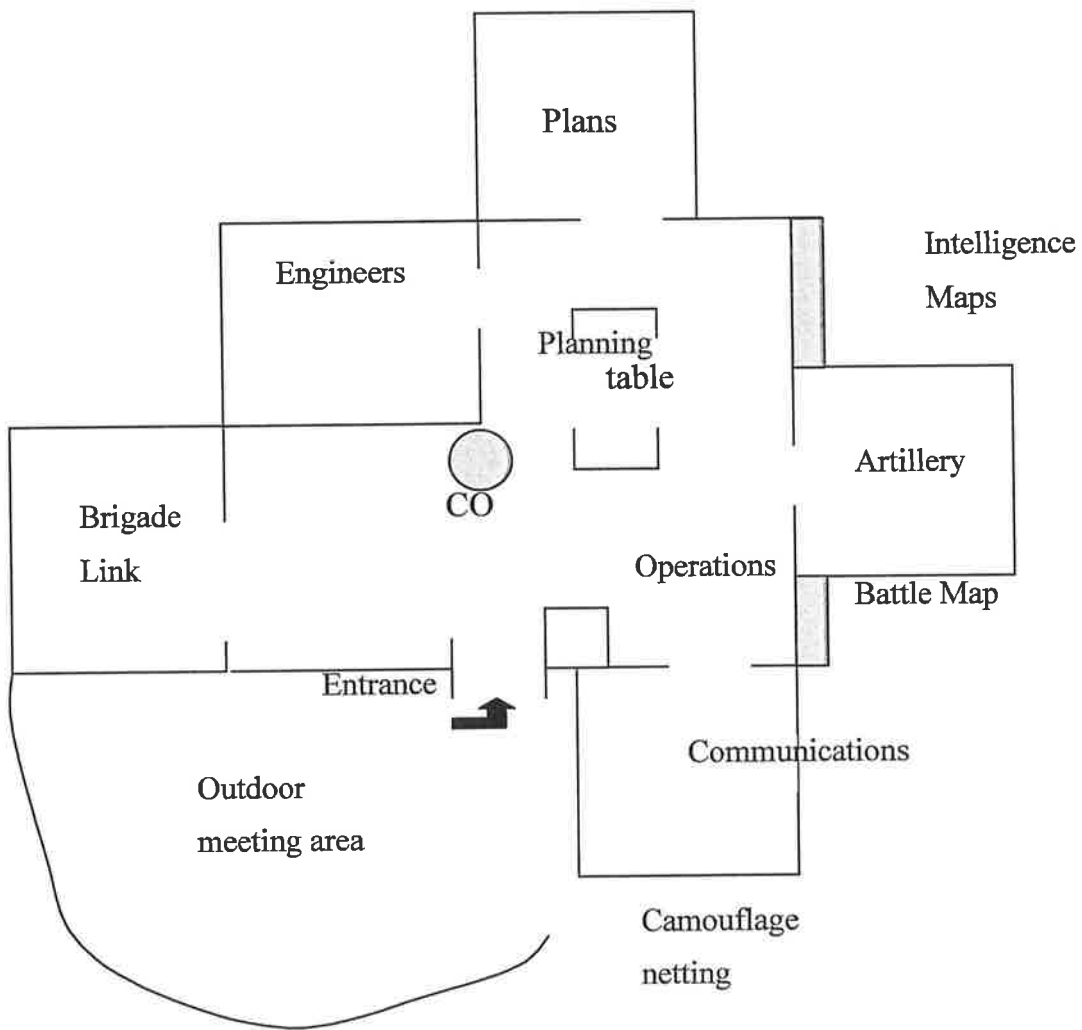


Figure 23. Unit HQ set up at 1AR CPX.

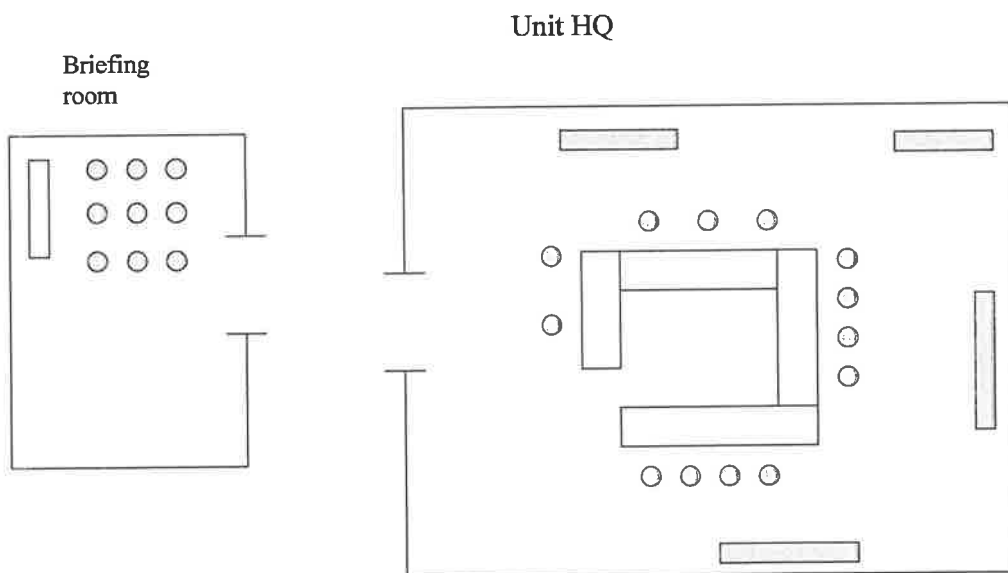


Figure 24. Unit HQ set up at Exercise Silicon Brolga.

Check sheets were used to record the frequency of certain behaviours exhibited in the HQ. Communicative behaviour was isolated as the variable for analysis, because this had been identified in previous chapters as being an influential element in CO decision-making. In addition, previous research has indicated this to be appropriate. Firstly, it is important because of its critical quality in the command decision-making process. For example, Billings and Reynard (1981) found that 70% of aviation accidents involve communication problems. This suggests that communication is central to team performance in time-pressured situations. Moreover, Rouse and Morris (1986) have suggested that communication is the key to creating shared mental models (SMM) of the situation amongst a team. Finally, communication is also quite easily observable without the researcher becoming obtrusive.

Check sheets were used to capture quantitative behavioural data. These were initially based on previous understandings of HQ communicative behaviour (Mills, 2000; Chapman, Mills, Kardos, Stothard & Williams, 2002). The check sheets were then modified based on preliminary observations made during Forum Express 02⁴⁶. Further consolidation of the check sheets occurred in the initial stages of 1 AR CPX. The final check sheet, used for data collection, is included in Appendix XXI. All communications included on the check sheet were aimed at describing the social nature of the information, knowledge and opinion transfer within and around unit level HQ. The communicative behaviours found on the checklist can be divided into three main types:

1. Communication from the CO to the HQ team;
2. Communication from the HQ team to the CO;
3. Communication from the CO to the Subordinate Commander (Sub-unit).

⁴⁶ Forem Express 02 was an experiment run by DSTO that set up a synthetic Army unit HQ (with volunteers from 9 Brigade) and provided an event script in order to test a number of research questions.

Definitions for the categories incorporated in the check sheet are given in Appendix XXII.

Choosing an appropriate observation period on which to base check sheets is difficult because of the volatile tempo of operations. During one campaign, members of a HQ team may find themselves experiencing different moments of urgency and relative calm. In this study, observations were organised according to 5-minute coding windows. Observational periods were relatively short due to the fast tempo of operations (at times) and the exercise duration.

The occurrence of a behaviour was sampled in phrases (i.e. a behaviour was coded each time it occurred in entirety within the 5-minute coding window). Each behaviour observed within each five minute coding window was recorded in the appropriate box on the checksheet. Thus, frequency of communicative behaviour within 5-minute time blocks was recorded for analysis and behaviour across time was also recorded.

Short interview scripts were created to supplement the behavioural frequency data. These scripts focused on important information, contextual influences, the use of previous experience, drawing on other team members' previous experience, typicality of the situation, and trust (see Appendix XXIII). An A5 notebook was used to record field notes and field interviews were recorded on a Sony mini disk recorder (MZ-R90).

6.2.5 Procedure

The first part of this research required that the researcher develop and pilot appropriate behavioural analysis checksheets. This was accomplished during Forum Express. The researcher was positioned in a separate room and was able to observe the BattleGroup HQ via a video link. The investigator made a variety of notes throughout the exercise. These focused on the types of behaviours exhibited, communicative behaviours commonly observed in the

HQ that could then be operationalised in order to test the previously stated hypotheses. This check sheet was then piloted for the remainder of the exercise to ensure its adequacy.

Research data collection occurred during 1 AR CPX and Exercise Silicon Brolga. Before the exercises commenced, information sheets and consent forms were sent to the Formation HQs for distribution to the potential participants to be observed. The researcher travelled to these training exercises and in both cases was introduced into the unit level HQ environment by an Army Liaison Officer. An appropriate seating position was also suggested. In both situations, the researcher attempted to be as unobtrusive as possible. A second observer also attended both exercises, so that multiple observations were available for checking reliability.

Throughout the duration of the exercise observations were recorded on check sheets, and notes were taken on unexpected events or those potentially associated with team decision-making events, relationships and other observations. Towards the end of the exercises the researcher engaged some of the key HQ staff in short interviews to clarify certain points from the exercise. Data were typically collected over 3-5 days depending on the duration of the exercise. The researcher would take breaks in order to collate notes, consolidate understanding, and rest.

6.3 Overall Presentation of Results

The results will be presented in two sections. First, the qualitative results based on interviews and field notes will be presented. The qualitative results serve two purposes:

1. To provide further description of the context of the current research (to facilitate interpretation and generalisability of results). Cronbach (1975) noted that the context of the research should always be considered. The researcher should always accurately describe and interpret the elements unique to that locale and any events.

2. To describe further insights extracted from observational notes and interviews across the two exercises that relate to the social nature of decision-making in unit level HQ.

The qualitative results are largely descriptive and should be viewed as supplementary to the results reported in the quantitative section.

Secondly, the quantitative results based on the behavioural and reliability coding are presented collected. Following this a number of descriptive statistics and comparative statistics are presented to show differences between the exercises observed and between the different kinds of communication recorded.

6.4 Qualitative Results and Discussion

6.4.1 Similarities across exercises

As was noted, similar types of communications were observed at both exercises but their frequencies differed. This is probably partially due to the time frames associated with decision-making in different environments. In a peacekeeping operation, the time frame available in which to make decisions is usually longer than that available in a war-fighting scenario, so that the frequency of communication during peacekeeping would generally be higher.

An important similarity noted across both exercises was that, when asked to identify the most influential element on their decision-making, both COs indicated that the Brigadier's intent was most crucial. This response was probably due to the emphasis given to COs' intent statements in training and doctrine, which normally include satisfying their superior, due to the authority gradient.

These observations support the fact that both exercises represented different scenarios in which our Army may find itself in the future and are thus both useful for analysis.

6.4.2 Typicality of the exercises

As already emphasised, one purpose of field observation was to increase the external validity of results reported in previous chapters. However, there is clearly a difference between military training exercises and military operations; and how comparable the exercise was with an operational problem is therefore important. In order to generalise inferences, it was important that the observed exercises provided typical examples of operations. One key interview question probed this point. From responses to this question all participants believed that this condition was satisfied. For example, one CO commented:

“The environment was quite realistic. We received the type of information we would get if it was real”

Thus, the typicality of the exercises was supported.

6.4.3 Comments on the settings

Freedom of communication between team members varied between exercises. It is likely that this was partly due to the differing designs of unit HQ observed across the two exercises (see Method). The different situations appeared to influence the nature of communication between HQ staff. As noted, the compartmentalised nature of the 1AR CPX HQ setup made it impossible for staff to communicate freely with one another. It was commented by staff that this set up was experimental and not ideal for carrying out their normal business processes. This made it more necessary for HQ staff to move between areas and communicate with other staff, and generally talk more loudly. On the other hand, the open nature of the Exercise Silicon Brolga setup seemed to create an environment where although there was the potential for free communication, HQ staff did not communicate as frequently. This was most likely due to the nature of the exercise (being an extraction exercise rather than warfighting). However, the researcher suggests that it may also reflect the layout of the HQ and the use of computer-based decision support tools at Exercise Silicon Brolga.

The team members were able to observe each other's planning maps etc., which would have negated the need to ask as many questions.

There is a need for further research to investigate empirically the effect that a face-to-face set up in unit HQ has on the type of information transferred between team members, decision timeliness, the production of SMM, as well as subsequent performance.

6.4.4 Input from the Commander

From observations at both exercises, it was noted that each CO spent differing amounts of time within the unit HQ. At 1AR CPX, the CO was in the HQ more frequently. During this time he was actively engaged in communication with his staff, or positioned so that communications could be overheard. The CO said:

I demand they talk to each other. Hearing them is a way of battle tracking. You heard me tell the Ops officer 'we don't need to talk to them on the radio, just listen'. If it's not what we need to hear then we need to call them. You've got to build it in training. It is not always exactly what you want. As long as it's mostly what you want, you've got to live with it. Often the bits that are not what you want are better because they're there and you're not.

Observations also suggested that the relationships between CO and HQ staff differed across exercises. The 1 AR HQ team seemed to interact more with the CO directly, compared with the HQ staff observed during Exercise Silicon Brolga. It seemed that there were different implicit rules of relationship operating at the two exercises. This could be due to the different underlying culture of the work group, or the nature of the operation.

6.4.5 Personal experience vs shared experience

Numerous observations were recorded in the field notes and interviews where the CO used his own experience to deal with situations, or had drawn on the experience of his team. This confirmed the taxonomy of experience described in Chapter 4.

Several different types of knowledge presented in this taxonomy were drawn upon in the exercises attended. The COs referred to their practical soldier knowledge as influencing their ability to understand what is happening on the ground. For example, one CO commented that,

“If you can’t visualize what someone is saying ...you can’t add value to that....A whole range of experiences add value”.

This experience then facilitates the co-ordination of events, because the CO has an implicit knowledge of the broader circumstances associated with events reported up to the unit HQ.

The researcher also noted that the CO would ask his HQ team questions in order to fill in the gaps in his own knowledge. For example, one CO said:

I don’t know a whole lot about combat engineering. I don’t know a lot about offensive support. I don’t know the fire orders that go to an artillery HQ- to a gun line to make things happen, but I do know what questions I need to ask of those guys...What are reasonable demands to make of them in a certain context.

...their job is to provide advice. I’ll go you know “how long will it take to do this. How long will it take to cover?” ...he will give answers...

In these cases, the CO has not been able to draw on his own practical or theoretical soldier experience, but instead has relied on his experience as a CO to, firstly to recognise where the gaps lie in his own knowledge and, secondly, to know which questions to ask in order to fill these knowledge gaps. Thus, he has been able to draw on knowledge of practical soldiering within his team to fill these gaps. Observations also confirmed that the CO uses his team’s practical soldiering knowledge to guide his planning and decision-making during a rehearsal. During this event, a plan can be talked through. This kind of exercise allows HQ

team members with different expertise to determine whether there are any flaws in a current plan. This qualitative finding supports the hypotheses investigated in the current chapter concerning the critical contribution of the HQ team to the CO's decision-making process.

Finally, the complexity of the environment and tasks also present a requirement for team work. One CO noted that,

"You can't command something as complex as this yourself. My span of command about 5-7 things..... 14 tanks you simply can't do that."

These findings are in line with the current doctrine, which states that, decision-making at a unit level should be CO led and staff driven (Australian Army, 2004). Unit level planning and decision-making is a team process and everyone's knowledge feeds into the eventual decision. As far as possible, a theory is supported by knowledge from one or more team members.

6.4.6 Social identity and trust

Trust was an issue that emerged from the previous CDM interviews and the field observations suggested that trust has the potential to affect the level of knowledge sharing between HQ staff and the CO. In particular, the CO was observed to share knowledge more freely with certain members of the HQ team within the exercises.

Lewis and Weigert (1985) and Robinson (1996) defined trust in terms of expectations that another's actions will not be detrimental to one's interests. This definition therefore frames trust as a cognitive function. There have also been suggestions that trust may be characterised as affective or cognitive (Klimoski, 2003b). In a military context, both cognitive and affective trust might be important. It could be that cognitive trust might become the more common determinant of the level of knowledge transfer between the CO and the HQ team as the apparent consequences for failure become more serious (Klimoski, 2003b).

During observations, the length of time that team mates had known each other appeared to impact on the trust shared between them. One CO mentioned the familiarity he had with his staff; the shared experiences, training environments and workplaces. Therefore, there was established trust. This was identified as integral to command decision-making.

Research on trust development has shown that individuals' perceptions of others' trustworthiness, and their willingness to engage in trusting behaviour when interacting with them, are largely history-dependant processes (Boon & Holmes, 1991; Deutsch, 1958; Lindsold, 1978; Pilisuk & Skolnick, 1968). According to such models, trust between two or more interdependant actors thickens or thins as a function of their cumulative interactions. Interactional histories provide decision-makers with information that is useful in assessing others' dispositions, intentions and motives. This information, in turn, provides a basis for drawing inferences regarding their trustworthiness and for making predictions about their future.

Also, it was observed that membership of the same regiment seemed to impact on the understanding and trust shared between two team members. At the 1AR CPX, most unit HQ staff had worked together before. However, some of the HQ staff were called from outside the unit team for this particular exercise. It was observed that there was poorer communication between these staff and the rest of the team. These "new" staff had to actively present their information and directly enquire of others, to keep updated on other information. Also, misunderstanding seemed to arise between these staff and the regular staff, possibly due to different understandings of correct business processes.

We know from organisational psychology that work teams tend to develop their own specialised culture and to understand each other's ways of working in these terms (Anthony, 1994). This unique culture can lead to an "in-group" bias that can result in people tending to be less confident in the abilities of people outside of their own group (Allport, 1954). Elements such as trust and communication are facilitated by the extent that individuals define

themselves as members of the in-group (Haslam, Eggins & Reynolds, 2003). These elements may have impacted on the HQ process at this exercise.

6.5 Quantitative Results

6.5.1 Reliability check

Reliability analysis was carried out for each of the below codes. For the current analysis, a reliability check was performed using 2.6 hours of data collected during 1AR CPX. Overall, 17 hours of behavioural frequency data were collected. This constitutes approximately 15% of the total data collected.

Both percent agreement and covariation were calculated between coders. The calculation of percent agreement was done by comparing the two coders' frequency calculations across 32 x 5-minute time segments. Agreement was defined as both coders recording exactly the same frequency for each variable in a given 5 minute time slot. It has been generally accepted that high reliability falls between 0.75 to 0.8 (Elliss, 1994) and that 0.70 is a good cut off score for reliability analysis (Neuendorf, 2002; Riffe, Lacy & Fico, 1998). Anything falling below this mark should be questioned. For the current analysis, variables were expected to have high amounts of shared variance ($R^2 > 0.70$) and high levels of percent agreement ($PA > 0.70$). Calculated reliability scores are shown in Table 38.

Table 38. Calculations for reliability of behavioural data in field work.

	Communicative Behaviour	Covariation (Pearsons)			Agreement		Accept (>70)		
		Reliability Coefficient (R)	Sig. (p)	Shared Variance (R ²)	Agree	Total			
Commander to HQ team	Supply information	0.90	.000	0.82	22	32	0.69	C	
	Ask team member for information	0.86	.000	0.74	23	32	0.72	✓	
	Ask team member for knowledge	0.89	.000	0.80	30	32	0.94	✓	
	Ask team member for opinion	1.00	.000	1.00	32	32	1.00	✓	
	Ask team member to generate COA	N/C	N/C	N/C	31	32	0.97	✓	
	Acknowledge problem raised by the team	0.80	.000	0.65	31	32	0.97	C	
	Supply knowledge	0.74	.000	0.55	28	32	0.88	✗	
	Run plan by a confident	1.00	.000	1.00	32	32	1.00	✓	
	Order/command given	0.87	.000	0.75	21	32	0.66	C	
	Supply situational information	0.87	.000	0.76	23	32	0.72	✓	
	Supply knowledge	0.92	.000	0.85	29	32	0.91	✓	
	Supply opinion	0.85	.000	0.73	26	32	0.81	✓	
HQ team to CO	Team member generates COA	0.77	N/C	0.59	31	32	0.97	✗	
	Ask question to clarify information/plan	0.57	.000	0.32	25	32	0.78	✗	
	Subordinate supplies info to HQ	0.84	.000	0.71	24	32	0.75	✓	
	Plans reported below	0.89	.000	0.80	26	32	0.81	✓	
	Plan accepted	1.00	.000	1.00	30	32	0.94	✓	
	Plans questioned	0.68	.000	0.47	32	32	1.00	✗	
	Plans adjusted c/o subordinate	N/C	N/C	N/C	30	32	0.94	✓	
	Subordinate questioned	N/C	N/C	N/C	31	32	0.97	✓	
	Subordinates	Supply information	0.90	.000	0.82	22	32	0.69	C
		Ask team member for information	0.86	.000	0.74	23	32	0.72	✓
		Ask team member for knowledge	0.89	.000	0.80	30	32	0.94	✓
		Ask team member for opinion	1.00	.000	1.00	32	32	1.00	✓
Ask team member to generate COA		N/C	N/C	N/C	31	32	0.97	✓	
Acknowledge problem raised by the team		0.80	.000	0.65	31	32	0.97	C	
Supply knowledge		0.74	.000	0.55	28	32	0.88	✗	
Run plan by a confident		1.00	.000	1.00	32	32	1.00	✓	
Order/command given		0.87	.000	0.75	21	32	0.66	C	
Supply situational information		0.87	.000	0.76	23	32	0.72	✓	
Supply knowledge		0.92	.000	0.85	29	32	0.91	✓	
Supply opinion		0.85	.000	0.73	26	32	0.81	✓	

Note: N/C- Not calculated due to insufficient data points; ✓ - High reliability (high shared variance, high percent agreement); C – Cautious acceptance (high shared variance/percent agreement [>70]), low shared variance/percent agreement [>65]); ✗ - Low Reliability (low shared variance, low percent agreement.

All variables achieving high-shared variance and high percent agreement were considered acceptable to use in current reporting and analysis. Variables labelled with “cautious acceptance” in Table 38 were further explored to determine the value of including them in analysis. It must be noted that it was difficult to achieve a high percent agreement in the current coding task because frequency of behaviour is a ratio level measure and was measured in a complex environment with high noise levels and multiple communications. To allow for the difficult conditions, it was decided that cautious acceptance would be given to variables satisfying one criterion above 0.70 and that were very close (within 0.05) of satisfying the other. Variables that were cautiously accepted were: Commander with Team, a) supply information ($R^2=0.82$, PA= 0.69), b) acknowledge problem raised by the team ($R^2=0.65$, PA= 0.97), c) Order/command ($R^2= 0.75$, PA= 0.66). Variables that did not achieve acceptable shared variance and percent agreement were excluded from the analysis.

6.5.2 A time series description of the communication frequency during the exercises

As described in the method section, both exercises attended varied in terms of the type of operation, and analysis for each exercise was therefore separate. Figure 26 shows that Exercise Silicon Brolga (Townsville) had a more constant communication workload across the period of observation. It was also generally a lower intensity, compared with 1 AR CPX (Darwin), where workload increased in intensity as time progressed and was most frequently higher.

Figure 26 shows an overall description of the varying workload during 1 AR CPX and compares the frequency of communications originating from the CO (blue) and the team (red). Generally, as would be expected, the CO is speaking more frequently and the higher periods of workload show upward shifts in both the CO's and the team's communications.

Figure 27 shows an overall description of the varying workload during Exercise Silicon Brolga. As can be seen, overall this is much lower intensity than in Figure 26.

Moreover, the distinct pattern of higher levels of communication for the CO in Figure 26 are not found in Figure 27 where the team and CO communication is more evenly balanced.

The researcher also noted the variable nature of communication in the HQ. In periods of high workload, the staff were more frequently contributing all types of information coded and in periods of lower workload there was much less communication. Future research should monitor the use of these types of communicative behaviours in relation to the situation and concurrent workload. Overall, the researcher concluded that the contributions of the team, although not constant, did occur at critical times.

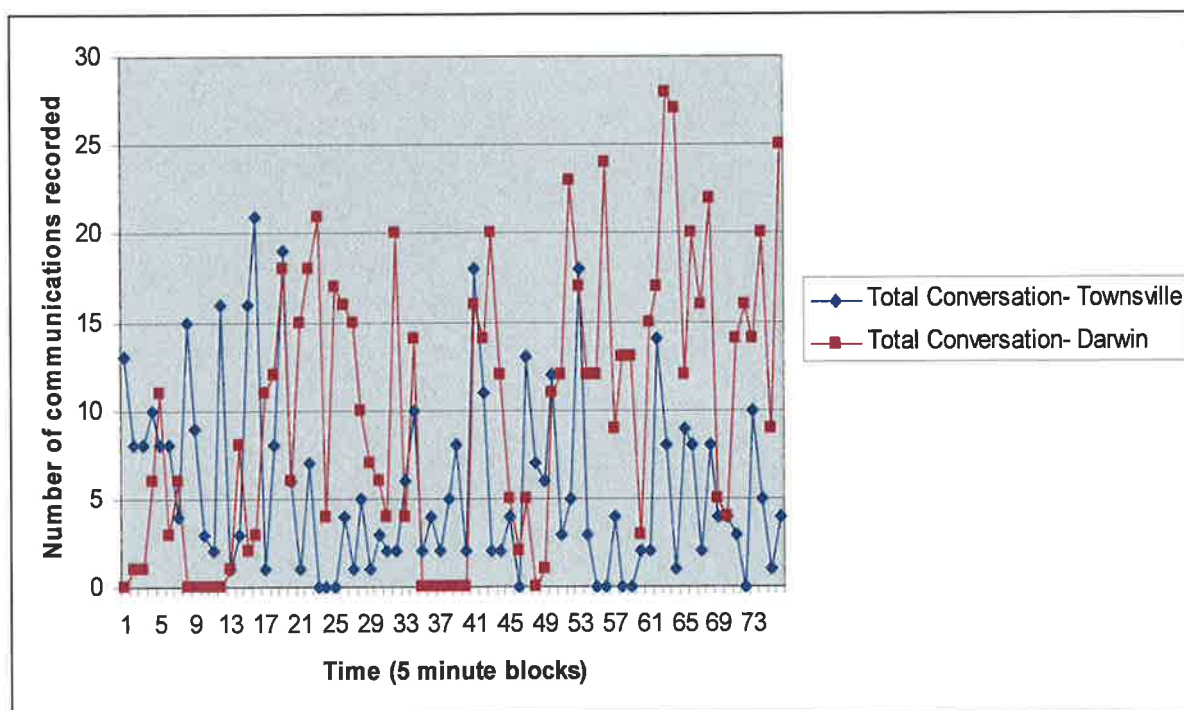


Figure 25. Comparing communication frequency at IAR CPX (Darwin) and Exercise Silicon Brolga (Townsville).

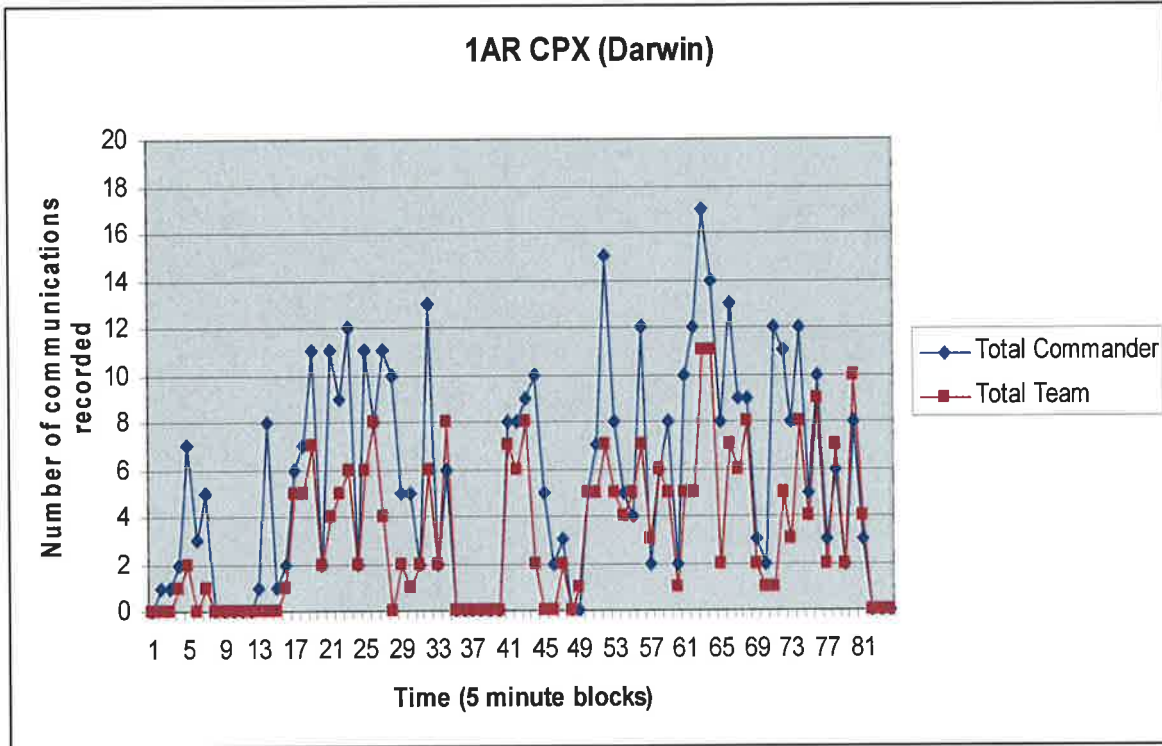


Figure 26. The varying communication frequency during 1 AR CPX (Darwin).

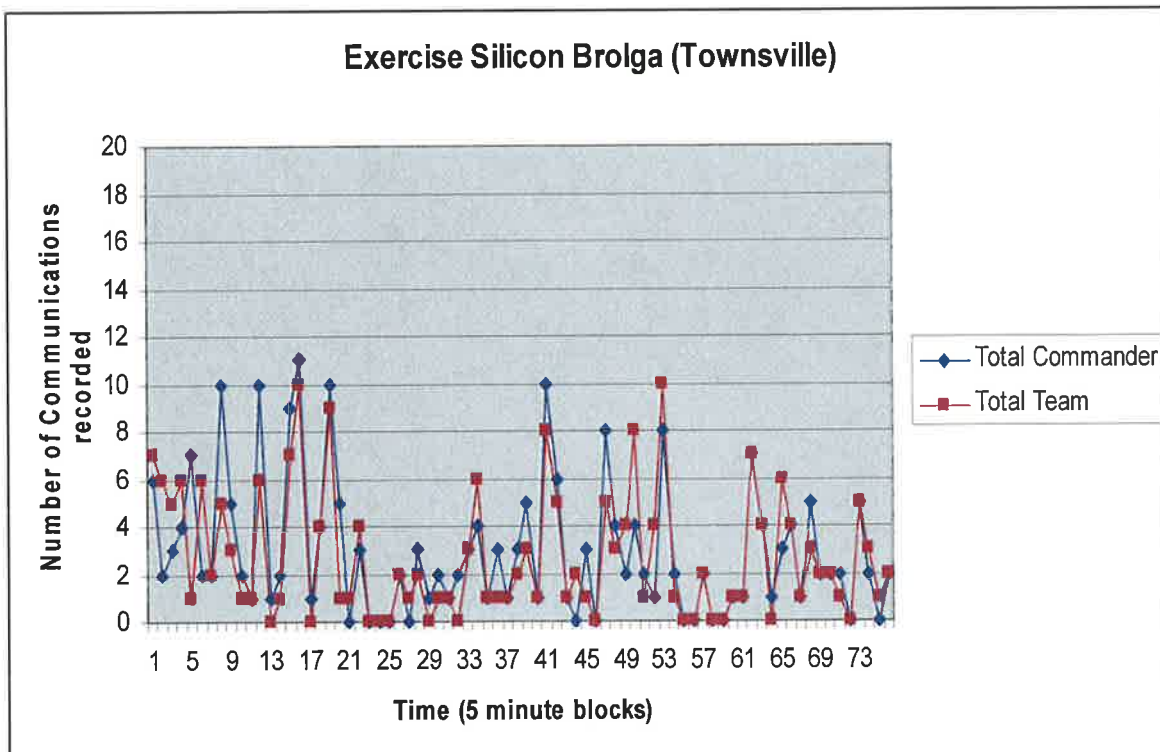


Figure 27. The varying communication frequency during Exercise Silicon Brolga (Townsville).

6.5.3 Correlations between variables

Correlations were found between some communicative behaviours. These are shown in Table 39. Those statistically significant correlations are highlighted in bold. Of particular relevance to the current research, highly significant correlations ($p < 0.01$) were found between:

- The CO supplying information to the HQ team and the CO asking the team for information ($r = 0.32$, $p < 0.01$).
- The CO asking the HQ team for information and the HQ team supplying information to the CO ($r = 0.65$, $p < 0.01$).
- The CO asking the HQ team for knowledge and the HQ team supplying knowledge to the CO ($r = 0.20$, $p < 0.01$).

6.5.4 Comparing overall communication across exercises

Overall the frequency of communication varied across exercises. A Mann-Whitney U test⁴⁷ revealed that overall the communication at 1AR CPX was significantly more frequent than at Exercise Silicon Brolga ($z = -2.75$, $p < 0.01$). Predominantly this difference seemed to lie in the communication originating from the CO which was significantly more frequent at 1AR CPX (Darwin; $z = -3.13$, $p < 0.01$). No significant difference was found in the frequency of communication originating from the team compared across both exercises ($z = -0.54$, $p > 0.05$).

⁴⁷ Because assumptions of parametric tests were violated in the current data, non-parametric tests were used. All assumptions for non-parametric tests were met (i.e. random sampling, similar shape, variability across distribution and independence).

Table 39. Correlations between observed behavioural variables in field work phase.

	Supply Information to team	Ask team for information	Ask team for knowledge	Ask team for opinion	Acknowledge problem raised by the team	Ask team member to generate a COA	Supply knowledge to the team	Supply information to the Commander	Supply knowledge to the Commander
Commander with Team									
Ask team for information	R .319								
	Sig .000								
Acknowledge problem raised by the team	R .201	-.029	.178	.338					
	Sig .005	.688	.013	.000					
Supply knowledge to the team	R .413	.317	-.112	-.041	.085	.355			
	Sig .000	.000	.119	.573	.238	.000			
Make a decision	R -.052	-.026	.352	.168	.317	-.060	-.084		
	Sig .471	.721	.000	.019	.000	.402	.242		
Team with the Commander									
Supply information to the Commander	R .282	.653	.388	.094	.133	.131	.185		
	Sig .000	.000	.000	.189	.064	.067	.009		
Supply knowledge to the Commander	R .006	.118	.203	.467	.229	.132	.140	.207	
	Sig .934	.099	.004	.000	.001	.066	.050	.004	
Supply opinion to the Commander	R .337	.347	-.024	.113	.071	.355	.260	.285	.286
	Sig .000	.000	.738	.115	.322	.000	.000	.000	.000
Ask a question of the Commander	R .511	.066	.078	-.102	.050	.164	.144	.088	-.010
	Sig .000	.357	.280	.153	.488	.022	.045	.218	.888

The way in which the CO interacted with the team is shown in Figure 28. This figure compares the frequency of each type of communicative behaviour across the two exercises observed. Two behaviours were excluded from the current bar graph because they were only recorded at 1AR CPX. These were: *Run plan by confidant*; and *Ask team member to generate COA*.

Although differences in frequency of communication existed between the two exercise sites, overall the most common types of communication were:

- The CO asking a team member for information;
- The CO supplying information to the HQ team;
- The CO giving an order or guidance to a team member.

Across both exercises requesting information and supplying information was the most frequent form of communication. As discussed previously the comparisons between the information, knowledge and opinions requested by the CO were a focus of the analysis. Hypotheses that information, knowledge and opinion would be requested by the CO at a frequency greater than zero were supported (see Table 40).

Information was required most frequently at 1AR CPX, compared with a much lower frequency at Exercise Silicon Brolga. Despite an overall lower frequency of communication across most areas, during Exercise Silicon Brolga (Townsville) the CO was recorded as asking the team for knowledge comparatively more frequently. The frequency at which the CO asked for a HQ team mate's opinion was similar across exercises. Thus, comparatively knowledge and opinions were sought more frequently during Exercise Silicon Brolga.

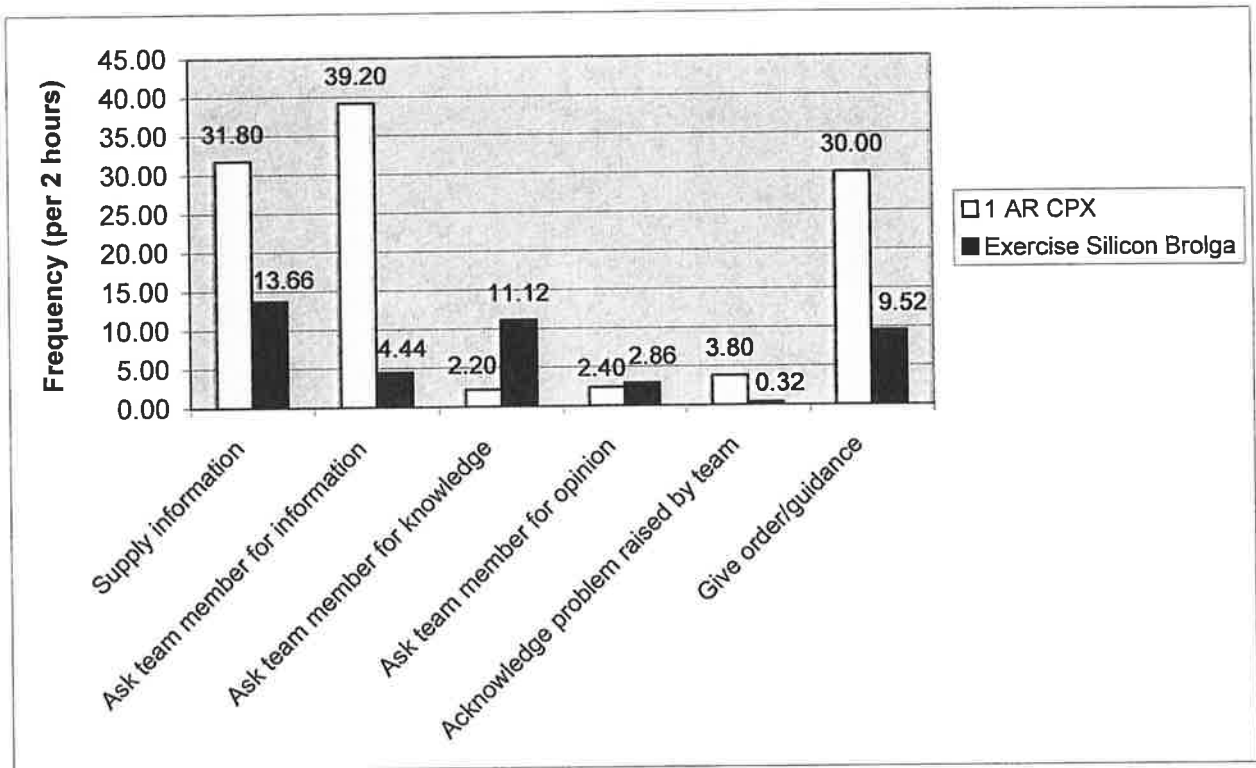


Figure 28. Average frequency of communication between the HQ team with the CO for each exercise.

Table 40. One sample t-test results for CO requesting information, knowledge and opinion (a comparison across exercises).

	Test Value = 0		
	t	df	Sig. (2-tailed)
CO asking HQ team for Information	7.98	159	.000
CO asking HQ team for Knowledge	5.70	159	.000
CO asking HQ team for Opinion	3.83	159	.000

The fact that on average about once an hour the CO drew on opinions of team members is a powerful argument for the importance of the team not only in SA formation but also informing decision-making. In fact, taking other communicative behaviours into account (knowledge and opinion) we can conclude that, on average, the CO drew on the unique experiences of the team almost six (5.74) times per hour. The CO requesting the team to input their unique experience into decision-making constitutes 13.5% of the total recorded communicative behaviour.

Other communicative behaviours observed that also implied a reliance on the HQ team to input their unique experience into unit decision-making were:

- Ask a team member to generate a course of action (COA);
- Acknowledge a problem raised by the team;
- Run a plan/ idea past a confidant.

6.5.5 Interaction between the headquarter staff and the Commander

The second set of communications recorded centred on how the HQ staff interacted with the CO. These behaviours are illustrated as a comparison of frequencies between the two exercises in Darwin (1 AR CPX) and Townsville (Exercise Silicon Brolga; see Figure 29).

The most frequent form of communication observed was the HQ team supplying information to the CO. Supply of knowledge and opinions were also observed. A series of one-sample t-tests confirmed that the HQ team were supplying information, knowledge and opinions to the CO at a frequency significantly greater than zero (see Table 41). Thus, the hypotheses were supported. Interestingly, knowledge was asked for far less frequently by the CO in 1 AR CPX but was given more frequently by HQ team members. This indicates that knowledge has been offered by the HQ team unprompted.

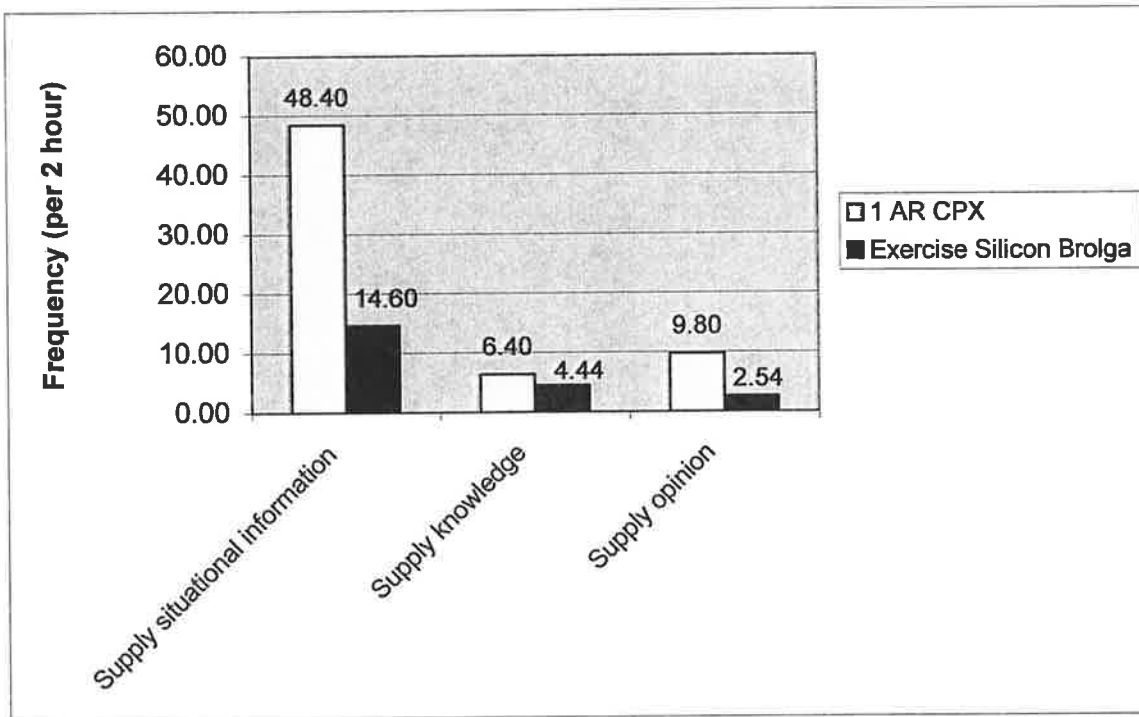


Figure 29. Average frequency of communication between the HQ team with the CO for each exercise.

Table 41. One sample t-test results for HQ team's supply of information, knowledge and opinion.

	Test Value = 0		
	t	df	Sig. (2-tailed)
HQ team supply CO with Information	11.02	159	.000
HQ team supply CO with Knowledge	5.04	159	.000
HQ team supply CO with Opinion	7.19	159	.000

6.5.6 Comparing request with supply

Comparisons were made between the CO's requests for information, knowledge and opinion and the HQ team's contribution of these variables (see Figure 30 and Figure 31).

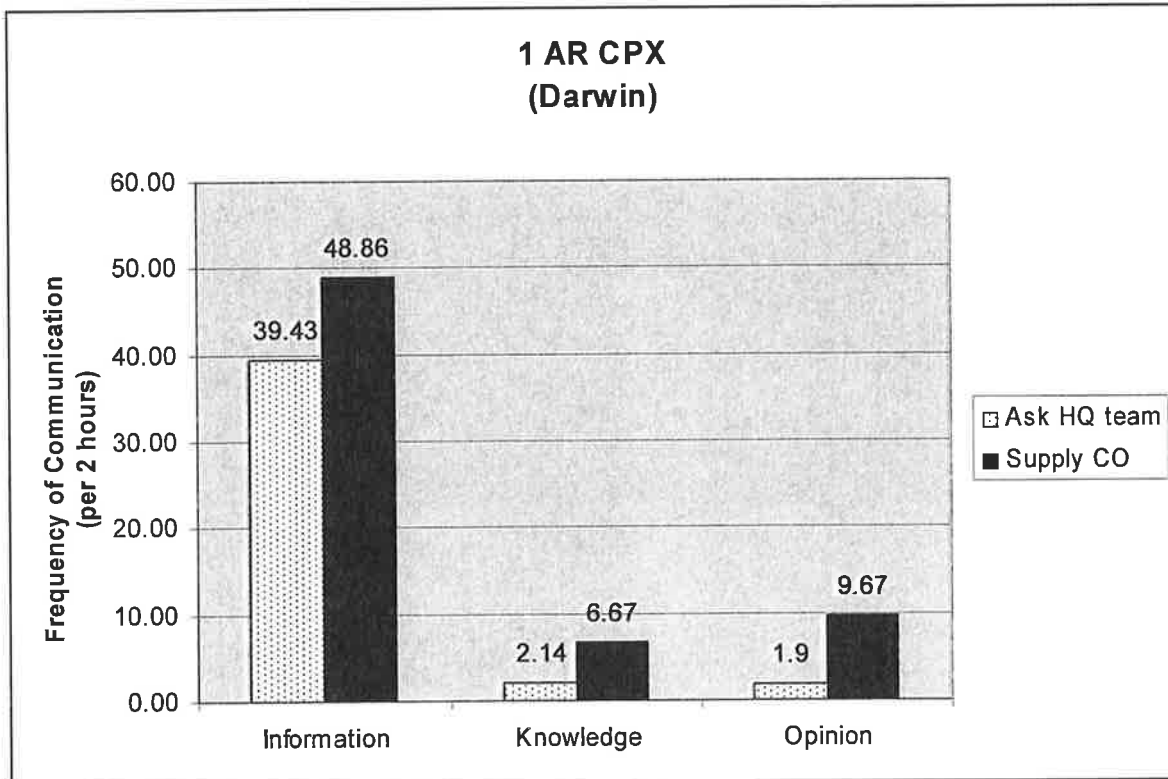


Figure 30. A comparison of request and supply of information, knowledge and opinion in 1AR CPX.

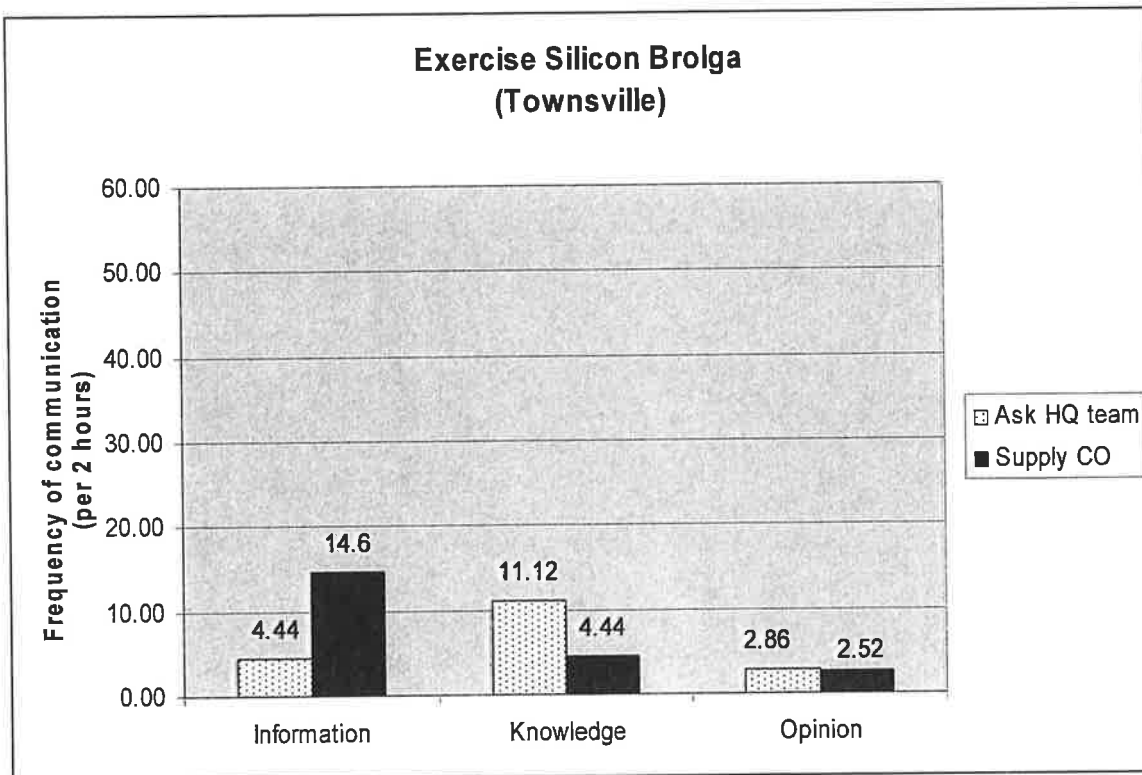


Figure 31. A comparison of request and supply of information, knowledge and opinion in Exercise Silicon Brolga.

Across both exercises, the rate of request and supply of information (Level 1 SA) was higher than knowledge (Level 2) or opinion (Level 3). During 1 AR CPX, the rate of supply of information, knowledge and opinion was higher than the corresponding rate of request. A Mann-Whitney U test⁴⁸ was used to determine whether there were significant differences between the frequency at which information, knowledge and opinions were requested and supplied at this exercise 1 AR CPX.

⁴⁸ Because assumptions of parametric tests were violated in the current data, non-parametric tests were used. All assumptions for non-parametric tests were met (i.e. random sampling, similar shape, variability across distribution and independence).

Table 42. Comparing means for the frequency of the CO's request and the team's supply of information, knowledge and opinion (1AR CPX).

Communicative Behaviour	z-score	Significance
Information	-0.856	p>0.05
Knowledge	-2.099	p<0.05
Opinion	-4.201	p<0.05

At 1 AR CPX significant differences were found between the request and supply of knowledge and opinion (see Figure 30 and Table 42). No significance existed between request and supply of information.

A Mann-Whitney U test was also used to determine whether there were significant differences between the frequency at which information, knowledge and opinions were requested and supplied at Exercise Silicon Brolga.

Table 43. Comparing means for the frequency of the CO's request and the team's supply of information, knowledge and opinion (Exercise Silicon Brolga).

Communicative Behaviour	z-score	Significance
Information	-5.754	p< 0.01
Knowledge	-3.508	p< 0.01
Opinion	-1.022	p> 0.05

Significant differences were found between request and supply of information and knowledge (see Table 43). In respect to knowledge the significant difference was found in the opposite direction to that expected, indicating that the CO requested knowledge significantly more frequently than the HQ team supplied knowledge. No significant difference was found between request and supply of opinion.

6.5.7 Interaction with subordinate Commanders

The third set of communication recorded centred on how the CO was interacting with Subordinate Commanders. Figure 32 shows the behaviours noted at the 1AR CPX. This communication could not be monitored at Exercise Silicon Brolga because most communication between HQ and Subordinate Commanders was done via the computer support system.

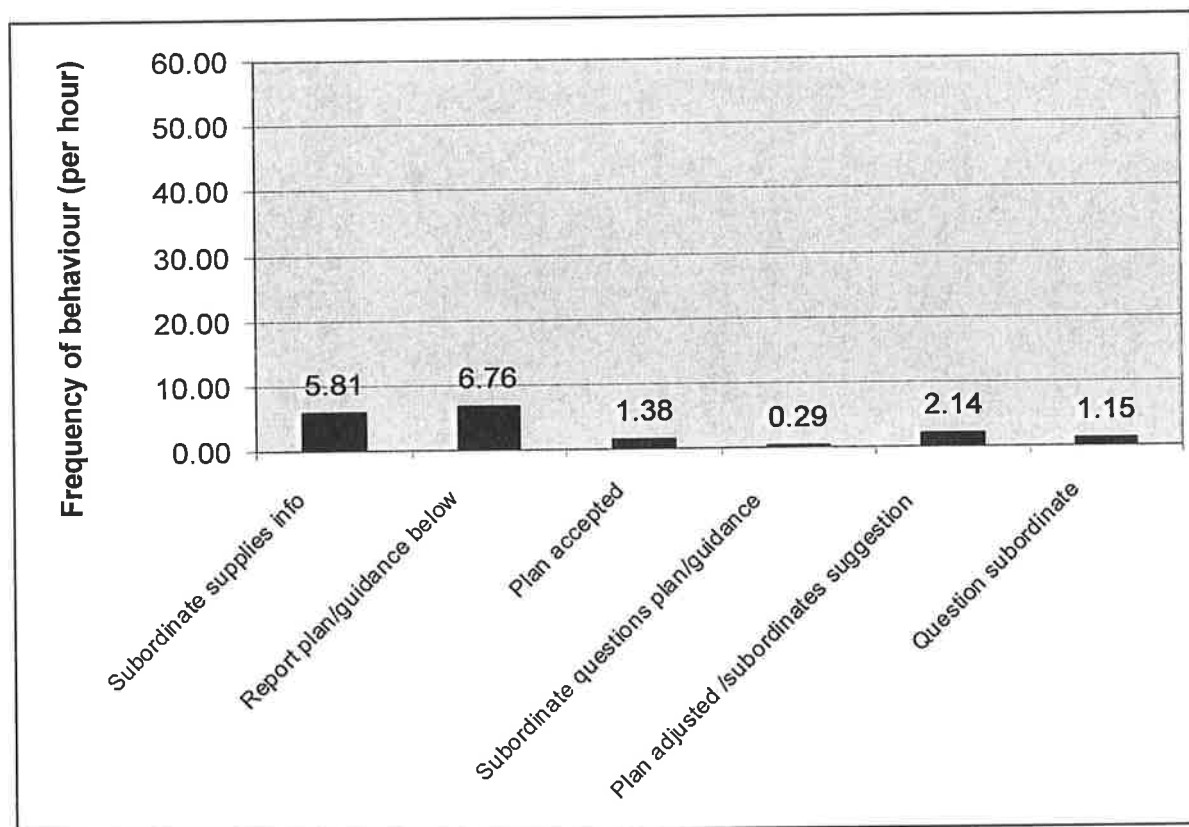


Figure 32. Description of communication with subordinates at 1 AR CPX.

From Figure 32, it is apparent that the common types of communication observed between the HQ staff and the CO differed from those between the CO and Subordinate Commander. The most frequent form of communication was the CO reporting plans or guidance to the Subordinate Commander. In line with the initial hypothesis, the next most frequently occurring communicative behaviour was the Subordinate Commander supplying information. As predicted, the Subordinate Commander was not noted as supplying knowledge or opinions to the Unit CO. In forming the plan at sub-unit level, subordinates may have been actively drawing on their unique experience, but in this exercise it was not while in collaboration with the Unit CO. In contrast, the unit HQ staff would normally be involved in the planning at unit level and hence their opinions and knowledge are valuable to the CO at that level. Two unexpected observations were: the frequency at which Subordinate Commanders would question the plan being transmitted to them and the consequent frequency at which a plan was adapted, due to a Subordinate Commander's suggestion. This suggests that the Subordinate Commander's contributions are, at times, having a substantial impact on the decision-making.

6.6 Discussion

The aim of this study was to explore how the HQ team contributes to the CO's decision-making process. This has been done by looking at: qualitative data on the interaction between the CO and the HQ team and quantitative data concerning frequency of different types of communication between the HQ team and the CO and the Subordinate team.

6.6.1 Interpreting qualitative results

To summarise, the qualitative exploration was able to provide us with a description of the exercises attended, which confirmed the realistic nature of the exercises (and hence the usefulness of the observations) and the differences inherent in the two exercises. This reinforces

the decision to separate out the data analysis across the two exercises. The two main descriptive findings that have supported and elaborated on previous elements identified to impact on decision-making were the further exploration of experience and trust. Further support was provided for the different types of experience drawn upon in decision-making, identified in Chapter 4. In addition, support has been established through field notes and short interviews, for the important role of trust in unit level HQ.

6.6.2 Summary of the impact of the HQ team on decision-making

Data showed that the HQ team were feeding into the CO's SA at all three levels identified by Endsley (1995), at a frequency significantly greater than zero. Typically, information was requested and given most frequently. To explain the differing frequency of communication of information, knowledge and opinion, we need to be aware that these are qualitatively different elements of communication. Situational specific information is generally going to be transmitted at a greater rate, because it is largely "unknown" at the beginning of an exercise/ mission and constantly changing as the exercise/ mission progresses. Information is needed to build up a picture of the current situation. During the establishment of an understanding of the current situation, knowledge is required to discern the meaning and importance of various pieces of information. Opinions are then used to contribute to option generation, mental simulation and decision-making. Following this, the CO would generally want to draw mostly upon information and knowledge from the team. From this the CO could draw on personal experience and / or the experience of the team to formulate opinions. Moreover, data showed that the HQ team are likely to be actively contributing to the CO's mental model needed for decision-making at the perceptual level (Level 1), the comprehension level (Level 2) and the projection level (Level 3) of SA (ie. information knowledge and opinion are supplied to the CO at a greater frequency than they are requested).

Significant differences were found between request and supply of knowledge at both exercise sites. However, surprisingly the significant difference occurred in different directions. At Exercise Silicon Brolga the CO actually requested knowledge significantly more frequently than it was supplied by the team to him. One explanation for this could be that the CO at this exercise did not have a clear understanding of his team's existing bank of knowledge. Another explanation might be that, due to the existence of the on-line communication option at this exercise, knowledge may have been transmitted back to the CO in this way and thus was unable to be monitored. It would require further research to seek and confirm the most reasonable explanation for this.

Differences between request and supply of information and opinion only achieved significance for each variable at one exercise. This could be due to a number of reasons but it is this researcher's considered opinion that this was most likely due to the relationship between the CO and the team; and how long they had worked together. One would anticipate that, for those teams who had worked together for a longer period of time, they would have a more realistic understanding of what each other would know and hence be able to communicate more effectively and efficiently because of this. This is in line with the theory of transactive memory, which holds that in groups certain knowledge is held by certain people. When this knowledge is required, group members know who to approach for retrieval.

At this stage, further research needs to be done to establish under which conditions this contribution of information, knowledge and opinion is occurring significantly more frequently than it is being requested (as current results were mixed).

6.6.3 Summary of CO communication with subordinates

Finally, the subordinates' communicative behaviour at 1 AR CPX was also recorded. In support of the hypothesis it was found that subordinates did communicate information to the CO.

Out of all communication occurring between subordinates and unit HQ, supplying information was the second most common. This occurred on average 5.81 times per hour. No instances were recorded in which the CO directly requested this information. Thus, the contribution of information seems to be an active process. As hypothesised, there was no transmission of knowledge or opinions from subordinates to the CO observed. The most likely explanation for this is that the CO issues his intent to the subordinates and then they are responsible for forming a plan to satisfy this intent. During the plan formation process that is occurring in the subordinate HQ, subordinates are they are actively drawing on their unique experiences, but not while in collaboration with the unit level CO. The unit level CO is not directly involved in the sub-unit level planning and therefore will not necessarily need to draw on knowledge and opinion, but will only need to be updated on information as this affects the overall situational picture. Alternatively, but less likely, it could also relate to the authority gradient between the CO and subordinates and hence the subordinates' unease at actively expressing knowledge or opinions.

Although not actively offering knowledge or opinion to the CO to inform planning, the sub-unit team is offering opinions about the suitability of the plans or intent as transmitted to them by the CO. Moreover, it is worth noting the frequency at which the plan was adjusted based on the subordinates' feedback. This implies input from subordinates at level 3 of SA. Therefore, subordinates were found to impact on decision-making at both pre-decision and post-decision points.

6.6.4 Overall summary and conclusions

In combination, these findings support the working hypothesis that the CO relies on his/her team to make decisions. The theory of transactive memory could be applied to explain the observations of the HQ team process by which knowledge and even opinions are often retrieved from the team to inform decision-making. This would explain the sharing of unique previous

experience between HQ staff and the CO. Thus, there is a division of cognitive labour within the group. This presents a basis for future research in the Australian Army on the structure of transactive memory and how this knowledge might be used to improve command support systems and training.

In light of current shifts to Networked Centric Warfare (NCW) these results present implications. A challenge for future design is to not hinder the active contribution that the HQ team make to the CO's three levels of SA. These results highlight the importance of including the team's contributions into any model of unit decision-making in the Australian Army.

Four limitations were identified in this phase of the research. One limitation of the current research is that it is difficult to make definite generalisations from such research (Cronbach, 1975). Full consideration needs to be given to this context in influencing the outcome, and then any generalisation is a "working hypothesis, not a conclusion" (Cronbach, 1975, p.124-125). This stance has been taken with the current research. Despite investigation across two different regiments, the observations must be much more widely applied in order to generate results with good generalisability.

Already in the current research, there have been many differences noted between regiments. As was noted, factors that differed between regiments were:

- The physical set-up of unit level HQ;
- The methods of communication (e.g. computer based decision-support tool, radio, telephone, verbal);
- Type of mission being exercised;
- The interaction between the CO and the team;
- Underlying group culture.

It is expected that such differences would be consistently found throughout the Australian Army. It should be noted that, despite the differences between these regiments, similar communicative behaviours were still observed occurring at different frequencies, likely due to the nature of the exercises and teams. Thus, the categories of communication coded were thought to be general enough not to limit their application to one particular context. It would be expected that these categories would be applicable to communicative behaviour across regiments, but may be observed at varying frequencies and complemented with a different range of other communications.

A second limitation has been the lack of comparison with a Reserve exercise. Original coding categories were developed from observing a Reserve exercise, so it is clear that the same types of communications would be applicable at such an exercise; but their frequencies and proportion are unclear. Due to organisational difficulties it has not been possible for the researcher to attend a Reserve exercise in order to compare the results generated. This comparison was included in the earlier CDM interviews. Ideally, this should be done in the future. A third limitation was the difficulty of tracking all communications because of a lack of access to computer based communications. Both exercises used computers as decision support tools. Therefore, communication was also sent electronically through this system. However, access to event logs was not permitted. Also, at Exercise Silicon Brolga, there were no audible radio communications. All transmissions were via the computer or a phone line. This meant that interaction with subordinates was impossible for the researcher to monitor. Because data were also transferred over the computer, a substantial portion of communication was lost by only recording voice. In the future, if access could be granted to the computer logs, more thorough analysis could be carried out.

A final limitation was in the method of behavioural data recording. As described in the *Method* section, the occurrence of a behaviour was sampled in phrases (i.e. a behaviour was coded each time it occurred in entirety within the 5-minute coding window). Each behaviour observed within each 5-minute coding window was recorded in the appropriate box on the checksheet. However, certain communicative behaviours may have taken comparatively more time. This is not reflected in the current coding method. Future research should therefore consider the length of each coding frame in relation to the exercise. It is also recommended that a method be devised to monitor the request and supply of information, knowledge and opinions, because this could not be directly linked in the current data recording method.

In sum, the current field studies have indicated that the unit HQ team feed information to the CO at each of the levels of SA (as identified by Endsley, 1995). Results have shown that the team most likely actively feeds information into all levels of SA. However, this may depend on the conditions of the exercise/ mission and further research is required. These results, in combination with the qualitative data, indicate that the CO is reliant on his/her HQ team during the decision-making process. Thus, the results support the previous interview findings. The results also support the theory of transactive memory to explain information exchange within the context of the Australian Army. The inclusion of this social aspect of decision-making seems integral in any descriptive model.

Future research should plan to gather a broader base of observations, in order to more adequately understand the significance and generalisability of these data. Observations should be across regiments and involve both Reserve and Regular officers. The method used for recording observations should also be considered in future research, so as to monitor correlational relationships more accurately.

It also seems that the subordinates are impacting on the decision-making process to a certain extent, particularly at the first level of SA (perception). Further research should elaborate on this information and also investigate the types of contributions being made by Brigade HQ (higher HQ) on the unit level CO's decision-making process.

Other areas that should be pursued in further research include: the role of trust in information sharing and the impact that high risk situations may have on this; and the extent to which non-verbal communication may impact on NDM.

In essence, these findings have added validity to previous Q-sort and interview findings that have identified the perceived impact of the HQ team on NDM at a unit level in the Australian Army. Notably, this research has also confirmed the existence of a number of different types of experience that can be drawn upon to influence NDM. In conclusion, the inclusion of the team in the model of decision-making for unit CO decision-making is integral. By increasing the awareness of the elements impacting on NDM, we are better able to understand what implications changes in the current unit level HQ set up may have. These things will be incorporated into a revised model for unit level NDM in Chapter 8.

To this point, research in this thesis has been mostly qualitative in nature, with limited experimental control possible. It has also been labour intensive and difficult to organise because it has meant taking up valuable resources (time and space during planned training exercises, Army Personnel time etc.). A recent idea has been that to understand NDM more thoroughly, it may be possible to simulate NDM style situations using computer technology. In essence, designing a computer simulation that requires operator intervention to control/ manage an NDM type situation has been suggested. Some research has been done in this area and current NDM simulations are available. These simulations have been found to be useful tools in a number of cases.

However, in light of this new information about the breadth of the elements that are actively contributing to CO decision-making in the field, it is important to understand the extent of the value associated with microworld research. The question now arises as to whether these same elements can be accounted for/ investigated using a computer simulated microworld. This would be a more cost-efficient and controlled research environment and thus would bring a number of advantages. However, the suitability of this type of environment for exploring certain NDM questions is to date unknown. This will be explored in the next chapter.

CHAPTER 7. Investigating NDM in a Simulated Microworld:

What Questions Should We Ask?

7.1 Introduction

Naturalistic Decision-making (NDM) theory explains how experts make decisions under time pressure, in dynamic situations characterized by uncertainty and high stakes (Zsombok, 1997). The decision process relies on the automatic availability of situation awareness (SA). In establishing SA, experts draw on previous experience when recognising typical cues that are automatically linked to potential courses of action (Klein, 1999). Once generated, decision options are evaluated sequentially. Examples of real life environments where NDM has been observed are military operations, firefighting scenarios and in emergency operating rooms.

Because of the extreme complexity associated with these environments, where the mastery of expertise in decision making can take 10 or more years to achieve, research environments and opportunities for investigating these processes have been extremely limited. Currently, the most common methods used by NDM researchers have been field observation and interview techniques. However, recent technological advances have resulted in the availability of more complex simulations with varying levels of fidelity, designed to replicate the real time pressure, dynamicity, complexity and high stakes associated with an NDM environment (e.g. Omodei & Wearing, 1995). The quality of such resources can vary enormously; and, although high fidelity simulation can produce circumstances that appear close to real life, this is also extremely expensive and resource intensive to establish. A popular form of simulation used for NDM research has therefore been low fidelity computer-based simulation using tools called “microworlds” (Brehmer & Dörner, 1993).

A microworld generates an on-screen environment with which the user must interact in order to produce a good outcome (e.g. fight fires in a forest to save land from burning and people from being killed (Artman, 1999; Granlund, 1998). There are several potential advantages associated with such simulations. A microworld is much more cost efficient than field research, typically requiring no more resources than a computer in a room. Moreover, this medium is an attractive alternative to field research because there are often limitations to participant accessibility and the availability of appropriate research exercises. Another advantage over field research is increased experimental control. It is not surprising then that interest in the potential of this type of research has increased in recent times (Rigas, Carling & Brehmer, 2002; Weaver, Bowers, Salas & Cannon-Bowers, 1995). However, before accepting microworld simulation as a medium for research, it is important to consider what types of research questions can sensibly be answered using microworlds.

NDM research questions can be broken down into three broad topics: the development of expertise; the perceptual-cognitive skills associated with expert decision-making; and the broader context of influence impacting on expert decision-making that may lead to situation-specific content knowledge and skills. Thus, to ascertain which research questions are appropriate for exploration with a microworld, the current research sought evidence for each of the three questions that follow.

1. Do microworlds provide conditions under which the development of expertise can be observed?

A well-cited model of expertise development proposed by Dreyfus (1972) suggested that expertise requires transition through five stages. This progression begins with variable awkward performance and continues to a point where decisions become intuitive and responses more immediate and logical to the decision-maker. Later research by Rasmussen (1983) and Anderson

(1991) reduced these five stages to three substantively different stages. When expertise has been acquired, often cognitive processing is not conscious; and “intuition” has been used in recent literature to describe this type of fluid information processing and decision-making (see Klein, 1999, 2003). Similarly, microworld users, although bringing some of their own understandings to the task (like for example, how fires should spread according to the direction of the wind) would be expected to build up a larger repertoire of experiences as they become more practised in using the tool. In this regard, the cognitive complexity of decision-making in a microworld has been questioned (Chapman, Nettelbeck, Mills & Welsh, 2006). To handle the complexity and novelty associated with decision-making in a real-world NDM situation, a broad bank of well-established experience is required which can be drawn upon for decision-making. Chapman and Mills (2003) have highlighted several types of experience beyond domain specific experience that feed into decision-making; and have questioned whether a comparable range of experience is necessary to perform expertly on a microworld simulation. If the microworld is an appropriate testing context for development of expertise we would expect it to produce the stages of cognitive development representative of NDM expertise. Moreover, as suggested by Chapman and Mills (2003), a range of experience would be necessary for expert performance.

2. Does a microworld provide an environment that promotes perceptual-cognitive processing in NDM contexts?

Lane and Alluisi (1992) suggested that NDM skills could be considered in terms of general perceptual-cognitive principles and situationally embedded skills. It would be expected that general principles could be demonstrated with research using microworlds, because it has already been established that these are similar across domains of expertise (Glaser, 1987). It is suggested that, in order for experts to make decisions, a continual SA is required (Klein, 1989; Hutton & Klein, 1999). Both novice and expert decision-makers build a certain level of SA to

inform decision-making. As decision-makers become more skilled, however, they also develop better SA, knowing which information is important and which information can be filtered out (Hutton & Klein, 1999). This developed SA leads to four perceptual-cognitive indicators of expertise. These are accuracy of prediction, completeness of action and speed of response (Glaser, 1976; Klein & Peio, 1989). Subsequently Klein has also emphasised the importance of planning behaviour in complex environments (as observed in the military; see Schmitt & Klein, 1999). We would expect therefore that behaviours associated with high performance scores on *NFC* could be coded into these categories.

However, it is unclear whether a microworld structure can be sufficiently “real world” to require the complex, situationally embedded skills that experts rely on. Research has generally found that experts in their chosen domain outperform other decision-makers (Shanteau, 1992) because of expert content knowledge, which is context specific and which defines the boundaries of the application of an individual’s expertise. Such knowledge has commonly been researched by cognitive task analysis or other tests of declarative knowledge that focus on how people see relationships between concepts (Militello, 2001). Moreover, context-specific knowledge required within a microworld will not necessarily transfer across other forms of expertise. For example, military experts without previous experience using a firefighting microworld did not perform at a significantly different level compared with civilian novices on the same task (Chapman et al., 2006). It was therefore important then to control for any previous relevant NDM experience in the study, wherein we have explored whether a microworld is a suitable research tool for drawing conclusions about general perceptual-cognitive principles associated with NDM.

3. What elements are taken into account in decision-making in a microworld?

Serfaty, MacMillan, Entin and Entin (1997) have emphasised that laboratory-based decision-making tasks are frequently artificial, although what impact, if any, this has on the

external validity of results remains uncertain. Typically the decision-maker collects information from a computer simulation, using only vision and/or audition, whereas decision-making in the real world can draw upon several senses. Moreover, the physical complexity of the microworld environment is more simple than the real world equivalent. The current research therefore investigated the extent to which personal and situational elements, found to be important in the real world, are also important for decision-making in the microworld (Chapman & Mills, 2003).

7.1.1 The current study

The testing tool was a computer simulation called Networked Fire Chief (*NFC*, Omodei, Taranto & Wearing, 1998), a microworld that has been used previously to research the principles of NDM. The task emulates a fire-fighting scenario and the operator is required to make decisions under continually changing conditions. *NFC* generates cognitive task simulations that a person would encounter in a real-life system involving uncertainty, complexity and feedback loops. Another reason for selecting this software was its availability for public use.

In Figure 33, the land types are represented by different colours on the screen. Purple represents residences, dark pink/brown represents pastures (with cattle), dark green is national park, and light green is grassland. Helicopters are represented by yellow squares and red squares represent fire trucks. Fires are small red hollow squares. Once landscape is burnt it turns black, and cannot be burnt again. Performance data is recorded in files on the computer for each scenario run.

The study aimed to investigate the development of expertise, the perceptual-cognitive skills demonstrated and the broader situational and personal elements associated with decision-making in *NFC*. These results have been compared with findings from previous research (Chapman & Mills, 2003).

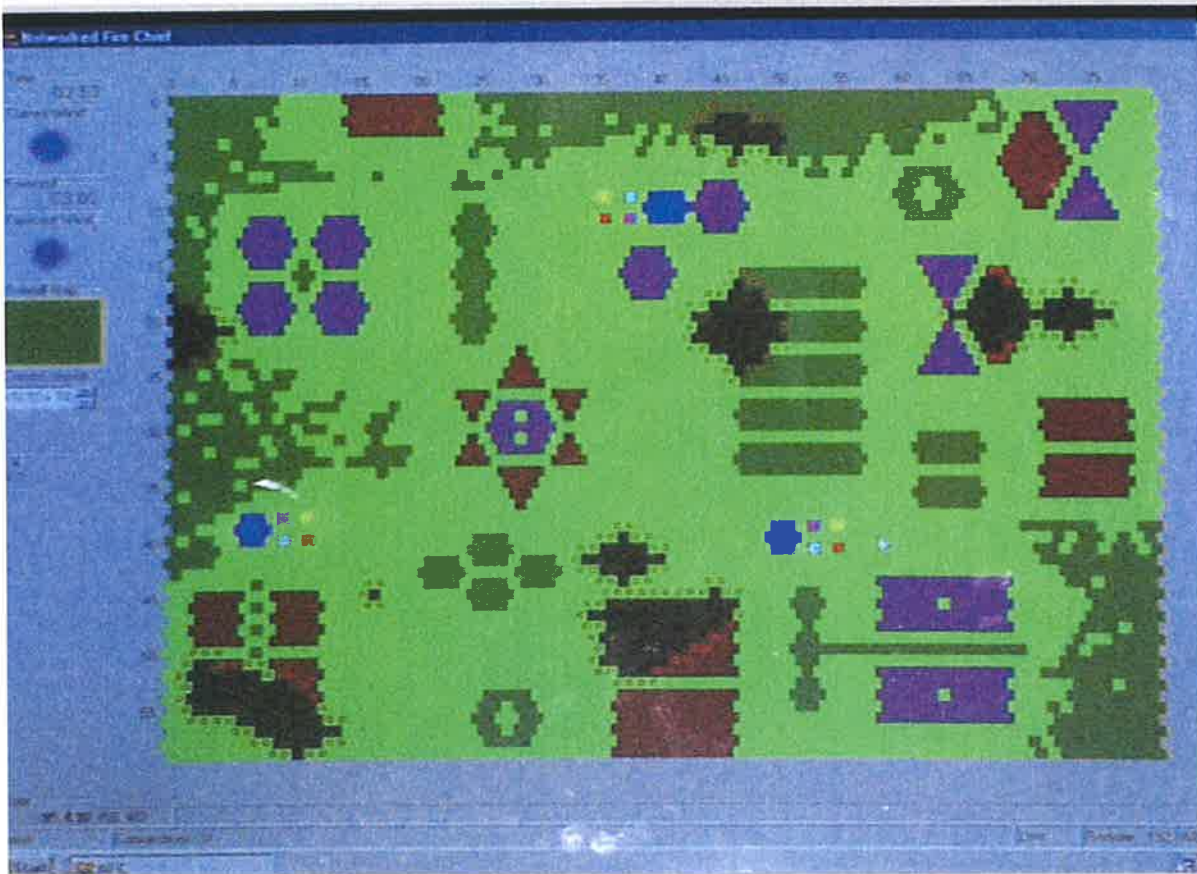


Figure 33. An example of a typical NFC scenario.

Predictions were:

1. A clear process for development of performance expertise, according to developmental milestones described in the literature, will be apparent on *NFC*.
2. The NDM perceptual-cognitive performance characteristics of speed, accuracy, efficiency and planning will be observed.
3. A complex range of situational and personal elements will be perceived to impact on NDM.

7.2 Method

7.2.1 Participants

Participants were 10 male and 10 female unpaid volunteers aged from 19-24 years (mean= 20.4) who were either studying towards or already held a tertiary degree. All were friends or associates of the author and normal ethical requirements were observed.

7.2.2 Apparatus

The *NFC* simulation was run on a computer in an isolated room. The situation *NFC* creates is that of fighting fires that spontaneously break out on a map. Participants use fire fighting appliances to extinguish fires. Appliances have been created with some of the same limitations (water capacity, travelling speed, crew rest requirements) as their real-world equivalents. Variations in weather, fire fighting appliance limitations and land priority must all be considered when allocating resources to fight the fires. Performance scores are obtained from the percentage of landscape left after a designated period of time has elapsed, taking into consideration land priority.

All participants were given an information sheet outlining the nature and purpose of the study (Appendix XXIV). If they were willing to participate they were also asked to sign a consent form before beginning (Appendix XXV). Trials ran according to a schedule (Appendix XXVI). Before beginning the trial participants were trained to interact with the *NFC* program via a short training protocol that introduced them to important issues such as the aim of the exercise, the colour coding of the various land types/ resources, the screen's features, and how to operate the interface (Appendix XXVII). Following this a questionnaire was administered to ensure that participants understood the program to a standard requirement (Appendix XXVIII). A standardized minimum level of mouse control skills in the *NFC* environment was first established

by administering a short computer mouse skills test (Welsh, 2000) that incorporated the completion of all mouse skills required for use of *NFC* (Appendix XXIX). Successful completion of this task within an appropriate specified time limit of 2 minutes was a pre-requisite for all participants.

Twenty equivalent *NFC* scenarios were developed from five prototype scenarios that were flipped horizontally, vertically, and then horizontally again. These were established beforehand by pilot testing to be near-identical in level of difficulty, despite differences in appearance (Appendix XXX).

A behavioural check sheet developed from a preliminary task analysis of an expert on *NFC* (see Chapman et al., 2006, p.44) coded participants' behaviours on *NFC* within four categories linked to perceptual-cognitive skills associated with NDM (Appendix XXXI). These were frequency for accuracy, completeness of action (ie. efficiency), speed and planning as observed on *NFC* (Glaser, 1976; Klein & Peio, 1989; Schmitt & Klein, 1999). These observations were represented as frequency counts. Definitions for observations are found in Appendix XXXII. Interview questions, based on the principles of critical decision method (CDM, Klein, Calderwood & McGregor, 1989), and initially piloted with inexperienced *NFC* users, were targeted towards attaining information on skill development and also the changing understandings of the *NFC* environment, decision skills of the participants and contextual elements. Questions focussed on the participant's recognition of a situation, scanning behaviours, critical cues, use of information, expectations or conclusions drawn from given information, and elements impacting on decision-making (Appendix XXXIII). Definitions for interview coding are found in Appendix XXXIV. Post-trial questionnaires accompanied the interview (Appendix XXXV). These encouraged further written reflection on the replay, and demographic

information. The participant's opinions about useful information for decision-making in *NFC* were also collected together with any information about previous real-world NDM experience.

7.2.3 Procedure

Participants completed a session on *NFC* that lasted approximately three hours. This investigated the effect of practice on the participant's understanding of *NFC* concepts and also provided a large data set to investigate the relationship between performance and behaviour. The *NFC* program was introduced according to the training protocol. Following training, the participant completed a short quiz, to test acquired knowledge about the content of the training protocol. Any questions not answered were re-explained. This quiz checked that the participant understood the program to a level sufficient to eliminate performance impediments caused by poor knowledge of the simulation interface.

The participant then completed the short mouse skills test (Welsh, 2000), to establish basic mouse skills before completing the 20 equivalent *NFC* scenarios (each lasting 5 minutes). Between scenarios the first author returned to the room to open the next scenario, while at the same time encouraging the participant to improve their score in the following scenario (Cannon-Bowers, Salas & Pruitt, 1996; Hurlock & Montague, 1982). To minimise fatigue, a short break was taken after trial 10.

Short interviews were conducted with the participant after the first and last trials. To begin the interview a pre-designated section of the scenario was replayed. This short replay involved a critical decision point ⁴⁹(such as a land priority decision). After reviewing this,

⁴⁹ A critical decision point was defined as a critical point where a decision must be made in order for events to proceed favourably.

questions began. Interviews were taped on video and audio recorders. Following this short interview post-trial questionnaires were administered.

7.3 Results

7.3.1 Reliability of coding

Inter-rater comparisons assessed validity for both the content analysis of interviews and the behavioural analysis of *NFC* replay files. The data were coded by the first author and a trained associate independently and a reliability coefficient was calculated (Neuendorf, 2002). The mean inter-rater reliability for the behavioural data was 0.81. The mean inter-rater reliability for the content analysis data was 0.84 (Appendix XXXVI). These were considered adequate, given that 70% inter-coder agreement is considered acceptable (Miles & Huberman, 1984).

7.3.2 Development of expertise

Development of expertise was investigated by reviewing the performance scores generated by *NFC* (percentage of landscape unburned), and the behaviours exhibited. Performance scores ranged from 81.17% to 95.87% of landscape not burned. From the performance scores generated by each scenario, expertise development scores were created to determine the extent to which practice on *NFC* resulted in improved performance. Expertise development was defined as

$$\frac{B - A}{10}$$

where A= the average score obtained in the first 10 scenarios and B= the average score obtained in the last 10 scenarios. This formula controlled for slight variations in scenario construction.

Across all participants, an average improvement of 1.56% was found between the average performance score from the first 10 scenarios compared with the average performance score from the last 10 scenarios.

Development of expertise was also investigated in terms of behaviours exhibited in early trials (Trials 1 and 6 which were mirror versions) in comparison with the final trials (Trial 14 and 19 which again were mirror versions). Table 44 shows changes in the behaviour coded in the subcategories relating to speed, accuracy, efficiency and proactive planning. All behaviours associated with speed, efficiency and proactive planning improved with practice but the only accuracy behaviours that showed significant improvement were the consideration of land priority and wind direction when placing appliances around a fire.

Whether content knowledge developed and could be related to improving speed, accuracy and efficiency of decision-making was investigated in terms of the information taken into account when making decisions (extracted through the post-trial questionnaire and the short interviews). A function of the post-trial questionnaire was to identify the importance that participants placed upon eight pieces of information related to NDM (see Table 45) and how these varied with practice. Table 45 describes the agreed ranks obtained by ranking average outcomes provided by the participants following trial 1 and trial 20. Discrepancy scores added across the eight pieces of information for trials 1 and 20 indicated the extent of agreement between all participants' rankings. Agreement among participants was first calculated by subtracting each average ranking for each piece of information from the overall ranking into which that piece of information had been placed after averaging the participants ranking (see Table 45).

Table 44. A comparative description of the frequency of mean behaviours relating to speed, accuracy, efficiency and proactive planning measures within the *NFC* trial.

	First Trials		Last Trials		Significance	
	Mean	SD	Mean	SD	t	p
Speed Measures						
Time taken to allocate appliances (secs)	19.15	6.58	14.44 (faster)	1.21	4.44	<0.01
Time taken for appliance to reach fire (secs)	21.15	10.05	11.44 (faster)	1.60	6.04	<0.01
Helicopter sent first if available (% of time)	62.08	43.20	86.25 (more frequent)	10.13	-3.45	<0.01
Closest appliance used to fight fire (% of time)	67.92	42.93	95.63 (more frequent)	7.24	-4.03	<0.01
Accuracy Measures						
Wind direction considered (grid squares from optimal)	2.55	1.15	1.01 (closer)	0.34	8.15	<0.01
Appliance allocation ratio (Appliances: fire size)	0.26	0.13	0.25 (slightly lower)	0.08	0.60	>0.05
Spread of fire into crucial land considered (% of time)	85.00	28.19	88.75 (more frequent)	11.60	-0.78	>0.05
Land priority considered (% of time)	54.97	44.36	100.00 (more frequent)	0.00	6.42	<0.01
Efficiency Measures						
Refilling is done (no. of times)	4.55	2.59	5.70 (more frequent)	1.92	-2.25	<0.05
Refilling is done nearby (% of times)	83.99	16.27	91.13 (more frequent)	14.13	2.10	<0.05
Idle while fighting fire (secs)	264.85	155.05	119.25 (less time)	109.75	4.85	<0.01
Proactive Planning Measures						
Use of fire break	0	0	0.50 (more frequent)	0.51	-6.25	<0.01
Area burnt off using fire breaks	0	0	2.10 (more area)	2.19	-6.06	<0.01
Resources kept in proximity of crucial land.	0	0	5.86 (more frequent)	0.43	-86.71	<0.01

Table 45. Description of participants' changing attitudes towards eight pieces of important information.

	Accuracy/ allocation		Speed of appliances		Accuracy/ Placement		Efficiency		DISCREPANCY SCORE
	Land priority	Burn rates	Speed of Appliance	Distance of appliance from fire	Wind	Water left in appliance	Distance of appliance from water	Water capacity of appliance	
Average Trial 1	2.75	3.4	3.5	3.2	5.2	5.2	6.1	6.2	
Ranking Trial 1	1	3	4	2	5	6	7	8	
Discrepancy Trial 1	1.75	0.4	0.5	1.2	0.2	0.8	0.9	1.8	7.55
Average Trial 20	1.6	2.9	3.15	3.65	5.85	5.7	6	7.15	
Ranking Trial 20	1	2	3	4	5	6	7	8	
Discrepancy Trial 20	0.6	0.9	0.15	0.35	0.85	0.3	1	0.85	5.00

From Table 45, it can be seen that the average overall ranking of each of the critical pieces of information was relatively constant from trial 1 to trial 20, although, the agreement between participants about these rankings was more similar after trial 20. Nonetheless, relative discrepancy was low from the outset because many participants had accurately identified the important content knowledge after only the first trial.

7.3.3 Perceptual-cognitive skills observed in the *NFC* microworld

It was hypothesised that high performance on *NFC* would be associated with behaviours linked to accuracy, efficiency, speed and proactive planning measures. Using replay files from *NFC*⁵⁰, behavioural observations were made during scenarios 1, 6, 14 and 19 (ie. mirror versions

⁵⁰ Each scenario completed by the participant was recorded by the computer system and stored as a replay file.

derived from the first and fourth scenarios). Scenarios 15 and 20, as later versions for analysis, were not used because there were missing replay files. Performance scores were correlated with the varying frequency of behaviours exhibited, to identify significant relationships (see Table 46). All behaviours associated with speed of fire extinguishing correlated with high performance scores. These behaviours included: the average time taken to place an appliance at a fire (reaction time), the average time taken for the appliance allocated to that fire to reach its destination (response time), and the frequency with which the closest vehicle was used as a first response unit. In terms of accuracy, the only significant correlation was between performance and placement of the appliance in an optimal position, according to the direction of the wind. In terms of efficiency, the duration of time that vehicles spent idle when they could have been fighting fires correlated negatively with performance. The number of commands made and the number of times vehicles were refilled during the scenario correlated positively with performance. Finally, in terms of proactive planning measures, both the number of firebreaks made and the area that these covered correlated positively with performance on *NFC*.

Table 46. Correlations between speed, accuracy, efficiency and proactive planning measures with performance.

Speed	r	p
Average time between fire outbreak and appliance allocation	-0.54	<0.01
Average time for first responder unit to reach fire	-0.49	<0.01
Percent of times helicopter sent first	0.28	>0.05
Percent of times closest appliance sent first	0.36	<0.05
Average time taken to extinguish fire	0.50	<0.01
Accuracy		
Average distance of appliance from optimal position (wind direction)	-0.56	<0.01
Average ratio of appliances to fire size	0.13	>0.05
Spread of appliances around fire	0.16	>0.05
Average distance of appliance from optimal position (land priority)	0.38	>0.05
Efficiency		
Number of refilling breaks taken	0.58	<0.01
Average time spent refilling	0.02	>0.05
Average time spent idle	-0.58	<0.01
Land covered by fire (end of simulation)	0.18	>0.05
Number of commands made	0.52	<0.01
Proactive Planning Measures		
Number of firebreaks	0.75	<0.01
Area covered by firebreaks (end of simulation)	0.68	<0.01

7.3.4 Elements impacting on decision-making in the *NFC* microworld

A content analysis was carried out on the data extracted from post-trial interviews using QSR NUD.IST® (Non-numerical Unstructured Data Indexing Searching and Theorizing computer software version 6). The data were subdivided into single line text units, because this is the smallest unit of analysis that can be coded and retrieved by QSR NUD.IST®. The coding was inductive and revealed that a number of elements were identified in relation to decision-making on *NFC*. The relative contribution of these topics to the discussions after trial 1 and trial 20 are shown in Figure 34.

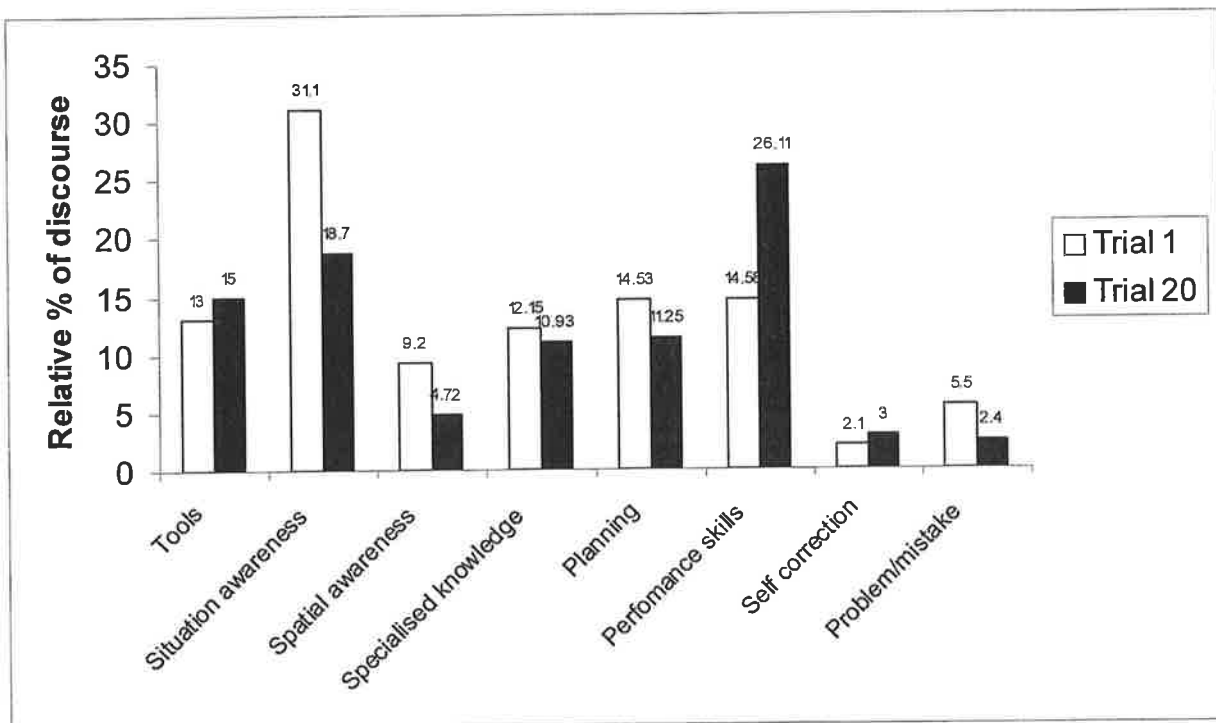


Figure 34. Relative frequencies of major constructs identified in NFC post-trial interviews.

The relative proportions of discourse relating to the coding categories varied between trials. Overall, situation awareness was often discussed in terms of continually monitoring the screen for

new fires as well as monitoring for progress of fires already attended (to ensure no idle appliances). This decreased in the interview following trial 20. Performance skills were the second coding category that dominated the majority of responses across trials. These were defined as when the participant mentioned other skills that they used that impacted on their performance (e.g. monitoring appliances, computer mouse control skills). Performance skills were discussed more frequently in the interview following trial 20. Planning, tools, and specialised knowledge also contributed substantially to responses following trial 1 but were taken up less frequently after trial 20. Planning was discussed in terms of pre-distribution of appliances near crucial areas, and also the production of fire breaks. Tools referred to how participants described the ways in which helicopters and fire trucks were used. Specialised knowledge referred to the knowledge required to best respond to the *NFC* situation (e.g. influence of wind, burn rates of land).

7.4 Discussion

7.4.1 Development of expertise

It is obvious from these results that improvement in performance scores across 20 trials was small and largely limited to the first few trials. The average difference between the first scenario and the last scenario was only an additional 1.56% of landscape protected from burning. It is concluded, therefore, that the *NFC* task was not sufficiently complex to permit significant improvement as participants developed expertise. Nonetheless, despite little improvement in performance, the way in which participants dealt with the scenarios clearly changed. Speed of responding improved as participants gained more practice on *NFC*. They located problems (in this case the fires) more quickly and developed mechanisms to increase speed of reaction, like choosing the appliance capable of the quickest response, and actually extinguishing a fire. Accuracy and efficiency also improved as participants gained practice on *NFC*. In particular, the amount of time

appliances spent idle while tasked to be fighting fires was approximately halved. These improvements clearly reflected heightened awareness of the environment in which participants were operating. It could be concluded, therefore that, as participants became more familiar with their environment, they were better able to utilise environmental information appropriately. Such improvement requires increased expert context knowledge, which informs situationally mediated skills as described by Lane and Alluisi (1992). In addition, increased context knowledge allowed better SA development to inform decisions relating to speed, accuracy, efficiency and planning.

Questionnaire results supported the importance of these cognitive skills, as demonstrated by the priority placed on a number of variables as participants gained experience on *NFC*. Questionnaire responses confirmed that participants' attitudes were more similar after completion of the set trials (showed by the decreasing discrepancy scores) as participants acquired a more refined content knowledge of information critical to decision-making on *NFC*. Overall, participants rated the information in the following order of importance (from most important to least important): land priority (accuracy/ allocation), burn rates (accuracy/ allocation), speed of appliance (response speed), distance of appliance to fire (response speed), wind (accuracy/ placement), water left in appliance (efficiency of response), distance of appliance from water (efficiency of response), water capacity of appliance (efficiency of response). As indicated, each of these variables is related to higher-level NDM perceptual-cognitive behaviour. Thus, from these rankings, the order of priority placed by participants on NDM performance skills was: accuracy/ allocation, speed, accuracy/ placement and efficiency. From this, a decision hierarchy for the participants on *NFC* has been constructed (see Figure 35). The fact that pieces of information relating to accuracy were considered at different points can be explained in terms of a decision hierarchy. Fires would break out as participants were monitoring the *NFC* screen. If multiple fires were burning the first decision required was to allocate priority of response. Secondly, the speed of

response was decided (appliance choice). As the appliance was moving towards the fire the third decision made concerned the position of placement around the perimeter of the fire. This separation of the two levels of accuracy allowed the appliance to first be allocated and response time thus decreased before the second level accuracy decision needed to be made.

This hierarchy is in line with Klein and Peio's (1989) and Glaser (1976) theories. This finding therefore supports the idea that, at a general level, the types of psychological skills associated with expertise are exhibited on the *NFC* microworld (Omodei & Wearing, 1995). Despite this, however, the *NFC* program was limited in its capacity to create an environment for developing expertise, because of its small number of situation variables. In effect, the complexity of the microworld is probably not sufficient to require a lengthy period of skill acquisition. The amount of information required for mastery of decision-making on the *NFC* microworld is not comparable with that which would be present in a real world environment. In a real world situation, NDM experts must learn how to cope with a large number of constraining variables. Therefore, although the investigation of some elements of NDM seems practical using *NFC*, the development of expertise may not be.

7.4.2 Perceptual-cognitive skills observed in the *NFC* microworld

Performance on *NFC* correlated with a number of behavioural measures. It correlated with most measures of speed, but not the percentage of times a helicopter was used as an initial response unit. This could be because fire trucks were located closer to fires in many cases and hence provided a quicker response, consistent with the observation that the closest appliance to a fire was used as an initial response unit on a high percentage of occasions.

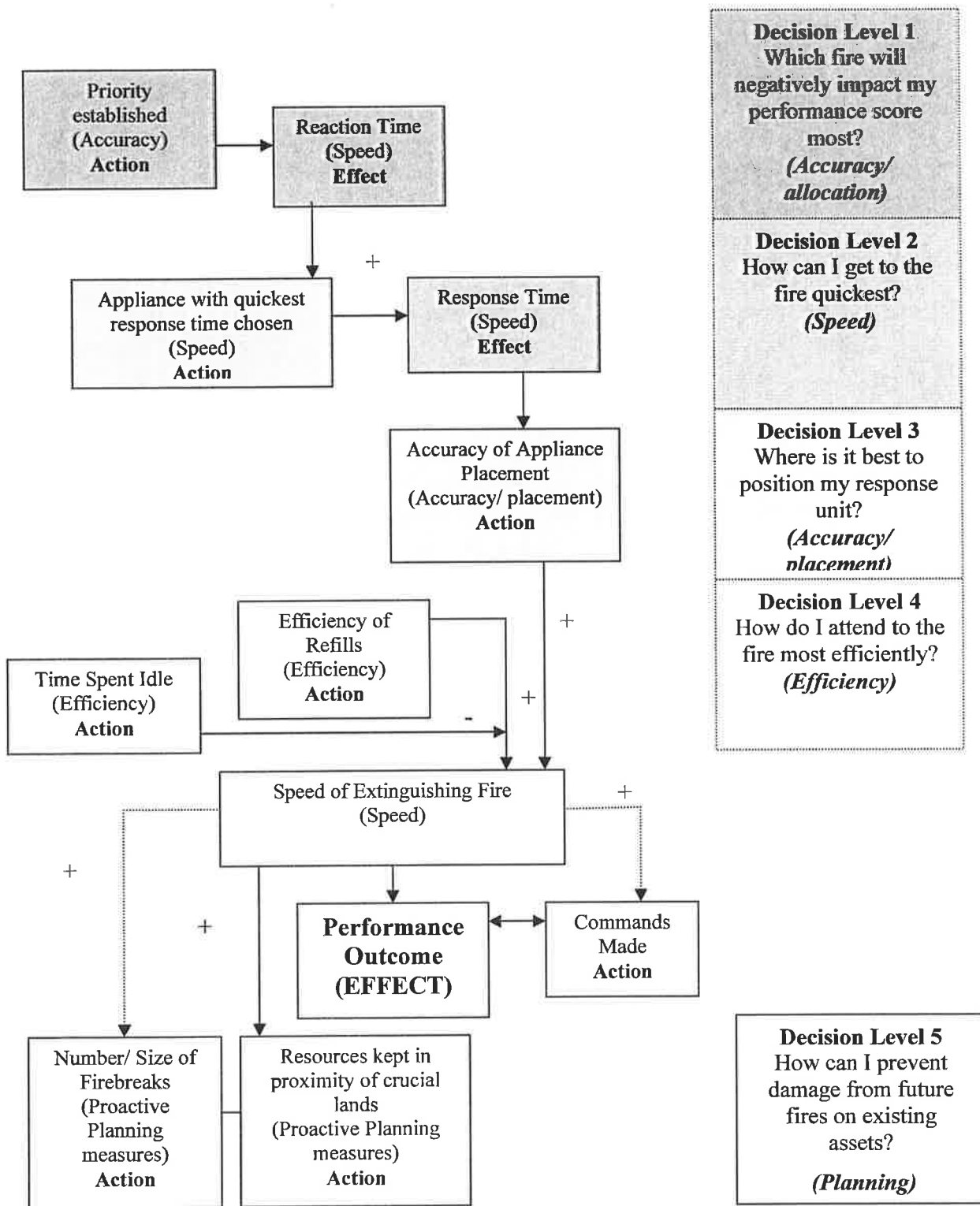


Figure 35. Concept map depicting relationships between NFC decisions.

Consideration of wind direction, which influenced accuracy when placing the appliance in the optimal position, also correlated with performance. However, other accuracy measures did not significantly correlate with performance, indicating that they were not as crucial in determining performance scores.

Two efficiency measures that significantly correlated with performance were: the number of times appliances were refilled, and the time spent idle by appliances (tasked to be fighting fires). Unexpectedly, the more moves made on *NFC* (number of commands), the better the performance outcome. However, this could be explained because, as participants became quicker, and more skilled in *NFC*, their monitoring of the current scenario was better, they wasted less time (e.g. time spent idle) and they became more efficient in moving and allocating resources.

Proactive planning measures (use of firebreaks) also correlated significantly with performance. It is likely that the better the participants were performing, the more time they had to engage in proactive measures. This supposition is also supported by interview data that indicated that the participants' main reason for not using firebreaks was a lack of time.

Overall, perceptual-cognitive skills observed were in line with expert type processing (as discussed by Glaser, 1976; Klein & Peio, 1989; Schmitt & Klein, 1999). Moreover, general skills as discussed by Lane and Alluisi (1992) were recorded, as well as some situation specific skills (e.g. improvement in skills due to increased knowledge of important environmental information). Thus, at a basic level the *NFC* microworld was found to require the use of both general expert skills and situationally mediated skills associated with expert content knowledge.

7.4.3 Elements impacting on decision-making in the *NFC* microworld

Content knowledge was collected through both interviews and the post-trial questionnaire. Responses confirmed that speed, accuracy, efficiency and proactive planning measures were all

perceived as important determinants of performance. Thus, it seems that, at a higher conceptual level, *NFC* requires similar types of skills in terms of the development of expertise as those proposed by Klein and Peio (1989), Glaser (1976) and Schmitt and Klein (1999).

Content analysis of interviews found that, as participants gained practice, they discussed their situation awareness less frequently. This could be explained because there were limited pieces of situational information contributing to SA. After the first trial the discussion of specialised knowledge and spatial awareness was also more frequent than after trial 20. It is suggested that after the first trial the participants were most likely trying to understand important situational elements and patterns in the environment. This would enable them to better predict future events. As they developed expertise, their discussions of situational considerations most likely decreased, because they had developed sufficient specialised knowledge about these things to enable them to inform recognitional decision-making. After the initial trial participants also discussed planning more frequently, compared with the end of their experience. This outcome is consistent with theory suggesting that decision-making becomes more intuitive as practice is gained. In support of this, actual outcomes of planning were observed more frequently in later trials, despite the fact that outcomes were discussed less frequently.

Performance skills likely increased because participants learnt that there were certain moves that could be made to decrease response times (e.g. while deciding what front on which to fight a fire, an appliance could start moving in that direction to save time). Similarly, monitoring and using tools was referred to more frequently as experience was gained, consistent with theory that opportunity for the efficient use of tools increases with practice. Other observations supporting improvement were that self-correction was discussed marginally more frequently; and mistakes were made less frequently after the final interview. A more substantial increase in self-monitoring

from the first to the last trials would have been expected, given that theory suggests that experts are more skilled in this area than novices (Hutton & Klein, 1999).

Thus, from the post-trial interviews and the questionnaires, the elements impacting on decision-making supported the existence of development of perceptual-cognitive skills in expertise in NDM. However, the specialised knowledge required and elements considered were limited to a relatively restricted range of personal and situational considerations, compared with previous research in real-life environments (Chapman & Mills, 2003). Chapman and Mills (2003) found that personal elements were considered to be the most important elements impacting on decision-making, and these included fatigue, emotion, perspective and personality. It is questioned whether *NFC* could be sufficiently complex to evoke these variables and the resulting interactions. Thus, the human element which has been identified as a most important component of NDM in the field is largely missing from *NFC*.

Situational elements that have been previously identified do somewhat reflect those incorporated in *NFC*. However, the complexity and number of situational variables associated with the microworld are extremely limited compared with the number of influences in the real world. This limited list of situational elements associated with NDM would likely explain the extremely rapid development of expertise across trials.

7.4.4 A concept map of decision-making on *NFC*

Considering the behavioural data in combination with the questionnaire responses, a more detailed concept map has been provided to illustrate the relationships between the various behaviours observed (see Figure 35). Overall, from the behavioural and questionnaire data it is clear that participants were concerned with five different levels of decision. Following initial awareness that a particular fire has broken out a decision is made about allocation priorities. These priorities then require decisions regarding allocation of appliances (accuracy/ allocation). For *NFC*,

sending the closest appliance first was most beneficial to the performance outcome ($r= 0.36$, $p<0.01$). This decision was essentially associated with maximising speed of response. Following this, a third level decision about where to place appliances around the fire was necessary. This decision related to accuracy/ placement, which also impacted performance outcomes ($r= -0.56$, $p<0.01$ respectively). Once engaged in fighting the fire, monitoring the situation was essential (efficiency), because time spent idle frequently decreased performance scores ($r= -0.58$, $p<0.01$). A fifth level of decision involved proactive planning strategies for managing the scenario (e.g. firebreaks). The use of firebreaks correlated significantly with performance in terms of percentage of landscape protected from burning ($r= 0.75$, $p<0.01$), with interview data indicating that participants used firebreaks only if they had time to do so. Moreover, another planning strategy discussed was placing appliances strategically around the screen to decrease response times. In short, only experienced players reach this decision level.

To conclude, the environment that was created was dynamic and required a series of inter-dependant decisions, as is indicative of an NDM environment. The concept map in Figure 35 reduces decision points into accuracy/ allocation, speed, accuracy/ placement, efficiency and planning. In terms of reducing NDM to simple concepts, this is useful, but it has been argued in much of the literature that *in situ* NDM is more complex than can be captured in these terms (Lipshitz, Klein, Orasanu & Salas, 2004b). These authors have also emphasised the importance of considering the complex array of situational, team and organisational elements that impact NDM in the real world. In addition, the experience required by real world NDM experts is not comparable with that of an *NFC* user. Finally, personal elements identified by Chapman & Mills (2003) were not generated by the *NFC* microworld. These findings therefore suggest that, although useful for generating many of the basic perceptual-cognitive skills associated with NDM, *NFC* is limited in

its scope to model an environment that requires an array of specialised knowledge, experience, and an ability to break down complex information.

7.4.5 Limitations

The current sample size was small because of the labour intensive nature of the post-trial behavioural analysis, which included extensive qualitative interview data. Each participant completed 20 trials, four from which were used to record behavioural data. The 80 data points achieved were sufficient for statistical analysis but, given broader time constraints, a larger study would be useful. Interviews were conducted after the first and last trials, but it would have been useful also to collect some qualitative understanding of the varying perceptions of decision-making half way through the task. This should be considered in future research.

The structure of the *NFC* scenarios was designed by the researcher. The author was mindful in structuring the scenarios to incorporate challenging decision points in each. However, from the beginning of the trials participants were scoring quite highly. The concern may be that the scenarios were set at a basic level and development beyond that observed was not possible. However, in contradiction to this concern, free burn scores (scores generated if there was no intervention with the scenario) indicated that if participants had intervened poorly with the scenarios, the range of scores would have been much lower. It could be that the training received beforehand was comprehensive enough to ensure participants were skilled beyond a novice level, and took minimal time to reach expertise. This supports the argument that the *NFC* environment is not complex enough to warrant long periods for skill acquisition. It is the author's considered opinion that the major issue is that by reducing an *NDM* environment into a controllable microworld, while still achieving psychological fidelity, the complex interactions between personal and situational elements are not able to be reproduced. Therefore, this limits the scope of research possible on the platform. To support this hypothesis it would be useful to replicate this research

using scenarios set at a more difficult level (with a greater number of fires and lower free burn scores). The length of the scenarios could be modified to check for differences in performance if scenarios ran for longer. Also, for simplicity in the current research, team and organisational constraints also identified by Chapman and Mills (2003) were not included. Therefore, it is unclear how accurately *NFC* models these constraints. The inclusion of these elements in future research would also assist to produce a more complex environment. In addition, the effect of the training protocol should also be researched to ascertain the difference in performance skill of those who have received training and those who have not.

Finally, because of missing replay files, behavioural data were collected in trials 14 and 19, rather than 15 and 20. It is the authors considered opinion that this would not have altered outcomes substantially. However, it would have been a more accurate measure of final skills if analysis of trials 15 and 20 had been possible.

7.4.6 Conclusions about the usefulness of *NFC* for investigating expert performance

The current research has demonstrated that *NFC* requires similar high level perceptual-cognitive skills (e.g. accuracy/ allocation, speed, accuracy/ placement, efficiency and proactive planning measures) to those found in real world NDM situations. This is in line with previous research on skills associated with expert performance (Glaser, 1976; Klein & Peio, 1989; Schmitt & Klein, 1999). Thus, this particular microworld has successfully produced the high level perceptual-cognitive skills associated with decision-making in an NDM environment. However, the current research has also found that the time taken, and the knowledge and experience required for development of expertise, are reduced substantially in the *NFC* context. Although accomplished within the first few 5-minute trials on *NFC*, the processes whereby expertise is developed can require a very substantial period of time in real-world circumstances. One would expect, therefore, that improving skill acquisition could be demonstrated within a simulated microworld across all

trials available. That this was not so suggests that the task was not sufficiently challenging and, consequently, *NFC* is not recommended as an ideal context to explore the development of expertise. Moreover, the lack of personal elements identified to impact on decision-making in the *NFC* environment also presents limitations on the scope of research suitable for the microworld platform. This presents an argument for the necessity of field-based research to establish reliable conclusions.

Lane and Alluisi (1992) have discussed what is required to understand expertise in terms of basic skills (the mastery of a system/ individual) and warfighting skills (the mastery of a system within a military environment/ co-ordination). To date, the relative influence of domain-specific elements and higher-level perceptual-cognitive elements on decision-making performance is largely unknown. Although it seems that the *NFC* microworld creates an environment achieving psychological fidelity, its ability to provide an environment to explore NDM more deeply is questionable. Overall therefore, we recommend that, despite the convenience of microworlds, their use should be regulated by an understanding of the limitations of their applicability. To do this, a good understanding of the importance of the situational and personal elements in determining decision-making is required, and further research is necessary to achieve this.

CHAPTER 8. Lessons Learnt Regarding CO Decision-making in the Australian Army

The broad aim of this thesis has been to explore CO decision-making in the Australian army environment. NDM theory has provided the theoretical platform, and within the context of the Australian Army the research has tested and expanded on Klein's (1989) RPD model. More specifically, the thesis has had four aims, as follows:

- To provide validation for the RPD model within the context of the Australian Army;
- To better define NDM in terms of expertise as defined by the RPD model;
- The identification and description of the wider elements impacting on NDM;
- To develop and apply a rigorous and replicable research methodology;
- To determine the extent of usefulness of computer simulation as a research tool for future exploration of NDM.

To address these aims, the author undertook four related studies that have addressed the following areas.

Study 1. Critical decision method was used to interview unit level COs about their decision-making experiences. From these data, the validity of the RPD model in the Australian Army context was explored. In addition, the array of elements impacting on decision-making in this context were identified and explored.

Study 2. A Q-sort was used to analyse the responses of both unit level COs and OPSOs, to determine the relative importance of the elements identified in interviews to impact on NDM. A second aim here was to explore whether similar opinions were held across the participants regarding the relative importance of the elements.

Study 3. Two field exercises were observed and additional data were collected to explore the external validity of the previous results. In particular, the critical nature of the contributions of the HQ team to decision-making was further explored.

Study 4. *NFC*, a computer-simulated microworld was used to investigate whether, in light of results from the previous research, this was a useful tool to investigate NDM for application of results to the Australian Army.

The current chapter will draw upon the findings from these four studies to discuss how each of the initial aims has been achieved. Following this the other main learning points from the thesis will be summarised and discussed. Limitations will be explored, and suggestions will be presented for future research, including discussion of implications for current Army development, training and structure.

8.1 Addressing the Aims

8.1.1 The validity of the RPD in the Australian Army context

The RPD model has become a widely cited model capable of application to decision-making within military style environments, where there is time pressure, high stakes and uncertain information. Despite its potential, to the author's knowledge, the model had not been trialled in the context of the Australian Army. The first aim of the thesis was to seek validation for the RPD model as relevant to understand decision-making in the Australian Army. This was achieved within studies 1, 2 and 3. Study 1, using CDM interviews, showed that the majority of decision points involved the generation of only one or two options. This indicated a sequential method of decision-making such as that described in the RPD model. Secondly, all decisions that were discussed in the interviews depended on the use of previous experience. This reliance on experience to trigger suitable courses of action is a central tenet of the RPD model. Moreover, a number of the elements

impacting on decision-making that were identified during interviews supported the RPD. For example, the use of previous experience to recognise solutions was discussed by all participants. Moreover, SA was identified indirectly during discussion about the importance of communication of information, knowledge and opinion from within the team.

Study 2 (Q-sort) further supported the RPD model appropriate for decision-making in the Australian Army because many concepts that were ranked highly by participants supported assumptions of the RPD model. For example, experience was held as an extremely important element and the importance of the three levels of SA was supported by the high ratings given to communication of information, knowledge and opinion and also environmental context.

The influence of the three different levels of SA was demonstrated in the results from study 3 (fieldwork). These observations clearly showed the three different levels of SA feeding into HQ CO decision-making.

Based on these findings, it is concluded that evidence indicates that decision-making in the Australian Army unit HQ requires the development of SA, draws on experience to recognise appropriate courses of action and results most often in the generation of only one or two decision options. All of these observations support the existence of RPD in the Australian Army unit HQ.

A limitation identified in addressing this aim was that RPD was supported on the basis of the existence of SA, generation of one or two options and the presence of recognition through experience. Other evidence for the existence of the RPD could have also been sought in terms of mental simulation or story building. Another limitation was that these results are all based directly on the interpretations of the researchers, without having been checked against the opinions of the participants. In future research it would be useful to take the RPD model to the participants and to seek feedback from them as to its appropriateness.

8.1.2 Better defining NDM concepts

The RPD model emphasises the importance of experience for decision-making. But to use this knowledge to enhance our training/ decision-making, we need to be clearer about what type of experience feeds into decision-making. This question was explored in studies 1 and 3. Interviews conducted in study 1 identified a number of different types of experience that fed into decision-making by COs at the unit level of the Australian Army. This included experience gained within the Army, but also experience gained external to the Army. Experience gained within the Army could be broken down into soldier-level experience and CO-level experience. Field notes from study 3 supported interview data on the various forms of experience being drawn upon by the CO.

Each individual within the team, including the CO, had their own set of unique experiences (both internal and external to the Army). Therefore, depending on the make-up of experience the CO had, he would fill in the gaps in his current understanding of the situation, by drawing on the experience of those around him. This was evidenced in the interviews. Therefore, by drawing on the experiences of his team, the CO had access to an extremely large pool of experience, to draw on when decision-making. This observation is in line with the theory of transactive memory.

Drawing from the theory of transactive memory, not all team members have all knowledge held by a team. Instead, teams develop a shared system for storing knowledge, whereby each individual is only responsible for a portion of what the whole team knows. An implication of this dispersed knowledge storage system is that each team member should have an understanding of who holds what knowledge within the team (Wegner, Erber & Raymond, 1991). This allows for efficiency of information storage and retrieval (Cordery, McDonald & Mitchell, 2003).

To apply this model in unit HQ, the CO would require a good overview of the knowledge and experience of his HQ team. However, this may be problematic in a military environment where the core HQ team is relatively stable for a period of time, but different peripheral team members

may join a unit HQ depending on the goals and skills mix required for the specific operation. Therefore, the CO may be aware of the types of knowledge and experience his core team would have access to, but may be less aware of the knowledge and experience of peripheral members. It is suggested here that an adaptive mechanism may develop to cope with this difficulty, such that the HQ team will volunteer information, knowledge and opinions to the CO without having been asked for these things. In a situation where critical time constraints apply, this process would help to expediate the decision-cycle, which is crucial in such NDM situations. This argument is supported by results from the field study that indicated that members of the team often actively contribute information, knowledge and opinion (without the CO having to know where to seek these).

A limitation within the interpretation of the results from the field studies was an assumption that all information, knowledge and opinions transferred by the HQ team was actually received and considered by the CO. This assumption was based on the interview analysis that suggested that the CO does draw on his HQ team for these things. However, these things may only be considered a portion of the available time. A follow up study would therefore be beneficial, to see what percentage of the information, knowledge and opinion actively offered by the team is actually taken into account by the CO when decision-making.

Other questions that arose but were unable to be explored with the current set of data were: for what proportion of the time are each of these different types of experience being drawn upon? in what kind of situations are they most likely triggered? and within each of these categories are there common essential experiences that are often drawn upon? These questions would provide future avenues for exploration by further research. With increased knowledge on how experience informs decision-making, the design of training and command support tools would be informed.

8.1.3 Identifying and describing the wider elements impacting on NDM

It has been noted that an improved understanding of the elements impacting on NDM in the Australian Army context was required. This was explored in studies 1, 2 and 3. Because of a lack of previous research, study 1 used qualitative interviews to collect data. It was envisaged that an array of influential elements (as perceived by the CO) could be best extracted using this method. In addition, the interview phase allowed for deeper exploration of how these elements should be defined. Data revealed that there were a number of elements perceived to impact on decision-making. These were grouped into four categories: personal elements, team elements, situational elements, and organisational elements. These categories are listed in order of how frequently they were discussed within the interviews. However, it was recognised that another study was required to more accurately prioritise these elements in terms of their actual perceived importance in the decision-making process. This was achieved in study 2 using the Q-sort method.

The second study was designed in such a way as to force comparisons between the elements identified in the first study. It was also structured to identify whether the relative importance assigned to the elements was similar across COs/ OPSOs or whether there were distinct groups of opinion. The Q-sort study found that the actual importance of the elements (as ranked in the Q-sort task) was slightly different to the frequency of expression discovered in the interview. Overall, the order of importance derived from the Q-sort was: personal elements, team & organisational elements, and situational elements. Thus, the importance of organisational elements was held at a similar level to the team elements. This ordering indicates that elements closer to “self” were regarded as more important in the decision-making process, and those furthest away were comparatively less important. The second finding was that the way in which the elements were ranked was relatively comparable across the majority of the COs and OPSOs who participated in

the study (i.e. most respondents had a similar frame of reference). This indicates that the result will have most likely have good generalisability.

Personal elements (e.g. experience and personality) are regarded as being most important in decision-making and included references to: emotion, personality, fatigue, experience and perspective. Despite the inclusion of the concept of experience, the RPD model does not incorporate other personal elements. Neither have they been researched specifically within NDM, with the single exception of experience, which is discussed as part of the RPD model. The only personal element that did not rate as extremely important was emotion.

Some of these elements have just begun to receive research attention in relation to decision-making behaviour, but are yet to attract interest in the NDM literature. For example, emotion (Bechara, 2004; Hockey, Maule, Clough & Bdzola, 2000; Sayegh, Anthony, Perrewe, 2004), personality (Lauriola & Levin, 2001; Lauriola, Russo, Lucidi, Violani & Levin, 2004), and fatigue (Drillings & Mullen, 2005; Hockey, Maule, Clough & Bdzola, 2000) have been recently investigated in terms of their impact on decision-making. This research has typically not, however, been in the context of the Australian Army. Thus, although the influence of these elements is beginning to be recognised, they have not yet been discussed in the NDM literature and this presents a lead for future research.

Team and organisational elements were ranked as the next most important in decision-making. Under the category of team elements, the team were often discussed in terms of their influence on decision-making. Sub-elements investigated were: decision responsibility, trust, communication (by team) of information, knowledge and opinions. In fact, the CO would often draw on his team's experiences in areas where his own experience may have been limited. Most of the sub-elements that were grouped under team elements implied shared responsibility for parts of the decision-making process. In addition, organisational elements included such sub-elements as:

army culture, organisational constraints (resources), communication with higher management, intelligence and subordinates. In essence, the sub-elements in this category included being aware of oneself as being part of a larger organisation and making decisions that would be congruent with that membership. Based on the importance allocated to both the team and the organisation as influential elements on decision-making, this finding confirmed that decision-making in unit HQ is a diffuse process.

Because of the complexity of the decision-making and the broad range of experience required for informed decision-making, the CO's surrounding structure (e.g. team and organisational knowledge and support) was seen as integral for decision-making. The Q-sort confirmed that, overall, although the ultimate responsibility for decision-making rests with the CO, communication both at a team level and an organisational level was perceived to be highly important as an activity feeding into decision-making. The contributions of information, knowledge and opinion by the team were all ranked as highly important. The importance given to these forms of communication fits with a structured and supportive organisational network, established to facilitate difficult decision-making. In essence, the COs and OPSOs were aware that the decision needed to be embedded within the rules and experience of the team and broader organisation. This is a concept that lies at the heart of the diffuse decision-making argument, and presents implications for structuring HQ teams.

The main strength of the field study was that it provided external validation to the interview and Q-sort results, indicating that the CO was dependant on the SA provided by the team and organisation for decision-making. The communication that was monitored between the CO and the HQ team and the CO and the wider team revealed:

- Unit HQ team members were feeding information to the CO at each of the levels of SA (as identified by Endsley, 1995).

- Results indicated that the team was most likely actively feeding information into all three levels of situation awareness.

These results, in combination with the qualitative data, support the hypothesis that the CO is reliant on his HQ team during the decision-making process.

Although monitoring the organisational level of communication was more difficult due to the set up of the exercises, this study also revealed that:

- The subordinates were contributing information to the CO's three levels of SA.
- The subordinates are contributing to the eventual outcome both before and after the CO's decision.

These data validate the Q-sort findings that the team (and to a smaller extent the organisational team) have an important influence on decision-making. Not only are team members perceived to be important influences by the CO, but behavioural data confirmed that they actively contribute to the CO's three levels of SA. This implies dependence.

Finally, situational elements, while identified as important in the interviews, have been placed as comparatively less important when compared with elements internal to the Army framework. Situational elements are typically included in the RPD model as playing an essential role in developing SA. However, interviews have highlighted a group of these that specifically impact on decision-making. Most of these are under-researched in a military context. The broad sub-element "environmental elements" was not surprising because these have been discussed frequently as part of SA formation. However, some of the other elements such as "*outside organisation influences*", and "*culture*" have not to date received much attention in research or discussion within the field. The lower level of importance placed here could be explained because, although personal, team and organisational elements are likely to remain relatively stable, situational elements are much more prone to extreme variation. For example, while one's

personality will likely remain constant, the type of enemy one is facing is more variable. As mentioned before, the layering of importance tends to view everything internal to the Army as most important to decision-making, and the situation external to the Army as less influential. This presents a situation where individuals empower themselves and the Army to have the greatest impact on outcome in the decision-making event. Because they are more likely able to influence and control aspects within themselves or their team, and less likely able to impact external situation, it makes sense to focus a large amount of cognitive resource here. This indicates an internal locus of control (Rotter, 1966). In other words, control of the situation is perceived to reside within oneself and within the Army. It is likely that having a well functioning person, team and organisation assists the CO to handle more difficult combinations of situational events that are presented. This is likely to be an adaptive coping mechanism in such emergency situations.

Some elements identified were validated in study 3 (field work), others were supported through previous research but not necessarily within the Australian Army context (e.g. personal elements/ emotion) as impacting on decision-making, and others require further research to validate. Table 47 (below) illustrates how each element has been corroborated or validated. Many of the team and organisational elements (especially in terms of communication), not yet validated in an Australian Army context, were able to be observed in the field study. Only a partial validation has been noted for some of the variables because not all of the elements were able to be quantitatively measured using check sheets and some were recorded through the use of behavioural field notes. Therefore, although there is support that this element could be validated, future research is required to do this. Unfortunately all of the elements that were extracted in interviews and ranked in the Q-sort were not able to be observed in the field. This was because the researcher could not have ultimate control in setting up an Army exercise to validate all of the elements (e.g. invoking emotion, controlling for personality types or generating fatigue). Despite this, as discussed above,

many of the personal elements and situational elements have been corroborated in other forms of research, and now just require validation within an Army context.

Table 47. Validation of elements identified to influence unit level CO decision-making in the Australian Army.

Element	Validated	How Validated/ Corroborated
Team		
Decision responsibility	PARTIAL	Field Notes
Communication /Diffuse responsibility	YES	Field observation
Trust	PARTIAL	Field Notes
Organisational		
Diffuse responsibility /communication (organisational)	YES	Field observation
Organisational constraints	PARTIAL	Field notes
Resources	YES	(Omodei, McLennan, Elliott, Wearing & Clancy, 2005)
Army culture	PARTIAL	Field notes
Situational		
Culture	PARTIAL	(Lieven, 2001; Mills & Smith, 2004)
Timing/ time pressure	YES	(Klein, 1999)
Environment	YES	(Endsley, 1997; Klein, 1999)
Outside organisations	NO	
Decision aids	NO	
Personal		
Emotion	YES	(Lauriola & Levin, 2001; Lauriola, Russo, Lucidi, Violani & Levin, 2004)
Personality	NO	
Perspective	NO	
Experience	YES	(Klein, 1989)
Fatigue	YES	(Hockey, Maule, Clough & Bdzola, 2000)

Finally, the elements identified need to be modelled to improve understanding of decision-making within HQ. Figure 36 below represents how these elements may be impacting on decision-making, based on findings here.

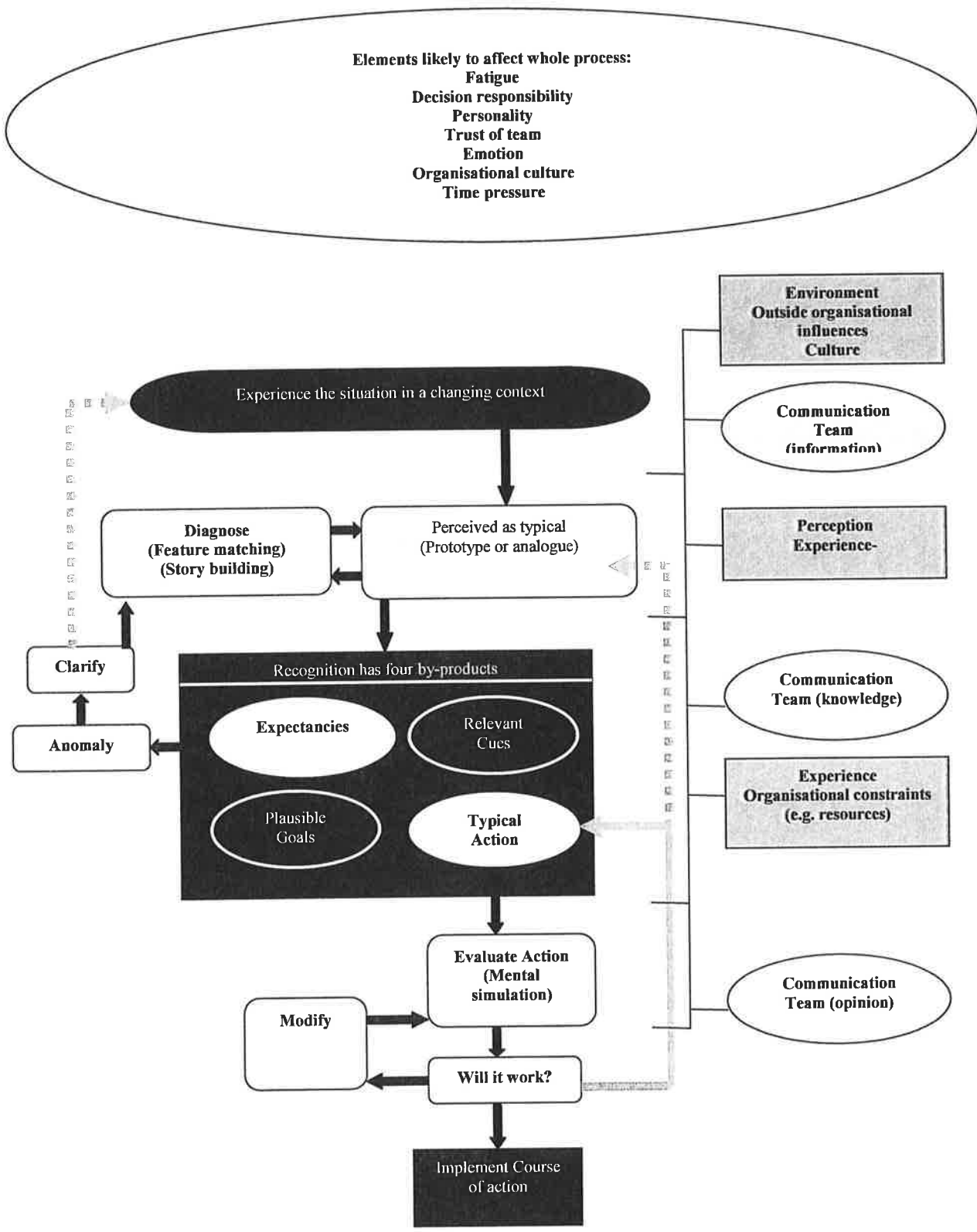


Figure 36. Theoretical representation of how elements identified may influence the decision process.

In sum, overall a number of elements have been identified to impact on CO decision-making. Some of these have already been discussed in the NDM literature, while others present opportunities for future research. A limitation therefore was that not all elements identified were able to be validated in the current research. Some received partial validation through field notes, or research from a different field. Future research will need to test whether these elements do actually impact on decision-making. Also, future research should investigate possible interactions between these elements.

8.1.4 Developing and using a rigorous and replicable research methodology

Research in the field of NDM has typically used interviews or observations as research methods (often containing qualitative elements). In response to this, there has been criticism of NDM researchers for using soft techniques (e.g. Yates, 2001). This thesis has therefore sought to develop and implement sound methods that are reliable and valid. The research methods used have a number of strengths, drawing on principles of triangulation in order to increase external validity through observing the same results across three different research methodologies. The types of methods used tend to offer higher levels of external validity because they are field based and thus *in situ*, and direct application of results to the field is therefore appropriate. Both quantitative and qualitative data have been collected allowing both depth of exploration as well as breadth and definition. The data have achieved high levels of reliability amongst coders. Therefore, this would suggest that the tools used were reliable and that the results should be replicable. The methods used were all approved for use by the Australian Army and were not deemed to be overly demanding or time consuming for the participants. This was an extremely important requirement, because without approval of the method, data collection would not have been able to commence. A new tool was developed to administer the Q-sort, to suit the distributed, security restricted environment. This tool was time efficient, because it enabled respondents to complete the Q-sort at a time convenient to

them and results generated from the sort were automatically recorded by the computer and sent directly back to the researcher. This was a cost-effective method for distribution, because it did not require the researcher to travel nationally for distribution and to be present for sorting. The response rate using this tool was deemed acceptable, taking the unusual environment into consideration.

However, several weaknesses of the methodology were also identified. Firstly, sampling could not be randomised because of the structure of the formal research networks within the Australian Army, whereby the researcher cannot have direct previous contact with potential participants. Instead, science officers within the various brigades must first seek available participants on behalf of the researcher and then provide the details of willing participants only to the researcher. The researcher therefore has little control over this process and must select all volunteers as participants.

Another weakness was the time consuming nature of the data collection and analysis. Despite reliance on small sample sizes, and the relatively small total population for investigation, the time associated with data collection and analysis was significant. Even if available, larger samples would be extremely difficult to accommodate within the current methodology. In particular, the reliability checks performed on the majority of data required training of associates and a substantial amount of analysis time offered by these associates to confirm accuracy of data. In a corporate sense, this extensive time commitment would translate into high costs for this research methodology.

Finally, generalisability of the findings is questionable because of the small sample sizes. Nonetheless, although resource intensive, this methodology is recommended as a useful addition to the methodological tool kit currently employed within NDM. In addition, the researcher would

commend the efforts of NDM researchers tackling the difficulties associated with field based, qualitative research, because the value of these methods is high, despite the associated difficulties.

8.1.5 Determining the extent of usefulness of computer simulation as a research tool for future exploration of NDM

Following the support provided by studies 1, 2 and 3 for the complexity of CO decision-making in Australian Army unit HQ, the question arose as to what extent simulated microworlds might be used to investigate principles of NDM for application in this environment. Study 4 addressed this question by analysing how expertise is acquired, and what kinds of perceptual-cognitive skills and behaviours were required for expert decision-making in a simulated microworld (specifically *NFC*). In addition, the extent to which personal and situational elements contributed to performance within this simulated context was also explored.

Results from this study suggested that, although mastering *NFC* was associated with the development of high level perceptual-cognitive skills (e.g. speed, accuracy, efficiency and proactive planning measures) in a similar way to the development of expertise in real world NDM situations (Glaser, 1976; Klein & Peio, 1989; Schmitt & Klein, 1999), *NFC* lacked the complexity associated with real world NDM environments. This was apparent in the limited amount of improvement observed between the beginning and end of trials. In addition, the elements impacting on decision-making were particularly limited. In particular, microworlds may not be complex enough to evoke personal elements such as emotion, perspective and personality impact on the decision-making process. Therefore, although microworlds achieve psychological fidelity, the author suggests that in the field of NDM we are still unsure about the nature of complex interactions between many of the elements and what impact these elements may have on decision-makers. Therefore, it would be wise to postpone dependence on a reductionist approach to the field until we are better able to understand what impact the array of elements may have on NDM.

This suggestion presents an argument for the necessity of continued field-based research. Further research should be aimed at better understanding the importance of personal, team, organisational and situational elements in determining decision-making outcomes. This will eventually lead to a better understanding of the extent of applicability of microworlds. In light of these considerations, the appropriateness of methods such as the use of microworlds for future NDM research should, for now, be questioned until we are better able to clarify which problems may be tested in such an environment.

8.2 Other Important Lessons Learnt

It is acknowledged that there are a variety of conditions under which decision-making occurs. Many researchers now suggest that trying to fit one model of decision-making to the myriad of different decision scenarios faced in the real world is not sensible. We need to acknowledge that there are a number of variable pressures associated with decision-making. Some examples of these pressures that have been drawn upon to define an NDM environment are: the time frames associated with the decision, varying levels of risk, the clarity and availability of necessary information and the importance of the outcome. These are all often variable in NDM scenarios. It is suggested that depending on the nature and combination of these variables, different models may be required to describe decision-making.

NDM has been suggested as a paradigm focussing on the extreme ends of each of these variables (e.g. high levels of time pressure, high stakes, high risk and low levels of certainty; Klein, 1999). Klein (1989), a pioneer of NDM, studied decisions made in the US Military. He noticed that in such a dynamic environment with high stakes, time pressure and uncertainty, traditional models of decision-making were not adequate. Klein (1999) reported that decision-making in such an environment was dependant on SA and expertise. Moreover, various options were not considered and compared together, but instead analysed sequentially. Moreover, the decision did not have to

be optimal, but instead was made in a timely manner, and was workable. The difference in processing was explained as an adaptive method to cope with the high-pressure context. It has been suggested that decision-making in other environments such as emergency service type organisations also follow a similar process.

Research has shown that earlier decision models, such as the classical decision-making model, although not useful in NDM type scenarios, may be useful as prescriptive models where the situational variables are different. The classical decision-making models emerged from the field of cognitive psychology. Based on laboratory experiments it was suggested that a decision-maker would use all of the available information to weigh up the pros and cons of any given course of action before making an optimal decision. Although this process is not suitable for situations with high stakes where time pressures apply, it may suit situations where there is low time pressure and information is clearly defined.

Figure 37 draws upon understandings derived from the current research and other literature to begin to map when different decision-making models may be appropriate for explanation of decision-making. This figure categorises decisions according to the different extremes of time pressure, associated stakes and availability and clarity of information. According to the different combinations of variables, an environment is created that may be more or less amenable to certain decision-making models.

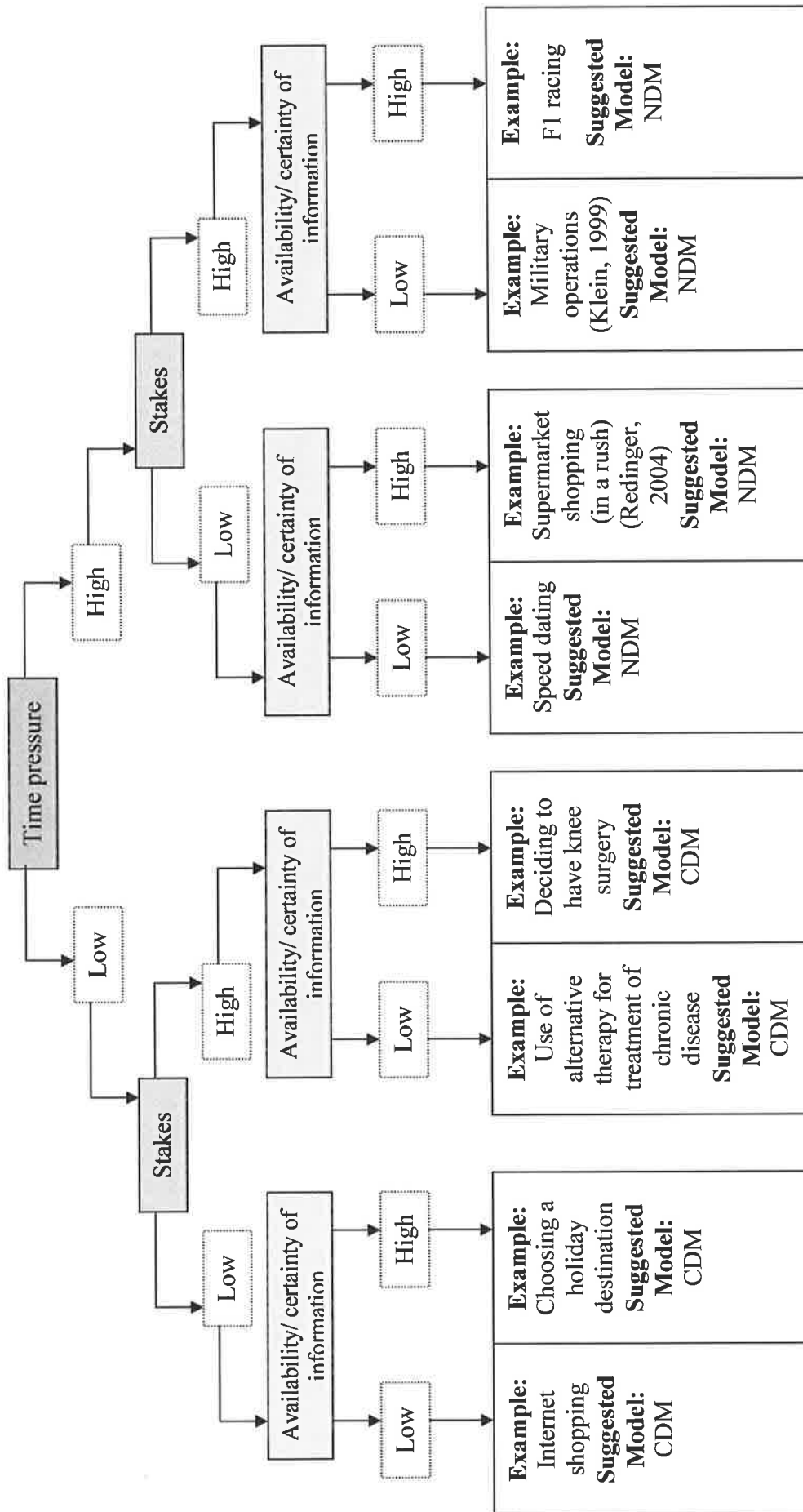


Figure 37. Suggested decision-making used across contexts varying in: time pressure, availability/certainty of information and associated stakes.

Some of these contexts have been specifically discussed in the decision-making literature. For example, Redinger (2004) researched the habit of supermarket shoppers and found that a similar process to RPD is used to choose products in the supermarket. Other contexts will require further research in order to ascertain which model fits as a best explanation. According to the flow chart in Figure 37, the critical variable to determine whether NDM or CDM will be used may be the level of time pressure associated with the decision.

It may also be that in situations such as an Army HQ, where the tempo of operations is continually changing, different models will fit into the same environment depending on the goal and combination of situational variables at the time (Bryant, Webb & McCann, 2003). For example, Killion (2000) writes in *Military Review*:

“the situational understanding now available at higher echelons and the commensurate ability to visualize the battlespace allow recognitional decision making to a degree not feasible in the past. Conversely, real-time or faster-than-real-time decision-aiding technologies allow COA analyses at the tactical level to a degree not possible previously, enabling more effective analytic planning and replanning. As a result of these elements, these two complementary modes of decision making will likely become increasingly interwoven and interdependent. Selecting the dominant mode of operations will depend on both situational elements, such as time constraints and size/makeup of staff, and personal ones, including decision-making style, level of expertise and management style.” (p.67)

This model provides a number of hypotheses requiring further research.

8.3 Applications of the Current Research

The findings from the current study should be used in the following ways:

- To assist in the design of decision support tools;
- To guide the delivery of Army training;
- To inform future efforts to restructure the Australian Army.

Because of increasing evidence for NDM, it is important to consider how acceptance of this model will impact on decision-support tools. Killion (2000) in *Military Review* stated

“The emergence of this new model of decision making has direct implications for issues such as training for command, evaluating the expertise of commanders and designing decision-support systems.’ The model suggests markedly different decision-support systems, focusing on accurate situation assessment and case-based reasoning (recalling similar cases) as opposed to the feature-based comparison of options inherent in systems such as JOPES.”
(p. 67)

A particular value of this research lies in the fact that it improves our understanding of what elements are perceived by COs and OPSOs as impacting on decision-making. Thus, decision support tools can be constructed accordingly to accommodate these elements and present them in a way that reflects their importance as described in the Q-sort.

There are three main points from the current dissertation that have relevance to the future of training in the Australian Army.

- Different types of activities producing experience (e.g. story telling, practical soldier-experience) should feed into training protocol.
- Cultural awareness training needs to be incorporated into Army programs.
- Diffuse decision-making needs to be considered in the construction of training (team/ organisational level training).

Understanding more fully what is involved when experience contributes to the RPD process can only improve training standards. We are now aware that there are a number of different types of experience that are drawn upon in NDM. As reported in Chapter 4 these are:

- Actual operational experience (as a CO);
- Actual operational experience (as soldier or lower rank);
- Experience derived from training;
- Experience outside the military (everyday learning / knowledge);
- Experience drawn from others stories etc.;
- Experience derived from books (drawing on history, etc).

Thus, although practical experience is important, it should not be the only focus to improve decision-making. It will be important in the future to also investigate what types of experience tend to contribute most to the decision process.

The emerging theme of culture presents some challenges for the Australian Army. COs and teams may need to be exposed to more rigorous, formalised cultural training before being required to interact with other cultures. Recently some work has been done in the Australian Army context on cultural awareness training by Mills and Smith (2004). This work successfully piloted a methodology that can be used to produce a set of generalisable cultural sensitivity skills. As far as the current research findings go, introduction of such a method would be a step in the right direction. Moreover, more research needs to explore how teams consisting of members with different cultural backgrounds may operate most effectively in NDM environments. This need was also highlighted by Klein (2004).

Another area in which results from this thesis should inform practice is in regards to the observation of diffuse decision-making. Clearly diffuse decision-making is occurring, yet current doctrine does not clearly recognise this. Training needs to be sensitive to the fact that

members of a team are required to contribute information not only in its raw form, but also after processing it and adding their own experience and judgments. In addition, the active contribution to information by the team relies on a common understanding of what the CO needs to know and when s/he needs to know it. This presents implications for the set up of a HQ. Ideally a broad variety of experiences should be held by staff within a HQ. However, we also know that teams who have shared common experiences develop better SMM and are most often more effective. An understanding about how this mix is best achieved is a worthy aim for future research.

There have also been lessons learnt for future structure of the unit HQ in the Australian Army. This research has improved our understanding of the elements that are currently impacting on the decision-making of unit level COs. This understanding is crucial if we are to critically analyse what elements would most likely be affected by restructuring unit HQ, and empirically test this effect. For example, we can speculate that the split HQ team would affect elements as indicated below in Table 48. From this, we can empirically test what effect the split has on these elements (positive or negative) and also how this may be taken into consideration in future structuring of the Army unit level HQ.

Table 48. A summary of elements expected to be impacted on by HQ distribution.

Elements that would most likely be affected by HQ split	Elements that would most likely not be affected by HQ split
Team communication	Personality
Organisational communication	Fatigue
Perspective	Emotion
Trust (team)	Experience
Morale	Organisational culture
	Environmental elements
	Culture
	Time pressure
	Decision responsibility
	Influence of outside organisations

8.4 Limitations of the Research

Overall, limitations of the research, as related to each of the four initial aims have been highlighted in the above sections. In summary these were:

- RPD was supported on the basis of the existence of SA, generation of one or two options and the presence of recognition through experience. Other evidence for the existence of the RPD (such evidence of mental simulation or story building) was not sought.
- Results were based on the interpretations of the researchers, and have not been checked against the participants' understandings.
- An assumption that all information, knowledge and opinions transferred by the HQ team were actually received and considered by the CO.
- Not all elements identified were able to be validated in the current research.
- Sampling could not be randomized.
- The qualitative methods used and the small sample sizes involved limits the generalisability of the findings within the Australian Army.

Overall, a final limitation identified by the author may be the applicability of these results across NDM fields. It is the author's considered opinion that the results from this research are useful at a number of levels. However, it is worth noting that all research has been carried out in the context of the Australian Army. Most NDM scenarios might be assumed to involve at a broad level personal, team, organisational and situational elements that would necessarily be considered in the decision-making process. However, whether the sub-elements associated with each of these categories would vary across organisations should be investigated. Thus, it would be necessary to run similar research across a number of different NDM situations to ascertain the generalisability of these results. One example of where differences might arise would be the difference between NDM environments that are typically dealing with people (e.g. emergency medicine, Army), as opposed to those that are

typically dealing with natural disasters (e.g. fire service, emergency response services). In addition, it would be expected that, whether the NDM job deals with the individual, or whether with a group, salient elements associated with decision-making will most likely vary.

Ideally a similar methodology could be used across NDM environments where decisions and actions were associated with an individual (e.g. critical care nursing), a group (e.g. a military engagement), and one where the object of decision-making was an ongoing environmental disaster (e.g. firefighting). This approach would permit comparison of outcomes, to identify common elements across domains but, equally importantly, unique elements to specific domains. Results from such research should also assist to understand the extent of applicability of results generated across domains.

8.5 Lessons Learnt for Future Research

Overall, areas for future research, as related to each of the four initial aims, have been highlighted in the above sections. In summary, future research should:

- Take the RPD model to the participants and also seek feedback from them as to its appropriateness.
- Investigate to what extent the information, knowledge and opinion actively offered by the team is actually taken into account by the CO when decision-making.
- Explore the proportions of the time for which each of the different types of experience are being drawn upon, in what kind of situations they are most likely triggered; and, within each of these categories, whether there are common essential experiences that are often drawn upon.
- Validate whether all the elements identified do actually impact on decision-making.
- Investigate possible interactions between the identified elements.

- Further research the appropriateness of the use of microworlds for future NDM research.
- Investigate whether, in situations where the tempo of operations is continually changing, different decision-making models provide the most appropriate explanations.

Now that the personal, team, organisational and situational elements perceived to impact on decision-making in the Australian Army have been identified, it is important to isolate the various elements and run more focused studies, in order confirm the nature and direction of relationships with decision-making. For example:

- What kinds of experience are most salient/ influential on decision-making? (e.g. actual vs anecdotal)?
- How does personality affect the decision process?
- What aspects associated with interacting with a different culture impact on decision-making?

In terms of the diffuse nature of decision-making, further research should focus on:

- The role of trust in information sharing, and the impact that high risk situations may have on this.
- The extent to which non-verbal communication can influence the production of shared mental models.

Future research should also plan to gather a broader base of observations, across a number of emergency services, to understand more adequately the significance and generalisability of these results. Observations should be across regiments and involve both Reserve and Regular officers. It is anticipated that, although the unit level Australian Army HQ team is a relatively unique organisational unit, the influential elements extracted should be broad enough to bear relevance to other emergency-type organisations also. Studies should be structured to confirm this hypothesis.

8.6 Conclusion

As described, this research has been exploratory. It has drawn together a number of different theories and research to better understand decision-making at unit level HQ in the Australian Army. The five aims of the thesis were achieved. Firstly, a valuable result has been the validation of the RPD at unit level in the Australian Army. Secondly, this research has continued in the work to better define expertise within RPD. Thirdly, it has explored other elements that impact on decision-making and a number of these elements have been validated through field research. Research directed to these elements has already begun to appear in the literature, but there is considerable scope for further research in real-life contexts. Fourthly, a strong methodology was structured and implemented, to achieve the initial aims of the research. Finally, evidence has indicated that the use of microworlds for research on NDM should be mediated by an understanding of their limitations. Two learning points have been the confirmation of the diffuse nature of unit level decision-making in the Australian Army. Also, the contextual boundaries for NDM have been proposed for further discussion within the field.

In conclusion, RPD is a useful model for investigating decision-making in the Australian Army. It will become increasingly important, as the Army continues to progress towards the age of NCW, to understand the complex web of elements impacting on the process. Moreover, improved definition of each of these elements is essential. The current research has built upon the RPD to propose a hypothetical model for decision-making at the level of unit HQ in the Australian Army, and incorporated a number of the identified elements. From this point it will be important for further research to determine the validity and generalisability of this model. Limitations in the current program of research have been identified and these should be addressed in future studies, and balanced against time and resource constraints.

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Appendix I: Summary List of Factors Affecting Teamwork

(Adapted from Morgeson, Aiman-Smith and Campion, 1997).

Factor(s)	Description	Examples
Contextual Factors	Variables that pertain to the environment in which the team activity is embedded	Culture Climate Training/Education systems Reward systems Information systems
Structural Factors	Variables impinging primarily from sources external to the team, but may include some internal to the team (e.g. Team organisation)	Physical environment Organisational arrangements Technological systems
Team Design Factors	Variables inherent to the team itself	Work design Task interdependence Team size/composition Leadership
Process Factors	Variables inherent to the way in which the team functions	Boundary management Task cohesion Performance norms Communication Team interactions Potency/self efficacy Team spirit
Contingency factors	Variables impinging from sources internal and external to the team	Team application/mission Resource availability Procedural requirements Rules on operation, managing, or decision-making.

Appendix II: Definitions for Group Biases

(from Vaughan & Hogg, 1995)

Evaluation apprehension - The physical presence of members of the same species causes drive because people have learned to be apprehensive about being evaluated.

Socialising - Dynamic relationship between the group and its members that describes the passage of members through a group in terms of commitment and changing roles.

Conformity pressures - The pressure to conform to group norms in order to identify with and be accepted by that group.

Social loafing - A reduction in individual effort when working on a collective task (in which ones outputs are pooled with those of other group members) compared to when working either alone or coactively.

Domination due to status imbalance - Different group members have a different perceived status in the group. Status usually depends on their consensual prestige and their tendency to initiate ideas and activities that are adopted by the group. High status members tend to dominate idea formation in groups.

Free riding - When a group member is avoiding costly obligations and group membership and allowing other members to incur the costs.

Group think - A mode of thinking in highly cohesive groups in which the desire to reach unanimous agreement overrides the motivation to adopt proper rational decision-making procedures.

Appendix III: Q-sort Method Background and Justification

As mentioned, Q-methodology was first suggested by British physicist/ psychologist William Stephenson (1902-1989)⁵¹. Q-methodology critically draws on ideas from behaviourism (Watson, 1913) but these ideas are viewed according to more naturalistic framework presented by Kantor (1938). These were the two theories that bore most influence on Stephenson's (1953) design.

In the 1950s and 60s behaviourism was the dominant theory in the field of psychology. Behaviourists explained phenomena (particularly learning) without referring to underlying mental processes. The focus was on observable behaviour and how an organism adapts to the environment. At this time methods such as introspection had recently been dismissed as unscientific. Because of the association between introspection and the study of internal factors, things that could not be observed were dismissed by behaviourists. Thus, because mentalistic processes were not considered objective or observable, they were ignored.

Stephenson (1953) agreed with the importance of the study of behaviour. However, he suggested that there was no basis upon which to separate observable behaviours (e.g. physical behaviours), from inner behaviours (e.g. thoughts). He suggested that the internal factors that introspection had attempted to investigate and the internal frames of reference inherent in people (that Stephenson termed *subjective behaviour*) were two different things (Stephenson, 1953). He emphasised that these internal frames of reference were just as important to study as observable behaviour, because they could assist to provide explanations for many of our

⁵¹ Stephenson was a student of Spearman's, and hence had a strong grounding in statistical analysis. During his time behaviourism was the most prominent theoretical stance in psychology and R-analysis was a favoured form of statistical analysis.

actions. Also, by understanding a person's *subjective behaviour*, this could facilitate the interpretation of objective data (Murray, 1992).

Therefore, Stephenson (1953) suggested that objective⁵² and subjective⁵³ behaviours were both valuable to study and could be done so with an empirical basis. Defining subjectivity is important at this stage. Stephenson (1981) noted that the dictionary gives two definitions for the term subjectivity. They were:

1. Particular to a given person; personal.
2. Proceeding from or taking place in a person's mind rather than the external world

Stephenson (1981) rejected the first of these definitions as categorical. The second was acceptable for his purposes, so long as *mind* was taken to mean nothing more than *from one's own standpoint*. Thus, Stephenson (1981) retrieved that which was empirical but which behaviorism had discarded along with the non-empirical. In this sense the boundaries of research at this time were redefined (Brown, 1999).

In developing the alternative methodology, Stephenson (1981) still adhered to many behavioural principles. The analysis of behaviour in the Q-methodology is similar to Skinner's approach to scientific psychology. It differs in that the dependant variable is not observable physical behaviour but internal behaviour. However, in both cases scientists are interested in the changes in response to different stimulus conditions. Essentially, participants' operant behaviour is analyzed, not for the purpose of testing hypotheses about different effects of the stimuli, but rather for the purpose of discovering constancies in behavioural response patterns.

⁵² Objective-testable operations and reliable events/ observed by others.

⁵³ Subjective- inner experience/ can be observed by the person themselves (Stephenson, 1981).

The second prominent theory that Stephenson (1953) drew upon in the conception of Q-methodology was Kantor's (1938) theory of interbehaviour. Kantor agreed with many posits of behaviourism, but did not support the behaviourist view of de-contextualizing research. Instead, he suggested that in order to adequately understand any psychological event, one must understand the contributing parts. Kantor (1978) suggested that in order to account for behavior, researchers needed to engage in more thorough observation of the behavior of specific individuals in relation to concrete objects and events. He argued that beginning with a presumed mental event as a basis for predicting external action was too limiting. Based on this reasoning Stephenson (1953) wanted to base science on "confrontable events and field conditions" (p. 12); thus making it more externally valid. Consequently, he drew on this more contextualized approach to scientific inquiry in the construction of Q-methodology.

Thus Q-methodology arose based on realist ideas. Essentially it was in response to the need to: gain an understanding of inner behaviour (as well as observable behaviour) and include context in data collection techniques. Neither of these things infers that Stephenson intended Q-methodology to be post-positivist nor post-behaviourist. Instead, he was trying to show that at that point in history positivism had gone awry due to lack of method. Upon the conception of Q-methodology Stephenson adhered to many positivist principles such as ideas of experimental design and sampling theory (Brown, 1995). Thus, while it has been employed in post-positivist research, there are no underlying post-positivist philosophies that would exclude it from being used within a positivist framework.

Some critical assumptions must be made, however, to allow the placement of Q-methodology in a positivist framework. Because Q-methodology generally uses a series of statements as independent variables, the main assumptions held by Q-methodologists relate to the nature of human communication. It is assumed that: opinions are subjective; subjective points of view are communicable; communications are self-referent, based on an individual's

past and present experiences. With these three assumptions met, it can be assumed that subjective communication can be analysed objectively. Thus, it is argued that Q-methodology can be applied within a positivist framework.

As with all methodologies, Q-methodology has received criticisms. These have stemmed from both qualitative and quantitative researchers. The author has addressed these criticisms in terms of the philosophy, aims, construction and analysis of the current study. The main criticisms drawn from the literature that will be addressed are shown in Table 49.

Table 49. A summary of criticisms of Q-methodology.

Criticisms of Q-methodology	
1.	The items are pre-selected and hence limiting on finding the truth (Kitzinger, 1999).
2.	A restricted response format is used which does not allow for views falling outside that format (Kitzinger, 1999).
3.	The use of complex statistical procedures can force the results to say things that they are not really saying (Kitzinger, 1999).
4.	The production of categories means the slotting of all participants into these groups (Kitzinger, 1999).
5.	The problem with all the variables being sorted into piles is that the weightings given to each of those items is considered to be identical when really it could be that they are not all weighted equally (Carr, 1992).
6.	Does not include a large enough number of randomly selected participants (Kitzinger, 1999; Sexton et al., 1998).
7.	Fails to establish the content validity of Q-structures (Kitzinger, 1999).
8.	Seeks to interpret factors with insufficient numbers of defining Q-sorts (Kitzinger, 1999).

Answering Criticism 1: The criticism that the items are pre-selected and hence limiting to finding the truth misses the aim of Q-methodology. In order to facilitate direct comparison between individual Q-sorts it is necessary to provide a standard sample of

statements. The aim of Q-methodology is not to discover all items of relevance to a certain topic⁵⁴. Instead, it uses a relevant sample of items and allows the investigation of their comparative importance. Similarities and differences in the way these items are viewed between participants are also explored. Hence the issue is not that the pre-selected sample is too limiting, but that it is representative and relevant. This is ensured by pre-selecting items according to Fisher's experimental principles, and in accordance with the research question being investigated. Thus, control over the representativeness and relevance of the sample is maintained.

Answering Criticism 2: It is a true statement that a restricted response format is used, which does not allow for views falling outside that format. However, restricted response format is maintained in order to enable a clear statistical analysis. This is in line with Adolphe Quetelet's theory that the variability of most phenomena could be represented by a normal distribution. This forced distribution also makes people consider the relative importance of things rather than the individual importance. This is useful in achieving a better understanding of the phenomenon of interest because the individual variables (statements) do not occur in isolation but must be organised in terms of their importance in a COs decision-making. Thus, the results generated are more externally valid.

Answering Criticism 3: The use of complex statistical procedures cannot force the results to say things that they are not really saying (as has been suggested by [1987]). The statistical procedures are entirely reliant on the way in which the participants have structured their Q-sorts. Thus, it is considered by the researcher that the interpretation of the result is participant guided and not statistically manufactured.

⁵⁴ In the current research the factors perceived to be the most important influences on unit-level decision-making will have already been determined during the interview stage.

Answering Criticism 4: It is true that the production of categories means categorising all participants here but this is necessary to produce interpretable data. The resultant production of categories offers us a platform on which we can establish a theory. It must be remembered that the results are not a definitive answer and should not be viewed as such.

Answering Criticism 5: In terms of the criticism that the weightings given to each of those items sorted in the same pile is considered to be identical when really it could be that they are not, needs to be responded to in terms of the purpose of the study. Instead of looking at exact weightings of statements the researcher is interested in comparative ratings, and similarities across individuals. Thus, the actual value of the item is not so important as its comparative weighting in the context of the Q-sort.

Answering Criticism 6: It is true that Q-methodology does not include a large number of randomly selected participants. The requirement for only a small sample size is in line with the purpose of the Q-methodology, which is to study intensively the opinions of selected individuals. This intensive study allows the generation of laws that may be governing human behaviour. Moreover, in the case of the current study, the actual potential population is already limited. Thus, a method not requiring large numbers of participants is appropriate.

Answering Criticism 7: In terms of the criticism of the content validity of Q-structures, it seems nonsensical to establish the content validity of an opinion. However, it is sensible to determine whether opinions that are revealed using the Q-sort translate into real world behaviour. This can be discovered through triangulation and was done in the current research (phase 3: observational field study). The reliability of Q-methodology studies has also been questioned in the literature. Calculating a test-retest reliability (and Cronbach's alpha) is considered to be an adequate measure for reliability (Stephenson, 1985). Q-methodology has been found to have a test- retest reliability score of 79% (Tatano Beck, 1999), which is adequate for use in the current study.

Answering Criticism 8: A fair criticism of some users of Q-methodology is that they have sought to interpret factors with insufficient numbers of defining Q-sorts. Some Q-sort studies have presented factors with only one person loaded onto that factor. Suggestions have been made to increase the objectivity of the interpretation of factors. Both Dennis (1986) and Reid (1999) suggested that there should be a minimum number of participants loading on each factor in order to establish its importance. They calculated that this number would vary between 4 and 5. The current study adhered to this guideline.

Appendix IV: Study 1- CDM Interview Participant Information Sheet

The Influence of Context on Expert

Naturalistic Decision-making:

A Comparison of Part-time and Full-time Experts

Participant Information Sheet

My name is Taryn Chapman, and I am an employee of the Defence Science and Technology Organisation (DSTO) Land Operations Division and a PhD candidate at Adelaide University. My PhD topic is concerned with comparing full-time and part-time experts in naturalistic decision-making (NDM). NDM is the process by which experienced people, make decisions in dynamic, uncertain, and often fast paced environments. I am interested in studying how context influences decision quality. This work feeds directly into the BCSS evaluation task and should help to support future releases.

The initial stages of this work involve gathering some information from subject matter experts on previously experienced emergency situations. This information will be gathered using interviews, based on principles of cognitive task analysis (CTA). This interview process is a retrospective interview strategy that will focus on non-routine events (critical incidents where decisions have been made). It will endeavour to construct a broader understanding the contextual factors that surround military decision-making. Participants will also be asked for their insights into factors that may contribute to expert error. The interview process will finally evolve into a discussion of BCSS and how it supports this decision-making process. This interview process will take about 2 ½ hours, and will be recorded for later analysis. Demographic information will also be collected. This data will be used to plan future laboratory studies.

All names and personal information pertaining to you, will be kept confidential in the analysis and reporting of the data collected. You are free to withdraw from the interview at any time. If you are interested in reading a copy of the final report this will be available to you upon request.

Thank you for your cooperation. Please feel free to contact me (0410318356) or my supervisors Dr Vanessa Mills (82597914) or Associate Professor Ted Nettelbeck (83035738) for any further information.

Taryn Chapman

Appendix V: Study 1- CDM Consent Form

UNIVERSITY OF ADELAIDE
DEPARTMENT OF PSYCHOLOGY

**The Influence of Context on Expert
Naturalistic Decision-making:
*A Comparison of Part-time and Full-time Experts***

CONSENT FORM

Participants Name:.....

Project Title: The Influence of Context on Expert Naturalistic Decision-making:
A Comparison of Part-time and Full-time Experts

Name of Supervisors: Associate Professor Ted Nettelbeck and Dr Vanessa Mills.

Name of PhD student: Taryn Chapman.

1. I consent to participate in the above project. The nature of the project, including questionnaires or procedures, has been explained to me, and is summarised on an information sheet I have been given.
2. I authorise the Supervisor or PhD student named above to use these questionnaires or procedures with me.
3. I understand that:
 - a) I am free to withdraw at any time.
 - b) The project is for the purpose of research or teaching, and is not for treatment.
 - c) The confidentiality of the information I provide will be safeguarded.
 - d) There are no known adverse effects of these questionnaires or procedures.

Signed:.....
(Participant)

Date:.....

E-mail address:.....

6. When was the last time you were involved in combat training?
Please write number in appropriate time span.

 Hours ago.
 Days ago.
 Weeks ago.
 Months ago.
 Years ago.
Other .

7. About how frequently over your experience have you been involved in military operations (peacekeeping or war time)? *(Please explain).*

8. When was the last time you were involved in military operations (peacekeeping or war time)? *Please write number in appropriate time span.*

 Hours ago.
 Days ago.
 Weeks ago.
 Months ago.
 Years ago.
Other .

9. Are you or have you ever been involved in another organisation that requires you to make emergency decisions? (For example: CFS, hospital emergency room, military). *(Please circle appropriate answer.)*

Yes

No

Questionnaire is completed. Thank you for your effort

Appendix VII: Study 1- CDM Interview Script

Critical Decision Method Outline

You've had a chance to read the information sheet I have emailed you, describing what we're going to go through today. Basically this information should firstly increase our knowledge of context and decision-making, which will feed into the BCSS evaluation task at the DSTO. Secondly, it will help me out with my PhD.

So we're interested in naturalistic decision-making, and how context influences expert decision-making. The reason I've asked you here today is to draw upon your expertise in the military. Have you got any questions so far?

(Respond to any questions presented)

During the interview I will be asking you about a good decision that you remember making, and secondly we will contrast this with a poor decision. For the purpose of this interview we will define a decision point as

"A critical point where a decision must be made in order for events to proceed."

(Demonstrate this with interview cue card #1)

I am interested in critical decisions in particular, so those verging on a state of crisis or emergency.

This interview is confidential, and any names that you may mention will be changed in the transcription of the interview.

Good Situation

1. Incident Selection and Recall

I want you to try and remember a time when you were faced with a critical decision, where you believe the eventual decision outcome was good (for example you saved someone's life, avoided confrontation etc). The example should be an instance where the decision outcome matched up with your expectations.

I'd like you to try and talk me through the event...If you could paint me a picture of the context in which it happened firstly, and then describe the problem, and the decisions and actions taken.

(Demonstrate this with interview cue card #2)

(Take notes on the decision description as participant explains)

OK...Let me read that back to you and if there are any parts that you would like to add to or change, please feel free to point them out.

(Summarise participant's description and allow for any feedback, correction or clarification that may be needed)

2. Time Line Identification

I'd like to try to construct a timeline of the events you've just recalled.

(Demonstrate this with interview cue card #3)

I'd like to particularly focus on the context surrounding any major decision points, and any other information that you believe was critical to your eventual decision outcome

(Give participant sketchpad and pen to draw a flow chart)

3. Progressive Deepening

I'd like to now expand on your description of the event, and particularly focus on the context surrounding any major decision points, and any other information that you believe was critical to your eventual decision outcome

We can use this table to organise some of the details.

(Demonstrate this with interview cue card #4)

Decision Point	Contextual Information	Situation Assessment	Cues and Strategies	Why was this Decision Difficult?



Drawn from incident recall

Describe the environment – physical, psychological, relational.

What was your assessment of the situation – future prediction?

What cues/strategies did you rely upon?

How would this have been difficult for a novice?

These are to be added to the progressive deepening as appropriate.

Probe Type	Probe Content
Cues	What could you see, hear, smell, taste, feel? What cues were most influential? What information did you disregard? Why?
Knowledge	<p>What sort of information did you feel was most influential in your decision-making?</p> <p>Did you feel you had enough information to make a good decision?</p> <p>What if (a cue in the environment) had not been present?</p>
Standard scenario	Does this example fit with a standard scenario? Were you trained to deal with it? If it does not, how does it differ? Does this make it more/less difficult? Why?
Analogues	<p>Were you reminded of previous experience?</p> <p>What was it that reminded you; the environment or the problem dynamics?</p> <p>Did you draw upon this previous experience?</p>
Goals	What were your specific goals at this time?
Options	What other courses of action were available to you?
Mental Simulation	Did you imagine the possible consequences of this decision? How did reality differ from your prediction? Did the changing context influence the decision outcome in an unexpected way?
Basis	How did you choose this option and disregard others/ What rule was being followed?

Experience	How do you believe that someone who didn't have your experience would have reacted differently in the situation outlined? Would the context have influenced their decision-making? How?
Time Frames	How much time pressure was associated with this decision? How long did it actually take to make it? Was this within the time frame?
Mood/Morale	Do you believe the mood/ morale surrounding your decision influenced your decision-making?
Computer Systems	Were there decision tools, or other computer systems that may have influenced your decision-making? How? How could you have been supported better?
Hypotheticals	What if you were in a different environment on this occasion? Do you believe this would have influenced your decision-making? How and Why? How did other people in the environment influence the decision you made?
Other	Is there anything else that you feel is important that you'd like to add?

4. What if?

To be applied as necessary.

OK thank you for your help on that

BREAK.

Poor Situation

1. Incident Selection and Recall

Next I'd like you to try and remember a time when you were faced with a critical decision, where you believe the eventual decision outcome was poor, where events could have been handled better in hindsight. Think of an example where the decision outcome did not match up with your expectations.

(Display interview cue card #1)

I'd like you to try and talk me through the event...If you could paint me a picture of the context in which it happened firstly, and then describe the problem, and the decisions and actions taken.

(Demonstrate this with interview cue card #2)

(Take notes on the decision description as participant explains)

OK...Let me read that back to you and if there are any parts that you would like to add to or change, please feel free to point them out.

(Summarise participant's description and allow for any feedback, correction or clarification that may be needed)

2. Time Line Identification

I'd like to try to construct a timeline of the events you've just recalled.

(Demonstrate this with interview cue card #3)

I'd like to particularly focus on the context surrounding any major decision points, and any other information that you believe was critical to your eventual decision outcome

(Give participant sketchpad and pen to draw a flow chart)

3. Progressive Deepening

I'd like to now expand on your description of the event, and particularly focus on the context surrounding any major decision points, and any other information that you believe was critical to your eventual decision outcome

We can use this table to organise some of the details.

(Demonstrate this with interview cue card #4)

Decision Point	Contextual Information	Situation Assessment	Cues and Strategies	Why was this Decision Difficult?

↑	↑	↑	↑	↑
---	---	---	---	---

<p><i>Drawn from incident recall</i></p>	<p><i>Describe the environment – physical, psychological, relational.</i></p>	<p><i>What was your assessment of the situation – future prediction?</i></p>	<p><i>What cues/strategies did you rely upon?</i></p>	<p><i>How would this have been difficult for a novice?</i></p>
--	---	--	---	--

These are to be added to the progressive deepening as appropriate.

Probe Type	Probe Content
Cues	What could you see, hear, smell, taste, feel? What cues were most influential? What information did you disregard? Why?
Knowledge	<p>What sort of information did you feel was most influential in your decision-making?</p> <p>Did you feel you had enough information to make a good decision?</p> <p>What if (a cue in the environment) had not been present?</p>
Standard scenario	Does this example fit with a standard scenario? Were you trained to deal with it? If it does not, how does it differ? Does this make it more/less difficult? Why?
Analogues	<p>Were you reminded of previous experience?</p> <p>What was it that reminded you; the environment or the problem dynamics?</p> <p>Did you draw upon this previous experience?</p>
Goals	What were your specific goals at this time?
Options	What other courses of action were available to you?
Mental Simulation	Did you imagine the possible consequences of this decision? How did reality differ from your prediction? Did the changing context influence the decision outcome in an unexpected way?
Basis	How did you choose this option and disregard others/ What rule was being followed?

Experience	How do you believe that someone who didn't have your experience would have reacted differently in the situation outlined? Would the context have influenced their decision-making? How?
Time Frames	How much time pressure was associated with this decision? How long did it actually take to make it? Was this within the time frame?
Mood/Morale	Do you believe the mood/ morale surrounding your decision influenced your decision-making?
Computer Systems	Were there decision tools, or other computer systems that may have influenced your decision-making? How? How could you have been supported better?
Hypotheticals	What if you were in a different environment on this occasion? Do you believe this would have influenced your decision-making? How and Why? How did other people in the environment influence the decision you made?
Other	Is there anything else that you feel is important that you'd like to add?

4. *What if?*

To be applied as necessary.

OK thank you for your help on that. Your time has been appreciated. I feel that some really useful things have come out of what you've said. I will email an analysis of your interview to you, if you are interested. Thank you again for your time.

Card 1

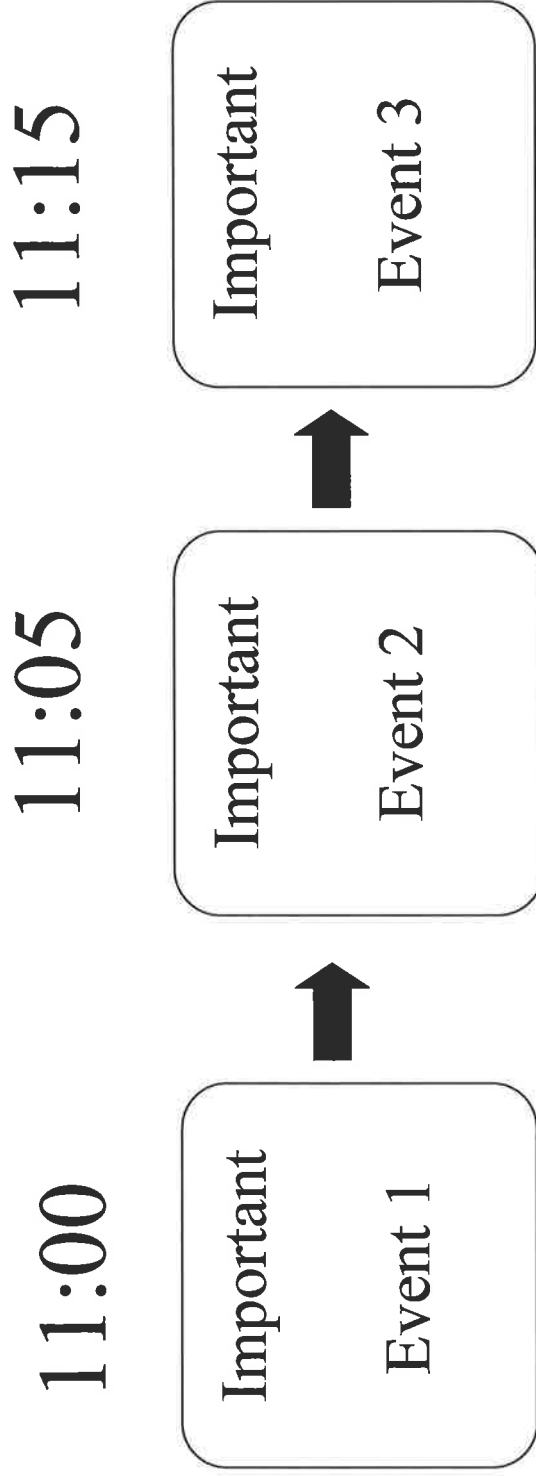
Decision point.....

“A critical point where a decision must be made in order for events to proceed.”

Card 2

- ❖ **Explain the context.**
- ❖ **Describe the problem.**
- ❖ **What were the decisions made?**
- ❖ **What were the actions taken?**

Example Time Line:



Card 4

Major Decision Point	Contextual Information	Cues and Strategies	Situation Assessment	Why was this Decision Difficult?



Drawn from incident recall.



Describe the environment – physical, psychological, relational.



What cues/strategies did you rely upon?



What was your assessment of the situation – future prediction?



How would this have been difficult for a novice?

Code Book

Version 1

Using Critical Decision Method to Explore
Elements Affecting Expert Decision-making

Taryn Chapman

(2003/2004)

Overall Segregation of Categories

Element	Defining Statement	Sub categories	
Organisational	Any influence within the organisational structure* of the Army exterior to the Headquarters team. *Organisational structure- A structure through which individuals cooperate systematically to conduct business.	Organisational constraints Army culture Higher management	Intelligence Subordinates Other regiments
Personal	Any influence on decision-making done, made, or performed or originating from within a person. Can be situationally triggered by the situation, or a stable personal characteristic.	Fatigue Motivation Perspective Emotion Physical stress Instinct/flair Personality elements Morals	Experience Age Desire to please others Intelligence (IQ) Reputation Respect
Team	Any influence within the immediate battalion headquarters team.	Comradery Trust Support	Communication Morale
Situational	Any influence external to the Army organisation, arising from the current situation*. * The combination of circumstances at a given moment; a state of affairs.	Time of Day Lead up activities Timing Decision aids Physical presence Culture	Outside organisational influences Cultural dealings Environmental influences Resources availability/use

***Initial free coding arrived at the following set of categories and definitions.*

Coding Scheme - Revised

***Once the codes had been regrouped the following coding scheme and definitions were established.*

Situational Elements

Immediate environment	Visual support (Computer or other)
	Spatial position
Wider environment	Culture
	Outside organisational influence
	Environmental influence
	Context of operations
Temporal influences	Time of day
	Timing
	Lead up activities

Organisational Elements

Organisational Mechanisms	Organisational communication:
	Higher management
	Intelligence
	Subordinates
	Other regiments
	Diffuse responsibility
Organisational Status	Politics
	Organisational constraints:
	Resources
	Army Culture

Team Elements

Team mechanisms	Diffuse task/responsibility
	Communication
Team status	Team personalities
	Team emotion
	Team morale
Team relationships	Comradery
	Trust

Personal Elements

Situationally mediated characteristics	Fatigue
	Perspective
	Emotion
	Stress
Relatively stable characteristics	Flexibility/contingency
	Personality
	Moral
	Experience
	Age
	IQ
	Instinct
Reputation	

Coding Scheme Definitions

Situational Elements

Immediate environment	<i>Visual support (computer or other)</i>	Use of computer or other visual display to gather, organise and/ or search for information to facilitate decision-making.
	<i>Spatial position</i>	Mention of the actual, physical position of the Commander during the decision-making process (i.e. Are they detached from the actual situation)
Wider environment	<i>Culture</i>	Any reference to interactions with people of another culture (infers the requirement for cultural knowledge) Interaction may be in terms of: Peacekeeping operations, Coalition operations or Wartime.
	<i>Outside organisational influence</i>	Any reference to a non-military organisation that may have been taken into consideration in the decision-making process. Examples are: UN, Government, Aid organisations, Media (public perception).
	<i>Environmental influence</i>	Any reference to the wider physical (not within HQ) environment of operations as being considered in decision-making.
	<i>Context of Operations</i>	Any reference to the type of operation (e.g. peacekeeping, warfighting).
Temporal influences	<i>Time of day</i>	Any reference to the time of day being considered in the decision-making (e.g. the decision needs to be made before nightfall).
	<i>Timing</i>	Reference to the actual timing of the decision being important in decision-making (e.g. the decision must be made in the next hour).
	<i>Lead up activities</i>	Any mention of the decision being dependant on specific lead up activities (e.g. the decision is necessary because x and y happened).

Organisational Elements

General	Organisational Communication	Any reference to communication within the organisation (Army) included in the decision-making process. May be in the form of orders, information or knowledge sharing etc.
		Higher management -Reference to some one from higher management influencing the decision process (usually a Brigadier).
		Intelligence - Reference to intelligence influencing the decision process (usually via information presentation).
		Subordinates - Reference to subordinates (external to unit HQ) influencing the decision process.
		Other regiments - Reference to other regiments or other parts of the Defence force influencing the decision process.
	Diffuse responsibility	Reference to responsibility being shared across levels of the Organisation (Army).
	Politics	Reference to organisational politics influencing the decision.
	Organisational constraints	Reference to doctrine or other Australian Army guidelines as constraining decision-making.
	Resources	Reference to the state of or the availability of resources as impacting on the decision process.
	Army Culture	Reference to the culture of a particular portion of the Army as bearing an impact on the decision made.

Team Elements

Team mechanisms	<i>Diffuse task/responsibility</i>	Reference to responsibility being shared across levels of the team (unit HQ).
	<i>Communication</i>	Any reference to communication within the HQ team (included in the decision-making process). Some examples include supply of information, knowledge or opinion etc.
Team status	<i>Team personalities</i>	Any reference to the personality of team members influencing the decision-making process.
	<i>Team emotion</i>	Any reference to the emotional state of team members influencing the decision-making process.
	<i>Team morale</i>	Any reference to the morale of team members influencing the decision-making process.
Team relationships	<i>Comradery</i>	Any reference to the level of comradery between team members influencing the decision-making process.
	<i>Trust</i>	Any reference to the level of trust between team members influencing the decision-making process.

Personal Elements

Situationally mediated characteristics	<i>Fatigue</i>	Any reference to the fatigue influencing decision-making.
	<i>Perspective</i>	Any reference to the position of the interviewee or individual make-up influencing the way s/he saw the situation during decision-making.
	<i>Emotion</i>	Any reference to the emotional state of the interviewee influencing decision-making.
	<i>Stress</i>	Any reference to the stress levels of the interviewee influencing decision-making.
Relatively stable characteristics	<i>Flexibility/contingency</i>	Any reference to the habit of maintaining plan flexibility by mentally simulating COA and generating contingencies.
	<i>Personality</i>	Any reference to the personality of the interviewee influencing decision-making.
	<i>Moral</i>	Any reference to the morals of the interviewee influencing decision-making.
	<i>Experience</i>	Any reference to the experience of the interviewee influencing decision-making.
	<i>Age</i>	Any reference to the age of the interviewee influencing decision-making.
	<i>IQ</i>	Any reference to the IQ of the interviewee influencing decision-making.
	<i>Instinct</i>	Any reference to interviewee's instinct informing decision-making.
	<i>Reputation</i>	Any reference to the reputation of the interviewee influencing decision-making.

Appendix X: Study 1- CDM Coding Inter-rater Reliability Table

	Overall				
	L1	L2	L3	Disagree	PA
Personal Elements	36	35	35	4	0.90
<i>Situationally Mediated Elements</i>	6	6	6	1	0.86
Fatigue	2	2	2	0	1.00
Perspective	1	1	1	0	1.00
Emotion	3	3	3	1	0.75
Stress	0	0	0	0	
<i>Relatively Stable Characteristics</i>	30	29	29	4	0.88
Flexibility/Contingency	4	4	4	1	0.80
Personality	6	5	5	1	0.83
Moral	0	0	0	0	
Experience	17	17	17	2	0.89
Age	0	0	0	0	
IQ	1	1	1	0	1.00
Instinct	1	1	1	0	1.00
Reputation	1	1	1	0	1.00
Situational Elements	57	55	55	6	0.90
<i>Immediate Environment</i>	8	7	7	1	0.88
Computer or Other Visual Support	5	5	5	0	1.00
Spatial Position	3	3	3	1	0.75
<i>Wider Environment</i>	34	34	34	4	0.89
Culture	16	16	16	2	0.89
Outside Organisational Influence	6	6	6	0	1.00
Environmental Influence	10	10	10	2	0.83
Context of Operations	2	2	2	0	1.00
<i>Temporal Influences</i>	16	15	15	1	0.94
Time of Day	1	1	1	0	1.00
Timing	12	11	11	1	0.92
Lead Up Activities	3	3	3	0	1.00

	Overall				
	L1	L2	L3	Disagree	PA
Organisational Elements	74	73	73	5	0.94
<i>General</i>	53	53	53	3	0.95
Organisational Communication	15	15	15	1	0.94
Resources	15	15	15	0	1.00
Diffuse Responsibility	18	18	18	2	0.90
Politics	1	1	1	1	0.50
Organisational Constraints	4	4	4	0	1.00
Army Culture	2	2	2	0	1.00
<i>Structure</i>	21	20	20	2	0.91
Higher management	8	7	7	1	0.88
Intelligence	5	5	5	1	0.83
Subordinates	2	2	2	0	1.00
Other Regiments	6	6	6	0	1.00
Team Elements	46	44	44	5	0.90
<i>Team mechanisms</i>	26	26	26	3	0.90
Diffuse Task/Responsibility	12	12	12	2	0.86
Communication	10	10	10	1	0.91
<i>Team Status</i>	10	10	10	2	0.83
Team Personalities	4	4	4	1	0.80
Team Emotion	1	1	1	0	1.00
Team Morale	5	5	5	1	0.83
<i>Team Relationships</i>	14	12	12	2	0.86
Comradery	3	1	1	2	0.33
Trust	11	11	11	0	1.00
OVERALL RELIABILITY					0.93

Appendix XI: Study 2- Q-sort Statements for Commanders

COs Statements Focused on Personal Elements		
Localised decision-making	Diffuse decision-making	None
<i>Personality</i>		
4. My character traits affect decision-making, fundamentally.	53. The character traits of my command team are all important predictors for the eventual decision outcome.	42. Character traits do not have an effect on decision-making.
<i>Experience</i>		
16. It is important to feed my experience into the decisions made.	5. It is important to feed the collective experience of my command team into the decisions made.	54. Experience is not important for decision-making.
<i>Emotion</i>		
28. I sometimes find myself being influenced by my emotion when making-decisions.	17. My command team's emotions can influence decision-making.	6. Emotion does not influence decision-making.
<i>Perspective</i>		
40. I solely determine the perspective from which the current situation is viewed.	29. My command team determines the perspective from which the current situation is viewed.	18. Perspective does not influence decision-making.
<i>Fatigue</i>		
52. If I am fatigued, this can slow down the whole decision process, and lead to untimely decisions.	41. If my command team are fatigued, that will negatively affect the decision-making.	30. Fatigue does not influence decision-making.

Personal

COs Statements Focused on Organisational Elements

Localised decision-making	Diffuse decision-making	None
<i>Higher management</i>		
1. I feel the restrictions set by higher management influence me greatly throughout decision-making.	50. I feel the restrictions set by higher management influence the command team greatly throughout decision-making.	39. Restrictions set by higher management do not greatly influence decision-making.
<i>Subordinates</i>		
13. I take feedback from subordinates into account when making decisions.	2. The command team takes feedback from subordinates into account when making decisions.	51. Decision-making is not influenced by feedback from subordinates.
<i>Intelligence</i>		
25. Although information gathered by intelligence is important, I believe that my own interpretation of that information is most important.	14. The role of the intelligence officer is critical in providing his/her interpretation of information gathered to aid in decision-making.	3. Information gathered by intelligence is not important in decision-making.
<i>Organisational Constraints</i>		
37. During decision-making it is predominantly me who needs to take into account that we are part of a larger organisation (e.g. doctrine, limitation on resources)	26. During decision-making it is predominantly my command team who need to take into account that we are functioning as part of a bigger organisation.(e.g. doctrine, limitation on resources)	15. Despite the fact that we are part of a larger organisation, I feel that decisions are not constrained by this. (e.g. doctrine, limitation on resources)
<i>Organisational Culture</i>		
49. During decision-making it is predominantly me who needs to consider the impacts that different "organisational cultures" throughout the Army, might have on decision-making.	38. During decision-making it is predominantly my command team who need to consider the impacts that different "organisational cultures" throughout the Army, might have on decision-making.	27. "Organisational culture" does not affect decision-making.

COs Statements Focused on Team Elements

Localised decision-making	Diffuse decision-making	None
Team		
<i>Decision Responsibility</i>		
7. In the end all responsibility lies with me for the decision made.	56. In the end my command team and I share responsibility for the decisions made.	45. It is not important to determine where responsibility for the decision lies.
<i>Team Communication</i>		
19. The most important aspect of communication is feeding situational information to me to inform decision-making.	8. If I communicate my intent well to the command team, then the decision outcome is usually good.	57. Good communication is not crucial for good decision-making.
<i>Evaluating a Plan</i>		
31. I am usually confident in my own ability to evaluate a plan, and do not need to consult with my command team before making a decision.	20. I like to seek support from my command team when evaluating a plan by consulting them before making a decision.	9. Evaluating a plan is not important.
<i>Judgements</i>		
43. My own judgements are most important during decision-making.	32. I tend to rely on the judgements generated by my command team during decision-making.	21. Judgements are not necessary for decision-making.
<i>Trust</i>		
55. I only trust myself to deem what information is important.	44. I am happy to trust my command team to supply information that they deem to be important.	33. Trust is not important for decision-making.

COs Statements Focused on Team Elements

Localised decision-making	Diffuse decision-making	None
<i>External Organisations</i>		
10. I can feel pressured by groups external to the Army (such as aid organisations or other government organisations) to make certain decisions.	59. I believe that my command team can feel pressured to make certain decisions by groups external to the Army (such as aid organisations or other government organisations).	48. Groups external to the Army (such as aid organisations or other government organisations) do not impact on decision-making.
<i>Time Pressure</i>		
22. Most pressure caused by time limitations is felt by me during decision-making.	11. The time pressure associated with decision-making is mainly experienced by my command team.	60. Pressure does not influence decision-making.
<i>Decision Aids</i>		
34. I believe that the information provided by decision aids impacts predominantly on me during decision-making.	23. Information from decision aids impacts mostly on my command team during decision-making.	12. Decision aids do not impact on decision-making.
<i>Cultural Groups</i>		
46. If we are dealing with different cultural groups, it is most important that I take this into account when making decisions.	35. If we are dealing with different cultural groups, it is most important that the command team takes this into account when making decisions.	24. Dealing with different cultural groups does not affect decision-making.
<i>Environmental Influence</i>		
58. The external environment in which I am operating influences me most during decision-making.	47. The external environment in which we are operating influences my command team most during decision-making.	36. The external environment has no influence on decision-making.

Situational

Appendix XII: Study 2- Q-sort Statements for Operations Officers

OPSOs Statements Focused on Personal Elements		
Localised decision-making	Diffuse decision-making	None
<i>Personality</i>		
4. The Commander's character traits affect decision-making, fundamentally.	53. The character traits of the command team are all important predictors for the eventual decision outcome.	42. Character traits do not have an effect on decision-making.
<i>Experience</i>		
16. It is important to feed the Commander's experience into the decisions made.	5. It is important to feed the collective experience of the command team into the decisions made.	54. Experience is not important for decision-making.
<i>Emotion</i>		
28. I sometimes feel the Commander is being affected by emotion when making decisions.	17. The command team's emotions can influence decision-making.	6. Emotion does not influence decision-making.
<i>Perspective</i>		
40. The Commander solely determines the perspective from which the current situation is viewed.	29. The command team determines the perspective from which the current situation is viewed.	18. Perspective does not influence decision-making.
<i>Fatigue</i>		
52. If the Commander is fatigued, this can slow down the whole decision process, and lead to untimeliness.	41. If the command team are fatigued, that will negatively affect the decision-making.	30. Fatigue does not influence decision-making.

Personal

OPSOs Statements Focused on Organisational Elements

Localised decision-making	Diffuse decision-making	None
Higher management		
1. I feel the restrictions set by higher management influence the commander greatly throughout decision-making.	50. I feel the restrictions set by higher management influence the command team greatly throughout decision-making.	39. Higher management does not set restrictions on decision-making.
Subordinates		
13. The Commander takes feedback from subordinates into account when making decisions.	2. The command team takes feedback from subordinates into account when making decisions.	51 .Decision-making is not influenced by feedback from subordinates.
Intelligence		
25. Although information gathered by intelligence is important, I believe that the Commander's interpretation of that information is most important.	14. The role of the intelligence officer is critical in providing his/her interpretation of information gathered to aid in decision-making.	3. Information gathered by intelligence is not important in decision-making.
Organisational Constraints		
37. During decision-making it is predominantly the Commander who needs to take into account that we are part of a larger organisation.	26. During decision-making it is predominantly the command team who need to take into account that we are functioning as part of a bigger organisation.	15. Despite the fact that we are part of a larger organisation, I feel that decisions are not constrained by this.
Organisational Culture		
49. During decision-making it is predominantly the Commander who needs to consider the impacts that different "organisational cultures" throughout the army, might have on decision-making.	38. During decision-making it is predominantly the command team who need to consider the impacts that different "organisational cultures" throughout the Army, might have on decision-making.	27. "Organisational culture" does not affect decision-making.

OPSOs Statements Focused on Team Elements

Localised decision-making	Diffuse decision-making	None
Decision Responsibility		
7. In the end all responsibility lies with the Commander for the decision made.	56. In the end the command team share responsibility with the Commander for the decisions made.	45. It is not important to determine where responsibility for the decision lies.
Team Communication		
19. The most important aspect of communication is feeding situational information to the Commander to inform decision-making.	8. If the Commander communicates his intent well to the command team, then the decision outcome is usually good.	57. Good communication is not crucial for good decision-making.
Evaluating a Plan		
31. The Commander seems to usually be confident in his own ability to evaluate a plan and does not need to consult with the command team before making a decision.	20. The Commander likes to seek support from the command team when evaluating a plan by consulting us before making a decision.	9. Evaluating a plan is not important.
Judgements		
43. The Commander's own judgements are most important during decision-making.	32. The Commander tends to rely on the judgements generated by the command team during decision-making.	21. Judgements are not necessary for decision-making.
Trust		
55. I feel the Commander only trusts himself to deem what information is important.	44. The Commander seems happy to trust the command team to supply information that they deem to be important.	33. Trust is not important for decision-making.

Team

OPSOs Statements Focused on Situational Elements

Localised decision-making	Diffuse decision-making	Combined
External Organisations		
10. The Commander can feel pressured by groups external to the Army (such as aid organisations or other government organisations) to make certain decisions.	59. I believe that the command team can feel pressured to make certain decisions by groups external to the Army (such as aid organisations or other government organisations).	48. Groups external to the Army (such as aid organisations or other government organisations) do not impact on decision-making.
Time Pressure		
22. Most pressure caused by time limitations is felt by the Commander during decision-making.	11. The time pressure associated with decision-making is mainly experienced by the command team.	60. Pressure does not influence decision-making.
Decision Aids		
34. I believe the information provided by decision aids impacts predominantly on the Commander during decision-making.	23. Information from decision aids impacts mostly on the command team during decision-making.	12. Decision aids do not impact on decision-making.
Cultural Groups		
46. If we are dealing with different cultural groups, it is most important that the Commander takes this into account when making decisions.	35. If we are dealing with different cultural groups, it is most important that the command team takes this into account when making decisions.	24. Dealing with different cultural groups does not affect decision-making.
Environmental Influence		
58. The external environment in which we are operating influences the Commander most during decision-making.	47. The external environment in which we are operating influences the command team most during decision-making.	36. The external environment has no influence on decision-making.

Situational

Appendix XIII: Study 2- Q-sort E-mail Text

Email Text

Hello,

My name is Taryn Chapman, and I am a PhD candidate at Adelaide University. My PhD topic is concerned with expert decision-making in military Headquarters (HQ) environments. The Defence Science and Technology Organisation (DSTO) Land Operations Division are supporting this research.

I have been given your email address by <insert name of science officer>, and would appreciate your help with my current research.

This research is an extension from interviews conducted last year falling under the BCSS Human Factors Evaluation Task. The interviews identified a range of factors impacting on battalion decision-making. The current research is aimed at organising these factors along a continuum from "most strongly agree" to "most strongly disagree". This is done by completing a computerized constrained choice ranking task. This takes about 30 minutes, and results will then be recorded in the following files.

C:\WINDOWS\jil\5.txt

C:\WINDOWS\jil\4.txt

C:\WINDOWS\jil\3.txt

C:\WINDOWS\jil\2.txt

C:\WINDOWS\jil\1.txt

C:\WINDOWS\jil\0.txt

C:\WINDOWS\jil\1.txt

C:\WINDOWS\jil\2.txt

C:\WINDOWS\jil\3.txt

C:\WINDOWS\jil\4.txt

C:\WINDOWS\jil\5.txt

C:\WINDOWS\jil\Questionnaire.txt

I would really appreciate it if you could email these back to me at:

<taryn.chapman@dsto.defence.gov.au>

The Australian Defence Human Research Ethics Committee (ADHREC) has approved the protocol.

Please read the participant information sheet below for a more detailed description of the task, and its relevance. Attached to this email are the ADHREC guidelines for volunteers. Please read through these and address any concerns to ADHREC (details included listed on the information sheet). Also attached is an executable file containing the ranking task. If you have time, I would appreciate your assistance in this matter ideally before the 13th October.

If you choose to participate, to ensure confidentiality of the results your assigned participant number is <insert participant number>.

Thank you again for your time.

Regards,

Taryn Chapman

Perceptions of Command Decision-making

Participant Information Sheet

My name is Taryn Chapman, and I am a PhD candidate at Adelaide University. My PhD topic is concerned with expert decision-making in military Headquarters (HQ) environments. The Defence Science and Technology Organisation (DSTO) Land Operations Division are supporting this research.

Brief Description of the Study

To date research has been conducted using interviews and field observation to identify factors impacting on battallion decision-making, not previously elaborated in current models. The current phase of the study is concerned with identifying the perceived relative impact of these factors on the battallion decision-making process. This work feeds directly into the BCSS evaluation task and should help to support future releases.

The method I have chosen to use is called a Q-sort. This technique requires you to sort a range of statements along a continuum according to your level of agreement with them. The continuum will range from “more strongly disagree” to “more strongly agree”. This technique is appropriate because it allows the researcher to gain an understanding of the internal frames of reference being drawn upon during decision-making. This viewpoint is obviously important when considering the design of command support systems, as their success is undoubtedly linked with their ease of use and the desire of the end user to make use of them. Also, being part of a larger research project, a more holistic view of the process will be developed. Thus, benefits of the study for the Australian Defence Force will be the increased knowledge of the factors affecting the battallion decision-making process as perceived by Commanders and Operations officers. This could inform future development of training procedures, and command support systems.

Your Part in the Study

Participation in the study is entirely voluntary; there is no obligation to take part in the study, if you choose not to participate there will be no detriment to your career. You are also free to withdraw from the study at any time with no detriment to your career.

The Research Task

The research task should take no longer than 30 minutes to complete.

After reading through this information, you will be required to open the attached file. This will present you with an explanation of ethical issues relating to this research. Please read through these. If you accept these conditions then your consent to participate in the current study will be noted by your selection of the box “I accept” before moving to the next screen.

Upon opening the next page you will firstly open a short demographic questionnaire on the screen. Please fill this out as it provides a necessary participant profile to pair with your completed Q-sort. Once you have finished this you will be asked to click on the button marked “finished”.

A new window will then appear on the screen. This is the Q-sort program. Simple instructions on how to use the program will also be available on the screen at this time. The Q-sort task basically requires you to arrange a number of statements along a continuum (ie. “more strongly agree” to “more strongly disagree”). This is done by positioning a set of statements in a pre-determined distribution found in the attached program. You may find that some of the statements seem strange. It is possible that these were included to create a balanced experimental design, to aid in statistical calculations. Once you are satisfied with your arrangement of the statements you will click on the “finish/send” button. The arrangement will be saved by the computer and can then be sent back, via the secure network, to the researcher for analysis. If you are interested in reading a copy of the final report this will be available to you upon request.

Risks of Participating

There are no known risks involved in the current study. You will be required to operate a computer which is considered to be a normal activity.

On Duty

While completing this task you will be considered to be 'on duty'.

Statement of Privacy

All personal information, will be kept confidential in the analysis and reporting of the data collected. Data will be stored on the researcher's password protected computer; thus only the researcher will access this information. The collected data will be used for this study and no other, without permission from the participant.

Name of Investigators

Thank you for your cooperation. Please feel free to contact me (0412318356) or my supervisors Dr Vanessa Mills (82597914) or Professor Ted Nettelbeck (83035738) for any further information.

Should you have any complaints or concerns about the manner in which this project is conducted, please do not hesitate to contact the researchers in person, or you may prefer to contact the Australian Defence Human Research Ethics Committee at the following address:

Executive Secretary
Australian Defence Human Research Ethics Committee
CP2-7-66
Department of Defence
Canberra ACT 2600
Telephone: (02) 6266 3837
Fax: (02) 6266 4982
E-mail: ADHREC@defence.gov.au

Or you can contact the convenor of the Human Research Ethics Sub-committee in the Psychology Department at the University of Adelaide, Dr. Paul Delfabbro (83035744).

Taryn Chapman

Perceptions of Command Decision-making

Consent Form

(date)

Participant Number: _____ <field> _____

Project Title: Investigating Perceptions of Command Decision-making

Name of Responsible Investigator: Taryn Chapman

1. I consent to take part in the above research project
2. I acknowledge that I have read the information supplied in the body of the email entitled "Investigating Perceptions of Command Decision-making"
3. I have had the project, so far as it affects me, fully explained to my satisfaction. My consent is given freely.
4. I authorise the responsible investigator to use the techniques and questionnaires described with me.
5. I understand that:
 - a. I am free to withdraw from the project at any time.
 - b. The project is for the purpose of research and not for treatment.
 - c. The confidentiality of information I provide will be safeguarded.

Save information to: _____ <field> _____

"I accept"

"I do not accept"

Appendix XVI: Study 2- Q-sort Demographic Information (SCREEN 3)

Demographic Information

Sex (*please circle*): Male Female

Age: _____ years.

Rank: _____.

Please read the following questions carefully and fill them in accordingly.

How many years experience have you had as a military officer?

_____.

2. During this time how long have you been working:

Full-time _____.

Part-time _____.

3. Have you worked in different locations during this time?

Yes No

If so, could you please list these here.

_____.

4. How often have you been involved in job related training?

every day weekly monthly every six months yearly

5. About how frequently over your experience have you been involved in practical combat training?

every day weekly monthly every six months yearly

6. When was the last time you were involved in combat training?

Please write number in appropriate time span.

_____ Hours ago.

_____ Days ago.

_____ Weeks ago.

_____ Months ago.

_____ Years ago.

Other _____.

7. About how frequently over your experience have you been involved in military operations (military operations other than war, or war time)? Please explain.

8. When was the last time you were involved in military operations (military operations other than war, or war time)?

_____ Hours ago.

_____ Days ago.

_____ Weeks ago.

_____ Months ago.

_____ Years ago.

Other _____.

9. Are you or have you ever been involved in another organisation that requires you to make emergency decisions? (For example: CFS, hospital emergency room, military).

Yes

No

Thank you for completing the demographic questionnaire.

Perceptions of Command Decision-making

Instructions

Before you begin the Q-sorting task please read through the following instructions. They describe the task requirements. It may be beneficial for you to print out the current page to use as a guide while completing the Q-sort. As you are completing the Q-sort you can refer back to this page by clicking on "Back". If you have any questions please call the responsible researcher (Taryn Chapman- 0412318356).

Once you have read these instructions you will be presented with a sample of 60 statements relating to command decision-making. I am interested in knowing how strongly you agree or disagree with these statements. There may also be some statements that you feel neutral about.

You are being asked to sort statements in accordance with your degree of concurrence/ agreement with the statements. Where +5 is high agreement and -5 is high disagreement and the scales between -5 and +5 reflect shades/levels of agreement. Please note that you may not be indifferent about the statements placed into the neutral column. They may be statements that you may slightly agree or slightly disagree with.

You will find the statements in a master list at the bottom of the Q-sort screen. To place a statement in a column, click and drag the statement to the appropriate column. To view statements once they have been placed in the columns simply click on the statement and it will be displayed in the text bar below. You can remove a statement from a column by dragging it back to the master list or to any other column in the Q-sort. The largest number of statements will be placed in the centre and the least amount of statements at each extreme point (as illustrated below).

More
Strongly
Disagree

More
Strongly
Agree

-5 -4 -3 -2 -1 0 +1 +2 +3 +4 +5

item	item	item	item	item	item	item	item	item	item	item
item	item	item	item	item	item	item	item	item	item	item
item	item	item	item	item	item	item	item	item	item	item
item	item	item	item	item	item	item	item	item	item	item
(4)	(4)	item	item	item	item	item	item	item	(4)	(4)
		(5)	item	item	item	item	item	(5)		
			(6)	item	item	item	(6)			
				(7)	item	(7)				
					(8)					

Please follow the steps listed below when arranging the statements on the grid.

1. Read and familiarise yourself with the statements.
2. Each statement will receive a score equivalent to the marker under which you place it. The specific vertical order in which the statement is placed is inconsequential. Arrangement should be done by moving between the statements on the right side of the distribution and the left side of the distribution. This enables you to arrange them by comparison with others. This should be repeated until all statements have been arranged.
3. Upon completion the final distribution should be reviewed in order to check that statements have been arranged correctly according to your own understanding of their importance.

After this stage the Q-sort is completed. Please click on the "Finish" button on the bottom right hand corner of the screen. Instructions will then be given on how to send the results back to the researcher via secure email for analysis.

Appendix XVIII: Study 2- Screen Freeze from Q-sort task (SCREEN 5)

Perceptions of Command Decision-making - Q-sort

Perceptions of Command Decision-making

Q-sort

	-5 More Strongly Disagree	-4	-3	-2	-1	0 Neutral	+1	+2	+3	+4	+5 More Strongly Agree
Ack											
Folk											

01 I feel the restrictions set by higher management influence me greatly throughout decision-making.
 02 The command team takes feedback from subordinates into account when making decisions.
 03 Information gathered by intelligence is not important in decision-making.
 04 My character traits affect decision-making, fundamentally.
 05 It is important to feed the collective experience of my command team into the decisions made.
 06 Emotion does not influence decision-making.
 07 In the end all responsibility lies with me for the decision made.
 08 If I communicate my intent well to the command team, then the decision outcome is usually good.
 09 Evaluating a plan is not important.
 10 I can feel pressured by groups external to the Army (such as aid organisations or other government organisations) to make certain decisions.
 11 The time pressure associated with decision-making is mainly experienced by my command team.
 12 Decision aids do not impact on decision-making.
 13 I take feedback from subordinates into account when making decisions.
 14 The role of the intelligence officer is critical in providing his/her interpretation of information gathered to aid in decision-making.
 15 Despite the fact that we are part of a larger organisation, I feel that decisions are not constrained by this.
 16 It is important to feed my experience into the decisions made.
 17 My command team's emotions can influence decision-making.
 18 Perspective does not influence decision-making.
 19 The most important aspect of communication is feeding situational information to me to inform decision-making.
 20 I like to seek support from my command team when evaluating a plan by consulting them before making a decision.
 21 Judgements are not necessary for decision-making.
 22 Most pressure caused by time limitations is felt by me during decision-making.
 23 Information from decision aids impacts mostly on my command team during decision-making.
 24 Dealing with different cultural groups does not affect decision-making.
 25 Although information gathered by intelligence is important, I believe that my own interpretation of that information is most important.
 26 During decision-making it is predominantly my command team who need to take into account that we are functioning as part of a bigger organization.
 27 "Organisational culture" does not affect decision-making.
 28 I sometimes find myself being influenced by my emotion when making decisions.
 29 My command team determines the perspective from which the current situation is viewed.
 30 Fatigue does not influence decision-making.
 31 I can use the confidence in my own abilities to make the plan and do not need to consult with my command team before making a decision.

← Back
Finish

Thesis: September 2006 3:25 PM

Appendix XIX: Study 2- Q-sort Correlation Matrix

		RCO 6	RCO 7	RCO 8	RCO 9	RCO 12	RCO 16
RCO 8	r	0.74	0.63				
	p	0.00	0.00				
RCO 9	r	0.60	0.50	0.77			
	p	0.00	0.00	0.00			
RCO 12	r	0.73	0.64	0.69	0.69		
	p	0.00	0.00	0.00	0.00		
RCO 16	r	0.74	0.71	0.72	0.67	0.75	
	p	0.00	0.00	0.00	0.00	0.00	
RCO 17	r	0.65	0.68	0.72	0.69	0.69	0.75
	p	0.00	0.00	0.00	0.00	0.00	0.00
RCO 19	r	0.61	0.56	0.60	0.58	0.64	0.50
	p	0.00	0.00	0.00	0.00	0.00	0.00
RCO 22	r	0.78	0.67	0.72	0.68	0.80	0.80
	p	0.00	0.00	0.00	0.00	0.00	0.00
CO 3	r	0.69	0.66	0.75	0.68	0.65	0.73
	p	0.00	0.00	0.00	0.00	0.00	0.00
CO 5	r	0.68	0.65	0.78	0.86	0.76	0.80
	p	0.00	0.00	0.00	0.00	0.00	0.00
CO 7	r	0.57	0.60	0.53	0.41	0.60	0.59
	p	0.00	0.00	0.00	0.00	0.00	0.00
CO 16	r	0.74	0.60	0.73	0.71	0.71	0.75
	p	0.00	0.00	0.00	0.00	0.00	0.00
2CO 1	r	0.61	0.45	0.53	0.56	0.55	0.63
	p	0.00	0.00	0.00	0.00	0.00	0.00
CO 2	r	0.62	0.52	0.61	0.60	0.52	0.60
	p	0.00	0.00	0.00	0.00	0.00	0.00
CO 10	r	0.58	0.51	0.68	0.68	0.47	0.61
	p	0.00	0.00	0.00	0.00	0.00	0.00
ROP 2	r	0.57	0.47	0.56	0.50	0.47	0.52
	p	0.00	0.00	0.00	0.00	0.00	0.00
ROP 3	r	0.57	0.40	0.71	0.66	0.63	0.46
	p	0.00	0.00	0.00	0.00	0.00	0.00
ROP 4	r	0.54	0.44	0.56	0.51	0.44	0.51
	p	0.00	0.00	0.00	0.00	0.00	0.00
ROP 5	r	0.67	0.46	0.63	0.65	0.63	0.63
	p	0.00	0.00	0.00	0.00	0.00	0.00
ROP 6	r	0.47	0.51	0.53	0.50	0.48	0.53
	p	0.00	0.00	0.00	0.00	0.00	0.00
ROP 7	r	0.47	0.52	0.51	0.55	0.50	0.64
	p	0.00	0.00	0.00	0.00	0.00	0.00
ROP 9	r	0.57	0.40	0.72	0.65	0.64	0.44
	p	0.00	0.00	0.00	0.00	0.00	0.00
ROP 10	r	0.74	0.57	0.63	0.57	0.67	0.63
	p	0.00	0.00	0.00	0.00	0.00	0.00
OP 6	r	0.49	0.53	0.53	0.51	0.49	0.53
	p	0.00	0.00	0.00	0.00	0.00	0.00
OP 17	r	0.66	0.60	0.74	0.69	0.77	0.72
	p	0.00	0.00	0.00	0.00	0.00	0.00

		RCO 17	RCO 19	RCO 22	CO_3	CO 5	CO 7
RCO 19	r	0.47					
	p	0.00					
RCO 22	r	0.70	0.62				
	p	0.00	0.00				
CO 3	r	0.68	0.56	0.73			
	p	0.00	0.00	0.00			
CO 5	R	0.73	0.59	0.74	0.72		
	p	0.00	0.00	0.00	0.00		
CO 7	r	0.46	0.53	0.58	0.56	0.51	
	p	0.00	0.00	0.00	0.00	0.00	
CO 16	r	0.63	0.56	0.85	0.77	0.74	0.56
	p	0.00	0.00	0.00	0.00	0.00	0.00
2CO 1	r	0.53	0.40	0.55	0.55	0.59	0.39
	p	0.00	0.00	0.00	0.00	0.00	0.00
CO 2	r	0.55	0.54	0.65	0.65	0.62	0.37
	p	0.00	0.00	0.00	0.00	0.00	0.00
CO 10	r	0.57	0.50	0.53	0.50	0.67	0.36
	p	0.00	0.00	0.00	0.00	0.00	0.01
ROP 2	r	0.44	0.48	0.54	0.61	0.60	0.38
	p	0.00	0.00	0.00	0.00	0.00	0.00
ROP 3	r	0.53	0.40	0.56	0.60	0.63	0.30
	p	0.00	0.00	0.00	0.00	0.00	0.02
ROP 4	r	0.43	0.47	0.53	0.61	0.61	0.36
	p	0.00	0.00	0.00	0.00	0.00	0.01
ROP 5	r	0.48	0.44	0.59	0.68	0.67	0.38
	p	0.00	0.00	0.00	0.00	0.00	0.00
ROP 6	r	0.41	0.27	0.45	0.53	0.50	0.39
	p	0.00	0.03	0.00	0.00	0.00	0.00
ROP 7	r	0.50	0.32	0.49	0.51	0.55	0.42
	p	0.00	0.01	0.00	0.00	0.00	0.00
ROP 9	r	0.51	0.41	0.55	0.60	0.63	0.32
	p	0.00	0.00	0.00	0.00	0.00	0.01
ROP 10	r	0.66	0.54	0.68	0.64	0.65	0.44
	p	0.00	0.00	0.00	0.00	0.00	0.00
OP 6	r	0.43	0.29	0.47	0.55	0.52	0.38
	p	0.00	0.02	0.00	0.00	0.00	0.00
OP 17	r	0.67	0.57	0.76	0.75	0.70	0.46
	p	0.00	0.00	0.00	0.00	0.00	0.00

		CO 16	CO 1	CO 2	CO 10	ROP 2	ROP 3
2CO 1	r	0.55					
	p	0.00					
CO 2	r	0.54	0.58				
	p	0.00	0.00				
CO 10	r	0.59	0.49	0.54			
	p	0.00	0.00	0.00			
ROP 2	r	0.60	0.47	0.58	0.38		
	p	0.00	0.00	0.00	0.00		
ROP 3	r	0.63	0.42	0.40	0.41	0.47	
	p	0.00	0.00	0.00	0.00	0.00	
ROP 4	r	0.60	0.46	0.58	0.37	0.99	0.46
	p	0.00	0.00	0.00	0.00	0.00	0.00
ROP 5	r	0.66	0.56	0.60	0.46	0.66	0.56
	p	0.00	0.00	0.00	0.00	0.00	0.00
ROP 6	r	0.46	0.35	0.41	0.36	0.36	0.43
	p	0.00	0.01	0.00	0.00	0.00	0.00
ROP 7	r	0.58	0.35	0.32	0.41	0.38	0.44
	p	0.00	0.01	0.01	0.00	0.00	0.00
ROP 9	r	0.63	0.40	0.39	0.39	0.48	0.99
	p	0.00	0.00	0.00	0.00	0.00	0.00
ROP 10	r	0.69	0.44	0.55	0.50	0.51	0.54
	p	0.00	0.00	0.00	0.00	0.00	0.00
OP 6	r	0.49	0.37	0.44	0.39	0.38	0.46
	p	0.00	0.00	0.00	0.00	0.00	0.00
OP 17	r	0.75	0.61	0.59	0.51	0.52	0.53
	p	0.00	0.00	0.00	0.00	0.00	0.00

		ROP 4	ROP-5a	ROP 6	ROP 7	ROP 9	ROP 10	OP 6
ROP 5		0.62						
		0.00						
ROP 6		0.33	0.46					
		0.01	0.00					
ROP 7	r	0.38	0.39	0.53				
	p	0.00	0.00	0.00				
ROP 9	r	0.47	0.56	0.43	0.44			
	p	0.00	0.00	0.00	0.00			
ROP 10	r	0.50	0.49	0.38	0.49	0.54		
	p	0.00	0.00	0.00	0.00	0.00		
OP 6	r	0.35	0.49	0.99	0.53	0.46	0.41	
	p	0.01	0.00	0.00	0.00	0.00	0.00	
OP 17	r	0.49	0.64	0.48	0.50	0.53	0.57	0.50
	p	0.00	0.00	0.00	0.00	0.00	0.00	0.00

A Field Study of Naturalistic Decision-making Experts

Participant Information Sheet

It is beyond a doubt that all our knowledge begins with experience

-Immanuel Kant, The Critique of Pure Reason

My name is Taryn Chapman, and I am a PhD candidate at Adelaide University, and a part-time employee of the Defence Science and Technology Organisation (DSTO). The topic I am currently researching is concerned with how Battalion Commanders make decisions, and what contextual factors may influence this. I have collected data on this through some interviews, and am interested in validating some of this data by observing your CPX between the dates of <insert dates>.

The proposed observational study is based on principles of ethnographic research. This is an unobtrusive method, which means that I will try to appear nonexistent as I observe the scene around me. I will be collecting data on the environment, expert behaviour, communication, the influence of context, and professional relationships. Short interviews (5-10 minutes) may be requested to clarify information obtained through observation. These will be at a time convenient, so as not to interrupt your exercise. Demographic information will also be collected. This data will be used to develop an understanding of how you and other experts in your organisation operate in a simulated real world environment. Future laboratory studies will be structured on this information.

All names and personal information pertaining to you, will be kept confidential in the analysis and reporting of the data collected. You are free to withdraw from the research at any time. If you are interested in reading a copy of the final report this will be available to you upon request.

Thankyou for your cooperation. Please feel free to contact me (0412318356) for any further information.

Taryn Chapman

e-mail: chapman@adam.com.au

CONSENT FORM

Participant's Name:.....

(please print name)

Project Title: A Field Study of Naturalistic Decision-making Experts

Name of Responsible Investigator: Taryn Chapman

1. I consent to take part in the above research project.

2. I acknowledge that I have read the attached Information Sheet entitled: "A Field Comparison of Part-time and Full-time Naturalistic decision-making Experts – Participant Information Sheet".

3. I have had the project, so far as it affects me, fully explained to my satisfaction by the research worker. My consent is given freely.

4. I authorize the responsible investigator to use the techniques and questionnaires described with me.

5. I understand that:
 - a) I am free to withdraw from the project at any time.
 - b) The project is for the purpose of research and not for treatment.
 - c) The confidentiality of information I provide will be safeguarded.
 - d) There are no known adverse effects of these questionnaires or procedures.

.....
(signature)

(date)

Appendix XXI: Study 3-Behavioural Coding Sheet for Field Work

Time:	Day:	Observer:								Location:					Other Notes:							
		Commander with HQ team								HQ Team					Interaction with Subordinates							
5		Supply situational Information	Supply knowledge	Ask team member for info	Ask team member for knowledge	Ask team member for opinion	Ask team member to generate COA	Acknowledge prob. raised by team	Run plan by a confident	Order/ guidance given	Supply situational information	Supply knowledge	Supply opinion	Generate COA	Ask question	Subordinate supplies info to HQ	Ask subordinate question (situation)	Report plan below	Plan accepted	Subordinate questions HQ	Plan adjusted on subordinate suggestion	Technical Problems
10																						
15																						
20																						
25																						
30																						
35																						
40																						
45																						
50																						
55																						
60																						
Total																						

Appendix XXII: Study 3-Field Study Behavioural Definitions

HQ Team	
Supply situational information	HQ team member supplies information (e.g. gathered through recon) to increase situation awareness.
Supply knowledge	HQ team member supplies specialist knowledge (e.g. In these conditions how long would it take for a tank to travel that distance?).
Make opinion/ judgement	HQ team member supplies a judgement or opinion based on their own experience. This is in response to a COA, and is COA specific (e.g. Based on the situation I think it would be wise not to move until we receive confirmation about enemy position)
Make suggestion	HQ team member applies specialist knowledge or situation awareness to add to the COA, without prompting from the Commander (e.g. How about notifying the local authorities about this?)
Generate COA	The Commander asks a HQ team member to generate a/some COA for the current problem.
Ask question	HQ team member asks question to clarify their understanding of the situation/COA.

Commander with HQ Team	
Supply situational information	Commander supplies information (e.g. gathered through recon/ reports) to increase situation awareness.
Supply knowledge	Commander supplies specialist knowledge (e.g. In these conditions how long would it take for a tank to travel that distance?).
Ask team member for information	The Commander asks a HQ team member for information (e.g. gathered through recon) to increase his situation awareness.
Ask team member for knowledge	The Commander asks a HQ team member for specialist knowledge (e.g. In these conditions how long would it take for a tank to travel that distance?).
Ask team member for opinion	The Commander asks a HQ team member for a judgement or opinion based on their own experience. This is in response to a COA, and is COA specific (e.g. Based on the situation I think it would be wise not to move until we receive confirmation about enemy position).
Ask team member to generate COA	The Commander asks a HQ team member to generate a/some COA for the current problem.
Acknowledge problem raised by the team	The Commander acknowledges the usefulness of a problem in the SA/ judgement/ COA brought up by a HQ team member.
Run plan by a confident	Before officially running the plan by the team, the Commander runs it by a confident (note who this is here).
Order or guidance given	Commander gives a specific order, or outlines his intent and allows his subordinate scope to intricately plan his/her own actions.

Interaction with Subordinates	
Subordinate supply info to HQ	Subordinate supply updated info to HQ (situational)
Report plans below	COA is reported below/ Orders given/ Intent given
Plan accepted	Subordinates accept the plan / intent
Subordinate questions HQ	Subordinate questions HQ about their awareness of the overall situation. This may include reporting both information (situation) and knowledge (experiential interpretation). Subordinates question the plan / intent.
Plans adjusted c/o subordinate	Plans adjusted in HQ on subordinate suggestion.
Ask subordinate question (situation)	Subordinate is questioned about the situation on the ground. This may include reporting both information (situation) and knowledge (experiential interpretation).

Interaction with Brigadier	
Report plan to Brigadier	The Commander reports the chosen COA to the Brigadier.
Plan changed by Brigadier	The plan is changed/ or not accepted by the Brigadier.
Plan Accepted by Brigadier	The plan is changed/ or not accepted by the Brigadier.

Qualitative Notes

Technical Problems	<i>Just notes on how this happens will be sufficient</i>
Technical Problems	Problems that are technical in nature (to do with radio communications, BCSS etc) are discussed.

Interaction with Outside Organisations	<i>Just notes on how this happens will be sufficient</i>
Information supplied by and outside Organisation	Outside Organisation supplies information to increase situation awareness.
Previous experience with an outside organisation discussed	Previous Experience with an outside organisation discussed (including how a decision might cause repercussions/ their possible involvement in a COA etc)

Shared Responsibility	<i>Just notes on how this happens will be sufficient.</i>
------------------------------	---

Acceptable Risk	<i>Just notes on how this happens will be sufficient</i>
Risk mentioned	The acceptable level of risk is outlined by the CO.
<i>Directly mentioned</i>	The word “risk” is actually contained within the discourse.
<i>Indirectly implied</i>	The word “risk” is not actually contained within the discourse, but its relationship to the topic is obvious.
Risk questioned	The risk involved in the plan is questioned as being acceptable by a HQ team member, a superior, or a subordinate.

Contextual Variables Identified

(To look for in the Exercise):

1. Environmental Variables

- Night time (Poor visual)
- Physical environ (extreme)

2. Operational Stresses (Stress/ Organisational and Social Pressures)

- Lack of or incomplete cultural understanding.
- Emotion
- Sleep deprivation
- Lose objectivity
- Severe Time pressure
- Poorly defined roles in an operation
- Incomplete information

3. Organisational Limitations (Organisational and Social Pressures)

- Poorly defined roles in an operation
- Organisational “yes” culture
- Changing rules for different situations
- Inadequate resources
- Too many SOPs

4. Individual Differences

- Military ego
- Inability to control biases
- Political agendas/ self promotion
- Command perspective/ position

5. Communication Issues (Ambiguity)

- Poor communication
- Trust of team
- Bad coordination between parties

6. Risk (Dynamic Risk)

- Unclear risk

Appendix XXIII: Study 3-Field Exercise Short Interview Scripts

Probe Type	Probe Content
Cues	What could you see, hear, smell, taste, feel? What cues were most influential? What information did you disregard? Why?
Knowledge	What sort of information did you feel was most influential in your decision-making? Did you feel you had enough information to make a good decision? What if (a cue in the environment) had not been present?
Standard scenario	Does this example fit with a standard scenario? Were you trained to deal with it? If it does not, how does it differ? Does this make it more/less difficult? Why?
Analogues	Were you reminded of previous experience? What was it that reminded you; the environment or the problem dynamics? Did you draw upon this previous experience?
Goals	What were your specific goals at this time?
Options	What other courses of action were available to you?
Mental Simulation	Did you imagine the possible consequences of this decision? How did reality differ from your prediction? Did the changing context influence the decision outcome in an unexpected way?
Basis	How did you choose this option and disregard others/ What rule was being followed?
Experience	How do you believe that someone who didn't have your experience would have reacted differently in the situation outlined? Would the context have influenced their decision-making? How?
Time Frames	How much time pressure was associated with this decision? How long did it actually take to make it? Was this within the specified time frame?
Mood/Morale	Do you believe the mood/ morale surrounding your decision influenced your decision-making?
Computer Systems	Were there decision tools, or other computer systems that may have influenced your decision-making? How? How could you have been supported better?
Hypotheticals	What if you were in a different environment on this occasion? Do you believe this would have influenced your decision-making? How and Why? How did other people in the environment influence the decision you made?
Other	Is there anything else that you feel is important that you'd like to add?

Appendix XXIV: Study 4- *NFC* Information Sheet

UNIVERSITY OF ADELAIDE
DEPARTMENT OF PSYCHOLOGY

Networked Fire Chief (NFC) Pilot Study: The Development of Expertise.

INFORMATION SHEET

My name is Taryn Chapman, and I am currently in my first year of PhD candidature in Psychology at the University of Adelaide. I am looking for people interested in participating in a pilot study that will look at the development and decay of expertise using a computer simulation called Networked Fire Chief (NFC).

The NFC program simulates fires, and requires you, the player, to systematically extinguish them. It incorporates variables such as time pressure, uncertainty, and high stakes, all of which are present in real life naturalistic environments (for example the military, a medical operating room).

The Naturalistic decision-making theory is concerned with decision-making in environments with variables present such as time pressure, high stakes, and uncertainty. In these environments it is a common finding that “experts” produce better performance outcomes. Within this study, my interest is in how the participants reach expertise, and how their mental models develop throughout the process.

As decision-makers become “experts” theory holds that they build up a repertoire of knowledge and experience based schema to aid in their decision-making. This will be tracked throughout the trials.

Your participation may aid in developing directions for future research in this area. You will be required for a three hour session. This includes a training session in the use of NFC, 20 practice scenarios to develop you to the level of expert, as well as interviews. All data produced will remain confidential.

Quantitative data will be collected, post hoc, using the programs replay function, to look at the development of your expertise. On top of this qualitative data from interviews will also be collected.

The study will be conducted in the psychology department (Room 111). Scheduling arrangements can be made to suit you. Day times, evenings, and weekends are fine. The testing period starts on 26th of May and will continue until the end of July.

If you are interested in the results, I would be more than happy to share my analysis with you after the event. I would greatly appreciate your support.

You can contact me via email:

<chapman@adam.com.au> OR <taryn.chapman@dsto.defence.gov.au>

Or on the phone: Monday, Tuesday, Friday: **0410318356**

Wednesday, Thursday: **8 259 7663**

After 5:30pm and weekends: **8 336 8673.**

Alternatively you are welcome to contact my supervisors Associate Professor Ted Nettelbeck on **83035738** or Dr Vanessa Mills **0413594143**.

Appendix XXVII: Study 4- NFC Consent Form

UNIVERSITY OF ADELAIDE
DEPARTMENT OF PSYCHOLOGY

Networked Fire Chief (NFC) Pilot Study:
The Development of Expertise.

CONSENT FORM

Participants Name:.....

Project Title: The Development of Expertise using *Networked Fire Chief*.

Name of Supervisors: Associate Professor Ted Nettelbeck and Dr Vanessa Mills.

Name of PhD student: Taryn Chapman.

1. I consent to participate in the above project. The nature of the project, including questionnaires or procedures, has been explained to me, and is summarised on an information sheet I have been given.
2. I authorise the Supervisor or PhD student named above to use these questionnaires or procedures with me.

3. I understand that:

- a) I am free to withdraw at any time.
- b) The project is for the purpose of research or teaching, and is not for treatment.
- c) The confidentiality of the information I provide will be safeguarded.
- d) There are no known adverse effects of these questionnaires or procedures.

Signed:.....

(Participant)

Date:.....

E-mail address:.....

Appendix XXVI: Study 4- *NFC* Schedule for Participants

Schedule for Participant Number _____

15mins Learning how to use *Networked Fire Chief*.

5mins Short comprehension quiz

5 mins Short mouse skill test

(25mins)

5mins Trial 1

10mins Interview

(15mins)

40mins Trial 2-10

(40mins)

Short break

60 mins Trial 11-20

10mins Interview

(1hr 10mins)

Thank you for your participation.

Appendix XXVII: Study 4- NFC Training Protocol

Firechief Tutorial

1. Landscape and Appliances

The map window occupies the largest part of the Fire chief screen. Within the map area, different colours represent different objects.

The four different types of landscape are

1. **Clearing:** The lighter green colour (occupying most of the map in this case).
2. **Forest:** the dark green colour
3. **Pasture:** the brown/maroon colour
4. **Buildings:** The purplish colour

Buildings are considered the most valuable, and therefore your first priority. Following on from those the order of priority is the pasture (cows) the forest and finally the clearing. As these burn, points will be deducted from your performance score, depending on the values of the land burning. As being worth more or less the different land types also burn at different rates. The pasture burns the fastest, followed by the buildings and the forest, which burn at the same rate, and the grassland burns the slowest. This will be demonstrated later in the tutorial.

In addition to the landscape elements there is also a single resource element:

1. **Water:** the blue colour surrounding the example areas of landscape.
This is a resource element, rather than a landscape element because you need it to fight the fires. The appliances used to fight the fires will run out of water, and need to be refilled at a water square. Each water square has a limited amount of water, and will eventually run out. A fire truck can refill at the same square 3-4 times before emptying it. Water squares do not burn and therefore act as firebreaks.

Finally near the right bottom corner of the map window are the fire fighting appliances:

1. **Fire truck:** the red squares are fire trucks. These can be used to either fight fires or to burn off areas and create firebreaks. In the former case water is used

and a fire truck can extinguish 15 squares before needing to be refilled.

Burning off does not use water.

2. **Helicopter:** the yellow squares are helicopters. These move twice as fast as firetrucks but can only be used to fight fires, not to burn off. They are also less efficient: using more water each time they refill but only extinguishing 9 squares before needing to be refilled.

A little later we will look at the appliances in motion and how they are used to fight fires, but for now we are going to continue our familiarisation with the various features of the screen.

2. Screen Features

Looking at the screen you can see that it is divided into a number of distinct areas. Down the left side of the screen are a number of small areas with differing functions. Starting at the top these are:

1. **Time:** This shows how long the scenario has been running for.
2. **Current wind:** A pictorial representation of the strength and direction of the wind.
3. **Forecast:** Shows the expected time of any forecast wind changes
4. **Forecast wind:** A pictorial representation of the expected strength and direction of the wind following the change.
5. **Map Navigator:** You will not use this in the current scenario. Normally it shows what part of the map is visible in the main map window.
6. **Score:** This shows a weighted average of the amount of saveable landscape left unburnt.

To the right of the score box are 2 unlabelled boxes, which together run the length of the screen. These are:

1. **Co-ordinates:** the small box immediately to the right of the score shows the current location in the map window of the cursor.
2. **Message box:** Running from the co-ordinate box, completely across the screen is the message box, where information updates are displayed. Information about the status of appliances is sent by the computer or can be accessed by holding the cursor over an appliance during the scenario.

Below this there are several areas indicating the status of the system and network-which you need not worry about.

3. Wind and Fire

Now we are going to have a look at the program while it is running, in order to have a look at some features you cannot see unless it's running.

Looking at the top left side of the screen you can see that the **time** has started counting.

Immediately below is the **wind** icon, consisting of a blue outer circle, indicating current wind strength, and a red line indicating the direction the wind is blowing. Fires will spread faster in the direction of the wind.

Below the current wind is a forecast. This gives the time at which the wind is expected to change. Below this is the **forecast wind** icon- a shadowed version of the current wind forecast. It shows the expected strength and direction after the forecast change. If there is no change expected both boxes will be empty. However wind changes are not always forecast, and may be unpredicted.

If you look at the landscape areas you will see a small fire has started in each of them. The fire is represented by the small red squares overlaying the landscape being burnt. Once a square of landscape has been destroyed it turns black. Watch the fires burn for a while. Note how the advance at different rates in the direction the wind is blowing.

4. Fighting fires

(Demonstrate while explaining)

Before starting to fight the fires, you need to see how appliances react to commands. Both types of appliance are controlled in the same way- using the mouse to click and drag. You will see that as the cursor is placed over an appliance the cursor becomes a hand, and the appliances details appear in the message box.

Basic Commands

Left-clicking while over an appliance activates it (which means it will scan for fires around its perimeter, and start fighting any that are detected). If you left click and release it is activated without being moved. If no fires are detected it will switch itself off again.

Generally you will want to **left-click and drag** the appliance to where you want it to fight fires. Before releasing the button. This creates a destination marker (a purple square outline) that you want to place where you want the appliance to go. Again, upon arriving, the appliance will scan for fires. When placing an appliance near a fire you should endeavour to place it either on top of a fire square, or directly adjacent to one- otherwise it will deactivate and even if a fire subsequently approaches it will not activate until instructed. If an appliance is moved to or activated near a burning square it will automatically start to fight the fire until it is extinguished. It will then scan for more fire in its immediate vicinity and respond accordingly. While fighting, both appliances flash blue around the edges- if an appliance isn't flashing it isn't working.

As appliances fight they use water- as can be seen, if you hold the cursor over a working appliance. Its % of water is reduced each time it extinguishes a square. When this reaches 0%, the appliance can no longer fight and needs to be refilled. At this point a message will be (briefly) flashed in the message box giving the appliance number, type and location and saying it is out of water.

Refilling an appliance is as easy as **left-clicking and dragging** it to a water square. The appliance will automatically refill and return to its prior position (not it's initial location).

Right-clicking on an appliance returns it to its **initial position**- i.e. Where it was at the beginning of the scenario.

So far the commands have applied to both types of appliances. However, the burn-off commands only apply to the fire trucks.

Burning off a square prevents fire from passing through there. A series of such squares therefore constitutes a fire break. Only clearing can be burnt off to make firebreaks.

Attempting to do so in any other landscape will ignite a new fire. To burn off hold down the control (Ctrl) key and left click.

Ctrl+ left click causes the fire truck to burn the square it is on, turning it a grey colour to indicate that it has been so treated.

Ctrl+ left click and drag creates a destination marker which can be moved from anywhere on the screen. The fire truck will then burn off every square, starting from the one it is on, in a straight line to the destination marker. While a fire truck is burning off it flashes white around the edges to indicate it is working.

Redirecting Appliances

If you need to redirect an appliance that is in transit, all you need to do is **left click on the destination marker and drag** it to the desired location. If you are redirecting a fire truck that is burning off you will need to hold down Ctrl while redirecting the appliance.

Stopping Appliances

To stop a moving appliance, simply **left click on its destination marker**. It should stop where it is. If it does not you may not have deactivated the destination marker. This is the case if the destination marker is still visible, in which case try left-clicking on it again, until it disappears.

The same applies to stopping a fire truck that is **burning off**. Just hold down **Ctrl and left-click on it's destination marker**.

Stopping an **appliance that is fighting a fire** is very similar. Simply **left click on the appliance itself**. It will then finish the square it is currently fighting before deactivating. This can take several seconds. Holding the cursor over the appliance itself will tell you whether it has been deactivated or not.

If it is in **automatic** mode then it will continue fighting.

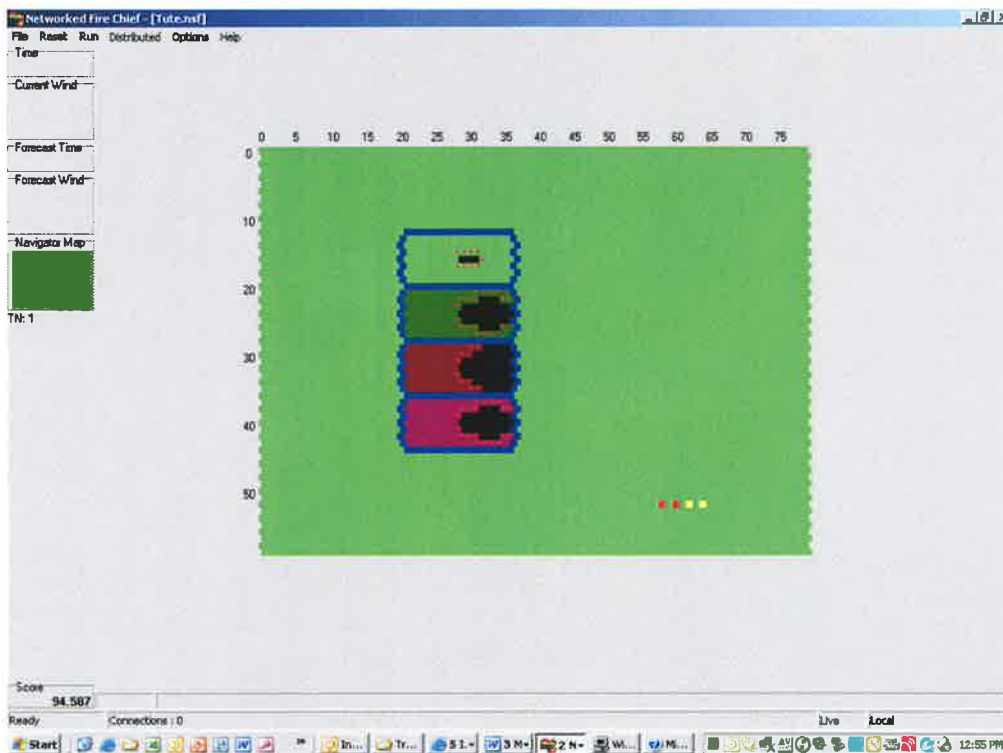
If it is in **manual** mode then it will stop after the current square.

Do you have any questions?

Familiarisation

Will you please try to do the following actions:

- Activate an appliance
- Move an appliance to fight a fire
- Build a fire break
- Redirect a moving appliance
- Redirect the fire break
- Deactivate an appliance the is fighting the fire
- Refill the appliance
- Return the appliances to their initial positions.



Note: This is a representation of the screen on which the participants practiced the skills learnt during the *NFC* training session.

Note: After completing the *NFC* training session move onto:

1. *NFC* post-tutorial quiz
2. Mouse tutorial

Appendix XXVIII: Study 4- NFC Post Tutorial Quiz

1. Name the four landscape types (and their corresponding colours) in order of priority/value.

1. _____.

2. _____.

3. _____.

4. _____.

2. What colour are the squares representing fire trucks and helicopters respectively?

Fire truck _____.

Helicopter _____.

3. Which appliance is more efficient at fighting fires?

_____.

4. How many times can an appliance refill at a single water square before emptying it?

_____.

5. Which appliance can be used to create firebreaks?

_____.

6. The time display indicates which of the following?

(a) How long the scenario has been running.

(b) How long the scenario has left to run.

7. The red line in the wind icon indicates which of the following?

- (a) The direction the wind is blowing from.
- (b) The direction the wind is blowing to.

8. What does the inner blue circle of the wind icon represent?

_____.

9. Are wind forecasts always accurate?

_____.

10. When does the message box display information about appliance status?

_____.

11. In which direction does the fire spread the fastest?

- (a) In the direction the wind is blowing.
- (b) At right angles to the direction the wind is blowing.
- (c) In the opposite direction to which the wind is blowing.

12. Which landscape elements burn....

Fastest _____.

Slowest _____.

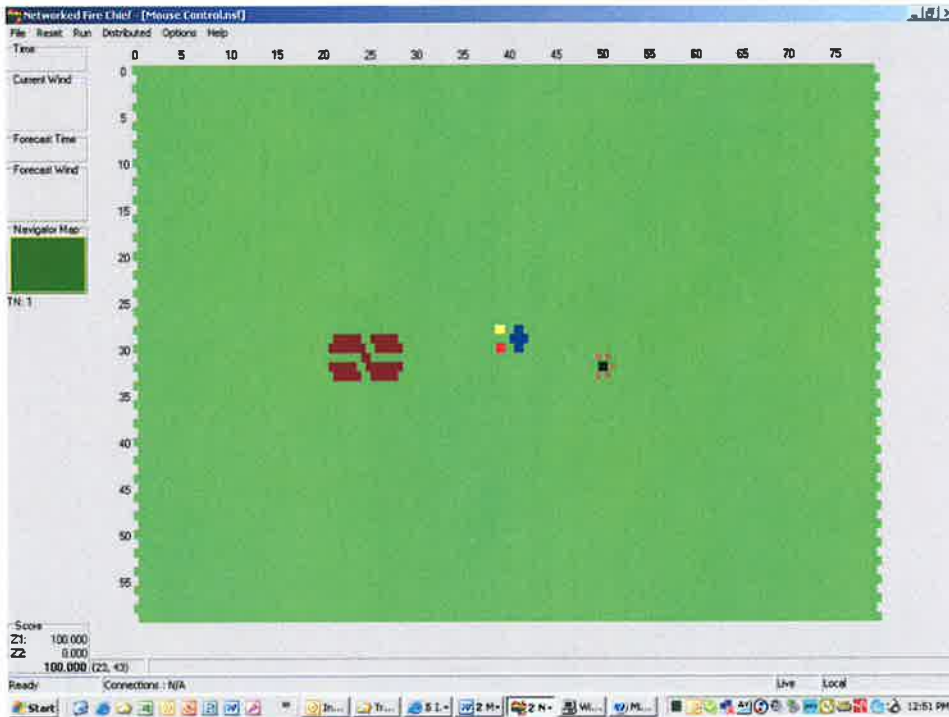
13. To activate an appliance in place you should....

- (a) Right-click it.
- (b) Left-click it.
- (c) Hold control and left-click it.
- (d) Hold control and right-click it.

14. If an appliance is left clicked and dragged to an area that is on fire, it will...
- (a) Move to the destination and then stop awaiting further orders.
 - (b) Move to the destination and then start to fight the fire.
 - (c) Burn off the area between its start point and destination.
15. When an appliance is left clicked and dragged to a water square, it will...
- (a) Move there and await further orders.
 - (b) Move there refill and then stop in place.
 - (c) Move there, refill and then return to its former position.
16. Right-clicking on an appliance...
- (a) Turns it on to fight fires where it is.
 - (b) Returns it to its starting position.
 - (c) Burns off the square it is currently on.
17. To redirect a moving appliance, you need to...
- (a) Left-click on the appliance and drag it to its new location.
 - (b) Left click on the appliance's destination marker and drag that to a new destination.
 - (c) Right-click on the appliance and drag it to a new location.
 - (d) Right click on the appliance's destination marker and drag that to a new destination.
18. How do you stop a moving appliance in place?
- _____.
19. If the appliance were making a firebreak what would you do?
- _____.

20. If an appliance has been redirected, it will...
- (a) Move to where the destination marker was and from there to the new destination marker.
 - (b) Move from wherever it currently is to the new destination marker.
21. If you left-click on an appliance that is fighting a fire it will...
- (a) Continue fighting the fire
 - (b) Stop immediately.
 - (c) Stop after extinguishing the square it is currently fighting.
22. How can you tell whether an appliance is active?
- (a) Active appliances flash around the edges or are moving.
 - (b) By holding the cursor over it and reading the message displayed in the message box.
 - (c) Both (a) and (b).
23. If an appliance is in manual mode have you successfully deactivated it?
-
24. Which landscape element/s may be burnt off to create firebreaks?
-

Appendix XXIX: Study 4- NFC Mouse Tutorial



You must:

- 1) Extinguish the fire
- 2) Make 2 firebreaks through the pastures (without setting the pastures on fire)

In a time limit of 2 minutes.

Appendix XXX: Study 4- Equivalency of Scenarios Constructed for use on NFC

Scenario Number	Expert Performance Score		
	First Attempt	Second Attempt	Average
1	95.7	96.1	95.90
2	96.5	95.7	96.10
3	96.9	96.2	96.55
4	95.8	96.1	95.95
5	96.4	96.8	96.60

Note: Scores generated by an expert NFC user.

Appendix XXXI: Study 4- NFC Behavioural Checklist

	Fire	Land type	Speed Measures						Accuracy Measures				Monitoring Behaviours				Proactive Measures		
			Time taken to allocate appliances	Time taken for appliance to reach fire	Helicopter sent first (if available)	Closest Appliance used to fight fire	Time taken to extinguish fire	Wind direction is considered in placement	Appliance allocation ratio.	Delay in adjusting for wind change (secs)	Spread of fire into crucial land considered	Land priority considered	Land priority not considered	Refilling is done	Refilling is done nearby	Idle while fighting fire (secs)	Use of fire break	Area burnt off using fire breaks	Resources kept in proximity of crucial land.
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
Total:																			

Appendix XXXII: Study 4- Defining Observable Skills on *NFC*

Defining Observable Skills:

1. *Speed Measures*

Time taken to recognise fire- The time between the fire breaking out and the participant allocating an appliance anywhere around that fire (ie. The destination marker appears within two squares of the perimeter of the fire).

Time taken to begin fighting a fire – The time between allocation of an appliance and extinguishing of a fire. This measure helps to indicate the spread of appliances around the screen., and the proximity of appliances to fire locations.

Helicopter sent first - If one is available and not involved or becoming involved in fighting a higher priority fire, and it is the quickest response unit to that fire, it is sent first to a new fire.

Closest appliance sent first – This is a measure of whether the participant uses the closest appliance

This is measured as the number of squares the appliance must move to reach the fire divided by the speed of the appliance. This takes into account that helicopters move 2 times as fast as fire trucks.

Time taken to extinguish the fire – A measure of the time from when the first appliance arrives at the fire until the fire is extinguished.

2. Accuracy Measures

Wind direction considered when initially allocating appliance- The appliance is positioned on the front of the fire. The number of squares away from ideal placement are counted and act as a measure of accuracy of placement. The smaller the number the more accurate the placement.

Ratio of appliances to fire - This is measured by looking at number of appliances compared with squares of fire as a ratio. This is measured at initial placement of appliances to a fire and when any extra appliances are added to the fire fighting team. A reasonable estimation is five fire squares to 1 appliance.

Delay between change in wind direction and correcting appliances positions- The time taken to reposition appliances on the appropriate front after a wind change. This only applies when there is a fire present, spreading in the direction of the new wind direction

*Spread of fires into crucial land considered –*In the case that one side of the fire is within one square of the boundary of more critical land (i.e. A clearing fire on the boundary of pastures) appliance/s should be placed to prevent fire spreading into the critical land. If an appliance is placed on the side of the fire closest to high priority land (whether the wind is blowing in that direction or not) a frequency count of this behaviour is taken.

3. Monitoring Behaviours

Land priority considered - In the case of fires this means that the fire involving higher priority land will be attended to more quickly. This is a frequency count and results in a percentage score for each fire responded to

Appliance refilled - Number of times appliances are refilled with water during the scenario.

Appliance refilled nearby – Appliance is refilled within the nearest ten squares of water available.

(if returning to its same position)

4. Proactive Measures

Use of fire breaks- The number of fire breaks made.

Size of fire breaks- the number of landscape squares firebreaks cover burnt to make firebreaks.

Resources kept in proximity of important land – Resources not currently involved in fighting fires are spread over the map, near high priority land. This is measured after the fires have been extinguished, or when there are idle standby appliances.

Appendix XXXIII: Study 4- *NFC* Semi-structured Interview Questions

Note: Replay critical decision point from scenario

Questions to ask:

1. Can you describe this situation to me?
2. What was the decision that you made?
3. What were the elements that you took into account when making this decision?
4. Did the decision feel intuitive?
5. Do you feel that you were able to draw on any of your experience in order to assist in your decision?
6. Did you think about using firebreaks? Why/ why not?
7. How did you decide to position your vehicles?
8. Do you have any regrets?

Appendix XXXIV: Study 4- Definitions for *NFC* Interview Coding

Factor	Category Label	
<i>Speed</i>	Tool usage	Any time the participant talks about consideration of tool usage as a factor of decision-making
<i>Accuracy</i>	Spatial awareness	Any time the participant talks about where things are on the NFC screen in relation to each other as a factor built into decision-making.
	Specialised knowledge (environmental)	Any time the participant talks about using their knowledge of the NFC environment (its constants and rules)
<i>Efficiency</i>	Situation assessment	Any time the participant talks about surveying the scene to better understand the current situation
<i>Proactive Measures</i>	Planning	Any time the participant talks about planning for the future (e.g. build firebreak or position/refill appliance)
<i>Other</i>	Other Performance skills	Any time the participant talks about any other skill that they used that impacted on their performance
	Self correction	Any time the participant talks about how they changed what they were doing (or would change) because recognising that it was not optimal.
	Problem/mistake	Any time the participant talks about something they did that they regretted.

Appendix XXXV: Study 4- NFC Post Trial Questionnaire

Networked Fire Chief



Expertise Interview

Demographic Information

Participant No: _____

Age: _____

Occupation: _____

Gender: _____

Trial: _____

Cognitive Modelling (*done in conjunction with replay function*)

Situation with land priority decision.

1. Can you help to fill in a model of the cognitive events surrounding this decision? (Refer to the example provided)

2. Do you feel that you made this decision without having adequate information?

Yes No (*Please circle appropriate response*)

If so, what more information would have been desirable?

Information Criticality

1. Thinking back to the trial you have just completed, I want you to rank the following list of information from most important (1) to least important (8).

_____ Water levels left in the appliance

_____ Water capacity of appliance

_____ Distance of appliance from fire

_____ Distance of fire from a water source

_____ Speed of the appliance

_____ Wind direction

_____ Land priority

_____ Burn rates of the various land types

Why did you rank them in this order?

Decision Evaluation

1. Thinking back again to the trial, do you remember making a decision that you regretted in hindsight?

Yes No *(Please circle appropriate response)*

If so, what was it?

Do you consider the decision was critical in that the wrong choice resulted in a situation that was difficult to manage?

Yes No *(Please circle appropriate response)*

Can you describe the cues that led you to make this decision?

What was the outcome?

Pro-active Measures

1. Did you use firebreaks in the current scenario?

Yes No (Please circle appropriate response)

How often did you use them?

1	2	3	4	5
never	occasionally	half of the time	frequently	always

If so, what was it that led you to use them?

Do you feel that they were effective?

Yes No *(Please circle appropriate response)*

Why? _____

Did you strategically position your vehicles not actively involved in fire fighting?

Yes No *(Please circle appropriate response)*

How often did you do this?

1	2	3	4	5
_____	_____	_____	_____	_____
never	occasionally	half of the time	frequently	always

Do you believe that you positioned them well?

Yes No *(Please circle appropriate response)*

Why? _____



Thank you for filling in the questionnaire above

Appendix XXXVI: Study 4- Reliability Calculations for *NFC* Behavioural and Interview Coding

Interview Coding	Total Coded	Agree	Disagree	PA
Spatial awareness	11	11	1	1.0000
Planning	9	9	0	1.0000
Tools	8	7	1	0.8750
Situation awareness	4	3	1	0.7500
Performance skills	4	2	2	0.5000
Self correction	4	4	0	1.0000
Problem/mistake	4	3	1	0.7500
Specialised knowledge	6	5	1	0.8333
				0.8385

Behavioural Coding	Check 1		Check 2		Check 3		Check 4	
	Disagree	Agree	Disagree	Agree	Disagree	Agree	Disagree	Agree
Quantity measures								
Time taken to allocate appliances	3.8	96.2	7.9	92.1	1.5	98.5	6.9	93.1
Time taken for appliance to reach the fire	4.1	95.9	8.4	91.6	7.1	92.9	1.1	98.9
Appliance allocation ratio	10.3	89.7	0.0	100.0	3.1	96.9	8.8	91.2
Idle while fighting fires	2.67	97.33	8.0	92.0	10.0	90.0	10.0	90.0
Area of fire break	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0
'Yes or No' measures								
Helicopter sent first	1.0	5.0	1.0	4.0	1.0	6.0	1.0	7.0
Closest appliance sent first	2.0	4.0	1.0	4.0	0.0	7.0	3.0	4.0
Wind direction considered in placement	2.0	4.0	0.0	5.0	0.0	6.0	3.0	5.0
Spread into crucial land considered	1.0	5.0	0.0	4.0	2.0	5.0	7.0	1.0
Land priority considered	0.0	5.0	0.0	5.0	2.0	4.0	4.0	4.0
Refilling done nearby	1.0	3.0	0.0	2.0	0.0	4.0	3.0	5.0
Use of fire break	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
Resources kept in proximity of crucial land	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0

Note: Those behaviours requiring a quantity to be recorded (rather than a 'yes or no') were compared between raters, and the proportion of difference between rater 1 (author) and rater 2 was recorded (e.g. If overall there was a discrepancy between raters of 10 seconds out of a total of 100 seconds (rated by the author), then the proportion of disagreement would be 10/100=10%).

Behavioural Coding	Check 5		Check 6		Check 7		Check 8	
	Disagree	Agree	Disagree	Agree	Disagree	Agree	Disagree	Agree
Quantity measures								
Time taken to allocate appliances	15.2	84.8	8.1	91.9	4.3	95.7	9.9	90.1
Time taken for appliance to reach the fire	11.1	88.9	22.2	77.8	11.6	88.4	5.3	94.7
Appliance allocation ratio	7.2	92.8	6.9	93.1	9.5	90.5	6.3	93.7
Idle while fighting fires	10.0	90.0	8.0	92.0	7.1	92.9	7.1	92.9
Area of fire break	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0
Yes or No' measures								
Helicopter sent first	2.0	5.0	1.0	5.0	2.0	4.0	4.0	3.0
Closest appliance sent first	3.0	5.0	3.0	3.0	0.0	6.0	2.0	5.0
Wind direction considered in placement	3.0	5.0	2.0	4.0	2.0	4.0	2.0	5.0
Spread into crucial land considered	3.0	4.0	2.0	4.0	0.0	5.0	0.0	7.0
Land priority considered	4.0	4.0	2.0	4.0	0.0	6.0	0.0	5.0
Refilling done nearby	2.0	2.0	2.0	2.0	0.0	3.0	1.0	6.0
Use of fire break	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
Resources kept in proximity of crucial land	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0

Behavioural Coding	TOTAL		Reliability Score
	Disagree	Agree	
Quantity measures			
Time taken to allocate appliances	6.40	82.49	0.82
Time taken for appliance to reach the fire	7.88	81.01	0.81
Appliance allocation ratio	5.79	83.10	0.83
Idle while fighting fires	6.99	81.90	0.82
Area of fire break	0.00	88.89	0.89
Yes or No' measures			
Helicopter sent first	13.00	39.00	0.75
Closest appliance sent first	14.00	38.00	0.73
Wind direction considered in placement	14.00	38.00	0.73
Spread into crucial land considered	15.00	35.00	0.70
Land priority considered	12.00	37.00	0.76
Refilling done nearby	9.00	27.00	0.75
Use of fire break	0.00	8.00	1.00
Resources kept in proximity of crucial land	0.00	8.00	1.00
			0.81