STUDIES FOR THE DEVELOPMENT OF EFFECTIVE LUCID DREAM INDUCTION TECHNIQUES

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Abstract

Lucid dreams are dreams in which the dreamer is aware that they are dreaming while the dream is still happening. Lucid dreaming has a wide range of potential benefits and applications in areas such as: scientific dream research; the treatment of nightmares; improvement of skills through rehearsal in the lucid dream environment; recreation; and, the use of lucid dreaming for problem solving and creative inspiration. Lucid dreaming is a learnable skill, and numerous lucid dream induction techniques have been developed. However, none of these techniques have been shown to be highly effective or reliable. The existing empirical literature on lucid dream induction suffers a wide range of limitations. Most studies have poor external validity and are based on small sample sizes consisting of self-selected lucid dreamers or university students. Other common issues include lack of random allocation to conditions, invalid or unreliable outcome measures, inconsistent operationalisation of lucid dreaming rates, and failure to measure variables that operationalise the way in which lucid dream induction techniques were practised. The lack of effective and reliable lucid dream induction techniques is the greatest obstacle to further research on lucid dreaming. Accordingly, the primary objective of the present thesis was to address this issue and conduct methodologically rigorous experimental research on lucid dream induction.

The thesis begins with five chapters that provide background information on lucid dreaming. Chapter 1 provides a general introduction and overview of the thesis. Chapter 2 reviews developments in the history of lucid dreaming. Chapter 3 provides an overview of the phenomenology of lucid dreams. Chapter 4 reviews research on psychophysiological correlates of actions and experiences in lucid dreams. Chapter 5 provides a discussion of potential benefits and applications of lucid dreaming.

Chapters 6, 7, 8, 9, and 10 present original research in the form of manuscripts that have been prepared for, submitted to or published by peer-reviewed academic journals. Chapter 6 presents a published review paper that investigated psychometric issues related to the tendency for retrospective measures of dream recall to yield substantially lower dream recall rates than logbook measures. Chapter 7 presents a published empirical study that addressed a range of psychometric issues raised in Chapter 6. Chapter 8 presents findings from a large experimental study (N = 169) on lucid dream induction; the National Australian Lucid Dream Induction Study (NALDIS). In this study, the *Mnemonic Induction of Lucid Dreams* (MILD) technique was shown to be effective for inducing lucid dreams. *Reality testing* was not shown to be effective. Chapter 9 presents findings from an extension of the NALDIS that investigated a novel lucid dream induction technique; the *Senses Initiated Lucid Dream* (SSILD) technique. Findings indicated that this technique was effective for

inducing lucid dreams. Chapter 10 presents findings from a randomised, double-blind, placebo-controlled experiment (*N* = 100) that investigated the effects of B vitamins on sleep and dreaming. Findings indicated that vitamin B6 supplementation before bed significantly increased the amount of dream content recalled. The thesis concludes with a general discussion in Chapter 11.

Declaration

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Chapter 1: General Introduction and Overview of Thesis

A lucid dream is a dream in which the dreamer is aware that they are dreaming while the dream is still happening (LaBerge, 1985). Lucid dreams are usually experienced from the first person perspective and involve vivid and highly integrated hallucinated perceptions in all the sensory modalities (LaBerge & DeGracia, 2000). The full range of possible human emotions can be experienced, and lucid dreams are usually reported as extremely realistic (LaBerge & Rheingold, 1991; Love, 2013). References to lucid dreaming can be found from over 2000 years ago (LaBerge, 1985). However, it was not until 1975 that the phenomenon was confirmed empirically. This was achieved by Hearne (1978) with the help of a proficient lucid dreamer, who was able to signal from within a lucid dream using pre-arranged left-right eye movements. Several of these eye movement signals were recorded using electrooculography (EOG). These signals all occurred during unambiguous REM sleep and corresponded with reports of lucid dreaming provided by the participant upon waking. This was achieved independently in research by LaBerge (1980), and numerous other studies have since replicated these findings (e.g. Dane, 1984; Fenwick et al., 1984; Ogilvie, Hunt, Tyson, Lucescu, & Jeakins, 1982; Tholey, 1983).

Several large surveys indicate that the prevalence of lucid dreaming (i.e. the proportion of people that have experienced at least one lucid dream) is approximately one quarter to one half of the general population. Stepansky et al. (1998) found a prevalence of 26% in a large survey (*N* = 1000) of people randomly selected from an Austrian electoral register, and Schredl and Erlacher (2011) found a prevalence of 51% in a large German survey (*N* = 919). In the latter, it was found that 20% of the population were frequent lucid dreamers according to Snyder and Gackenbach's (1988) criterion of having one or more lucid dream per month. In an earlier survey by Palmer (1979) a prevalence of 55% was observed among 357 American adults randomly chosen from a telephone directory. Blackmore (1984) observed a prevalence of 47% among 321 adults in the Netherlands randomly selected from an electoral register. The prevalence of lucid dreaming is typically greater among psychology students and has been found to range from 47% to 92% in various countries (Netherlands, 73%, Blackmore, 1982; Japan, 47%, Erlacher, Schredl, Watanabe, Yamana, & Gantzert, 2008; US, 71%, Palmer, 1979; Germany, 82%, Schredl & Erlacher, 2004; China, 92%, Yu, 2008). The prevalence of frequent lucid dreamers (one or more lucid dream per month) in student samples has been shown to range from 17% to 38% (Netherlands, 38%, Blackmore, 1982; Japan, 17%, Erlacher et al., 2008; US, 29%, Palmer, 1979; Germany, 36%, Schredl & Erlacher, 2004; China, 17%, Yu, 2008). In a recently published meta-analysis, Saunders, Roe, Smith and Clegg (2016) found an estimated mean lucid dreaming prevalence of 55% (based on data from 34 studies), and an estimated mean frequent lucid dreamer prevalence of 23% (based on data from 25 studies).

Lucid dreaming is a learnable skill, and a wide range of techniques for inducing lucid dreams have been developed (LaBerge & Rheingold, 1991; Love, 2013; Stumbrys, Erlacher, Schädlich, & Schredl, 2012; Tholey, 1983). Following the empirical confirmation of lucid dreaming in 1975, numerous empirical studies on lucid dream induction have been conducted. However, none of the techniques studied have been shown to be highly effective or reliable. Furthermore, the empirical literature on lucid dream induction suffers a wide range of limitations. In a recent systematic review of 35 lucid dream induction studies by Stumbrys et al. (2012), the majority of studies (60%) were classified as poor quality according to a methodological quality checklist developed by Downs and Black (1998), with the rest (40%) classified as moderate quality and none classified as high quality. Most studies were either unpublished Ph.D. dissertations or were otherwise not published in academic journals. All of the studies included in the review showed poor external validity, with participants mostly consisting of self-selected lucid dream enthusiasts or university students. Other common issues included insufficient statistical power due to small sample sizes, lack of random allocation, invalid or unreliable outcome measures, inconsistent operationalisation of lucid dreaming rates, and failure to measure variables that operationalise the way in which techniques were practised (e.g. number of technique repetitions).

Lucid dreaming has a wide range of potential benefits and applications. This includes applications in scientific dream research, the use of lucid dreaming for treating nightmares, improvement of skills through rehearsal in the lucid dream environment, lucid dream recreation for people who are limited in their ability to have enjoyable experiences while awake (e.g. due to disability or remote work locations), and the use of lucid dreaming for problem solving and creative inspiration. However, research on the potential benefits and applications of lucid dreaming has been limited by the lack of effective and reliable lucid dream induction techniques. Despite this being the greatest obstacle to further research, scientific interest in lucid dream induction has waned in recent decades. Following the empirical confirmation of lucid dreaming in 1975, 16 studies on lucid dream induction were published in the 1980s, 15 in the 1990s, only four in the 2000s and only three since 2010. As a result, until more effective and reliable lucid dream induction techniques are developed, lucid dreaming will remain highly inaccessible to those who might benefit from its many potential applications. The primary objective of the present thesis was to address this issue and conduct methodologically rigorous experimental research on lucid dream induction.

The thesis begins with five chapters that provide background information on lucid dreaming. Following the present general introduction and overview, Chapter 2 provides an overview of developments in the history of lucid dreaming, from its first mention in the writings of Aristotle up until the empirical confirmation of lucid dreaming in 1975. Chapter 3 provides an overview of the phenomenology of lucid dreams. Topics discussed include perceptual environments, perceptual experiences in individual sensory modalities, emotion, cognitive abilities, volitional action, behaviour and abilities of dream characters (i.e. representations of people, animals, etc.), duration of lucid dreams, and the ways in which lucid dreams can come to an end. Chapter 4 reviews research on psychophysiological correlates of actions and experiences in lucid dreams. Topics discussed include time perception in dreams and the physiological effects of simple and complex movements, respiratory and verbal behaviour, and sexual activity in lucid dreams. Chapter 5 draws upon research reviewed in Chapters 3 and 4 to provide a discussion of potential benefits and applications of lucid dreaming in the following areas: scientific dream research, treatment of nightmares, skill rehearsal, recreation, problem solving, and creative inspiration. Chapters 6, 7, 8, 9 and 10 present original research in the form of manuscripts that have been prepared for, submitted to or published by peer-reviewed academic journals. Some of the most promising and widely studied approaches to lucid dream induction are discussed in Chapters 8 and 9. However, a comprehensive review of lucid dream induction studies is not provided. This is because a systematic review of lucid dream induction studies has recently been published, and there has been little development in the field since. For a comprehensive review of lucid dream induction studies and techniques, see Stumbrys et al. (2012).

The relationship between lucid dreaming and general dream recall is one of the most robust relationships observed in the empirical lucid dreaming literature (see Erlacher, Schädlich, Stumbrys, & Schredl, 2014), and it is often recommended that novice lucid dreamers should work on improving their dream recall ability before attempting lucid dream induction techniques (e.g. LaBerge & Rheingold, 1991; Love, 2013). However, while reviewing the empirical literature on measures of general dream recall in preparation for conducting research on lucid dream induction, it became apparent to the present author that retrospective measures of dream recall (which involve estimating dream recall retrospectively) typically yield substantially lower dream recall rates than logbook measures (which involve recording one's dream recall each morning using a logbook). This raised important questions about the validity of retrospective and logbook measures of dream recall. Therefore, before conducting research on lucid dream induction, the present author conducted an extensive literature review on the measurement of dream recall. This formed the basis of the published review paper presented in Chapter 6. A range of psychometric issues were discussed, and recommendations for further research were provided.

Before proceeding with research on lucid dream induction, the present author considered it essential to address questions regarding the valid measurement of dream recall raised in the review paper presented in Chapter 6. Chapter 7 presents a published experimental study that followed up on recommendations for research provided in the review paper. This study was incorporated into the larger lucid dream induction study presented in Chapter 8, and investigated differences between multiple types of retrospective and logbook measures of general dream recall and recall of nightmares, bad dreams, lucid dreams and flying dreams. This study also included a novel measure of general dream recall developed by the present author, based on an earlier measure developed by Reed (1973). The measure operationalises dream recall as *Dream Quantity* (DQ) and assesses the amount of content recalled from each individual dream. A range of recommendations to the field for the use of retrospective and logbook measures of dream recall were provided.

Chapter 8 presents findings from a large experimental study on lucid dream induction; the National Australian Lucid Dream Induction Study (NALDIS). This study investigated two of the most promising and widely studied lucid dream induction techniques: *Reality testing* (LaBerge & Rheingold, 1991; Tholey, 1983) and the *Mnemonic Induction of Lucid Dreams* (MILD) technique (LaBerge, 1980; LaBerge & Rheingold, 1991). The NALDIS generated substantial media interest, including two nationally televised TV interviews with the present author and numerous radio interviews and news articles. This assisted with the recruitment of a highly diverse sample of participants (*N* = 169) from across Australia who completed a pre-test questionnaire, provided baseline logbook data during Week 1, and then practised a lucid dream induction technique during Week 2. Results indicated that the MILD technique was effective for lucid dream induction.

Chapter 9 presents findings from an extension of the NALDIS that investigated a novel lucid dream induction technique known as the *Senses Initiated Lucid Dream* (SSILD) technique (the double "S" in the acronym is intentional). Participants were 21 people who agreed to participate in a trial of an additional technique after completing the NALDIS. Results indicated that the SSILD technique was effective for inducing lucid dreams.

As discussed in the manuscripts presented in Chapters 8 and 9, a promising future direction for lucid dream induction is the combination of techniques such as MILD and SSILD with the use of drugs and supplements that enhance dreaming. Chapter 10 presents findings from a randomised, double-blind, placebo-controlled experiment that replicates a small pilot study (*N* = 12) by Ebben, Lequerica and Spielman (2002), in which supplementation with vitamin B6 (pyridoxine hydrochloride) directly before bed significantly increased the colour, vividness, emotionality and bizarreness of dreams. A highly diverse sample of 100 participants from across Australia participated. Participants were randomly allocated to one of three conditions that involved ingesting either 240mg of vitamin B6 (pyridoxine hydrochloride), a B complex preparation including a range of B vitamins, or a placebo.

Results indicated that participants in the vitamin B6 group recalled significantly more dream content than participants in the placebo group.

The manuscripts presented in Chapters 6, 7, 8, 9 and 10 are identical to those that have been prepared for, submitted to or published by peer-reviewed academic journals with only minor exceptions. Specifically, the numberings of headings, Tables and Figures have been changed for consistency with the overall structure of the present thesis, and references to additional content included in the Appendices of the present thesis have been included. The manuscripts presented in Chapters 9 and 10 have not yet been submitted to peer review journals because they refer to the as-yet unpublished manuscript for the NALDIS presented in Chapter 8. Therefore, references to the NALDIS in Chapters 9 and 10 appear as "Chapter 8" in the present thesis. Because the manuscripts are presented as prepared for peer-reviewed journals, there is some duplication of content between chapters. Note also that although UK English spelling is used throughout the thesis, American English spelling has been used in the manuscripts presented in Chapters 8 and 9 as per the requirements of the journals they have been prepared for. The thesis concludes with a general discussion of the research presented in Chapters 6, 7, 8, 9 and 10 and a discussion of future directions for research in Chapter 11. Ethics approvals, copies of experiment and promotional materials, and published versions of manuscripts are provided in the Appendices.

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Chapter 2: Historical Overview of Lucid Dreaming

2.1 Overview

The present chapter provides a brief historical overview of lucid dreaming. It begins with a review of early references to lucid dreaming that can be found prior to the 19th century. A brief overview of lucid dreaming in Eastern spiritual traditions is then provided. Modern developments in lucid dreaming are then reviewed in chronological order, organised according to major contributors to the field. The chapter ends with a brief overview of developments in lucid dream research that occurred following the empirical confirmation of lucid dreaming as a genuine phenomenon in 1975.

2.2 Early references to lucid dreaming

References to lucid dreams in Western literature are scarce prior to the mid-nineteenth century. The earliest known references to lucid dreaming can be found in the writings of Aristotle. For example, in his *Treatise on Dreams* written in the fourth century B.C.E., Aristotle wrote that "often when one is asleep, there is something in consciousness which declares that what then presents itself is but a dream" (Aristotle, in LaBerge, 1985, p. 21). This reference suggests that lucid dreaming may have been known to the ancient Greeks. However, they seem to have left no reports of actual lucid dreams and it is unclear what significance lucid dreaming might have had to them.

The earliest known account of a lucid dream is in a letter written in 415 C.E. by the influential philosopher and theologian St Augustine (Kelsey, 1974). In this letter he described two dreams of a physician named Gennadius while exploring the question of how the deceased might perceive the afterlife when the physical senses of the body have ceased to function. In the first dream, Gennadius was greeted by a mysterious young man and led into a heavenly city. Gennadius could hear beautiful music unlike anything he had heard before and was told by the youth that it was the hymn of the blessed and holy. Upon waking, Gennadius dismissed this as a mere dream and thought little more of it. However, in his sleep the following night he was again greeted by the youth, who proceeded to ask him a series of philosophical questions. He asked Gennadius whether he recognised him, to which Gennadius replied that he did. The youth asked Gennadius to describe where he recognised him from, and Gennadius recounted the events of the previous dream. The youth then told Gennadius that he was again seeing whilst in a dream, leading Gennadius to the realisation that he was dreaming. Thus, we have what may be the first written account of a lucid dream. The rest of the dream involved more questions prompting Gennadius to consider how he was able to see while dreaming when his body was in a different place and his physical eyes were closed. Ultimately, Gennadius became convinced of the existence of an afterlife and that the senses of the physical body are not necessary to perceive it.

Approximately 800 years later, the 12th century Spanish Sufi teacher Ibn El-Arabi known as "the Greatest Master" in the Arab world stated that "a person must control his thoughts in a dream" (Shah, 1964, p. 141). He appears to have held lucid dreaming in high regard and advised that "The training of this alertness will produce great benefits for the individual. Everyone should apply himself to the attainment of this ability of such great value" (p. 141). A century later, the influential Italian theologian and philosopher St Thomas Aquinas also made reference to lucid dreaming when discussing Aristotle's writings on the subject. Aquinas stated that lucid dreams occur especially "towards the end of sleep, in sober man and in those that are gifted with a strong imagination" (Aquinas, 1947, p. 430). Furthermore, he wrote that "not only does the imagination retain its freedom, but also the common sense is partly freed; so that sometimes while asleep a man may judge that what he sees is a dream" (p. 430). Several other references to lucid dreaming can be found in the centuries following Aquinas. However, many of these are vague or ambiguous, and it wasn't until 1867 that lucid dreaming was given its first in-depth treatment in the West.

2.3 Lucid dreaming and Eastern spiritual traditions

Lucid dreaming has been a central feature of some Eastern systems of spirituality for many centuries. Lucid dreaming is of particular importance in *Tibetan dream yoga*, a set of spiritual teachings and practices that were passed down from the Indian Tantric Buddhist teacher Naropa in the tenth or eleventh century C.E. (Evans-Wentz, 1935; Gillespie, 1988). Tibetan dream yoga is heavily based on Buddhist metaphysics and esoteric notions about the mind and body, which makes many of the practices highly inaccessible to the uninitiated. For example, some of the practices involve meditating on certain symbols or sounds that are of spiritual significance, or focussing one's awareness on imagined dots of various colours and in various places in the body while falling asleep. Once proficient at inducing lucid dreams, practitioners engage in formal concentrative meditation within the lucid dream environment and also develop a high degree of control over their lucid dreams. For example, practitioners learn to transform small things into larger things, hot things into cold things and single things into multiple things. In so doing, practitioners are said to accumulate experiences that help them gain a deeper realisation of the Buddhist teachings that all of reality is transient, illusory and mentally constructed. Much has been written about Tibetan dream yoga, but this is beyond the scope of the present chapter due to its esoteric nature and minimal influence on modern lucid dreaming research. The interested reader is directed to Evans-Wentz (1935) and Gillespie (1988) for more in-depth reviews.

2.4 Major contributors to modern lucid dreaming literature

2.4.1 Marquis d'Hervey de Saint-Denys

Lucid dreaming made its first substantial appearance in the West with the publication of *Les rêves et les moyens de les diriger; Observations pratiques* (Dreams and how to guide them; Practical observations) by Marquis d'Hervey de Saint-Denys (Saint-Denys, 1867). Indeed, and contrary to popular belief, Saint-Denys was the first to coin the term *lucid dream* (in his native language as *rêve lucide*). Saint-Denys was a distinguished oriental scholar at the College de France and had been keenly interested in dreams since his teenage years. He amassed 22 volumes detailing 1946 nights' worth of his own dreams over a period of about five years. Saint-Denys had his first lucid dream on the 207th night in this substantial record, which had such a strong impact on him that he then devoted much of his time to the subject. After six months he was having lucid dreams on approximately two out of every five nights, which increased to three out of every four nights within a year. After fifteen months he reported having lucid dreams virtually every night – very impressive given that no information on lucid dreaming was available to him. Saint-Denys's approach to lucid dreaming was highly methodical and he performed numerous experiments. For example, in one experiment he purchased a bottle of unfamiliar perfume and regularly exposed himself to its scent during his first trip to the mountainous Ardèche region of France. He was careful to lock the bottle away upon returning home so that no other associations would be formed. Then, on several occasions he asked one of his servants to sprinkle a few drops of the perfume onto his pillow while he was asleep. As predicted, he found that this caused him to dream of being in the mountains of the Ardèche region. These and many other ingenious experiments are described in his book. However, the work was never widely distributed and its impact was negligible (LaBerge, 1988). Long after its publication, Sigmund Freud claims to have been unable to obtain a copy and lucid dreaming is given no mention in the first edition of Freud's highly influential work *The Interpretation of Dreams*. However, later editions do gain a brief mention. In the second edition, Freud noted that:

> There are some people who are quite clearly aware during the night that they are asleep and dreaming and who thus seem to possess the faculty of consciously directing their dreams. If, for instance, a dreamer of this kind is dissatisfied with the turn taken by a dream, he can break it off without waking up and start it again in another direction – just as a popular dramatist may under pressure give his play a happier ending. (Freud, 1909, in LaBerge, 1988, p. 611)

It is interesting to consider whether lucid dreaming might have played a greater role in psychoanalysis and modern psychology if Saint-Denys's work had been more widely available. More recently in 1982 an abridged English version was published (Saint-Denys, 1982). However, this is also no longer in print and has become a rarity.

2.4.2 Frederik van Eeden

In 1913 the Dutch writer and psychiatrist Frederik van Eeden brought greater attention to lucid dreaming with his paper *A Study of Dreams*, published by the Society of Psychical Research (van Eeden, 1913). He provided a taxonomy of dreams that included lucid dreams, which he described as follows:

> In these lucid dreams, the re-integration of the psychic functions is so complete that the sleeper reaches a state of perfect awareness and is able to direct his attention, and to attempt different acts of free volition. Yet the sleep, as I am able confidently to state, is undisturbed, deep and refreshing. (van Eeden, 1913, p. 437)

The term *lucid dream* is often attributed to van Eeden, despite the fact that he cites the earlier work of Saint-Denys in his paper. Van Eeden made several important observations about lucid dreams, such as the possibility of experiencing the transition from the awareness of one's "dream body" to one's physical body while waking up from a lucid dream and the very high fidelity with which sensory experiences such as the taste of wine and the sensation of wetness can be simulated in lucid dreams. He also described what are now known as *false awakenings*, which is the common experience of being in a lucid dream and then dreaming of suddenly waking up – typically in one's own bed – when one is in fact still dreaming (Buzzi, 2011). False awakenings are given further consideration in Section 3.12.

1.4.3 Ouspensky

In 1931 Russian philosopher Ouspensky (1971) published a book outlining his personal experiments with lucid dreaming. He had a keen interest in altered states of consciousness and made extensive observations about his dreams in an attempt to understand their structure and origin. However, he felt that regularly thinking and writing about his dreams interfered with their content. In an attempt to address this problem he cultivated the ability to have lucid dreams, so that he could explore his dreams in real time while being careful to minimise the influence he had over them. Ouspensky used a relatively uncommon approach to lucid dream induction, which involved maintaining unbroken conscious awareness while falling asleep and then entering a lucid dream directly. This produces the type of lucid dream now known as a *Wake Induced Lucid Dream* or WILD. One of Ouspensky's contributions is that he highlighted the possibility of this approach to lucid dreaming. WILDs are described in greater detail in Section 3.3.2.

2.4.4 Alward Embury Brown

Following the publication of Ouspensky's book, Alward Embury Brown's (1936) paper *Dreams in Which the Dreamer Knows he is Asleep* was published in *The Journal of Abnormal Psychology*. At the time, many dream researchers were sceptical about lucid dreams, with some researchers arguing that they could be explained merely as instances of vivid imagination or daydreaming during brief periods of wakefulness. Brown attempted to counter this scepticism, and drew a clear distinction between lucid dreaming and daydreaming by describing several of his own lucid dreams.

2.4.5 Hugh Callaway

Lucid dreaming was again given detailed consideration in *Astral Projection: A Record of Research*, originally published in 1939 and written by English writer Hugh Callaway under the pseudonym Oliver Fox (1962). Despite the title of the book, it has a heavy focus on lucid dreaming and is in fact a portion of Callaway's personal dream journal interspersed with observations and commentaries. The book's title reveals some of the esoteric leanings of the author, who seems to have been intent on explaining his lucid dreams as instances of *Out of Body Experiences* (OBEs) rather than dreams. Notwithstanding, the book makes several important contributions, especially by drawing attention to the fact that lucid dreams often begin with the dreamer noticing some kind of anomaly within a dream. For example, Callaway's first lucid dream at the age of 16 was triggered when he noticed that the rectangular stones that made up the pavement out the front of his house had their long sides parallel to the curb, when in reality they should have been perpendicular. This led him to the realisation that he was dreaming, which he described as follows:

> Instantly, the vividness of life increased a hundredfold. Never had the sea and sky and trees shone with such glamorous beauty; even the commonplace houses seemed alive and mystically beautiful. Never had I felt so absolutely well, so clear-brained, so inexpressibly free! The sensation was exquisite beyond words. (Fox, 1962, pp. 32-33)

2.4.6 Celia Green

Several authors made references to lucid dreaming during the 1940s, 50s and 60s, but most of these references consist only of anecdotes. However, in 1968 one of the most important works in the history of lucid dreaming was published; Dr Celia Green's (1968) book *Lucid Dreams*. Green was a British psychophysical researcher and one of the founders of the Institute of Psychophysical Research. She drew upon the aforementioned works of Saint-Denys, van Eeden, Ouspensky, Brown, Callaway and several others, as well as original research conducted by the Institute of Psychophysical Research, to provide an extensive scholarly review of the existing literature on lucid dreaming. She discussed a range of topics including the nature of sensory experience and cognitive function in lucid dreams, the emotional quality of lucid dreams, and the extent to which it is possible to control lucid dreams. However, one of her greatest contributions was her suggestion that "it might be possible to train subjects, lucidly dreaming during sleep, to exercise sufficient control over some, at least, of their motor functions to signal to the experimenter" (Green, 1968, p. 130). This extends Dr Charles Tart's (1965) suggestion that it may be possible to establish two-way communication with a person while they are dreaming. As described below, later researchers successfully used this method to obtain empirical confirmation of lucid dreaming as a genuine phenomenon. It seems that Green's association with parapsychology reduced the appeal of her book among mainstream scientists and its immediate impact was minimal.

2.4.7 Carlos Castaneda

Carlos Castaneda's books went a long way to popularising lucid dreaming. His first book *The Teachings of Don Juan* (Castaneda, 1968) has sold millions of copies worldwide and was purportedly based on field work he conducted for his doctoral thesis in anthropology at UCLA. It describes a period of several years that he claims to have spent in Mexico's Sonoran desert with a Yaqui Indian shaman named Don Juan Matus, who took him on as an apprentice. Castaneda was supposedly introduced to a wide range of esoteric shamanic techniques and taken on numerous bizarre adventures into the wilderness that often involved the ingestion of mescaline-containing peyote cactus and other psychedelic plants and fungi. Castaneda also claims he was taught to have lucid dreams, which he referred to simply as *dreaming*. The weight of evidence strongly suggests that the events described were fabricated, and Castaneda has since been widely discredited (e.g. Shelburne, 1987). Notwithstanding, one of the techniques described in his third book *Journey to Ixtlan* (Castaneda, 1973) and in his ninth book *The Art of Dreaming* (Castaneda, 1993) is still widely used today as a means to induce lucid dreams. It involves examining one's hands several times per day with the hope that this action will then be repeated while dreaming. The technique helps to induce lucid dreams because very often, looking at one's hands in a dream will reveal certain anomalies (e.g. the presence of an extra finger or strange skin tone) that make it obvious to the dreamer that they are dreaming. In this way, the technique constitutes a form of *reality testing*, which is described in greater detail in Section 8.1.1.

2.4.8 Keith Hearne

Arguably the most significant event in the history of lucid dreaming was its empirical confirmation as a genuine phenomenon by Dr Keith Hearne during his doctoral research at Liverpool University (Hearne, 1978). Having read Green's (1968) book *Lucid Dreams*, Hearne reasoned that if the eye movements that characterise Rapid Eye Movement (REM) sleep correspond to the gaze of the dreamer, it may be possible for lucid dreamers to signal to the outside world using a series of pre-arranged eye movements. These eye movements could be measured in a sleep laboratory using electrooculography (EOG), making it possible to establish whether lucid dreams occur during sleep or whether they are simply instances of daydreaming that occur during brief periods of wakefulness. Hearne sought the help of proficient lucid dreamer Alan Worsley, who served as participant. Unfortunately, the measurement instruments had been turned off just prior to Worsley's first report of having performed the eye movements in a lucid dream. However, one week later and at approximately 8.00am on 12th April 1975, a signal consisting of several left-right eye movements was successfully recorded. The instruments showed that the signal occurred during a period of unambiguous REM sleep, and thus for the first time empirical confirmation of lucid dreaming as a genuine phenomenon was obtained. Hearne went on to obtain several more eye signals from within lucid dreams, and the original polysomnogram records are now on permanent display at the London Science Museum. An example of one of these eye signals is provided in Figure 1.1.

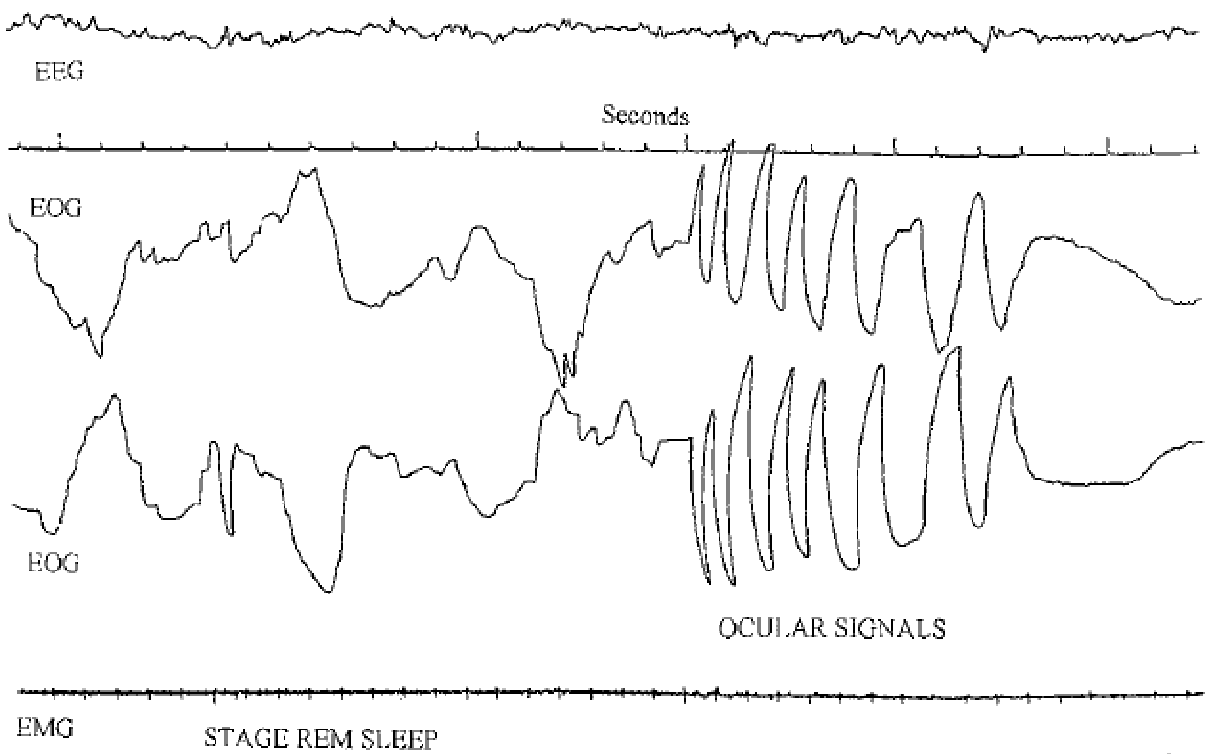

Figure 1.1. Polysomnogram showing one of the eye signals recorded during Keith Hearne's doctoral research. The signal consists of seven pairs of left-right eye movements that are easily distinguished from the preceding eye movements. Reprinted from K. M. T. Hearne, (1978). Lucid-dreams: an electro-physiological and psychological study. PhD thesis. University of Liverpool, England. Reprinted with permission.

2.4.9 Stephen LaBerge

By far the most well-known figure in the field of lucid dreaming and the person who has done the most to popularise it is Dr Stephen LaBerge, who earned his doctorate in psychology with research on lucid dreaming at the Stanford Sleep Centre in the late 1970s (LaBerge, 1980). He demonstrated that lucid dreaming is a genuine phenomenon using eye signals in the same way that Keith Hearne did, but apparently independently. It seems this led to some rivalry and confusion, with LaBerge occasionally being incorrectly credited for being the first to do this. During his doctoral research, LaBerge also devised what has become one of the most widely used and researched lucid dream induction techniques – the *Mnemonic Induction of Lucid Dreams* (MILD) technique (see Chapter 8). LaBerge went on to conduct numerous lucid dream induction studies and has written three books about lucid dreaming targeted at general audiences. Of these, his second book *Exploring the World of Lucid Dreaming* (LaBerge & Rheingold, 1991) has been the most influential. It describes a wide range of techniques for inducing lucid dreams, as well as techniques for prolonging and controlling lucid dreams. Although it was written 26 years ago this book is still often recommended as a starting place for people interested in learning how to have lucid dreams.

2.5 Summary

References to lucid dreaming can be found from as early as the fourth century B.C.E in the writings of Aristotle. However, lucid dreaming was given little attention in Western literature until the 20th century. Perhaps the most significant event in the history of lucid dreaming was its empirical confirmation in 1975. Following this, lucid dreaming has become widely known in the general population, and numerous scientific studies on lucid dreaming have been conducted. Much of this research is reviewed in later chapters. In Chapter 3, research on the phenomenology of lucid dreaming is reviewed. Chapter 4 provides a discussion of research on psychophysiological correlates of actions and experiences in lucid dreams. In Chapter 5, research into potential benefits and applications of lucid dreaming is discussed. Research on lucid dream induction is discussed in Chapters 8 and 9.

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Chapter 3: Phenomenology of Lucid Dreaming

3.1 Overview

The present chapter provides an overview of the phenomenology of lucid dreams. After considering definitions of lucid dreams, two principal ways in which lucid dreams are initiated are discussed. Following, various phenomenological aspects of lucid dreaming are discussed, including perceptual environments, perceptual experiences in individual sensory modalities, emotion, and cognitive abilities in lucid dreams. Volitional action in lucid dreams is then discussed before reviewing research on the behaviour and abilities of dream characters (i.e. representation of people, animals and other entities). Finally, the duration of lucid dreams and the ways in which lucid dreams can come to an end are discussed.

3.2 Definition of lucid dreams

Most commonly, lucid dreams are defined as dreams in which the dreamer is aware that they are dreaming while the dream is still happening (LaBerge, 1985). However, some researchers have proposed more sophisticated definitions (see Barrett, 1992; Gillespie, 1984; Moss; 1986; Tart, 1984, 1985, Voss, Schermelleh-Engel, Windt, Frenzel & Hobson, 2013). For example, Tart (1984) made a distinction between what he called “dreaming awareness dreams”, and lucid dreams, and suggested that to be classified as a lucid dream, a dream should involve clarity of consciousness that is on par with the clarity of consciousness that is typically experienced in waking life. Tholey (1985) adopted a more sophisticated approach, and described seven factors relevant to the definition of lucid dreams. These are: (1) clarity that one is dreaming; (2) clarity about freedom of choice within the dream; (3) clarity of consciousness; (4) clarity about the existence of waking life; (5) clarity of perception within the dream environment; (6) clarity of the meaning of the dream; and (7) clarity recollecting the dream upon waking. According to Tholey (1985), at least the first four of these factors should be present for a dream to be considered a lucid dream. More recently, Voss et al. (2013) developed a measure that involves rating dreams according to 28 questionnaire items, using Likert-type scales. This measure is called the Lucidity and Consciousness in Dreams scale (LuCiD), and is comprised of eight factors: Insight, Control, Thought, Realism, Memory, Dissociation, Negative emotion, and Positive emotion. Voss et al. (2013) found that lucid dreams were characterised in particular by significantly higher scores on the Insight, Control and Dissociation factors compared to dreams that research participants classified as non-lucid. However, one problem with this approach is that it is not uncommon for lucid dreamers to prefer exploring their lucid dreams as they unfold naturally, without attempting to exert control over it (see Section 3.9). Thus, although a lucid dreamer may be capable of controlling the dream, they may choose not to do so. Despite attempts to develop more sophisticated approaches to defining and measuring lucidity in dreams, the basic definition of a lucid dream being a dream in which the dreamer is aware that they are dreaming while the dream is still happening (LaBerge, 1985) remains the most widely used, and this is the definition that is used throughout the present thesis.

3.3 Initiation of lucid dreams

3.3.1 Dream Induced Lucid Dreams

Most lucid dreams occur when the dreamer realises they are dreaming during a non-lucid dream. These are called *Dream Induced Lucid Dreams*, or DILDs (LaBerge, 1980). Survey research suggests that DILDs account for at least 80% of lucid dreams (LaBerge, Nagel, Taylor, Dement, & Zarcone, 1981). In a survey of lucid dreaming enthusiasts by Stumbrys et al. (2014), it was found that DILDs were most likely to occur spontaneously without any clear trigger. These lucid dreams may be due to fluctuations in cortical arousal during sleep, especially in areas that are associated with self awareness and that are more active during lucid dreaming such as the dorsolateral prefrontal cortex (Hobson, Pace-Schott, & Stickgold, 2000; Stumbrys, Erlacher, & Schredl, 2013). For less experienced lucid dreamers, it appears that DILDs are most likely to occur during highly distressing or nightmarish dreams (Green, 1968; LaBerge & DeGracia, 2000; Stumbrys et al., 2014). It has been suggested that fear and anxiety in dreams cause greater awareness of the dream environment, increasing the likelihood that the dreamer will realise they are dreaming (LaBerge, 1985). Another common cause of DILDs is the recognition of an anomaly in a non-lucid dream that makes it obvious to the dreamer that they are dreaming, such as in the following example:

> I'm walking through a field that is fantastically animated with extravagant life: Magic Mushrooms (*Psilocybe cubensis*) popping up everywhere and growing to gigantic proportions. I realize the fantasy element of this scene: I must be dreaming. (LaBerge "SLB351", in LaBerge & DeGracia, 2000, p. 281)

3.3.2 Wake Induced Lucid Dreams

It is possible for lucid dreams to proceed directly from the waking state without any break in conscious awareness. Dreams of this kind are called *Wake Induced Lucid Dreams*, or WILDs (LaBerge, 1980). WILDs rarely occur spontaneously and usually require deliberate effort and much practice to achieve (LaBerge & DeGracia, 2000). A variety of WILD techniques exist, which mostly involve keeping the mind active while falling asleep with activities such as counting, meditating and focussing attention on visual imagery (LaBerge & Rheingold, 1991; Stumbrys, Erlacher, Schädlich, & Schredl, 2012). WILD techniques are more effective when performed after several hours of sleep or during afternoon naps when REM sleep (the sleep stage in which most dreams occur) is entered more quickly (LaBerge, 1980; LaBerge & Rheingold, 1991; Love, 2013). The experience of entering a WILD varies widely both within and between individuals. However, some elements of the experience are quite common (LaBerge & DeGracia, 2000; LaBerge & Rheingold, 1991). There is usually a relatively uneventful initial period as the mind and body become increasingly relaxed. Following, hypnagogic imagery will often occur, which typically involves fleeting and seemingly random visual images and auditory hallucinations. Strange physical sensations are also common at this stage, such as feelings of tingling, vibration, warmth, feeling that the body is in a position that differs from the one it is actually in, and feeling that the body is floating or slowly spinning. If the process is not interrupted, these hypnagogic hallucinations and sensations can increase in vividness and coherence, eventually stabilising into a fully fledged dream as in the following example:

> I woke from sleep. Had fleeting glimpses of my dream memories, then they were gone. I shut my eyes and could see hypnagogic images. A few scenes formed and faded but I don't recall what they were. The scene of a street formed vividly in front of my closed eyes. There was a river off to my left, 50-100 yards from the road. On the left seemed to be a construction site. There were buildings on my right. I was trying to observe details and I felt my foot step forward! This surprised me! Next thing I knew, I was walking along the street. (DeGracia "DDG48", in LaBerge & DeGracia, 2000, p. 283)

The time required to induce a WILD ranges from only a few minutes to up to an hour. WILDs tend to go for longer than DILDs because lucidity occurs at the onset of REM sleep (LaBerge & DeGracia, 2000). In contrast, DILDs may occur at any point during a period of REM sleep. For this reason, WILDs tend to be highly valued among lucid dreaming enthusiasts. However, because they are more difficult to achieve, many lucid dreamers focus their efforts on techniques for inducing DILDs instead.

3.4 Lucid dream environments

As with non-lucid dreams, lucid dreams take place in perceptual environments that are typically fully immersive and experienced from the first person perspective. LaBerge and DeGracia (2000) describe three broad categories of perceptual environments that occur in lucid dreams: *typical perceptual environments*, *surreal perceptual environments* and *minimal perceptual environment*s.

3.4.1 Typical perceptual environments

Typical perceptual environments are the most common in both lucid and non-lucid dreams, and are similar to environments typically encountered while awake. Elements of typical perceptual environments may be either familiar or novel, and perceptual quality can vary widely (LaBerge & DeGracia, 2000). For example, the environment may be brightly or only dimly lit. Typical perceptual environments can simulate environments encountered while awake so accurately that novice lucid dreamers often find it hard to believe they are dreaming (LaBerge & Rheingold, 1991). This is captured in the following example of a lucid dream:

> I dreamed that I was standing on the pavement outside my home. The sun was rising behind the Roman wall, and the waters of Blethingden Bay were sparkling in the morning light. I could see the tall trees at the corner of the road and the top of the old grey tower beyond the Forty steps. In the magic of the early sunshine the scene was beautiful enough even then... Then the solution flashed upon me: though this glorious summer morning seemed as real as real could be, I was dreaming! (Fox, 1962, pp. 32-33)

Typical perceptual environments in dreams differ from environments encountered while awake in some notable ways. They often contain bizarre elements such as strange locations and objects (LaBerge & DeGracia, 2000). Furthermore, a wide range of anomalies can occur (LaBerge & Rheingold, 1991). For example, sudden shifts from one location or scene to another are not uncommon, and light switches, electrical appliances and mechanical objects often do not work properly (Hearne, 1982). Other objects can also behave in unusual ways and actions performed in lucid dreams may produce unexpected results, such as in the following example:

> I was perfectly aware that I was dreaming and I considered what sorts of experiments I could make. I began by trying to break a glass, by beating it with a stone. I put a small tablet of glass on two stones and struck it with another stone. Yet it would not break. Then I took a fine claret-glass from the table and struck it with my fist, with all my might, at the same time reflecting how dangerous it would be to do this in waking life; yet the glass remained whole. But lo; when I looked at it again after some time, it was broken. It broke all right, but a little too late, like an actor who misses his cue. This gave me a very curious impression of being in a fake-world, cleverly imitated, but with small failures. (Eeden, 1913, p. 448)

3.4.2 Surreal perceptual environments

Surreal perceptual environments (LaBerge & DeGracia, 2000) are characterised by very rich perceptual content in one or more sensory modality that has no counterpart in ordinary waking life. This can involve environments composed of abstract shapes and colours such as in the following example:

> I was in the midst of a spectacular panorama of swirling activity and spiraling colors. The scene was staggering in its complexity. I was floating amongst the images, floating surrounded by these moving color patterns. I remember that I was amazed, but baffled, and didn't understand in the least what I was looking at, other than that it was very beautiful and moving around too much to make out any definite structure. (DeGracia "DDG70", in LaBerge & DeGracia, 2000, p. 286)

Surreal perceptual environments can resemble the hallucinations induced by some psychedelic drugs (LaBerge & DeGracia, 2000). However, it is important to note that in contrast to many of these experiences (see Aaronson & Osmond, 1970), surreal perceptual environments in lucid dreams are experienced as being fully immersive and in three-dimensional space as with typical perceptual environments. It is not known what surreal perceptual environments represent, although it has been speculated that they may be related to lower-level cognitive processes that underlie sensory perception (LaBerge & DeGracia, 2000). Surreal perceptual environments seem to occur with much lower frequency than typical perceptual environments (LaBerge & DeGracia, 2000).

3.4.3 Minimal perceptual environments

Minimal perceptual environments (LaBerge & DeGracia, 2000) contain only a minimum of sensory perception. It is common for typical or surreal perceptual environments to transition into a minimal perceptual environment during a lucid dream. This is often preceded by what lucid dreamers describe as the lucid dream becoming “unstable” (LaBerge & DeGracia, 2000). Vision is usually the first sense to be affected. This may involve visual perceptions becoming blurred or warped, taking on a cartoonish appearance, or becoming dim or completely dark. Audition, somatosensation and proprioception tend to persist after vision is lost (LaBerge & DeGracia, 2000). Awakenings commonly occur at this point. However, minimal perceptual environments may persist or transition back to a typical or surreal environment. When a minimal perceptual environment persists, the lucid dream may be experienced as a kind of perceptual “void” where affect, internal speech and other forms of cognition still occur, such as in the following example:

> Found myself in the void. My mind was wandering in all kinds of thoughts. Then I noticed that I could ‘leave’ my body. I flew off through the void. Everything was dark, kind of somber, and I didn’t have a body. I had the desire to be somewhere. Soon a large, what appeared to be wooden fort appeared in the mist. It was still quite dark but I could ‘see’ now. (DeGracia “DDG16”, in LaBerge & DeGracia, 2000, p. 287)

The cause of minimal perceptual environments is not known, although they may be related to periods of relatively low cortical activation that occur during REM sleep. Minimal perceptual environments appear to be more common than surreal perceptual environments, but not as common as typical perceptual environments (LaBerge & DeGracia, 2000).

3.5 Sensory modalities

3.5.1 Vision

Visual perception in lucid dreams can vary widely in all the usual qualities such as brightness, colour and contrast (LaBerge & DeGracia, 2000). There is usually a very high degree of detail and richness, although the perceptual environment can also appear unrealistic or impoverished. This can occur either for brief periods or may persist for the entirety of a lucid dream. Geometric anomalies are not uncommon (LaBerge & DeGracia, 2000), such as being able to see further around a corner than would ordinarily be possible due the angles involved, and other oddities such as in the following example:

> I looked up at the ceiling and got a nice visual surprise. The hallway seemed to repeat itself upward and curving out of sight, like the effect of two mirrors up against each other, except there were no mirrors. (DeGracia "DDG43", in LaBerge & DeGracia, 2000, p. 292)

Visual perceptions are sometimes unstable and prone to morphing, most likely because visual perceptions in dreams lack a stable source of sensory input. Morphing can occur with any visual element of a lucid dream environment, although perceptions of one's own hands, reflections of the self in mirrors, and other people's faces tend to be especially prone to this effect, such as in the following example:

> ...I was glad to have gotten her attention. But then I noticed as I was staring at her face, that her features kept shifting from that of an old lady to that of a beautiful young woman. (DeGracia "DDG61", in LaBerge & DeGracia, 2000, p. 292)

Written text is also very prone to morphing. Often, upon trying to re-read a piece of text, the dreamer will find that the letters change, become blurred, drip or run off the page, transform into incomprehensible symbols or change in semantic or lexical structure (LaBerge, 1996). This tendency is so reliable that attempting to re-read written text has become a widely used method for testing whether one is dreaming (see Section 8.1.1). However, it should be noted that there are some reports of written text being readable and meaningful to the dreamer (LaBerge & DeGracia, 2000).

3.5.2 Audition

Like vision, audition is prominent in lucid dreams and varies in all the usual qualities such as volume, pitch and timbre (LaBerge & DeGracia, 2000). It is typically possible to speak aloud and make other vocalisations. Conversation with other dream characters is typically characterised by syntactic and lexical accuracy, and is usually comprehensible (Meier, 1993). Musically talented lucid dreamers frequently report playing their instruments in lucid dreams, such as in the following example:

> In a 'high-school dream' that has become lucid, I walk up to the teacher who is demonstrating something on the piano as if I am an expected guest artist and sit down to play. I think of playing something from a book, but find that my vision is too weak. So I improvise a Fantasy in F$^{\#}$m, starting out prosaically enough, but building up gradually to a terrific climax. The dream fades with the last chord... (LaBerge "SLB270", in LaBerge & DeGracia, 2000, p. 294)

Auditory perceptions in lucid dreams are usually highly consistent with perceptions in other sensory modalities. However, this is not always the case. For example, there are reports of lucid dreams in which music is heard without any source being represented in the perceptual environment (LaBerge & DeGracia, 2000). Auditory anomalies commonly occur during attempts to induce WILDs. This may involve crackling sounds, buzzing, hissing sounds and hallucinated voices, among other things (LaBerge & Rheingold, 1991). Auditory sensations usually become more integrated with perceptions in other sensory modalities once the transition into a WILD is complete.

3.5.3 Somatosensation and kinaesthesia

Lucid dreams are typically experienced from the first person perspective with the same degree of somatosensory and kinaesthetic awareness as when awake. However this is not always the case (LaBerge & DeGracia, 2000). Some lucid dreamers report that they are able to shift their perspective from within their own body into that of another dream character. Lucid dreams can also be experienced from the perspective of a single point of disembodied consciousness, from the third person perspective and from many other bizarre perspectives, such as in the following example that involves the initiation of a WILD:

> After lying on my back for a long while, still seemingly awake, I suddenly feel as if I've turned into a bluish gas: actually a cloud of coarse blue spheres in the general form of my body that floats above the bed… (LaBerge "SLB880", in LaBerge & DeGracia, 2000, p. 295)

A commonly reported sensory experience in lucid dreams involves being dragged involuntarily through the perceptual environment by an unseen force. This phenomenon may be due to randomly created sensations of motion in vestibular and motor pathways in the brain, which may also explain the sensations of spinning and vertigo that are sometimes reported (LaBerge & DeGracia, 2000). Another common experience is the partial or complete inability to move. This may be experienced as either full paralysis or a feeling of only being able to move in slow-motion and with great effort. This is thought to be due to intrusion into the dream experience of sensory information from the physical body, which is subject to widespread muscle atonia during REM sleep (LaBerge & DeGracia, 2000). As with audition, many of the more bizarre somatosensory and kinaesthetic perceptions occur during the transition into a WILD. These can be very intense and it can take considerable discipline to observe them passively (LaBerge & Rheingold, 1991; Love, 2013).

3.5.4 Other senses

Perceptions in lucid dreams occur in all the other sensory modalities including gustation, olfaction and nociception, although as in waking life, perceptual experiences in some modalities are relatively infrequent (LaBerge & DeGracia, 2000). Food and beverages consumed in lucid dreams are usually (but not always) reported as tasting the same or very similar to what would be expected while awake, such as in the following example:

> I took the broken glass and threw it out of the window, in order to observe whether I could hear the tinkling, I heard the noise alright and I even saw two dogs run away from it quite naturally, I thought what a good imitation this comedy world was. Then I saw a decanter with claret and tasted it, and noted with perfect clearness of mind: 'Well, we can also have voluntary impressions of taste in this dream-world; this has quite the taste of wine. (Eeden, 1913, p. 448)

It is widely believed that pinching oneself while dreaming is painless, and this is often portrayed as a reliable test of whether or not one is dreaming. However, this act usually produces a realistic sensation of a pinch, and pain in dreams is often reported (LaBerge & Rheingold, 1991). Fortunately though, pain in lucid dreams is usually far milder than it would be while awake. LaBerge and Levitan (1998) investigated this by asking participants to pinch themselves in lucid dreams and then provide a rating of discomfort on a 7-point rating scale upon waking. It was found that discomfort was significantly lower when participants performed the task in lucid dreams (M = 1.5) than while awake (M = 3.9). However, there were exceptions to this, as illustrated in the following example from one of the participants:

> As soon as I knew I was dreaming, I remembered the experiment... so I stopped and pinched my left forearm with my right hand. At first, I didn’t feel anything but the touch. So, I pinched

> myself as hard as possible. The pain was so extreme that I yelled out “Oh my God!”… the sensation of pain [was] so severe … that I woke up. (LaBerge & DeGracia, 2000, pp. 296-297)

3.6 Emotion

The full range of possible human emotions can be experienced in lucid dreams. However, the emotional quality of lucid dreams is usually reported as either positive or neutral, with emotionally unpleasant experiences being quite rare (LaBerge & DeGracia, 2000). Because distressing experiences in dreams are a common trigger for lucidity, it is likely that many distressing experiences in lucid dreams are due to the continuation of distressing events that were occurring prior to the onset of lucidity. When lucidity is attained in this way, the negative emotions of distressing dreams are usually reduced if not completely eliminated (LaBerge & DeGracia, 2000; LaBerge & Rheingold, 1991). Indeed, the onset of lucidity is usually associated with strong feelings of elation and excitement:

> I realize that I’m dreaming again and that the real solution is to trust and *let go.* As I do so, leaping into the beautiful sunrise sky, I am overwhelmed with feeling and awaken with tears of joy. (LaBerge “SLB1027”, in LaBerge & DeGracia, 2000, p. 297)

As can be seen in the above example, the strong emotions that often accompany the onset of lucidity can be quite problematic because they often lead to involuntary awakening. This can be highly frustrating, especially for novice lucid dreamers that have invested considerable effort into lucid dream induction. Strong emotional arousal at any other point during a lucid dream can also cause an awakening, and for this reason it is widely recommended that one should try to remain calm during lucid dreams (Green, 1968; LaBerge & Rheingold, 1991; Love, 2013). High emotional arousal can also result in the dreamer becoming distracted by the events of the dream and forgetting that they are dreaming, resulting in a loss of lucidity. Experienced lucid dreamers usually learn to manage their level of emotional arousal in order to maximise the duration of their lucid dreams (LaBerge & Rheingold, 1991; Love, 2013).

3.7 Cognitive abilities

Cognitive abilities in lucid dreams vary considerably both between and within individuals (LaBerge & DeGracia, 2000). When a high degree of lucidity is attained, the dreamer is fully aware of the state they are in, acts in accordance with this understanding and is able to think and reason clearly. In contrast, when only a low level of lucidity is attained, the dreamer may be subject to unclear thinking, and may reach irrational or absurd conclusions (Barrett, 1992; Levitan, 1994). Under such circumstances, the dreamer is more likely to become absorbed in the events taking place in the dream and forget that they are dreaming. In extreme cases, the dreamer may be unable to retrieve basic information such as their own telephone number or the current date. However, severe deficits appear to be rare, and numerous studies have demonstrated that research participants can remember and then perform a wide range of experimental tasks in lucid dreams (see Chapter 4). In a study of memory in lucid dreams by Levitan and LaBerge (1993), 20 participants were asked to perform four different memory tasks while lucid dreaming: recall the date, recall where they were sleeping, recall a word learned prior to going to sleep, and recall a general knowledge fact that they were unable to recall while awake. Participants succeeded on 94%, 95%, 100% and 19% of trials for the four memory tasks respectively. However, novice lucid dreamers may have greater difficulty remembering and then performing tasks in lucid dreams (LaBerge & Rheingold, 1991). In an internet survey of lucid dreaming enthusiasts (Stumbrys et al., 2014), participants reported that they were able to recall intentions to perform specific actions in lucid dreams on only 48% of occasions.

3.8 Volitional action

Lucid dreamers can perform a wide range of volitional actions in lucid dreams (LaBerge & DeGracia, 2000; LaBerge & Rheingold, 1991; Love, 2013). It is also possible to perform actions that would be impossible while awake. The most commonly performed action of this kind is unassisted flying, but other actions such as walking through solid walls, transforming into animals and virtually anything else the dreamer can imagine are also possible (Green, 1968; LaBerge & Rheingold, 1991). However, attempts to perform ordinarily impossible actions are not always successful. For example, when attempting to fly, novice lucid dreamers may have difficulty staying in the air, controlling the direction of flight or achieving a desired altitude. Lucid dreamers often develop idiosyncratic methods for achieving desired outcomes in lucid dreams. For example, many methods for flying have been reported, including flapping one's arms like a bird, performing a swimming motion, and using willpower alone (Green, 1968; LaBerge & Rheingold, 1991). Difficulty can be experienced even when performing more ordinary actions. Participants in the survey of lucid dreaming enthusiasts by Stumbrys et al. (2014) reported that they succeeded in carrying out pre-planned volitional actions on only 44% of attempts. Failures were reportedly most commonly due to awakening, uncooperative dream characters, and actions producing unexpected results. It seems that the outcome of volitional actions performed in lucid dreams is largely determined by the dreamer's expectations, and the ability to perform both spontaneous and pre-planned actions is said to improve with experience (LaBerge & Rheingold, 1991; Love, 2013; Wolpin, Marston, Randolph, & Clothier, 1992). This is supported by the significant correlation observed by Stumbrys et al. (2014) between participants' self-reported success rate for performing pre-planned actions and lucid dreaming frequency.

3.9 Dream control

It is possible to exert mental control over many aspects of perceptual environments in lucid dreams (LaBerge & DeGracia, 2000; LaBerge & Rheingold, 1991; Love, 2013). This is referred to as *dream control* (LaBerge, 1985). Typical examples include stabilising a lucid dream that is fading, manifesting a particular object or dream character, and changing to a new location. As with volitional actions such as flying and passing through walls, attempts to control the dream are met with varying degrees of success. It appears that dream control can be improved with experience, and various techniques exist (LaBerge & DeGracia, 2000; LaBerge & Rheingold, 1991; Love, 2013). For example, a widely used technique for both stabilising a lucid dream and changing to a new location is to spin around rapidly while thinking about the desired location (LaBerge & Rheingold, 1991). If successful, the dreamer will find that the scene has changed to the desired location when they stop spinning. There are reports in the traditional Tibetan dream yoga literature (see Evans-Wentz, 1935; Gillespie, 1988) and also the occult Western literature (e.g. Leadbeater, 1984) of people being able to exert full control over all aspects of lucid dreams. However, this ability has not been reported in any scientific studies, and it seems that even among highly skilled lucid dreamers, the vast majority of the events that occur in lucid dreams are determined by factors outside of the dreamer's conscious awareness (LaBerge & DeGracia, 2000). Many lucid dreamers make no attempt to exert control while exploring their lucid dreams and simply allow them to unfold naturally. However, most of the participants (56%) in the survey of lucid dreaming enthusiasts by Stumbrys et al. (2014) reported that they did attempt to control their lucid dreams.

3.10 Dream characters

Lucid dreams are often populated with representations of people, animals and various other entities (Kahn, Pace-Schott, & Hobson, 2002). Research suggests that non-lucid dreams contain an average of 2-4 dream characters (Kahn et al., 2002; Kahn, Stickgold, Pace-Schott, & Hobson, 2000; Resnick, Stickgold, Rittenhouse, & Hobson, 1994). However, lucid dreams appear to contain fewer dream characters (Gackenbach, 1988). According to Green (1968), dream characters usually retain their identity during lucid dreams, and the appearance of "grotesque or deformed persons, demons, goblins or dwarfs" is rare (p. 63). Dream characters usually behave as though they are separate conscious entities with their own thoughts, emotions and intentions (Stumbrys, Erlacher, & Schmidt, 2011). For example, in a study by Tholey (1989), one lucid dreamer reported that when they asked a dream character if it had a consciousness of its own, it responded by saying "I am sure that I have a consciousness, but I doubt if you have one, because you ask me such stupid questions!" (p. 574). Tholey (1989) concludes that "at least some dream characters are capable of remarkable cognitive achievements" and that they should be "taken as seriously as if they had consciousness of their own" (p. 575).

Several studies have investigated the behaviour of dream characters in lucid dreams. Tholey (1989) found that lucid dream characters were able to write, draw, rhyme and say a word that was unknown to the dreamer. However, dream characters performed poorly at mathematical tasks and usually failed to provide a correct answer when the answer exceeded 20. Dream characters also performed poorly at basic mathematical tasks in a study by Stumbrys, Erlacher and Schmidt (2011). Dream characters answered correctly in only about a third of cases where coherent answers were provided. In several cases, dream characters were uncooperative. For example, one dream character started crying when presented with a mathematical problem, and two dream characters ran away. Dream characters performed poorly when asked to complete logical puzzles (e.g. finding the missing letter in a series) in a study by Stumbrys and Daniels (2010), but performed better on a more creative task that involved creating a metaphor for a specific situation. In a study by Schmidt, Stumbrys and Erlacher (2014), dream characters were asked to guess how many fingers the dreamer was holding behind their back. Based on lucid dream reports provided by participants, it appears that dream characters guessed correctly on 66% of trials. Similarly, dream characters guessed correctly on 62% of trials when the dreamer held their hands in front of them. In a second experiment, dream characters were asked to choose a random number between 1 and 10 and write it on a piece of paper. The dreamers then tried to guess the number before asking the dream characters to reveal what they had written, and reported that their answers were correct on 71% of attempts.

3.11 Duration of lucid dreams

A notorious and common problem for novice lucid dreamers is the tendency to wake up within only a few seconds of becoming lucid. As described above, this is often due to the emotional arousal that can accompany the realisation that one is dreaming. Lucid dreams verified in sleep laboratory studies with pre-arranged eye signals tend to be longer but are still quite brief, averaging about two minutes in duration (LaBerge, Levitan, & Dement, 1986; Stumbrys et al., 2014). Experienced lucid dreamers often report much longer lucid dreams outside of the laboratory setting spanning 30 minutes or more (LaBerge & Rheingold, 1991; Saint-Denys, 1982; Waggoner, 2009). Lucid dreams of this length are not implausible, because REM sleep periods average about 30 minutes in duration by the end of the night and can go for up to 60 minutes (Dement & Kleitman, 1957). Furthermore, as reviewed in Chapter 4, several studies have found that time perception in lucid dreams can be quite accurate (Erlacher, Schädlich, Stumbrys, & Schredl, 2014; Erlacher & Schredl, 2004; LaBerge, 1985). In the survey of lucid dreaming enthusiasts by Stumbrys et al. (2014), the average duration of lucid dreams was reportedly 13.9 minutes with a large standard deviation of 13.4 minutes. Several participants reported that their lucid dreams were typically one hour or more in duration. These findings differ markedly from the average duration of two minutes observed in sleep laboratory studies. Stumbrys et al. (2014) suggested that this may be due to participants of sleep laboratory studies being more emotionally aroused due to the requirement to perform specific experimental tasks while dreaming, or due to lighter sleep as a consequence of sleeping in an unfamiliar environment. It may also be the case that providing eye-signals while lucid dreaming disrupts REM sleep and promotes awakening (Stumbrys et al., 2014).

3.12 Cessation of lucid dreams

Lucid dreams commonly end with the dreamer forgetting that they are dreaming, which often happens when the dreamer becomes immersed in the events taking place in the dream. For this reason it is often advised that novice lucid dreamers in particular should repeatedly remind themselves that they are dreaming (LaBerge & Rheingold, 1991; Love, 2013). Lucidity is also commonly lost with what is known as a *false awakening*. This involves dreaming of having woken up, typically (but not always) in one’s own bed (Buzzi, 2011). Often, the dreamer’s bedroom is simulated so accurately that the dreamer does not even consider that they could still be dreaming (Green, 1968; Hearne, 1978). Much to the frustration of many aspiring lucid dreamers, it is common to then continue with a non-lucid dream before eventually experiencing a genuine awakening. As with false awakenings, genuine awakenings are often preceded by the dream becoming unstable or transitioning into a minimal perceptual environment. When lucid dreams end with an awakening, there is usually a high continuity of consciousness. This contrasts with the confusion and disorientation that commonly occurs during awakenings from non-lucid dreams (LaBerge & DeGracia, 2000). Lucid dreams can also end with the cessation of REM sleep and a transition into dreamless sleep prior to waking.

3.13 Summary

Lucid dreams occur in a wide range of perceptual environments and typically involve vivid and highly integrated hallucinated perceptions in all of the sensory modalities. The full range of human emotions can be experienced. Cognitive abilities can vary widely both within and between individuals, although severe deficits appear to be uncommon. A wide range of volitional actions can be performed in lucid dreams, including ordinarily impossible actions such as flying and walking through walls. It is also possible to exert control over lucid dreams. This appears to be a skill that can be improved with practice. Lucid dreams often include representations of other people, animals and other entities that behave as though they are independent conscious entities. Lucid dreams vary widely in duration from only a few seconds to up to 30 minutes or more, but seem to go for approximately 14 minutes on average.

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Chapter 4: Psychophysiological Correlates of Actions and Experiences in Dreams

4.1 Overview

In this chapter, research on psychophysiological correlates of actions and experiences in lucid dreams is reviewed and related to similar research on non-lucid dreaming. The chapter begins with research on eye movements that occur during sleep. Research investigating time perception in dreams is then reviewed. This is followed by a summary of research on dreamed movement, speech and respiration, and the extent to which these can be deliberately controlled and are accompanied by concomitant physiological activity. Research on autonomic responses to actions and experiences in dreams is then reviewed, and it is shown that physical exercise and sexual activity in dreams produce physiological responses similar to those that occur while awake.

4.2 Eye movements

According to the *scanning hypothesis*, the eye movements that occur during sleep correspond with dreamed eye movements in response to hallucinated visual stimuli. Although this hypothesis can be traced back at least as far as Ladd (1892), it was not until Aserinski and Kleitman's (1953) discovery of Rapid Eye Movement (REM) sleep and its close association with dreaming that it was investigated scientifically. The first study to provide empirical support for the hypothesis was conducted by Dement and Kleitman (1957) and involved participants being woken from REM sleep when one of four patterns of eye movement were observed for at least one minute. These were: mainly vertical movements; mainly horizontal movements; both vertical and horizontal movements; and very little or no movement. The procedure was repeated 35 times, and in all cases the participants' dream reports upon waking corresponded with the electrooculography (EOG) recordings of eye movements. For example, in one case of mostly vertical eye movements, the participant reported that they had been looking up and down while dreaming of climbing a ladder. In a study by Roffwarg, Dement, Muzio and Fischer (1962), participants were woken from REM sleep and asked to provide detailed descriptions of the visual imagery in the preceding 10-20 seconds of dreaming. These descriptions were used to make predictions about the number, direction and timing of eye movements prior to being woken, which were assessed for accuracy by two independent judges using EOG recordings. The results showed that the predictions were highly accurate when dream recall was vivid. However, several later studies (e.g. Firth & Oswald, 1975; Jacobs, Feldman, & Bender, 1972) were unable to replicate these findings.

The scanning hypothesis received stronger empirical support with the independent confirmation by Hearne (1978) and LaBerge (1980) during their doctoral research that lucid dreaming occurs during REM sleep using pre-arranged eye signals recorded using EOG. Hearne's research was described in Section 2.4.8. In LaBerge's (1980) doctoral research, five proficient lucid dreamers were asked to perform various combinations of eye movements and left and right fist clenches while lucid dreaming, and reported doing so in 30 out of 35 lucid dreams. An independent judge examined the EOG and EMG (electromyography) recordings of eye movements and muscle activity in the forearms, and for each case attempted to identify the 30-second epoch containing the signal out of approximately 1000 epochs. The judge succeeded in 24 cases and these all corresponded to the time at which participants reported having signalled. The signals were followed by an average of one minute of uninterrupted REM sleep, ruling out the possibility that participants were awake while signalling. Although some signals were not identified (due to unfavourable signal to noise ratios), there were no false positives. The chance of this success rate occurring by chance is vanishingly small and confirms that it is possible to communicate to the outside world from within a lucid dream. LaBerge found that eye signals were more reliably detected than hand signals, and Hearne found that the number of left-right eye movements observed using EOG was more likely to match the number that his participant reported performing when the signal consisted of fewer movements. Consequently, signals consisting of between two and four left-right eye movements are now typically used in lucid dreaming research (e.g. Dane, 1984; Fenwick et al., 1984; Ogilvie, Hunt, Tyson, Lucescu, & Jeakins, 1982; Tholey, 1983).

During his doctoral research, LaBerge (1985) also examined eye movements in response to moving visual stimuli. Two participants were asked to watch the tips of their fingers while moving their hands slowly from left to right while awake and also while lucid dreaming. Participants were also asked to simply imagine watching the movement of their hands with their eyes closed both while awake and while lucid dreaming. As hypothesised, EOG recordings showed smooth tracking eye movements when participants watched the movement of their hands while awake and also while lucid dreaming. In contrast, participants showed a series of rapid saccadic eye movements during both tasks that involved imagining the moving stimulus with eyes closed. It is very difficult to perform smooth tracking eye movements in the absence of a moving stimulus (Krauzlis, 2005), and these findings indicate that visual perception in lucid dreams is similar to visual perception while awake. Similar results were reported by Fenwick et al. (1984) for a participant that watched their hand move slowly from left to right in a lucid dream, and in a later study by LaBerge and Zimbardo (2000) that involved a participant watching their fingertip as they traced a circle in a lucid dream. In a neuro-imaging study involving positron emission tomography (PET) by Hong, Gillin, Dow, Wu and Buchsbaum (1995), eye movements during REM sleep were shown to involve the same cortical areas as eye movements performed while awake. This provides further evidence that visual stimuli in dreams affect the visual system in a way that is similar to the waking state.

4.3 Time perception

Time perception in dreams has been debated extensively by philosophers and psychologists. At one extreme, it has been argued that dreams are constructed instantaneously at the moment of awakening. This theory can be traced back to nineteenth century French scholar Alfred Maury (1861, as cited in LaBerge, 1985), who experienced a very long dream about the French Revolution. The dream included a lengthy court trial culminating in him being sentenced to death by guillotine. Just as the sentence was about to be carried out, Maury was woken by a piece of the headboard from his bed falling onto his neck. To explain this series of events he concluded that the entire dream must have been influenced by the falling object, and thus must have been created in its entirety at the moment of awakening (see also Dennett, 1976; Hall, 1981). This later became known as the *Goblot hypothesis*, named after French logician Edmond Goblot (1896, as cited in Erlacher, Schädlich, Stumbrys, & Schredl, 2014) who further developed the idea. In contrast, some accounts suggest a time dilation effect in dreams whereby the dreamer can experience far more within a given period of dreaming than they could if they were awake (see LaBerge, 1985). Indeed, there are many examples of people claiming to have had dreams that have lasted for several days, months or even years within a single night. The following remarkable example is from a young man who signed up to the popular online lucid dreaming forum "Lucidipedia" solely to share a dream that he experienced several years prior:

> When I got my eyes opened and my blurry vision got better I found myself in a hospital bed with nurses around. I didn't question it at the time as I was undeniably in hospital [...] to make a very very long story short I got out of the hospital. Went back to school graduated. Went to university, met my future husband, became a chemist, we bought a house, I got two kids. None of this felt like a dream. Time wasn't quirky, lights lit up perfectly, I red [sic] newspapers, was bored, excited, menstruating, sick and in love [...] I had to live all the dull moments and the most exciting ones. Time felt completely continuous [...] one day while I was driving home from my work in a heavy rain I lost the control of the car and helplessly

> watched as my car drifted towards a tree – and yes you guessed it – soon I woke up as my heart was bouncing like crazy. I had overslept and it was already noon [...] It felt like it had been 20 years since I last were in my room and my body [...] even today after over 10 years my imaginary dream kids feel almost equally real as the real ones. (Pasttimes, 2012)

The first scientific study on time perception in dreams was conducted by Dement and Kleitman (1957) and involved participants being woken after either 5 or 15 minutes of REM sleep and then estimating which of the two periods they had been dreaming for. Results showed that participants were correct on 92 out of 111 trials (82.9%). Furthermore, the correlations between the number of minutes spent in REM sleep and the word counts of participants' dream narratives ranged from $r = .40$ to $r = .71$. This is impressive given that written dream narratives can be influenced by many factors unrelated to dream content such as reporting style and literacy (see Chapter 6 for a discussion of this issue). These findings were extended by several similar studies (e.g. Glaubman & Lewin, 1977; Hobson & Stickgold, 1995) and indicate that dreams are not generated instantly upon waking. However, a limitation of these studies is that time estimates for non-lucid dreams provided upon waking can be highly inaccurate. This was demonstrated in a study by Moiseeva (1975) that involved participants being presented with a weak stimulus (e.g. the scent of cheese or the sound of rustling paper) for 10-30 seconds during REM sleep before being woken. Based on participants' dream narratives, it was established that stimuli were incorporated into dreams on 19% of trials. Participants were asked to estimate the duration of their dream experiences following stimulus incorporation and this was compared to the amount of time between stimulus presentation and awakening. Results showed that participants overestimated the duration of their dream experiences in 46.8% of cases. The duration was overestimated by up to five times for dreams that were "well formed with logical structure" and by up to 100 times for dreams of "complex structure, full of controversies, with simultaneous existence of unrelated aspects of activity" (p. 575). As argued by the author, this is likely due to complex and simultaneous events being organised into a linear temporal narrative, which may also explain the remarkable dream example provided above. Indeed, studies have shown that people tend to overestimate elapsed time when an unusually large or varied amount of events are experienced (Stetson, Fiesta, & Engleman, 2007).

The discovery that lucid dreamers can signal to the outside world (Hearne, 1978; LaBerge, 1980) allowed researchers to study time perception in dreams with unprecedented precision. In an unpublished pilot study described by LaBerge (1985), participants were asked to perform an eye signal in a lucid dream and then estimate a 10-second period by counting "one thousand and one, one thousand and two" etc. before providing a second eye signal. Results showed that participants required approximately the same amount of time to perform the task in lucid dreams – about 10 seconds – as it did for them to complete the task while awake (exact times were not reported). A later study by Erlacher and Schredl (2004) extended these findings by investigating the amount of time required to perform a motor task in addition to a time estimation task. Five proficient lucid dreamers were asked to estimate five seconds by counting "twenty-one, twenty-two" etc., perform 10 squats, and then count five seconds again. Participants provided eye signals between each task component, and results showed that the time required to complete the counting tasks was not significantly different in lucid dreams than while awake, replicating the findings of LaBerge (1985). However, it was found that performing the squats took 39.9% more time while dreaming than while awake. The authors suggested that this may be due to the squat task involving more complex activation of the body schema than the counting task.

The third and most sophisticated lucid dreaming study of time perception was conducted by Erlacher, Schädlich, Stumbrys and Schredl (2014) and involved three different conditions. In the counting condition, participants (*n* = 5) were asked to count from 1 to 10, then from 1 to 20 and finally from 1 to 30 in a lucid dream. These three counting tasks were performed consecutively and were separated by eye signals. In the second condition, participants (*n* = 8) followed the same procedure but walked 10, 20 and then 30 steps instead of counting. In the final condition, participants (*n* = 8) performed a gymnastics routine designed to take the same amount of time as walking 10 steps while awake that involved a series of jumps and a forward roll. Based on EOG recordings and participants' dream narratives, it was established that the tasks were completed successfully in 21 lucid dreams. Results showed that participants required 27.2% more time to perform the counting tasks while dreaming than while awake, although this difference was not statistically significant, and for two participants there was virtually no difference. For the walking tasks, participants took 52.5% more time while dreaming than while awake. However, for one participant there was no difference, and another participant took slightly less time while dreaming. Contrary to expectation, the difference was lowest (but still statistically significant) for the relatively complex gymnastics condition, which took 23.2% longer in lucid dreams but with two participants taking slightly less time. Results showed that the amount of time required to perform the three different counting and walking tasks was proportional. I.e., it took approximately twice as long to count to 20 than it did to count to 10, and it took approximately three times longer to count to 30 than to count to 10. This was the case with every participant for both the counting and the walking tasks. These findings indicate that although the overall time required to complete the tasks tended to be greater in lucid dreams than while awake, the temporal structure of the tasks was preserved.

4.4 Movement, speech and respiration

Several studies have demonstrated relationships between the content of non-lucid dreams and muscular activity in the body. McGuigan and Tanner (1971) and Shimizu and Inoue (1986) both found that dreams involving conversation were associated with significantly more EMG activity in muscles of the chin and lips than non-conversational dreams. Similarly, Gerne and Strauch (1985) found that EMG activity in the corrugator supercilii and zygomaticus major muscles (involved in frowning and smiling respectively) was significantly associated with the emotions reported in dreams. However, Hofer (1987, as cited in Schredl, 2000) was unable to replicate these findings. Muscular activity in larger muscles of the lower leg, upper arm and the wrist was investigated in a study by Wolpert (1960). Participants were awoken at various times and asked to provide detailed dream reports, which were rated by two independent judges as involving either high or low physical activity. A significant association was found between the amount of EMG activity prior to awakening and the ratings of dreamed physical activity. These findings were extended by Grossman et al. (1972) and Gardner, Grossman, Roffwarg and Weiner (1975), who were able to differentiate between dreams involving primarily arm or leg movements using EMG recordings of muscles in these areas. These studies demonstrate that physical activity in dreams is associated with muscular activity in the body. However, in these studies the majority of variance in EMG activity remained unaccounted for. Furthermore, when Wolpert (1960) re-analysed data for each participant separately, the relationships were mostly non-significant, and in the study by Gardner et al. (1975) there was a large number of reported dream movements that were not accompanied by concomitant EMG activity. This highlights the limitations of using non-lucid dreaming for studying psychophysiological correlates of actions and experiences in dreams.

Numerous lucid dreaming studies have shown that hand clenching in dreams is associated with muscular activity in the forearms (e.g. Dane & Van De Castle, 1984; Fenwick et al., 1984; LaBerge, Nagel, Dement, & Zarcone, 1981; LaBerge, Nagel, Taylor, Dement, & Zarcone, 1981; Ogilvie et al., 1982). Muscular responses to a range of other actions were investigated in a series of experiments by Fenwick et al. (1984) involving Allan Worsley as participant (the same participant as in Hearne's 1978 doctoral research). In one of these, Worsley was asked to signal the onset of lucidity with eye movements and then draw a triangle on a blackboard while watching the motion of his hand. He performed the task successfully, with EOG and EMG recordings showing concomitant eye movements and activity in muscles of his right forearm. Results were similar when Worsley moved his finger slowly from left to right in another lucid dream. Fenwick et al. (1984) also investigated whether the amount of EMG activity associated with movements performed in dreams was related to the size and proximity of the muscles involved. When Worsley moved his right arm in a lucid dream, the greatest EMG activity was observed in the flexor muscles of the fingers, with less activity observed in the forearm flexors and none in the larger flexor muscles of the shoulder. Similar results were found for the lower limbs, with EMG activity again being greatest in the smaller and more distal muscles. In a more complex experiment, Worsley was asked to move one of his fingers back and forth first five times, then four times, three times, two times and then just once during a lucid dream. Data from an accelerometer placed on his finger showed slight finger movements that precisely matched the movements performed in the dream. The procedure was repeated with the toes and produced similar results.

The above findings were extended by a study of EEG (electroencephalography) brain activity associated with dreamed hand clenching conducted by Erlacher, Schredl and LaBerge (2003). A single participant proficient at lucid dreaming spent three non-consecutive nights in a sleep laboratory and was instructed to clench their left hand four times in a lucid dream, then their right hand, and then count to four (without moving) before deliberately waking up. The three task components were separated by eye signals, and the entire procedure was completed successfully in two lucid dreams. EEG recordings showed that alpha power over areas of the motor cortex involved in hand movement were bilaterally decreased during both of the hand clenching tasks, indicating greater activity in the underlying cortical structures (Pfurtscheller & Neuper, 1997). In contrast, there was no decrease in motor cortex alpha power during the counting task. These findings are consistent with those of Pfurtscheller and Berghold (1989), who found bilaterally decreased alpha activity in motor areas when participants performed finger movements while awake. This suggests that movements performed in dreams may involve the same motor cortex activity as movements performed while awake.

As with movements of the eyes and other parts of the body, lucid dreaming studies have shown that it is possible to control verbal and respiratory behaviour in dreams, with concomitant physiological responses. In one of the experiments conducted during Hearne's (1978) doctoral research, participant Allan Worsley was asked to breathe in and out rapidly after signalling the onset of a lucid dream. Results showed a dramatic change from slow and regular to very rapid respiration following the eye signal. These findings were extended by LaBerge and Dement (1982b), who asked four proficient lucid dreamers to signal the onset of lucidity, hold their breath for five seconds, provide a second signal, and then breathe in and out as rapidly as possible for another five seconds before providing a third signal. Participants performed the task successfully a total of 12 times. As expected, an absence of respiration was observed between the first and second eye signals, and rapid respiration was observed between the second and third signals.

Fenwick et al. (1984) studied the relationship between respiration and verbal behaviour in dreams by asking participant Allan Worsley to count out loud while drawing marks on a surface in a lucid dream. EMG recordings showed activity in the right forearm during task performance and this occurred at or just after the start of exhalation, suggesting that speech in dreams is related to the respiration cycle in the same way as when awake (speech typically occurs during exhalation). In an EEG study conducted by LaBerge and Dement (1982a), four participants were asked to sing and to count to 10 in lucid dreams. Results showed greater activity in the left hemisphere during the counting task and greater activity in the right hemisphere during the singing task. This lateralised pattern of activation was similar to that observed when participants performed the task aloud while awake. Interestingly, there was no significant lateralisation in a control condition that involved simply imagining singing and counting while awake. These findings were extended by a non-lucid dream study by Hong et al. (1996) that investigated EEG brain activity associated with dreams that predominantly involved either talking or listening. A total of 12 dream reports from a single participant were collected, and results showed that dreams that involved talking were related to greater activation in Broca's area of the cortex, which is involved in speech production. In contrast, dreams that involved more listening were associated with greater cortical activation in Wernicke's area, which plays a critical role in speech comprehension (Blank, Scott, Murphy, Warburton, & Wise, 2002).

4.5 Autonomic responses

Several studies have investigated autonomic activity associated with actions and experiences in non-lucid dreams. However, findings from these studies are largely inconsistent (see Erlacher & Schredl, 2008; Schredl, 2000 for reviews). For example, Hobson, Goldfrank, and Snyder (1965) found that ratings of the amount of physical activity, emotion and vividness in dreams were significantly and positively correlated with both overall respiration rate and respiration variability. However, although Baust and Engel (1971) also found a positive association between respiration rate and more active participation in dreams, greater variability in respiration rate was related to *less* active participation. This study also examined cardiovascular relationships with dream content, but no significant correlations were found. Stegie, Baust and Engel (1974) suggested that the mixed findings in this area may be due to the high degree of variability in how individuals respond to emotional stimuli (see also Schredl, 2000). Studies of non-lucid dreaming that investigate autonomic responses by examining overall ratings of dream content are also limited by their inability to investigate responses to specific actions performed in dreams. Studies of lucid dreaming are able to address this limitation.

In a study by Erlacher and Schredl (2008), cardiovascular and respiratory responses to physical exercise performed in lucid dreams were investigated. Five proficient lucid dreamers were asked to count from 21 to 25 in a lucid dream, perform 10 deep squats, and then count from 21 to 25 again while marking the beginning and end of each task component with eye signals. Over the course of 15 laboratory nights, participants successfully performed the task 14 times in 11 lucid dreams. Results showed that heart rate was 13.3% higher while performing the squats than in the pre-exercise counting period (d = 0.54). An increase in respiration rate of 8.2% was also observed, although this did not reach statistical significance. However, a significant and abrupt reduction in respiration rate following the squat task was observed.

It is well established that REM sleep in humans is often accompanied by physiological activity associated with sexual arousal. This includes penile erections in males and clitoral engorgement, vaginal lubrication and erection of the nipples in females (Henton, 1976; Hirshkowitz & Moore, 1996; Rogers, Van De Castle, Evans, & Critelli, 1985). However, although this physiological activity is known to occur in the absence of dreams that are explicitly sexual (Martin, 2005; Pinel, 2011), very little research has investigated whether sexual dreams can *produce* these physiological responses. In a pilot study by LaBerge, Greenleaf and Kedzierski (1983), a single female participant proficient at lucid dreaming slept in a sleep laboratory and volunteered to engage in sexual activity while in a lucid dream. She was asked to provide eye signals when she became lucid, when she commenced sexual activity, and when she achieved orgasm. Physiological measures included respiration rate, heart rate, skin conductance level, vaginal pulse amplitude and vaginal EMG activity measured using a vaginal probe. The participant carried out the procedure exactly as requested. After becoming lucid, she reported flying out a window and continuing to fly for a brief period. She then descended to a group of people on the ground and tapped a male dream character on the shoulder, who proceeded to engage in sexual activity with her. The participant achieved orgasm and reported that it was “neither long nor intense, but was quite definitely a real orgasm” (LaBerge, 1985, p. 91). Results showed that during the 15 second orgasm epoch, all but one of the physiological variables reached their peak and were significantly higher than the mean values for the other REM sleep epochs of the night. The only exception to this was heart rate, which was only slightly and not significantly raised.

LaBerge (1985) reports having replicated LaBerge, Greenleaf and Kedzierski’s (1983) findings with two male participants. A penile strain gauge was used to measure sexual response, and it was found that the participants’ penile erections were at their peak during the period between them indicating the onset of sexual activity and the achievement of orgasm. After orgasm, there was an immediate and gradual reduction in penile erection. In neither case did dream orgasm result in actual ejaculation, or a so-called “wet-dream”. LaBerge reported that this is consistent with his own experiences: out of approximately 900 or so lucid dreams in his personal record there were 12 in which he experienced orgasm, but none of these resulted in ejaculation. As with the pilot study by LaBerge, Greenleaf and Kedzierski (1983), dramatically increased respiration rates were observed but with no significant increases in heart rate. These findings indicate that sexual arousal and even orgasm can be achieved in lucid dreams, causing physiological responses similar to those that occur while awake.

4.6 Summary

Studies of lucid dreaming have shown that although some actions may take longer to perform in dreams than while awake, they appear to retain their temporal structure. It has been demonstrated that eye movements during dreams correspond to the gaze of the dreamer, and that dreamed movements of the hands, feet, arms and legs produce activation in corresponding muscles in the body. Similarly, it has been shown that verbal and respiratory behaviour cause concomitant physiological responses, and that physical exercise and sexual activity in dreams affect the body in ways that are similar to when awake. Studies have also shown that verbal and respiratory behaviour, speech comprehension, and movements of the eyes and hands in dreams all involve patterns of brain activation that are similar to those that occur while awake.

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Chapter 5: Potential Benefits and Applications of Lucid Dreaming

5.1 Overview

The present chapter draws upon research on the phenomenology of lucid dreams reviewed in Chapter 3 and research on psychophysiological correlates of actions and experiences in lucid dreams reviewed in Chapter 4 to discuss potential benefits and applications of lucid dreaming in five key areas. The chapter begins by discussing the benefits of using lucid dreaming in scientific dream research. Research on the use of lucid dreaming as a treatment for nightmares is then reviewed. Attention is then directed towards methods for improving skills through rehearsal in the lucid dream environment. The recreational potential of lucid dreaming is then discussed. Finally, the use of lucid dreaming for problem solving and creative inspiration is explored.

5.2 Dream research

There are important limitations to the use of non-lucid dreaming in dream research. It is not possible to reliably influence the content of non-lucid dreams, and research participants are not able to perform pre-arranged experimental tasks in non-lucid dreams. Even if an event of interest does take place in a non-lucid dream, researchers must rely heavily on subjective reports provided upon waking. Lucid dreaming provides a means to address these limitations. Research participants are able to perform pre-arranged experimental tasks in lucid dreams and can mark the beginning and end of specific dream events with pre-arranged eye signals. This permits methodical testing of hypotheses, precise temporal matching of dream events with measures of physiological activity, and decreased reliance on subjective reports provided upon waking. When a research participant reports having performed eye signals before and after completing an experimental task, and when these eye signals can be clearly seen on the electrooculogram record, researchers can be more confident that the participant performed the experimental task as instructed.

As reviewed in Chapter 4, numerous sleep laboratory studies have shown that lucid dreamers are able to remember and perform a wide range of experimental tasks in lucid dreams, such as estimating the passage of time (LaBerge, 1985), gymnastics routines (Erlacher, Schädlich, Stumbrys, & Schredl, 2014), physical exercise (Erlacher & Schredl, 2004), conversing with dream characters (Tholey, 1989), and engaging in sexual intercourse with dream characters (LaBerge, Greenleaf, & Kedzierski, 1983). Studies such as these have allowed researchers to answer questions that studies of non-lucid dreams were unable to convincingly address. For example, studies of lucid dreaming have demonstrated that eye movements in dreams correspond to the gaze of the dreamer (see Section 4.2), that actions and experiences in dreams retain their temporal structure (see Section 4.3), and that movements of the hands, arms and legs, verbal, respiratory and sexual behaviour, and physical exercise (see Sections 4.4 and 4.5) are all associated with concomitant physiological activity. However, despite its advantages, lucid dreaming has been underutilised in dream research due to a lack of effective and reliable lucid dream induction techniques.

5.3 Treatment of nightmares

Nightmares are highly distressing and disruptive to sleep, and can have serious negative consequence for sufferers (Lancee, van den Bout, & Spoormaker, 2010; Zadra & Donderi, 2000). Chronic nightmares are especially common in people with *Post-Traumatic Stress Disorder* (PTSD) and occur in up to 60-80% of cases (Gavie & Revonsuo, 2010). They typically involve re-experiencing the traumatic event, which can re-traumatise the sufferer and promote further nightmares (American Psychiatric Association, 2013). Thus, in addition to being distressing in and of themselves, post-traumatic nightmares can play a central role in the development and maintenance of PTSD (Mellman & Hipolito, 2006; Spoormaker, 2008). Current treatments for nightmares such as exposure therapy (imagining the nightmare while awake) and *Imagery Rehearsal Therapy* (IRT, imagining the nightmare proceeding more favourably) are limited in that they do not enhance the sufferer's ability to cope with nightmares as they are actually happening. *Lucid Dreaming Treatment* (LDT) overcomes this limitation because lucidity allows the dreamer to explore alternative responses within the nightmare, change the content of the nightmare, or employ techniques to deliberately wake up. Simply knowing that one is dreaming and safe during a nightmare appears to significantly reduce distress (Gavie & Revonsuo, 2010; LaBerge & Rheingold, 1991; Spoormaker, Van Den Bout, & Meijer, 2003).

As discussed in Section 3.3.1 (see also Section 9.4.4), distressing experiences in dreams are a common trigger for lucidity, and the intense emotional arousal that occurs in nightmares may be especially conducive to lucid dream induction. LDT can involve performing general lucid dream induction techniques that increase the overall frequency of lucid dreaming (e.g. Holzinger, Klösch, & Saletu, 2015), or may involve imagining oneself becoming lucid during the course of a recurring nightmare (e.g. Spoormaker & Van Den Bout, 2006). With the latter approach, associations are formed between elements of the nightmare and the intention to become lucid, resulting in the nightmare itself becoming a trigger for lucidity. In a survey of lucid dreaming enthusiasts (N = 528) by

Stumbrys and Erlacher (2016), participants reported that they used lucid dreaming for overcoming fears or nightmares in 10.8% of their lucid dreams. In an earlier survey of lucid dreaming enthusiasts (*N* = 301) by Schädlich and Erlacher (2012), the second most commonly reported application of lucid dreaming was transforming bad or nightmarish dreams into pleasant ones (reported by 63.8% of participants). In contrast, this was the most commonly reported application of lucid dreaming (78.3% of participants) in a study of 12 narcolepsy patients by Dodet, Chavez, Leu-Semenescu, Golmard and Arnulf (2015). Similarly, 70% of narcoleptic lucid dreamers in a telephone survey by Rak, Beitinger, Steiger, Schredl and Dresler (2015) reported that lucidity provided relief during nightmares. The following excerpt provides an example of lucid dreaming being used to change the course of a recurring nightmare:

> I had a recurrent nightmare of being flooded in a tsunami. Once I was in this dream again, I said to myself, 'I am fed up with you, my tsunami dream.' Suddenly the tsunami became a person and apologized for disturbing me. I never had this nightmare again. (Dodet et al., 2015, p. 490)

Several empirical studies have investigated LDT. In a series of five case studies by Zadra and Pihl (1997), three out of five chronic nightmare sufferers had lucid dreams and were able to either control the nightmare or deliberately wake up. They reported feelings of joy, peace and fearlessness on becoming lucid, and nightmares had reduced dramatically or ceased completely at one-year follow-up. Similar benefits were reported in a series of case studies by Spoormaker, Van Den Bout and Meijer (2003) and in a single PTSD case study by Been and Garg (2010). In experimental research by Spoormaker and van den Bout (2006), chronic nightmare sufferers and PTSD patients allocated to LDT treatment groups but not those in a waitlist control group reported significant reductions in nightmare frequency at 12-week follow-up. However, the role of lucidity is unclear because only 6 out of 16 participants given LDT attained lucidity. In an online experiment by Lancee et al. (2010), participants were given IRT only, IRT with suggestions for improving sleep hygiene or IRT combined with LDT. All groups showed significantly reduced nightmare frequency, with the IRT plus LDT group showing a greater reduction in mean nightmare intensity than the other groups. However, the role of lucidity is again unclear because the authors did not report how successful LDT was at inducing lucid dreams. Most recently, Holzinger, Klösch and Saletu (2015) compared Gestalt therapy with Gestalt therapy combined with LDT for treatment of persistent nightmares. Both groups showed significantly reduced nightmare frequency at the end of the study and at three-month follow-up. In the Gestalt therapy plus LDT group, 75% of participants experienced lucid dreaming, compared to only 12.5% in the Gestalt therapy only group. Improvements were greater and sooner for participants that succeeded in having lucid dreams, suggesting that lucidity played an important role. These findings indicate that LDT could be highly effective if more reliable lucid dream induction techniques could be developed.

5.4 Skill rehearsal

Another promising potential application of lucid dreaming is improvement of skills through rehearsal in the lucid dream environment. This can be considered a special form of *mental rehearsal*, which involves imagining oneself rehearsing a skill while awake but without performing any physical movements (Rushall & Lippman, 1998). Studies have shown that mental rehearsal is effective for improving a wide range of skills, and it is commonly used by professional athletes to improve performance (see Driskell, Copper, & Moran, 1994; Feltz & Landers, 1983). Lucid dream rehearsal may be even more effective than mental rehearsal because relevant parameters such as body position, motion, gravity and other environmental factors can be much more vividly simulated. As discussed in Chapter 3, sensory experiences in lucid dreams occur in all of the sensory modalities and lucid dreams can feel just as “real” as experiences that occur while awake. As reviewed in Chapter 4, sleep laboratory studies have shown that actions performed in lucid dreams retain their temporal structure and are associated with concomitant physiological responses. This includes activity in the muscles that correspond to movements performed in dreams, EEG activity in the motor cortex, and autonomic responses such as increased respiration rate. For these reasons, it has been argued that movements performed in lucid dreams may be neurologically equivalent to movements performed while awake except for the widespread muscle atonia that prevents movements in lucid dreams from being carried out (Erlacher, Schredl, & LaBerge, 2003).

There are many anecdotes from people claiming to experience benefits from lucid dream rehearsal. For example, Erlacher, Stumbrys and Schredl (2011) describe a competitive high-diver who used lucid dreaming to practise complex dive routines. She claimed that she was able to perform her routines at reduced speed in order to focus on the most important details, leading to improved performance while awake. In a qualitative study by Tholey (1981, as cited in Stumbrys, Erlacher, & Schredl, 2016), six athletes proficient in lucid dreaming were asked to practise sports such as skiing and gymnastics during lucid dreams. These participants reported that they were able to rehearse their sports in lucid dreams without difficulty, and that lucid dream rehearsal led to improvements both within the lucid dream environment and while awake (see also Tholey, 1990). In Schädlich and Erlacher’s (2012) survey of lucid dreaming enthusiasts, 21.3% of respondents reported using lucid dreaming for skill rehearsal, and in Stumbrys and Erlacher's (2016) survey it was found that 4.2% of lucid dreams were used for this purpose. Similarly, out of 475 people who had experienced lucid dreaming in a survey of German athletes (Erlacher et al., 2011), 9.3% reported that they used lucid dreams to practise their sport. Most of these participants (77.3%) reported that lucid dream rehearsal led to improved performance while awake.

To date, only two experimental studies have investigated lucid dream rehearsal. In a pilot study by Erlacher and Schredl (2010), participants were asked to complete a task that involved throwing coins into a cup placed two metres away from them. All participants performed the task on two consecutive nights (pre- and post-test). Participants were assigned to three different conditions: practise the coin throwing task for as long as possible during a lucid dream following pre-test (six minutes on average), practise the task while awake for six minutes following pre-test, and a control condition that did not involve any practice between pre- and post-test. Participants who practised the task while awake showed the greatest improvement. An increase of 3.4 successful throws at pre-test to 6.4 at post-test was observed. Of the 20 participants in the lucid dream rehearsal group, seven were able to practise in lucid dreams and improved significantly from 3.7 to 5.3 successful throws. In contrast, participants in the lucid dream rehearsal group who were unable to induce lucid dreams showed no improvement. Their success rate diminished slightly from 3.4 to 2.9 successful throws. Similarly, participants in the control group showed no significant improvement (2.9 to 3.0 successful throws). The improvement observed for participants who practised while awake and for those in the lucid dream rehearsal group who succeeded in practising while dreaming differed significantly from those in the control group. There was no significant difference between participants who practised while awake and those in the lucid dream rehearsal group.

Erlacher and Schredl's (2010) findings were corroborated in a very similar follow-up experiment performed by Stumbrys, Erlacher and Schredl (2016). An experimental task that involved tapping four different sequences of adjacent keys on a keyboard using the non-dominant hand was used. The number of correct sequences performed and the number of incorrect keys pressed were used as measures of accuracy. Results indicated that accuracy was significantly higher at post-test for participants in the group that involved practising while awake (increase of 20%), in the lucid dream rehearsal group (increase of 17%), and in the mental rehearsal group (increase of 12%). In contrast, the improvement observed in the control group was smaller (increase of 5%) and not statistically significant. These preliminary findings and the abundance of anecdotal evidence suggests that lucid dream rehearsal can lead to improved performance while awake. Lucid dream rehearsal thus has potential applications in sports psychology, and provides an opportunity for athletes to train while asleep in addition to daytime training. This could be especially beneficial for athletes who are unable to train while awake due to illness or injury. Athletes could also continue to train when they do not have access to necessary equipment or environmental conditions (e.g. ski jumpers when they do not have access to a ski slope).

Lucid dream rehearsal may also have applications in medical settings. For example, practising physical movements in lucid dreams and the concomitant neurological activation may be beneficial for accident or stroke victims undergoing physical therapy, provided that medical problems are not having a significant impact on sleep and dreaming (see Jackson, Lafleur, Malouin, Richards, & Doyen, 2001 for a discussion of the therapeutic potential of mental rehearsal).

5.5 Recreation

As discussed in Chapter 3, lucid dreams can feel so life-like that novice lucid dreamers frequently mistake them for waking life. As discussed above, environmental factors such as wind, temperature and gravity are simulated with high fidelity. Perceptions occur in all of the sensory modalities, and the full range of human emotions can be experienced (see Section 3.6). Furthermore, it is possible to exert deliberate control over many aspects of lucid dreams. For example, it is possible to manifest objects or people, change to new locations, and acquire special abilities such as the ability to fly, breathe underwater or pass through solid objects. As discussed in Section 3.9, this is referred to as *dream control* and can be improved with practice (LaBerge & DeGracia, 2000; LaBerge & Rheingold, 1991; Love, 2013). Indeed, the range of possible actions and experiences in lucid dreams is virtually limitless. Thus, lucid dreaming has tremendous recreational potential. LaBerge and Rheingold (1991) capture this notion eloquently in their influential book *Exploring the World of Lucid Dreaming*: "by learning to have lucid dreams, you open for yourself a limitless amusement park full of all the delights you can imagine" (p. 167). Unsurprisingly, recreation appears to be the strongest motivator for people interested in learning to have lucid dreams, and was the most frequently used application of lucid dreaming in the surveys of lucid dreaming enthusiasts by Schädlich and Erlacher (2012; 81.4% of participants) and Stumbrys and Erlacher (2016; 42.8% of lucid dreams). The following excerpt provides an example of a recreational lucid dream reported by one of the participants:

> "I am standing on top of green mountains. I make it windy […] and then I jump about 30m onto the next cliff with a great feeling of happiness and bliss. I run very fast and […] dive into the sea. I breathe like a fish and have lots of fun. I feel totally free and I let myself drift into a

turquoise-coloured bay […] I am swayed by the water and the sun is shining on me. Everything is refreshing and relaxing." (Schadlich & Erlacher, 2012, p. 135)

The most commonly reported recreational activity in Schädlich and Erlacher's (2012) survey was flying (more than half of the participants). As discussed in Section 3.8, lucid dreamers often develop their own idiosyncratic methods for flying, such as flapping one's arms like a bird, performing a swimming motion and through willpower alone. The second most commonly reported recreational activity (approximately one quarter of participants) was sex. This is perhaps unsurprising given that lucid dreams provide an environment of virtually endless experiential possibility devoid of waking life social repercussions. As discussed in Section 4.5, a pilot study involving a single female participants (LaBerge et al., 1983) and follow up research involving two male participants (LaBerge, 1985) indicate that it is possible to achieve orgasm in lucid dreams and that sexual experiences in lucid dreams have concomitant physiological effects. Other recreation activities reported by participants of Schädlich and Erlacher's (2012) survey were exploring, having super powers, creating nice sceneries, eating, dancing and relaxing.

Some lucid dreamers report that they experience an afterglow after an exhilarating lucid dream that can last for the rest of the day after waking up (LaBerge & Rheingold, 1991; Love, 2013). Indeed, participants of Stumbrys and Erlacher's (2016) survey reported that the effect on mood upon waking following the use of lucid dreaming for various applications ranged from neutral to positive, with the most positive moods reported following wish fulfilment dreams. Lucid dream recreation may be particularly rewarding and beneficial for certain populations such as people who live or work in isolated locations such as Antarctica or in space, people with certain mental health conditions such as agoraphobia, people who are physically disabled, and people who suffer from chronic pain. In a study of 28 hospitalised burn victims by Raymond, Nielsen, Lavigne, and Choinière (2002), it was found that only 39% of participants experienced pain in their dreams. Furthermore, of the 63 dreams reported by these participants, only 30% involved the experience of pain. Thus, lucid dreaming may provide an opportunity to have enjoyable and rewarding pain-free experiences for people who are restricted in their ability to do so while awake. This could lead to substantial improvements in quality of life and mental wellbeing.

5.6 Problem solving and creative inspiration

There are numerous well-known cases of dreams being the source of inspiration for inventions, scientific discoveries and great works of art and literature. Examples include the invention of the sewing machine by Elias Howe, the discovery of the structure of the benzene molecule by Auguste von Kekulé, and the famous book *The Strange Case of Dr. Jekyll and Mr. Hyde* by Robert Lewis Stevenson. Dreams have also been a rich source of creative inspiration in many traditional cultures and systems of belief (see Garfield, 1974). However, very few scientific studies have investigated the use of dreams for problem solving and creative inspiration. In a survey of non-lucid dreams by Schredl and Erlacher (2007), it was estimated that approximately 8% of dreams involved artistic inspiration, emotional insights, solutions to work-related problems and motivation to take on challenges that the participant was having difficulty with. In a study by Barrett (2007), participants were asked to perform a dream incubation technique each night for one week designed to produce a dream about a specific problem of personal relevance. By the end of the study, approximately half of the participants reported having a dream that was relevant to the problem, and in 70% of these cases participants reported coming up with a solution. Similar results were reported in a study by White and Taytroe (2003). Participants who practised a dream incubation technique for a personally relevant problem reported significantly increased problem solvability, significant improvement in their problems, and significantly decreased problem-related distress.

A major limitation of dream incubation techniques is that they are highly unreliable. Even when dream incubation techniques are successful at influencing dream content, non-lucid dreamers are unable to consciously direct the course of the dream or focus their attention on the parts of the dream that are most relevant. Lucid dreaming gives the dreamer the ability to control the content of the dream and actively pursue creative inspiration and solutions to problems. Indeed, there are many anecdotal reports of lucid dreaming being used in this way. For example, LaBerge and Rheingold (1991) describe a computer programmer who claimed to regularly use lucid dreaming to solve work-related problems. The dreamer would manifest a representation of Albert Einstein in a workspace of his own design, and the two of them would explore possible solutions to coding problems on a blackboard. Once the dreamer felt that a solution had been achieved, he would attempt to memorise what was written on the blackboard, deliberately wake up, and then record the solution using a notepad. This person claimed that the solutions were helpful in the majority of cases. Other anecdotes include an artist whose work was inspired by the paintings she saw while walking through art galleries in her lucid dreams, and an architect who would walk through buildings they were designing in lucid dreams and make alterations until they were happy with the design (LaBerge & Rheingold, 1991). In the survey of applications of lucid dreaming by Schädlich and Erlacher (2012), 29.9% of participants reported using lucid dreaming for solving problems, and 27.6% of participants reported using lucid dreaming for coming up with creative ideas or insights.

Participants of Stumbrys and Erlacher's (2016) survey reported using 14.5% of their lucid dreams for solving waking problems.

Only one experimental study has investigated the effectiveness of lucid dreaming for basic problem solving. In a pilot study by Stumbrys and Daniels (2010), nine proficient lucid dreamers were given a problem to solve each day for ten consecutive days. Two types of problems were used: logical puzzles (e.g. finding the missing letter in a series) and devising metaphors. Participants memorised each problem before bed without solving it and then induced a lucid dream using a technique of their choice. Participants then sought a knowledgeable-looking character while lucid dreaming and asked them to solve the problem they had memorised. Participants in a control group followed the same procedure but were asked to simply reflect on their dreams in the morning and write down the first solution that came to mind without inducing lucid dreams. The logical puzzles were assessed as correct or not, and the metaphors were rated for originality, aptness, validity and aesthetic fit by two judges. Results showed no significant difference between the lucid dreaming and control groups for the logical puzzles. Correct answers were reported in only 18.4% and 15.4% of cases respectively. In the lucid dreaming group, only one of the eleven solutions provided by dream characters was correct. Similarly, overall ratings for the metaphors were not significantly different in the lucid dreaming group compared to the control group. However, the five solutions that were provided by dream characters were rated as superior to the other answers provided in the lucid dreaming group. These findings tentatively suggest that lucid dreaming might be more effective for certain types of problem solving, such as those that do not rely heavily on logical reasoning. This is consistent with studies by Tholey (1989) and Stumbrys, Erlacher and Schmidt (2011), in which dream characters performed poorly at mathematical problems (see Section 3.10). More research on the use of lucid dreaming for problem solving and creative inspiration is warranted.

5.7 Summary

Lucid dreaming has a wide range of potential benefits and applications. In dream research, lucid dreamers can perform pre-arranged experimental tasks and can provide eye signals that allow precise temporal matching with measures of physiological activity. Lucid dreaming shows promise as a treatment for nightmares, giving the dreamer control over distressing dream experiences as they are happening. Preliminary research indicates that rehearsing skills in lucid dreams can lead to improvements in performance while awake. Thus, lucid dreaming has potential applications in both sports psychology and in medical settings. Lucid dreaming has tremendous recreational potential, which could be highly beneficial for people who are restricted in their ability to have enjoyable experiences while awake. Lucid dreaming also has potential applications for problem solving and creative inspiration. However, further development and research into applications of lucid dreaming has been limited by a lack of effective and reliable lucid dream induction techniques, and further research on lucid dream induction is needed.

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Chapter 6: Review Paper on the Measurement of Dream Recall

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By signing the statement of authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Abstract

There are two methods commonly used to measure dream recall in the home setting. The retrospective method involves asking participants to estimate their dream recall in response to a single question and the logbook method involves keeping a daily record of one's dream recall. Until recently, the implicit assumption has been that these measures are largely equivalent. However, this is challenged by the tendency for retrospective measures to yield significantly lower dream recall rates than logbooks. A common explanation for this is that retrospective measures underestimate dream recall. Another is that keeping a logbook enhances it. If retrospective measures underestimate dream recall and if logbooks enhance it they are both unlikely to reflect typical dream recall rates and may be confounded with variables associated with the underestimation and enhancement effects. To date, this issue has received insufficient attention. The present review addresses this gap in the literature.

Is dream recall underestimated by retrospective measures and enhanced by keeping a logbook? A review

6.1 Introduction

There are two widely used methods for measuring dream recall in the home setting. The logbook method requires research participants to record their dream recall each morning using a logbook (AKA diary or journal), typically for a period of several weeks. Using this method, dream recall is most commonly operationalised as *Dream Recall Frequency* (DRF), which refers to the number of mornings in a given time period on which some amount of dream content is recalled. Participants are sometimes asked to record the number of separate dreams recalled each morning, which permits an alternative operationalisation referred to as *Dream Count* (DC) in the present review. Logbooks may also require participants to provide written narratives of their dreams, allowing additional operationalisations of dream recall such as the number of words per dream narrative. These logbooks are referred to as *narrative logbooks* in the present review as opposed to *checklist logbooks*, which do not require participants to write out their dreams. The primary alternative to the logbook method is the retrospective method, which involves asking participants to report their dream recall in response to a single question. These questions take a variety of forms but are typically either open-ended (e.g. "How many dreams do you recall per week?") or involve reporting one's DC or DRF by selecting one of several fixed response options (e.g. "almost every morning", "several times a week", "about once a week" etc.). Until recently, the implicit assumption has been that the choice between using retrospective or logbook measures is of little consequence and that the two are essentially equivalent (Beaulieu-Prévost & Zadra, 2007). However, this assumption is challenged by numerous studies that have used both measures in the same sample and found that retrospective measures yield significantly lower dream recall rates than logbook measures.

This retrospective-logbook disparity has two principal explanations. One of these is that retrospective dream recall measures have a tendency to underestimate true dream recall rates (Beaulieu-Prévost & Zadra, 2007; Schredl, 2002; Zadra & Robert, 2012). The other is that keeping a logbook tends to enhance dream recall (Beaulieu-Prévost & Zadra, 2007; Cohen, 1969; Cory *et al*., 1975; Goodenough, 1991; Schredl, 2002). If retrospective measures underestimate dream recall, they may provide a poor reflection of true dream recall rates and could be confounded with other variables related to underestimation (for example, participants with poorer long-term memory function may be more prone to underestimation). Similarly, if logbooks have a tendency to enhance dream recall, they may also fail to provide an accurate reflection of typical (unaltered) dream recall rates and may be confounded with variables related to the enhancement effect (for example, highly motivated participants may spend more time trying to recall dreams prior to making logbook entries and experience greater enhancements in dream recall as a consequence). It may even be the case that the retrospective-logbook disparity is due to a combination of both retrospective underestimation *and* logbook enhancement. If this is correct, *both* measures may be of limited validity. This might even explain why most studies on correlates of home dream recall have found only weak relationships and inconsistent or even contradictory findings (for reviews, see Beaulieu-Prévost & Zadra, 2007; Blagrove & Pace-Schott, 2010; Goodenough, 1991; Schredl & Montasser, 1996-1997a, 1996-1997b; Schredl *et al*., 2003; Zadra & Robert, 2012). Clearly then, the retrospective-logbook disparity is an important issue that has potentially far-reaching implications for research on home dream recall. However, as several authors have noted this issue has received insufficient attention and the cause of the disparity remains uncertain (Beaulieu-Prévost & Zadra, 2007; Schredl, 2002; Schredl & Fulda, 2005; Zadra & Robert, 2012). The purpose of the present review is to address this gap in the literature and raise awareness of psychometric issues related to the measurement of dream recall in the home setting.

6.2 Literature search

An extensive literature search was conducted to identify studies in which a retrospective-logbook disparity for general dream recall was reported or could be calculated. The primary search strategy was to identify studies in which logbooks were used and examine them to see if retrospective measures were also used. A secondary strategy was to identify and check the measures used in studies that were specifically about dream recall. Titles and abstracts were searched in the electronic databases Embase, MEDLINE, PsycINFO, and Scopus using the following search terms: *dream* AND (recall OR dream journal* OR diar* OR log*)*. Studies were excluded if they were not published in English, if they were not published in a peer-reviewed journal, if logbook dream recall was measured in a laboratory or non-home setting, if they were case studies or if they were non-controlled studies that involved an intervention during the logbook period likely to affect dream recall. The literature search was conducted in August-September 2014 and initially yielded 211 results from Embase, 418 from Medline, 1058 from PsycINFO and 246 from Scopus. Based on a preliminary reading of titles and abstracts, 235 studies that did not meet any of the exclusion criteria were identified as potentially relevant. Full texts of these studies were examined and a total of 24 studies were found in which a retrospective-logbook disparity was reported. Two studies (Antrobus, *et al*., 1964; Cory *et al*., 1975) were excluded because there was insufficient data to calculate the size of the disparity and one study (Paulson & Parker, 2006) was excluded because it involved a lucid dreaming training program that may have affected logbook dream recall rates. Four studies (Schredl, 2004a, 2008, 2009b, 2010) were discarded because they were based on the same dataset as an earlier study that also reported a disparity (Schredl *et al*., 2003). Details of the remaining 17 studies are presented in Table 6.1. In all cases, disparities are expressed as percentages of the retrospective dream recall rates (i.e. logbook rate minus retrospective rate divided by retrospective rate).

Table 6.1
Studies in which a retrospective-logbook disparity was reported or can be calculated.

Reference	Disparity	Type of retrospective measure (and response options / estimation period)	Type of Logbook
Schredl (2002)	-12%	Fixed response options, DRF (never, less than once a month, about once a month, twice or three times a month, about once a week, several times a week, almost every morning)	Narrative, DRF
Schredl *et al*. (2003) [a]	-12%†	Three separate DRF measures were administered at pre-test. One was the same as Schredl (2002) above but was administered once in a questionnaire about dreams ("DQ") and again in a questionnaire about sleep ("LISST"). The final measure was open-ended and based on the previous 28 days ("OE"). The disparity presented for this study is based on the mean of all three measures because they all yielded very similar DRF rates (DQ = -15%, LISST = -8% and OE = -14%)	Narrative, DRF
Schredl (2001) [b]	2%†	Fixed response options, DRF (never, less than once a month, about once a month, two or three times a month, about once a week, several times a week, almost every morning)	Narrative, DRF
Schredl and Engelhardt (2001) [c]	5%† (control group)	Fixed response options, DRF (never, less than once a month, about once a month, two or three times a month, about once a week, several times a week, almost every morning)	Narrative, DRF
Zadra and Robert (2012)	10% (narrative group)	Open-ended, DC (number of dreams typically remembered per week)	Narrative, DC
	61%* (checklist group)	Open-ended, DC (number of dreams typically remembered per week)	Checklist, DC
Beaulieu-Prévost and Zadra (2005)	13%*	Open-ended, DC (number of dreams typically remembered per week)	Narrative, DC
Schredl *et al.*(2010) [d]	14%†	Fixed response options, DRF (never, less than once a month, about once a month, twice or three times a month, about once a week, several times a week, almost every morning)	Narrative, DRF
Schredl *et al*. (2013)	15%†	Fixed response options, DRF (never, less than once a month, about once a month, twice or three times a month, about once a week, several times a week, almost every morning)	Narrative, DRF
Zadra and Donderi (2000)	15%†	Open-ended, DC (number of dreams typically remembered per week)	Checklist, DC
Beaulieu-Prévost *et al*. (2009) [e]	19%†	Open ended, DC (number of dreams typically remembered per week)	Narrative, DC
Schredl *et al*. (1996)	52%†	Fixed, DRF (less than once per month, once or twice per month, once or twice per week, several times per week)	Checklist, DRF
Baekeland (1970)	72%*	Open-ended, DRF (average frequency of recall every two weeks)	Checklist, DRF
Blagrove *et al*. (2009) [f]	82%† (control group)	Fixed response options, DRF (never, about once per year or less, less than once per month, one to three times per month, one to three times per week, four to seven times per week)	Checklist, DC
Cohen (1969)	200%†	Fixed response options, DRF (hardly ever, couple of times a month, about once a week or twice a week, just about every day or every other day)	Checklist, DRF
Levin and Fireman, (2002)	247%†	Not specified	Checklist, DRF
Referring and Keller (1974) [g]	605%* (Group 3)	Fixed response options, DC (no dreams, a couple per year, one or two per month, one per week, three per week, one per night)	Checklist, DRF
Yu (2014) [h]	610%†	Fixed response options, DRF (never, less than once a month, about once a month, two to three times a month, about once a week, several times a week, almost every morning)	Narrative, DRF

In four cases (Schredl *et al*., 2013; Schredl *et al*., 2010; Schredl *et al*., 1996; Yu, 2014), responses to retrospective measures had to be converted to DRF rates in order to calculate a retrospective-logbook disparity. This was done by using or adapting Schredl's (2004c) approach (i.e. never = 0.0 mornings per week, less than once a month = 0.13, about once a month = 0.25, two or three times a month = 0.63, about once a week = 1.0, several times a week = 3.5, almost every morning = 6.5).
[a] It was established through personal communication with the author (June 16, 2014) that logbooks were narrative type.
[b] Data was originally reported separately for singles and non-singles. Disparity calculated for all participants combined.
[c] Data was provided for several other groups of participants but these are not reported here because of high attrition rates that may have biased the disparities. There was no attrition in the control group (N = 152 for both measures).
[d] It was established through personal communication with the author (September 16, 2014) that logbooks were narrative type.
[e] Data was originally reported separately for participants with different "dreamer profiles". Disparity calculated for all participants combined.
[f] This study investigated the effects of Ketamine on dream recall. Disparity calculated for the control group only.
[g] This study included four different groups involving different amounts of contact with the experimenters and encouragement to enhance dream recall. Only group 3 is included because it is the only group that involved keeping a daily logbook but did not involve encouragement to enhance dream recall.
[h] Logbook DRF (M = 1.42 per week) was obtained through personal communication with the author (August 16, 2014).
*p = < .05.
†P value not reported.

The majority of studies (77%) included in Table 6.1 observed a retrospective-logbook disparity of between 10% and 610% and the mean (unweighted) disparity for all 17 studies was 115%. In several studies dream recall was operationalised as DC but mistakenly referred to as DRF and in all such cases this has been corrected. With only one exception, the operationalisation of dream recall was consistent for both retrospective and logbook measures. However, the disparity reported by Redfering and Keller (1974) may have been inflated due to retrospective-DRF being compared to logbook-DC. Indeed, such an effect is likely because although DRF cannot exceed the number of days in a given measurement period, the DC operationalisation has no upper limit (i.e. people can report substantially more dreams than there are days in a given measurement period). To illustrate, in a study by Schredl (2004b) it was found that participants recalled multiple dreams on more than 20% of mornings, with a maximum of 12 dreams recalled by one participant on a single morning. If the study by Redfering and Keller (1974) is excluded, the mean disparity for the remaining 16 studies is reduced to 85%.

Another factor that appears to have affected the size of the disparity is the use of narrative versus checklist logbooks. For the most part the studies that reported the greatest disparities used checklist logbooks whereas those in which the disparity was smallest used narrative logbooks. As has been argued previously (e.g. Robert & Zadra, 2008), participants are likely to underreport their true dream recall while keeping narrative logbooks in order to reduce the amount of time (often over half an hour) required to write out their dreams. This argument is supported by findings from Zadra and Robert (2012), who assigned participants to conditions involving either narrative or checklist logbooks. The authors found a significant disparity only in the latter group (see Table 6.1). Furthermore, logbook-DC was significantly higher in the checklist condition compared to the narrative condition (by 56%) and the checklist participants maintained their logbooks for significantly longer (31.6 vs. 24.7 days), which suggests that the narrative logbooks were more burdensome. These results replicate findings from an earlier study (Robert & Zadra, 2008), in which participants given checklist logbooks maintained them for significantly longer (30.1 vs. 23.2 days) and had significantly higher logbook-DC (by 42%).

In two of the studies included in Table 6.1 (Schredl, 2002; Schredl *et al*., 2003), the disparity was in the opposite direction and logbook dream recall rates were slightly *lower* than retrospective dream recall rates (-12% in both cases). However, when the participants in one of these studies (Schredl, 2002), were divided into groups according to their retrospective dream recall rates, “low recallers” (retrospective-DRF of 0-1 per fortnight) and to a lesser extent “medium recallers” (retrospective-DRF of 2-4 per fortnight) showed substantial and statistically significant disparities (421% and 81% respectively). The disparity was in the opposite direction and also smallest (-36%) for "high recallers" (retrospective-DRF of 5-14 per fortnight), which accounts for the lack of significant disparity for all participants combined. Based on additional data obtained through personal communication with the author (February 2, 2015), it was established that the same pattern was observed in the study by Schredl *et al*. (2003).[1] The disparity was 531% for low recallers, 89% for medium recallers and -31% for high recallers. A similar pattern of results was found by Zadra and Robert (2012) for participants in the narrative group (results were presented graphically and exact disparities could not be calculated), but not in the checklist group (for which the disparity appears to have been about the same for low, medium and high recallers). It is likely that several other studies included in Table 6.1 would have reported similar results if analyses had been conducted separately for low, medium and high recallers. Indeed, in a study by Antrobus *et al*. (1964), logbook-DRF was approximately 1000% higher than retrospective-DRF in "non recallers" (retrospective-DRF < once per month), but appears not to have differed among "recallers" (retrospective-DRF of 3+ nights per week). Similarly, Cory *et al*. (1975) found a retrospective-logbook disparity among low recallers but not high recallers. Unfortunately though, the size of these disparities could not be calculated (and for this reason they are not included in Table 6.1).

None of the studies presented in Table 6.1 provided sufficient data to explore gender differences in the retrospective-logbook disparity. However, additional data bearing on this issue was obtained for two studies through personal communication (February 2, 2015). In the study by Schredl (2002), the disparity was slightly larger for females (-15%; N = 212) than for males (-1%; N = 73).[2] The gender difference was reversed in the study by Schredl *et al*. (2003), with the disparity being slightly smaller for females (-13%; N = 373) than for males (-21%; N = 66).[3] Based on these results and in light of two recent meta-analyses (Schredl & Reinhard, 2008; Schredl & Reinhard, 2011) showing that the choice between retrospective and logbook measures does not affect gender differences in dream recall, it seems reasonable to conclude that gender is not likely to be an important factor for understanding the retrospective-logbook disparity. The above findings confirm that the retrospective-logbook disparity is a common occurrence and that it is often very substantial in size, especially among low recallers and when checklist logbooks are used. In the following sections, the retrospective underestimation and the logbook enhancement effects are given in-depth consideration as explanations for the retrospective-logbook disparity.

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[1] These disparities were calculated based on fortnightly "DQ" retrospective-DRF (see Table 6.1) and logbook-DRF rates provided by the author. For low recallers (N = 30), retrospective-DRF M = 0.38 (SD = 0.16) and logbook-DRF M = 2.40 (SD = 1.92). For medium recallers (N = 164), retrospective-DRF M = 1.77 (SD = 0.35) and logbook-DRF M = 3.34 (SD = 1.91). For high recallers (N = 245), retrospective-DRF M = 8.74 (SD = 2.73) and logbook-DRF M = 6.01 (SD = 3.44).

[2] Retrospective dream recall data for each gender was provided in the original paper but had not been converted to fortnightly DRF rates and thus did not permit calculation of gender differences for the disparity. Mean fortnightly retrospective-DRF was M = 4.92 (SD = 4.06) for females and M = 3.77 (SD = 3.76) for males.

[3] The disparities for females and males were based on the "DQ" retrospective-DRF measure (see Table 6.1). Retrospective fortnightly "DQ" DRF was M = 5.73 (SD = 4.17) for females and M = 4.61 (SD = 3.78) for males.

6.3 The retrospective underestimation hypothesis

Theoretical support for the retrospective underestimation hypothesis can be derived from research on frequency estimation. According to Tversky and Kahneman's (1973) *availability heuristic*, people estimate the frequency of events based on the *availability of exemplars*, i.e. the ease with which instances of an event can be brought to mind. If availability is high, people tend to estimate the frequency of an event to be greater than if availability is low. Numerous studies have shown that the availability heuristic is used in a wide range of situations (see Schwarz, 1998 for a review). In one of the most classic demonstrations, Schwarz *et al*. (1991) found that participants rated themselves as significantly more assertive after being asked to recall only six occasions on which they behaved assertively (a relatively easy task) compared to participants who were asked to recall twelve occasions (a more difficult task). This suggests that the ease with which exemplars were recalled (and not the *number* of exemplars) determined assertiveness ratings. Furthermore, the self-rated difficulty of recalling instances of behaving assertively was negatively correlated with self-rated assertiveness. These results were replicated by Aarts and Dijksterhuis (1999) in a study that used the frequency of a previously performed behaviour as the dependent variable rather than personality self-assessment. It was found that participants estimated their bicycle use to be 31% less frequent after being asked to recall eight different locations they had ridden to rather than three locations and this frequency rate was negatively correlated with the self-rated difficulty of recalling the locations (i.e. estimated frequency was greater when participants found the recall task less difficult). These authors argued that the availability heuristic is likely to influence frequency judgments for almost all behaviours that have been performed more than a few times. In light of this it seems highly likely that people will also use the availability heuristic when estimating the frequency with which they recall dreams.

When the availability of exemplars is closely related to the overall frequency of the event in question, the availability heuristic will tend to produce reasonably accurate frequency estimates. However, overestimation or underestimation may occur if the availability of exemplars does *not* reflect overall frequency. This is known as the *ease of recall bias* (see Buontempo & Brockner, 2008) and provides a plausible explanation for why retrospective measures might underestimate true dream recall rates. Individuals who are interested in their dreams and who tend to spend time thinking about them, writing them down, discussing them with other people or otherwise devoting attention to them are likely to have greater availability of dream recall instances and should thus be able to provide fairly accurate responses to retrospective dream recall measures. However, individuals who have little interest in their dreams are likely to spend less time recalling and encoding memories of dreams, resulting in lower availability of instances of dream recall and thus greater susceptibility to underestimation. This theory is consistent with studies that have shown "inner focus" variables to be more strongly correlated with retrospective dream recall measures than logbook measures. For example, in a meta-analysis by Beaulieu-Prévost and Zadra (2007) it was found that the estimated mean correlation between attitudes toward dreams (one of the most widely researched predictors of dream recall) and dream recall was significantly stronger when dream recall was measured retrospectively (r = .357) than with logbook measures (r = .252). Two other dream recall predictors were included in this meta-analysis – *absorption* and *psychological boundaries*. Both of these variables operationalise (among other things) the extent to which people are aware of internal experiences and they were both found to have statistically significant estimated correlations with retrospective measures (absorption, r = .246; psychological boundaries, r = .290) but not logbook measures (absorption, r = .086; psychological boundaries, r = .098). Other studies have shown that introversion (Early, 1977, as cited in Schredl, 2002), imaginative involvement and fantasy proneness (Levin *et al*., 2003) are also correlated with retrospective but not logbook measures.

If the above theory is correct, the underestimation effect should tend to be stronger for retrospective measures based on longer time periods (e.g. the previous 12 months) compared to those based on shorter time periods (e.g. the previous month). This is because measures based on longer periods should require participants to consider the availability of a greater number of exemplars, and frequency estimations tend to be lower when this is the case as discussed above (Aarts & Dijksterhuis, 1999; Schwarz *et al*., 1991). Furthermore, instances of dream recall should *on average* have lower availability during longer time periods due to the well-documented tendency for memories to become increasingly difficult to recall with the passage of time (Roediger *et al.*, 2010). Therefore, to the extent that the retrospective-logbook disparity is due to retrospective underestimation it should tend to be larger in studies that have used retrospective measures based on longer time periods. Indeed, among the studies presented in Table 6.1 that used checklist logbooks, the largest disparities were observed when participants were asked to consider their dream recall over longer time periods (the last few months) in response to questions involving fixed response options. The disparities were smallest when estimates were based on open-ended measures enquiring about the previous one or two weeks (the only exception to this is Schredl *et al*., 1996). This pattern of findings constitutes tentative empirical support for the theory of retrospective underestimation outlined above. In contrast, the studies in which *narrative* logbooks were used mostly reported small disparities, possibly due to participants underreporting their logbook dream recall in order to reduce the burden of participation as argued earlier.

The most compelling empirical support for the retrospective underestimation hypothesis comes from studies that have measured dream recall using retrospective measures based on different time periods within the same sample. Zadra and Donderi (2000) measured the recall frequency (DC) of lucid dreams, dreams about flying, bad dreams (defined as very disturbing dreams) and nightmares (very disturbing dreams that cause an awakening) during a 4-week logbook period and also using retrospective measures based on both the previous month and the previous 12 months. In every case the prorated retrospective-logbook disparity was greater when based on the 12-month retrospective measure than the 1-month measure (lucid dreams, 35% vs. 2%; flying dreams, 29% vs. 23%; bad dreams, 69% vs. 53%; nightmares, 162% vs. 92%). Similar results were reported in studies by Wood and Bootzin (1990), Pietrowsky and Köthe (2003) and Robert and Zadra (2008) that all compared 1-month and 12-month retrospective measures of various kinds of distressing dreams, although unfortunately no studies to date have attempted to replicate these findings using measures of *general* dream recall.[4] Nonetheless, it is difficult to explain why in every case the 12-month retrospective measures yielded lower recall rates than the 1-month measures if not because of a retrospective underestimation effect that varies as a function of the size of the estimation period. Retrospective underestimation may also account for the retrospective-logbook disparities based on the 1-month retrospective measures, although a logbook enhancement effect cannot be ruled out.

The above findings also discount an otherwise plausible alternative explanation for the retrospective-logbook disparity. Given that logbooks cause people to pay greater attention to their dreams, people might be more likely to notice and then include “borderline” instances of dream recall when making logbook entries that tend not to be captured by retrospective measures (e.g. single images or lingering emotions from otherwise forgotten dreams). If this is correct it could explain the retrospective-logbook disparity without needing to appeal to any retrospective underestimation or logbook enhancement effects. However, in the above studies substantial retrospective-logbook disparities were found even though the definitions for dreams were precise and consistent for both the logbook and the retrospective measures. This makes it very unlikely that the disparities were due to differences in what participants counted as instances of dream recall.

[4] In all but one of these studies, logbooks yielded the highest dream recall rates, followed by the 1-month retrospective measure and then the 12-month retrospective measure. However, Pietrowsky and Köthe (2003) found that the 1-month retrospective measure yielded the highest nightmare recall frequency, followed by the logbook measure and then the 12-month retrospective measure. This may be due to participants underreporting their true nightmare frequency during the logbook period in order to reduce the burden of having to complete a 43-item questionnaire for each day on which nightmares occurred.

There is no obvious reason to think that the cause of these disparities is different from the cause of the disparities observed in studies of general dream recall. Thus, it seems unlikely that disparities between retrospective and logbook measures of general dream recall can be accounted for by a wider range of instances of dream recall being captured by logbooks.

To the extent that retrospective measures are prone to an underestimation effect their validity is likely to be compromised by a wide range of confounding variables. For example, people who score more highly on “inner focus” variables such as those described above or who have better long-term memory function may have less difficulty recalling instances of dream recall and thus be less prone to underestimation. People may also be relatively immune to retrospective underestimation if they estimate their dream recall using a more elaborative cognitive process rather than a heuristic one. For example, participants could estimate their dream recall frequency over the previous 12 months by counting the number of times they recalled dreams during the previous month and then multiplying this number by 12. This would result in a dream recall rate that does not differ from the prorated 1-month estimate. The tendency to use this kind of elaborative processing is related to a range of variables (e.g. need for cognition, Suedfeld & Tetlock, 2001) that may constitute additional confounds for retrospective dream recall measures. Clearly, if retrospective measures underestimate dream recall they are likely to provide a poor reflection of true dream recall rates. Retrospective measures based on longer time periods are likely to be the least valid and are probably not suitable for studies investigating predictors of dream recall, whereas those based on shorter periods (e.g. the previous week or month) should be less problematic. However, it remains unclear whether the underestimation effect is likely to be related to the different forms that retrospective measures can take. For example, open-ended measures that require participants to estimate their dream recall over the past 12 months may not underestimate dream recall to the same extent as measures that include “once per year” as one of several fixed response options. The wording of retrospective measures and their response options may also influence the dream recall rates they yield irrespective of the time periods involved.

6.4 The logbook enhancement hypothesis

A highly plausible theory of why keeping a logbook might enhance dream recall can be obtained from one of the most prominent models of dream recall, the arousal retrieval model (Koulack & Goodenough, 1976; see also Goodenough, 1991; Schredl, 2009 for reviews). According to this model, dream recall is most likely when a period of arousal (wakefulness) interrupts or occurs shortly after dreaming, or else dream content is likely to be lost from short-term memory. Dream content must then be retrieved from short-term memory and consolidated into long-term memory if it is to be retained, and recall will be superior if retrieval occurs immediately upon awakening and in the absence of other distracting mental activity. It follows that logbooks should enhance dream recall because they require participants to spend time on the retrieval process each morning either immediately or shortly after awakening – participants must consider whether or not they can recall dream content in order to make a logbook entry. If this is correct, the size of the logbook enhancement effect should be proportional to the amount of time spent on retrieval. Consequently, the logbook enhancement effect should also vary as a function of one's pre-existing tendency to spend time trying to recall dreams. Individuals with a relatively weak tendency are more likely to be low recallers as a result and should then experience a relatively strong logbook enhancement effect, because keeping a logbook will cause them to spend substantially more time on the retrieval process than they otherwise would. In contrast, individuals with a strong pre-existing tendency to spend time recalling dreams are more likely to consequently be high recallers and should experience a relatively weak or non-existent logbook enhancement effect because keeping a logbook will have less (or no) impact on the amount of time they spend trying to recall dreams. This would explain why the retrospective-logbook disparity tends to be strongest in individuals with relatively low retrospectively measured dream recall rates.

In exploring the logbook enhancement hypothesis it is important to consider whether there are any alternative aspects of dream recall studies that might result in heightened logbook dream recall rates. For example, if participants are encouraged to enhance their dream recall while keeping a logbook or are asked to practise techniques designed to achieve this, it could lead to enhancements in dream recall that are *not* due to keeping a logbook. Alternatively, the demand characteristics of studies aiming to enhance dream recall may lead participants to exaggerate their dream recall. However, both of these factors are unlikely to explain the retrospective-logbook disparity because none of the studies included in Table 6.1 involved any encouragement or instruction to enhance dream recall. Of course, there may still be more subtle demand characteristics associated with simply participating in a study about dreams. However, it seems very implausible that this could result in participants exaggerating their dream recall to such an extent that it would account for the size of the retrospective-logbook disparities that many studies have observed (see Table 6.1). It is hard to imagine how dream recall would have otherwise been enhanced in these studies if not because of a logbook enhancement effect.

Despite it being theoretically plausible and widely believed among dream researchers that logbooks enhance dream recall (e.g. Beaulieu-Prévost & Zadra, 2005; Goodenough, 1991; LaBerge & Rheingold, 1991; Parker *et al.*, 2000; Schredl & Montasser, 1996-1997a; Wittmann *et al.*, 2006) there is a lack of empirical evidence that unambiguously demonstrates this. Of course, the existence of the retrospective-logbook disparity does not do so because the phenomenon can just as easily be explained by the retrospective underestimation hypothesis. However, the logbook enhancement hypothesis is tentatively supported by a study by Cohen and Wolfe (1973, study 4) that examined the effects of post-sleep distraction on dream recall. Immediately upon awakening, participants in an experimental group were required to phone a weather information service and write the forecasted temperature for the day on the top of a logbook sheet. After completing this task, which took approximately 1.5 minutes, participants were required to provide written narratives of their dreams. Participants in a control group were asked to simply lie still for 1.5 minutes before writing out their dreams. It was found that significantly fewer participants in the distraction group were able to recall dream content on the day of the experiment (33% versus 63%). There were no differences between the two groups on a retrospective dream recall measure administered at pre-test, nor were there any group differences in logbook dream recall rates for a subsequent 7-day period. These results were replicated in a second study reported in the same paper (study 5) and show that dream recall is superior when people focus on their dreams without distraction. This is precisely the kind of effect that keeping a logbook should have, especially for people who ordinarily tend not to pay attention to their dreams.

In lieu of more compelling empirical support, the logbook enhancement hypothesis can be assessed indirectly by examining predictions related to the mechanisms likely to underlie the enhancement effect. If the effect is proportional to the amount of time spent trying to recall dreams it should be influenced by motivation. Indeed, motivation is widely considered to be a key determinant of dream recall (e.g. Belicki, 1987; Goodenough, 1991; Reed, 1973; Schredl *et al*., 2001). It can thus be predicted that the logbook enhancement effect should tend to gradually decline over time in tandem with motivation as the initial novelty of participation wears off and participants spend less time trying to recall their dreams each morning (as long as they are not given ongoing encouragement or techniques for enhancing dream recall). Indeed, several studies have produced results consistent with this. Schredl (2001, as cited in Schredl & Fulda, 2005) found that narrative logbook-DC was 28% lower in the second week of keeping a logbook compared to the first and Bernstein and Belicki (1995-96) found that when narrative logbooks (eliciting written descriptions of only one dream per night) were maintained for two 14-day periods separated by several months, logbook-DC was significantly lower by 18% in the second period. Similar results were found by Schredl *et al*. (2001) using a sample of older adults that were asked to report their dream recall each week over the telephone for 26 weeks instead of keeping a logbook. The number of dreams reported in the second 4-week period was 22% lower compared to the first 4-week period and 39% lower in the final 4-week period (although only the latter comparison was statistically significant). Schredl *et al*. (2013) observed a 17% decline in narrative logbook-DRF over two time periods of approximately one week each (although the difference was not statistically significant) and Busby and De Konick (1980) reported a mean reduction in narrative logbook-DC of 21% in the fifth compared to the first week of keeping a logbook for two groups of participants across four different conditions that involved practising meditation, relaxation and two non-intervention periods. In the aforementioned study by Zadra and Robert (2012) the mean number of words per dream in the narrative group was 11% lower in the second 5-day period and 20% lower in the third 5-day periods compared to the first 5-day period (although only the latter was significant). There was also a significant reduction in logbook-DC in the second 5-day time period compared to the first that appears to have been between about 15% and 20% for both the narrative and the checklist groups (results were presented graphically and exact figures not provided). Similar results were reported in an earlier study by Robert and Zadra (2008).

In contrast to the above, the present author is aware of four studies that failed to observe significant reductions in logbook dream recall rates over time. Watson (2003) found no significant difference in logbook-DRF between the first three weeks and the last three weeks of a 14-week checklist logbook period and participants in a study by Schredl and Fulda (2005) who kept a checklist logbook for four weeks did not show any significant difference in logbook-DRF between the first and second 2-week periods. Dream recall rates based on a checklist logbook that involved rating the extent to which each dream was recalled remained stable over three consecutive 2-week periods in a study by Rochlen *et al*. (1999) and narrative logbook-DRF remained stable across two consecutive 20-day periods in a study by Segall (1980) for participants in a control group (the other group involved assertiveness training, which was expected to affect dream recall and is thus not described here). It is noteworthy that most of these studies used checklist logbooks whereas all the studies in which dream recall declined over time used narrative logbooks (except for the study by Schredl *et al.,* 2001, in which dream recall was assessed using weekly telephone interviews). However, Segall (1980) is an exception to this pattern and in studies by Zadra and Robert (2012) and Robert and Zadra (2008) participants showed similar declines in dream recall regardless of whether checklist or narrative logbooks were used. In light of this it seems unlikely that the four studies in which dream recall remained stable can be explained by the type of logbook used. An alternative explanation is that participants in these studies may have experienced little if any logbook enhancement effect to begin with. This could conceivably occur when participants have low motivation and consequently spend little or no time recalling dreams prior to making a logbook entry each morning for the entire logbook period. Indeed, participants in the study by Rochlen, *et al*. (1999) were recruited on the basis of having below-average interest in dreams and participants of all four studies involved undergraduates who were given course credit in exchange for participation. Thus, these studies, like those in which logbook dream recall rates declined over time, are consistent with the logbook enhancement hypothesis. However, none of these findings provide compelling empirical support for the hypothesis because reductions in logbook dream recall rates may simply reflect failures on behalf of participants to record their dream recall that increase in frequency over time due to waning motivation levels. This tendency to underreport might remain stable in studies involving participants with consistently low motivation, explaining the studies in which no reductions in logbook dream recall rates were observed.

It remains unclear whether narrative or checklist type logbooks are more likely to enhance dream recall. Studies that have compared the two have found that checklist logbooks yield significantly higher dream recall rates than narrative logbooks (Robert & Zadra, 2008; Zadra & Robert, 2012). This may be due to checklist logbooks having a stronger tendency to enhance dream recall, perhaps because people are willing to spend more time recalling their dreams prior to making a logbook entry if they are not required to provide written narratives for them. However, an alternative explanation is that both types of logbook have a similar effect on dream recall but participants are more likely to underreport their dream recall with narrative logbooks in order to reduce the burden of writing out their dreams. Narrative logbooks may even cause a *stronger* enhancement in dream recall than checklist logbooks, which could occur if writing out one's dreams facilitates dream recall. However, this would not be reflected by narrative logbook dream recall rates if the underreporting effect is stronger than the enhancement effect. Regardless of whether checklist or narrative logbooks are more likely to enhance dream recall, narrative logbooks will be more vulnerable to confounding variables associated with underreporting. For example, people who are less conscientious, who have poor sleep hygiene or who simply have less available time in the morning (e.g. due to 9-to-5 employment) may be less willing or able to report the full extent of their dream recall using narrative logbooks. Thus, checklist logbooks are likely to provide a more valid measure of dream recall than narrative logbooks.

6.5 Discussion

Several possible explanations for the retrospective-logbook disparity were explored in the present review. The disparity is unlikely to be due to participants exaggerating their dream recall or making deliberate attempts to enhance it while keeping a logbook because the demand characteristics of studies in which it has been observed were minimal and none of them involved any encouragement or instruction to enhance dream recall. The disparity is also not likely due to participants including a wider range of instances of dream recall in logbook measures compared to retrospective measures because several studies have observed substantial disparities for specific kinds of dreams that were defined precisely and consistently for both retrospective and logbook measures. The two most plausible remaining explanations are that retrospective measures tend to underestimate dream recall and that keeping a logbook tends to enhance it. These two explanations were referred to as the retrospective underestimation hypothesis and the logbook enhancement hypothesis respectively and were both explored in relation to theoretical considerations and available empirical evidence.

The retrospective underestimation hypothesis is supported theoretically by Tversky and Kahneman's (1973) availability heuristic, according to which people estimate the frequency of events based on the ease with which exemplars can be brought to mind. People who spend less time recalling and encoding memories of dreams should find it more difficult to recall instances of dream recall and thus be more prone to underestimation. The retrospective underestimation effect should also be stronger for retrospective measures based on longer periods of time (e.g. the previous 12 months) than those based on shorter periods (e.g. the previous month). This is because frequency judgments have been shown to be lower when people are required to consider the availability of a larger number of exemplars (e.g. Aarts & Dijksterhuis, 1999; Schwarz *et al*., 1991) and also because forgetting becomes increasingly likely over time (Roediger *et al*., 2010). Indeed, the retrospective-logbook disparity is for the most part greatest in studies that have used retrospective measures based on longer time periods. Furthermore, studies that have used multiple retrospective measures based on different time periods in the same sample have shown that retrospective dream recall rates are significantly lower when based on longer time periods, at least for specific types of dreams including lucid dreams, flying dreams, bad dreams and nightmares (Pietrowsky & Köthe, 2003; Robert & Zadra, 2008; Wood & Bootzin, 1990; Zadra & Donderi, 2000). Taken together these findings constitute compelling empirical support that retrospective measures underestimate dream recall, at least when they are based on relatively long time periods. Retrospective measures are likely to be confounded with a wide range of variables related to this underestimation effect, such as "inner focus" variables (e.g. introversion, fantasy proneness, absorption etc.) and memory function. Consequently, retrospective measures are likely to be most valid when they are based on shorter time periods (e.g. the previous two weeks).

The logbook enhancement hypothesis is supported theoretically by the arousal retrieval model of dream recall, according to which dream recall is proportional to the amount of time spent trying to retrieve memories of dreams (Koulack & Goodenough, 1976). Participants must consider whether they can recall dreams prior to making logbook entries and for this reason logbooks should enhance dream recall, especially for participants who ordinarily do not pay much attention to their dreams. However, although this theory is highly plausible and theoretically supported, there is a lack of empirical evidence bearing upon it directly and more empirical research is needed to confirm that logbooks enhance dream recall. It also remains unclear whether narrative or checklist type logbooks would be more likely to enhance dream recall, although participants will be more likely to underreport the number of dreams they recall while keeping narrative logbooks in order to reduce the substantial burden of writing out their dreams and may choose to only include the most salient or memorable dreams. In contrast, participants are more likely to report all of the dreams they recall with checklist logbooks because checklist logbooks can be completed quickly and easily regardless of the number of dreams recalled. Thus, checklist logbooks are likely to be the most valid and are the most suitable for studies investigating predictors of dream recall. However, it may be the case that narrative and checklist logbooks are similarly valid in certain populations, such as lucid dreaming enthusiasts or people who are otherwise willing to spend as much time as necessary providing comprehensive narrative logbook entries every morning. If narrative logbooks are used it is likely that word counts will be the least valid operationalisation because they will be the most vulnerable to the underreporting effect and other possible confounds such as verbal intelligence or writing style. In contrast, DC and DRF are likely to be less affected by underreporting and thus more valid, although further research is needed before firm conclusions can be made about this. But even when validity is maximised and underreporting is minimised, checklist and narrative logbooks are both likely to enhance dream recall, meaning that even if they provide a valid measure of *enhanced* dream recall they may still fail to provide an accurate reflection of *typical* (unaltered) dream recall.

6.6 Recommendations for future research

The theory of retrospective underestimation outlined above would be strengthened if it could be shown that people estimate their dream recall using the availability heuristic. This could be done by replicating the study conducted by Aarts and Dijksterhuis (1999) using frequency of dream recall as the dependent variable rather than frequency of bicycling. The relationship between the retrospective underestimation effect and the size of the estimation period could be further explored by administering multiple retrospective measures based on various different time periods (e.g. the previous week, month and 12 months) in the same sample and this should be done using measures of general dream recall. If measures based on longer time periods yield lower dream recall rates this would suggest an underestimation effect that increases with the size of the estimation period. It would also be informative to explore whether different types of retrospective measures that include the same time period yield different dream recall rates, such as open ended measures based on the previous 12 months and measures that include “once per year” as one of their fixed response options. Future studies should measure variables likely to be associated with retrospective underestimation such as need for cognition and participants’ self-rated certainty that their responses to retrospective measures are correct. If greater need for cognition and certainty is associated with a smaller retrospective-logbook disparity it would suggest the presence of a retrospective underestimation effect related to heuristic processing. The lack of empirical research bearing directly on the logbook enhancement hypothesis could be addressed by logbook studies that ask people to record the amount of time they spend thinking about their dreams prior to making logbook entries each morning and to also rate the extent to which they think their dream recall improved (if at all) at post-test. If these variables were significantly correlated with a retrospective-logbook disparity it would suggest that keeping a logbook enhanced dream recall by causing participants to spend more time on the retrieval process. This could be complemented by a qualitative approach whereby participants are asked at post-test if they think their dream recall improved during the logbook period, and if so, why.

Future studies should also calculate and explore the retrospective-logbook disparity separately for low, medium and high recallers because the disparity has been shown to vary as a function of retrospective recall rates (Antrobus *et al*., 1964; Cory *et al*., 1975; Schredl, 2002; Schredl *et al*., 2003; Zadra & Robert, 2012). Demand characteristics should be minimised because they could potentially bias both retrospective and logbook dream recall rates. For example, participants might exaggerate their dream recall if they think that high recall rates are desired. What counts as an instance of dream recall should be made clear to participants and this should be consistent for retrospective and logbook measures to ensure that both measures operationalise dream recall comparably. Otherwise, there is a risk of participants including a wider range of dream recall instances (especially borderline cases) in their logbook entries than in their retrospective estimates. It is also important that retrospective-logbook disparities are not derived by comparing DRF measures with DC measures because although DRF rates cannot exceed the number of days in a measurement period, DC has no upper limit. For this reason DC may be better able to capture logbook enhancement effects than DRF and may thus be more appropriate for exploring the retrospective-logbook disparity, especially among high recallers. Indeed, logbook DRF will not capture enhancement effects at all among participants for whom baseline DRF is already close to 100%.

6.7 Conclusions

The retrospective-logbook disparity is likely to be due to a combination of both retrospective underestimation and logbook enhancement. Retrospective and logbook measure are both likely to be confounded with a wide range of variables that may have little or no relationship to true dream recall rates. This calls into question much of the existing empirical literature on predictors of home dream recall, especially studies in which narrative logbooks (as opposed to checklist logbooks) or retrospective measures based on relatively long time periods have been used. In light of this, further research exploring the extent to which retrospective measures underestimate dream recall and logbooks enhance it should be considered a high priority among dream researchers.

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Chapter 7: Empirical Investigation into Measures of Dream Recall

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Abstract

In a recent review, Aspy, Delfabbro and Proeve (2015) highlighted the tendency for retrospective measures of dream recall to yield substantially lower recall rates than logbook measures, a phenomenon they termed the *retrospective-logbook disparity*. One explanation for this phenomenon is that retrospective measures underestimate true dream recall. Another explanation is that keeping a logbook tends to enhance dream recall. The present study provides a thorough empirical investigation into the retrospective-logbook disparity using a range of retrospective and logbook measures and three different types of logbook. Retrospective-logbook disparities were correlated with a range of variables theoretically related to the retrospective underestimation effect, and retrospective-logbook disparities were greater among participants that reported improved dream recall during the logbook period. These findings indicate that dream recall is underestimated by retrospective measures and enhanced by keeping a logbook. Recommendations for the use of retrospective and logbook measures of dream recall are provided.

Is dream recall underestimated by retrospective measures and enhanced by keeping a logbook? An empirical investigation

7.1 Introduction

Dream recall in the home setting is assessed using two widely used types of measures. Logbook measures involve keeping a daily record of one's dream recall, which is usually operationalised as either the number of mornings on which dream content is recalled (regardless of how much is recalled) or the number of separate dreams recalled each morning. These two operationalisations are referred to as *Dream Recall Frequency* (DRF) and *Dream Count* (DC) respectively (Aspy, Delfabbro, & Proeve, 2015). Some logbooks elicit written narratives of each dream recalled and are referred to as *Narrative logbooks*, whereas logbooks that do not elicit dream narratives are referred to as *Checklist logbooks*. In contrast to logbook measures, retrospective measures of dream recall involve estimating one's DRF or DC for a recent specified time period (e.g. the past week) or by selecting one of several response options (e.g. "almost every morning", "several times a week", "about once a week" etc.). Until recently, there has been an implicit assumption that retrospective and logbook measures are essentially equivalent and that the choice between them is of little consequence in empirical research (Beaulieu-Prévost & Zadra, 2007). However, in a recent review, Aspy et al. (2015) drew attention to the tendency for logbook measures to yield substantially higher dream recall rates than retrospective measures. Aspy et al. (2015) termed this the *retrospective-logbook disparity*, a phenomenon that previous authors have also drawn attention to (Beaulieu-Prévost & Zadra, 2007; Schredl, 2002; Schredl & Fulda, 2005; Zadra & Robert, 2012). Aspy et al. (2015) found that out of 17 studies in which a disparity was reported or could be calculated, the majority (77%) found that logbook dream recall rates were between 10% and 610% higher than retrospective rates with an unweighted mean disparity of 115%.

There are two principal explanations for the retrospective-logbook disparity. According to the *retrospective underestimation hypothesis* (Aspy et al., 2015; see also Beaulieu-Prévost & Zadra, 2007; Schredl, 2002; Zadra & Robert, 2012), retrospective measures tend to underestimate true dream recall rates. According to the *logbook enhancement hypothesis* (Aspy et al., 2015; see also Beaulieu-Prévost & Zadra, 2007; Cohen, 1969; Cory et al., 1975; Goodenough, 1991; Schredl, 2002), keeping a logbook enhances dream recall due to greater attention being paid to dreams each morning. Both of these explanations have important implications for the measurement of dream recall. If the retrospective underestimation hypothesis is correct, retrospective measures may be confounded with a range of variables related to the tendency to underestimate dream recall but that are unrelated to true dream recall rates. Similarly, if the logbook enhancement hypothesis is correct, logbook measures may fail to accurately reflect ordinary dream recall rates and may be confounded with variables related to the enhancement effect. Indeed, although there have been well over 100 empirical studies on correlates of home dream recall using a variety of retrospective and logbook measures, most of these have found only weak relationships and findings are often inconsistent or even contradictory (for reviews, see Beaulieu-Prévost & Zadra, 2007; Belicki, 1987; Blagrove & Pace-Schott, 2010; Goodenough, 1991; Schredl & Montasser, 1996-1997a, 1996-1997b; Schredl, Wittmann, Ciric, & Götz, 2003; Zadra & Robert, 2012). Aspy et al. (2015) gave in-depth consideration to the retrospective-logbook disparity and concluded that it is likely to be the result of both retrospective underestimation and logbook enhancement effects. This calls into question much of the existing empirical literature on home dream recall, and Aspy et al. (2015) concluded that further research into this issue should be considered a high priority among dream recall researchers.

7.1.1 The retrospective underestimation hypothesis

According to Tversky and Kahneman's (1973) availability heuristic, people estimate the frequency of events based on how easily specific instances of the event in question can be recalled. This heuristic has been shown to apply in a wide range of situations (see Schwarz, 1998 for a review) and provides theoretical support to the retrospective underestimation hypothesis. Retrospective measures should be fairly accurate when the number of instances of dream recall brought to mind reflects the true frequency of dream recall. However, when this is not the case underestimation is likely to occur, an example of what is referred to as the *ease of recall bias* (see Buontempo & Brockner, 2008). Underestimation should thus be more likely to occur among people who have little interest in dreams or that spend relatively less time thinking about them, discussing them with other people, or attending to them generally. This is because such people should find it harder to recall occasions on which they recalled their dreams. Tentative support for this theory comes from studies that have found "inner focus" variables (variables that operationalise awareness of inner mental experiences) to be more strongly correlated with retrospective measures of dream recall than logbook measures, such as absorption and psychological boundaries (Beaulieu-Prévost & Zadra, 2007), introversion (Early, 1977, as cited in Schredl, 2002), imaginative involvement and fantasy proneness (Levin, Fireman, & Rackley, 2003). Attitude toward dreams has also been shown to be more strongly correlated with retrospective measures than logbook measures (Beaulieu-Prévost & Zadra, 2007). Aspy et al. (2015) theorised that retrospective underestimation should be less likely to occur if people estimate their dream recall using an elaborative cognitive process rather than a heuristic one, e.g., by estimating their dream recall over the past month and multiplying this by 12 to estimate their dream recall over the past year. Elaborative processing is operationalised by variables such as *need for cognition* (Suedfeld & Tetlock, 2001), which may thus be related to retrospective underestimation (Aspy et al., 2015). However, to date there have been no investigations into correlations between the aforementioned variables and disparities between retrospective and logbook measures of dream recall.

The theory of retrospective underestimation predicts that measures based on longer time periods will be more prone to underestimation. This is because such measures should require participants to recall more instances of dream recall. Indeed, several studies have shown that frequency estimates tend to be lower when people are asked to recall a greater number of instances (e.g. Aarts & Dijksterhuis, 1999; Schwarz et al., 1991) and it is well documented that the tendency to forget becomes increasingly likely over time (Roediger, Weinstein, & Agarwal, 2010). Unsurprisingly, of the studies reviewed by Aspy et al. (2015), the largest retrospective-logbook disparities were mostly found when retrospective measures based on relatively long time periods were used (e.g. the past year vs. the past month). However, the strongest empirical support for the retrospective underestimation hypothesis comes from several studies that used logbook measures and multiple retrospective measures of specific types of dream recall in the same sample. Zadra and Donderi (2000) found that retrospective-logbook disparities for nightmares, bad dreams, lucid dreams and dreams about flying were greater when retrospective measures based on the past month were used than when retrospective measures based on the past year were used. Similar findings were reported by Wood and Bootzin (1990), Pietrowsky and Köthe (2003) and Robert and Zadra (2008), who measured various types of distressing dreams using logbook measures and retrospective measures based on the past month and the past year. It is important to note that in all of these studies, what counted as an instance of dream recall was clearly defined and consistent across retrospective and logbook measures. This rules out the otherwise plausible theory that the disparities were simply due to participants noticing and then including more borderline instances of dream recall (e.g. single images or other remnants from dreams that were mostly forgotten) when making logbook entries than in their responses to retrospective measures. Aspy et al. (2015) argued that there is no clear reason to think that the cause of these disparities is different from the cause of the disparities observed between measures of general dream recall, and concluded that these findings provide strong support for the retrospective underestimation hypothesis. However, more research is needed to replicate these findings and investigate differences between different retrospective measures of general dream recall.

7.1.2 The logbook enhancement hypothesis

The logbook enhancement hypothesis is theoretically supported by the arousal retrieval model of dream recall (Koulack & Goodenough, 1976; see also Goodenough, 1991; Schredl, 2009 for reviews). According to this model, dream recall will be greatest if a period of arousal (wakefulness) occurs during or shortly after dreaming. Otherwise, it is likely that dream content will be lost from short-term memory. Dream content must then be retrieved in order for it to be consolidated into long-term memory and retained. Dream recall will be greatest when retrieval occurs shortly after arousal and without distraction. It follows that logbooks will tend to enhance dream recall because participants need to spend at least some time on the retrieval process in order to make a valid logbook entry and this is typically done immediately or shortly after waking. The logbook enhancement effect should thus be related to the amount of time spent on recalling dreams prior to making each logbook entry. The logbook enhancement effect should also be related to one's pre-existing tendency to spend time recalling dreams. People who typically spend little time recalling dreams should experience a relatively strong enhancement effect because keeping a logbook will result in them spending more time than usual on the retrieval process. In contrast, people who have a stronger pre-existing tendency to spend time recalling their dreams should experience less of an effect because keeping a logbook will have relatively little (if any) effect on the amount of time they spend recalling dreams. This may explain why several studies have found the retrospective-logbook disparity to be greatest among "low recallers" (people with low retrospective recall rates) and smallest among "high recallers" (Antrobus, Dement, & Fisher, 1964; Cory, Ormiston, Simmel, & Dainoff, 1975; Purcell, 1987; Schredl, 2002; Zadra & Robert, 2012). However, it is important to note that the tendency for the retrospective-logbook disparity to be greatest among low recallers does not unambiguously support the logbook enhancement hypothesis. An alternative explanation is that low recallers are simply more prone to retrospective underestimation.

Although it is both widely believed (e.g. Beaulieu-Prévost & Zadra, 2005; Goodenough, 1991; LaBerge & Rheingold, 1991; Parker, Bauermann, & Smith, 2000; Schredl & Montasser, 1996-1997a; Wittmann, Schredl, & Kramer, 2006) and theoretically likely that logbooks tend to enhance dream recall, there is a lack of unambiguous empirical evidence in support of this. Aspy et al. (2015) suggested that future studies could address this gap in the literature by asking research participants to record the amount of time spent trying to recall dreams prior to making each logbook entry and to rate how much they think their dream recall improved at the end of the logbook period. If these variables were found to be correlated with the differences between retrospective and logbook measures of dream recall for each participant, this would support the logbook enhancement hypothesis. Aspy et al. (2015) also suggested that future studies should further investigate whether Checklist or Narrative type logbooks are more likely to enhance dream recall. The retrospective-logbook disparities in the studies reviewed by Aspy et al. (2015) tended to be larger when Checklist logbooks were used. Furthermore, studies that have compared Checklist and Narrative logbooks have found that Checklist logbooks yield significantly higher dream recall rates than Narrative logbooks (Robert & Zadra, 2008; Zadra & Robert, 2012). However, the explanation for these findings is unclear. It may be the case that participants are willing to spend more time recalling dreams when given Checklist logbooks because the amount of content recalled has minimal effect on the overall burden of making Checklist logbook entries. An alternative explanation is that participants are more likely to underreport their true dream recall while keeping Narrative logbooks in order to reduce the substantial burden of having to provide written narratives for each dream. Further research investigating whether Checklist or Narrative logbooks are more likely to reflect true (unaltered) dream recall rates is warranted.

7.1.3 Aims and hypotheses

The present study follows suggestions for further research by Aspy et al. (2015) and provides a thorough empirical investigation into the retrospective underestimation hypothesis and the logbook enhancement hypothesis as explanations for the retrospective-logbook disparity. Several retrospective and logbook measures based on different time periods were used to assess general dream recall as well as recall of nightmares, bad dreams, lucid dreams and flying dreams. Three different types of logbooks were used: a Checklist logbook, a Narrative logbook and a “Quantity logbook” that quantifies the overall amount of dream content recalled by asking participants to specify how completely each individual dream is recalled. This operationalisation of dream recall will henceforth be referred to as *Dream Quantity* (DQ). Based on the preceding review, it was hypothesised that logbook measures of dream recall would yield significantly higher dream recall rates than comparable retrospective measures of dream recall.[1] Furthermore, it was hypothesised that retrospective-logbook disparities would be greatest for low recallers and smallest for high recallers. The following additional experimental hypotheses related specifically to the retrospective underestimation hypothesis and the logbook enhancement hypothesis were investigated:

[1] It is very important that retrospective-logbook disparities not be based on comparisons between measures that use different operationalisations of dream recall. Although DRF cannot exceed the number of days in a given measurement period, DC has no upper limit.

7.1.3.1 The retrospective underestimation hypothesis

- It was hypothesised that retrospective measures of dream recall based on longer time periods would yield significantly lower dream recall rates than comparable retrospective measures based on shorter time periods.
- It was hypothesised that there would be significant negative correlations between retrospective-logbook disparities and the following pre-test variables: self-rated confidence that responses to retrospective measures were correct, the frequency of thinking about dreams, the frequency of discussing dreams, the amount of attention paid to dreams, attitude toward dreams, interest in dreams and need for cognition.

7.1.3.2 The logbook enhancement hypothesis

- It was hypothesised that retrospective-logbook disparities would be significantly greater for participants that recorded all of their dreams while keeping a logbook compared to participants that recorded only some of their dreams.
- It was hypothesised that retrospective-logbook disparities would be significantly greater for participants that attempted to improve their dream recall while keeping a logbook compared to participants that did not attempt to improve their dream recall.
- It was hypothesised that retrospective-logbook disparities would be significantly greater for participants that reported improvement in dream recall while keeping a logbook compared to participants that did not report improvement.
- It was hypothesised that there would be significant positive correlations between retrospective-logbook disparities and the amount of time spent trying to recall dreams while keeping a logbook.
- It was hypothesised that there would be significant positive correlations between retrospective-logbook disparities and participants' self-rated improvement in dream recall while keeping a logbook.

7.2 Method

7.2.1 Participants

The present study is based on data from a pre-test questionnaire and a baseline period logbook used in a larger study comparing the effectiveness of different lucid dream induction techniques. A total of 420 participants who did not meet the exclusion criteria signed up for the study and completed the pre-test questionnaire. The sample consisted of 221 (53%) females, 197 (47%) males and 2 participants who identified their gender as “other” (0.5%). The mean age was 34.4 (*SD* = 14.2) and ranged from 18 to 82. Most of the participants were employed non-students (*n* = 271, 65%), with 112 (27%) participants being students and 37 (9%) being unemployed or retired. A total of 187 participants went on to complete and return their Week 1 logbooks. The ratio of males to females did not differ between participants who did and did not complete the logbook: $\chi^2(1, N = 418) = 1.49$, $p = .222$. Participants who completed the logbook were significantly older than those who did not (see Table 7.1). The proportions of participants who were employed non-students, students, and unemployed or retired did not differ among participants who did and did not complete the logbook: $\chi^2(2, N = 420) = 5.02$, $p = .081$. Participants heard about the study from a range of recruitment sources: 138 (33%) from physical posters or flyers distributed in public locations across the Australian states of South Australia, Victoria and New South Wales; 89 (21%) from word of mouth; 59 (14%) from nationally televised news interviews with the author; 43 (10%) from newspaper articles; 38 (9%) from social media; 27 (6%) from other internet sources; and 26 (6%) from radio interviews. Participants were excluded from the study if they had been diagnosed with any kind of mental health disorder, sleep disorder or neurological disorder; suspected they *might* have one of these disorders; were experiencing a traumatic or highly stressful life event that was interfering with their sleep; suffered from persistent insomnia or were unable to keep a regular sleep schedule; had experienced sleep paralysis more than once in the past 6 months; found it unpleasant to think about their dreams; or were under 18 years of age. All participants who completed the study went into a raffle to win one of five $200 gift vouchers or one of ten $50 gift vouchers.

7.2.2 Materials

Materials included an online pre-test questionnaire and physical packages that contained an instructions sheet for the first week of the study (see section 2.3), three different types of Week 1 logbook and a sealed white envelope containing materials for the second week of the study. This envelope had the words "Week 2 materials – do not open until Week 1 is complete" printed on the front to discourage participants from attempting the lucid dreaming techniques prematurely, because this might have influenced responses during the Week 1 baseline period. All participants reported that they did not open the Week 2 envelope before completing their Week 1 logbooks. In the present paper, pre-test variables begin with a capital "P" to distinguish them from logbook variables, which begin with a capital "L."

7.2.2.1 Pre-test questionnaire

Demographic questions. Participants were asked to indicate their age, gender, occupation and how they heard about the study.

General dream recall. Several retrospective measures of general dream recall were used. The first of these (*P DRF Schredl*) was Schredl's (2004) widely used DRF measure that asks participants "How often have you recalled your dreams recently (in the past several months)?" Participants respond using a Likert-type scale ranging from 0 to 6 (0 = "never", 1 = "less than once a month", 2 = "about once a month", 3 = "two or three times a month", 4 = "about once a week", 5 = "several times a week" and 6 = "almost every morning"). Responses are converted to the approximate number of mornings per week with dream recall using the following class means: 0 = 0, 1 = 0.125, 2 = 0.25, 3 = 0.625, 4 = 1.0, 5 = 3.5, 6 = 6.5. Participants were then asked "How confident are you that your answer to the last question (about your dream recall) is accurate?" (*P DRF confidence*) and responded using a Likert-type scale ranging from 1 ("not at all") to 5 ("very"). This question appeared on a new page to ensure that participants could not modify their answer to the previous question (participants were not able to navigate back to previous pages of the pre-test questionnaire). Two more general dream recall measures were then presented. The first assessed DRF over the last week (*P DRF last week*) by asking "How many days during the last week did you remember your dreams from the previous night?" Participants selected one of eight options from a drop-down menu ranging from "0 days" to "7 days." Following, the number of separate dreams recalled over the past week (*P DC weekly*) was assessed by asking "On average, how many separate dreams do you usually remember per week?" Participants could select any whole number between 0 and 50 or "more than 50" from a drop-down menu.

Dream-related behaviours. Three questions assessed dream-related behaviours. The first of these (*P Dream think freq*) asked "How often do you spend time thinking about your dreams?" The same response options and recoding as Schredl's (2004) dream recall measure (see above) were used except that an additional response option (7 = "several times a day", recoded as 21.0 times per week) was offered. The other two questions were adapted from Brown and Donderi's (1986) 72-item *Sleep and Dream Questionnaire* (SDQ) and were both answered using Likert-type scales ranging from 1 to 5: "How often do you discuss your dreams with family or friends?" (*P Dream discuss freq*; 1 = "never", 5 = "very often"); "How much attention do you usually pay towards your dreams?" (*P Dream attention*; 1 = "very little", 5 = "very much").

Recall of specific types of dreams. Four questions adapted from Brown and Donderi's (1986) *Sleep and Dream Questionnaire* (SDQ) were included to assess retrospective dream recall for nightmares (*P DC nightmares month*), bad dreams (*P DC bad dreams month*), lucid dreams (*P DC lucid month*) and flying dreams (*P DC flying month*) over the past month. *Nightmares*: "Nightmares are very disturbing and often elaborate dreams in which the unpleasant visual imagery and/or emotions *wake you up* (i.e., the dream's unpleasant content woke you up while the dream was still ongoing). Please estimate the number of nightmares you have had in the past month." *Bad dreams*: "Bad dreams are very disturbing dreams which, though being unpleasant, do not cause you to awaken (e.g., you feel that the dream occurred earlier in the night prior to your awakening or you remembered it only after being awakened by external factors such as your alarm clock). Please estimate the number of bad dreams you have had in the past month." *Lucid dreams*: "Lucid dreams are those in which a person becomes aware of the fact that he or she is dreaming while the dream is still ongoing. For example: 'I was in England talking to my grandfather when I remembered that (in real life) he had died several years ago and that I had never been to England. I concluded that I was dreaming and decided to fly to get a bird's eye view of the countryside…' Please estimate the number of lucid dreams you have had in the past month." *Flying dreams*: "Please estimate the number of flying dreams (dreams in which you were able to fly) you have had in the past month." A second version of the above four questions (with the word "month" changed to "year") was used to assess recall over the past year. Both times, the four questions appeared together on a single page and the order of the two pages was randomised. The first page appeared directly after the questions about dream-related behaviours and the second page appeared after the *Need for Cognition Scale – short form*. For the past month questions, participants answered by selecting any whole number from 0 to 30 or "more than 30" from a drop-down menu. For the past year questions, participants chose from 0 to 365 or "more than 365." Responses to the past year questions were prorated to monthly rates (by dividing by 12) to permit direct comparison with past month versions of the questions.

Attitude toward dreams. Attitude toward dreams (*P ATD*) was assessed using Schredl, Brenner and Faul's (2002) *Attitude Toward Dreams scale*. This measure includes 10 statements such as "If I am very moved by a dream, I try to make sense of it." Participants indicate their level of agreement using a Likert-type scale ranging from 1 ("not at all") to 5 ("total agreement"). Eight of the items are reverse scored and all items are then summed and averaged, resulting in a score ranging from 1 to 5 (higher scores indicate more positive attitude toward dreams). This scale was chosen because it avoids a problem that is common in other measures of attitude toward dreams whereby items with direct reference to dream recall are included, which results in attitude toward dreams being confounded with dream recall (Schredl, 2010; Schredl et al., 2002). Schredl et al. (2002) found high test-retest reliability for this scale when it was re-administered after four weeks (r = .73) and good internal consistency at both testing times (α = .91 and α = .89). In the present study, an internal consistency of α = .74 was observed.

Interest in dreams. A single item measure was used to assess interest in dreams (*P interest in dreams*). Participants indicated their level of agreement with the statement "I am interested in my dreams" using a Likert-type scale ranging from 1 ("not at all") to 5 ("total agreement").

Need for cognition. Need for cognition (*P Need for cognition*) was assessed using the *Need for Cognition Scale – short form* developed by Cacioppo, Petty and Kao (1984). This measure includes 18 statements such as "I would prefer complex to simple problems." It is based on the original 34 item *Need for Cognition Scale* developed by Cacioppo and Petty (1982). Participants indicate their level of agreement with each statement using a 9-point Likert-type scale that ranges from -4 ("very strong disagreement") to +4 ("very strong agreement"). Responses are summed after reverse scoring nine of the items, resulting in scores that range from -72 to 72 (higher scores indicate greater need for cognition). Cacioppo, Petty and Kao (1984) found that the short form was strongly correlated with the full version of the scale (r = .95) and had good internal consistency (α = .90; see also Cacioppo, Petty, Feinstein, & Jarvis, 1996 for a review). In the present study, an internal consistency of α =.87 was observed.

7.2.2.2 Week 1 logbooks

Three different Week 1 logbooks were used. Each logbook used a different primary measure of general dream recall but were otherwise identical. The following instructions appeared on the first page of all three logbooks: "If you are not sure of an exact answer, please provide your best estimate. Do not provide descriptions of amounts in your answers. For example, when reporting how much time you spent sleeping last night, provide an exact estimate such as '7 hours and 45 minutes', not 'nearly 8 hours' or 'a bit less than usual'." Questions were answered each morning for seven days and appeared in the same order as below. Chronbach's alpha reliability coefficients for the measures of general dream recall are provided in Table 7.5. Participants first indicated the date of each entry so that the number of days taken to complete all seven entries could be assessed (*L Days to complete log*). The total number of logbook entries made by each participant (*L Total log entries*) was also counted. The amount of time spent trying to recall dreams prior to making a logbook entry (*L Mins recalling dreams*) was assessed in all three logbooks using the following questions: "Did you spend any time thinking about or trying to recall your dreams before filling in this logbook?" ("yes" or "no") and then "If 'yes', how much time?......minutes." All three logbooks then included the question "Can you recall anything *specific* about your dreams from last night?" ("yes" or "no"). This, along with answers to the primary measures of general dream recall, were used to determine the number of days with dream recall (*L DRF*) and the number of separate dreams recorded (*L DC*).

Primary measures of general dream recall. For the Checklist logbook, participants were instructed: "Please provide a brief title for each dream you can remember." Participants were then provided with seven blank lines preceded by "Dream #1", "Dream #2" etc. to provide brief titles. For the Narrative logbook, participants were instructed: "Please provide detailed descriptions for each dream you can remember. Please be as thorough as possible and write out everything you can remember about your dreams. Please also draw a horizontal line between each dream so that we can tell how many separate dreams you had." Participants were provided with approximately two blank horizontally ruled pages to provide dream narratives. They were also instructed to use additional blank pages provided to them if they ran out of space. The Quantity logbook was the same as the Checklist logbook but included an additional measure that quantifies the overall amount of dream content recalled by asking participants to rate how completely each individual dream is recalled. This operationalisation of dream recall is referred to as *Dream Quantity* (DQ) in the present paper. Participants were instructed: "Please provide a brief title for each dream you can remember. Then, rate the amount of content you can recall from each individual dream using the following categories. Please be as thorough as possible and rate *all* of the dreams that you can recall." The four categories were presented as follows:

> *Fragmentary* (F): You recall some content (such as a single scene or an isolated image), but not enough to provide any "flow" in the narrative. There are no transitions from one scene or event to the next.
>
> *Partial* (P): You recall enough content for there to be some "flow" in the narrative from one scene or event to the next. However, you're pretty sure that *most of the dream has been forgotten*.

Majority (M): You recall a substantial amount and you're pretty sure you can recall *at least half* of the dream. However, there are frustrating gaps indicating that a significant amount is still missing.

Whole (W): Fairly complete recall of the dream without any frustrating gaps in your memory of what happened (although the beginning of the dream and some details might still be missing).

Participants were provided with seven blank lines as per the Checklist logbook to provide brief titles and ratings. This measure was adapted from an earlier measure developed by Reed (1973, see also Reed 1976). The number of categories was reduced and the definitions were made more concise to render the measure quicker and easier for participants to complete. Responses were converted to numerical values as per the procedure originally devised by Reed (1973): "F" = 1, "P" = 2, "M" = 4, "W" = 8. Reed (1973) found that this geometrical series closely approximated the proportional number of elements reported in the dreams of successive categories. A total of 729 dreams were rated as follows: F, 195 (27%); P, 211 (29%); M, 195 (27%); W, 128 (18%). Numerical values were summed for each logbook entry, resulting in total dream recall scores (higher scores indicate greater recall of dream content). This variable is referred to as *L DQ* in the present paper. In all three logbooks, the following question appeared directly after the primary dream recall measure: "How long did it take for you to provide [brief titles / brief titles and ratings / written descriptions] for all of your dreams?......minutes" (*L Mins to record dreams*).

Secondary measures of general dream recall. Three additional questions were used in all three logbooks to assess overall self-rated dream recall (*L Recall rating*), difficulty (*L Recall difficulty*) and clarity (*L Recall clarity*) using Likert-type scales ranging from 1 to 5: *L Recall rating*, "On a scale of 1 to 5, how much do you recall of your dreams from last night?" (1 = "nothing specific", 2 = "hardly anything", 3 = "a small amount", 4 = "a moderate amount", 5 = "a large amount"); *L Recall difficulty*, "On a scale of 1 to 5, how difficult was it for you to remember your dreams from last night?" (1 = "not at all difficult", 2 = "slightly difficult", 3 = "somewhat difficult", 4 = "quite difficult", 5 = "very difficult"); and *L Recall clarity*, "On a scale of 1 to 5, how clear are your memories of your dreams from last night?" (1 = "not at all clear", 2 = "slightly clear", 3 = "somewhat clear", 4 = "quite clear", 5 = "very clear").

Recall of specific types of dreams. Four questions were included to assess the number of nightmares (*L DC nightmares*), bad dreams (*L DC bad dreams*), lucid dreams (*L DC lucid*) and flying dreams (*L DC flying*). Definitions were the same as in the pre-test questionnaire (see section 2.2.1) and were provided in parentheses. The questions took the following form: "Did you have any flying dreams [definition included in parentheses] last night?" Participants ticked a box to indicate either "yes" or "no." Participants were then asked "If 'yes', how many?" and given a blank space to provide an answer. Dream recall rates were prorated to monthly rates (by multiplying by four) to permit direct comparison with retrospective DC measures of these specific types of dreams.

Summary questions. The following questions were presented only once and appeared directly after the questions for Day 7 in each logbook. Participants were asked, "Over the last seven days, did you typically provide brief titles for *all* of the dreams you remembered each morning before filling in your logbook or only for *some* of your dreams? (don't include dreams you recalled later in the day after you made a logbook entry)" ("all" or "some"), and were then asked to rate the extent to which they reported their dreams with the following question: "If you answered "some" above, how many of the dreams that you remembered in the morning did you typically provide brief titles for each morning?" Response options were "0-20%", "20-40%", "40-60%", "60-80%" and "80-100." These were converted to the following values for analysis: 0.1, 0.3, 0.5, 0.7 and 0.9 (*L Percent recorded*). Unfortunately, there were some errors in the wording of the above two questions in the Narrative logbook and thus the Narrative logbook group had to be excluded from analysis of these variables. Participants were then asked "Did you make any deliberate attempt to improve your dream recall while keeping this logbook?" ("yes" or "no"). Two questions were used to assess self-reported improvement in dream recall: "Was your dream recall better than usual while keeping this logbook over the last seven days?" ("yes" or "no"). Following, "On a scale of 1 to 5, how much did your dream recall improve while keeping this logbook?" (*L Recall improvement*; 1 = "not at all", 2 = "slightly", 3 = "somewhat", 4 = "quite a lot", 5 = "very much"). Participants were then asked "Did you open the white envelope for Week 2 before completing this logbook?" ("yes" or "no"). Finally, participants were asked "On average, how long did it take you to fill out this logbook each morning?......minutes." (*L Mins per log entry*).

7.2.3 Procedure

Participants accessed the online pre-test questionnaire and an information sheet outlining the study using a web URL that was included in all promotional materials and media items. The questionnaire was hosted by the popular survey management website *Survey Monkey* and was configured so that participants could not navigate backwards to change their answers. At the end of the questionnaire, participants provided postal details so that they could be sent the materials needed to complete the study via post. Participants thus completed the study in their own homes, which allowed participants from anywhere in Australia to take part. Participants were randomly allocated to the three different logbook groups. The Week 1 instructions sheet explained that the purpose of the first week was to gather baseline information about normal sleeping patterns and dream recall ability. Participants were urged to complete all seven logbook days consecutively and to do extra days at the end if necessary to make up for any skipped days. They were instructed to keep the logbook and a pen beside their bed and to make each entry first thing upon waking. They were asked not to make any attempt to have lucid dreams or to improve their dream recall during the first week and to only open the Week 2 envelope when all seven Week 1 logbook entries were complete. Participants were instructed to return their completed logbooks once they had completed their Week 2 logbooks using pre-paid envelopes provided to them. Several attempts were made to contact participants via email if they had not returned their completed materials within approximately six weeks of completing the pre-test questionnaire. Several participants returned their completed Week 1 logbooks after opting to withdraw from the lucid dream induction component of the study.

7.3 Results

7.3.1 Data preparation and overview of analysis

Logbook data from three participants was excluded from analysis because most questions were not answered and in some cases multiple answers were provided for the same question. Most variables were not normally distributed and non-parametric tests were used in most cases. Outliers were removed for correlations and multiple regression analysis using the outlier labelling rule (Hoaglin, Iglewicz, & Tukey, 1986; Tukey, 1977). A multiplier value of 2.2 was used as per the recommendations of Hoaglin and Iglewicz (1987). Retrospective-logbook disparities were calculated as follows: (mean logbook rate – mean retrospective rate) / mean retrospective rate. For disparities between two retrospective measures based on different time periods, the following method was used: (shorter retrospective measure – longer retrospective rate) / longer retrospective measure. The low, medium and high recaller groups were defined according to the following recoded responses to Schredl’s (2004) DRF measure: low recallers = 0.0, 0.125 and 0.25 per week; medium recallers = 0.625 and 1.0 per week; high recallers = 3.5 and 6.5 per week.

7.3.2 Descriptive statistics and preliminary analyses

Descriptive statistics with Wilcoxon signed-ranks tests for differences in pre-test variables between participants who did and did not complete the Week 1 logbook are presented in Table 7.1. The slightly higher rates of pre-test general dream recall variables among logbook completers suggests that logbook completers may have had slightly higher general dream recall. Logbook completers also had significantly lower need for cognition and were significantly older than non-completers, but were almost identical on all other measures. Thus, it appears that logbook completers were representative of non-completers in most ways. Because the mean age difference was substantial (7.5 years), correlations between age and all other variables were examined. It was found that age was only significantly correlated with four of the variables in Table 7.1: *L Mins recalling dreams*, (r = .21, p = .005); *L DQ*, (r = .28, p = .044); *L Recall rating* (r = .16, p = .034); and *L Recall difficulty* (r = -.16, p = .035). Since age was related to measures of dream recall that involved subjective self-ratings but not *L DRF* or *L DC*, it may be the case that older participants differed in their subjective judgments of their dream recall but did not differ in the true extent to which they recalled their dreams.

Table 7.1

Descriptive statistics for pre-test and logbook variables with Wilcoxon signed-ranks tests for pre-test differences between participants who did and did not complete the logbook.

Pre-test variable	*M* (*SD*)			Wilcoxon test		Logbook variable	*M* (*SD*)	*N*
	All participants (*N* = 420)	Logbook completers (*n* = 184)	Non-completers (*n* = 233)	*Z*	*p*			
Age	34.4 (14.2)	38.6 (14.9)	31.1 (12.6)	-5.29	<.001	L Mins recalling dreams	6.5 (8.2)	184
P DRF Schredl	2.8 (2.3)	3.1 (2.4)	2.6 (2.2)	-1.92	.055	L DRF	5.4 (1.5)	184
P DRF last week	2.9 (2.0)	3.1 (2.1)	2.8 (1.9)	-1.07	.287	L DC	12.0 (7.4)	184
P DC weekly	4.1 (4.5)	4.5 (4.3)	3.8 (4.6)	-1.73	.083	L DQ	6.1 (7.0)	53
P DC nightmares (month)	1.0 (2.3)	0.8 (1.8)	1.2 (2.7)	-0.66	.510	L Recall rating	2.8 (0.8)	184
P DC bad dreams (month)	2.1 (3.6)	1.8 (2.9)	2.3 (4.1)	-0.48	.632	L DC nightmares	1.1 (2.5)	184
P DC flying (month)	0.8 (2.5)	0.9 (2.9)	0.7 (2.1)	-0.76	.449	L DC bad dreams	2.9 (5.2)	184
P DC lucid (month)	1.4 (3.8)	1.4 (3.9)	1.4 (3.8)	-0.14	.890	L DC flying	0.9 (2.9)	184
P DC nightmares (year)	0.6 (1.9)	0.4 (1.4)	0.7 (2.3)	-1.22	.224	L DC lucid	3.0 (7.5)	184
P DC bad dreams (year)	1.1 (2.5)	1.2 (2.9)	1.0 (2.1)	-0.22	.823	L Mins to record dreams	3.9 (4.6)	184
P DC flying (year)	0.4 (1.3)	0.5 (1.6)	0.3 (1.0)	-1.80	.072	L Recall clarity	2.6 (0.9)	184
P DC lucid (year)	0.8 (2.7)	0.8 (3.0)	0.7 (2.4)	-0.56	.575	L Recall difficulty	3.1 (0.9)	184
P DRF confidence	4.1 (0.9)	4.2 (0.8)	4.0 (0.9)	-1.37	.170	L Recall improvement	2.4 (1.1)	173
P Dream think freq	4.2 (5.3)	4.2 (5.1)	4.2 (5.4)	-0.72	.475	L Mins per log entry	7.4 (5.8)	173
P Dream discuss freq	3.0 (1.0)	3.1 (1.0)	3.0 (1.0)	-0.67	.506	L Days to complete log	7.4 (3.1)	173
P Dream attention	3.4 (1.1)	3.4 (1.1)	3.4 (1.2)	-0.05	.958	L Total log entries	7.0 (0.2)	184
P ATD	4.4 (0.5)	4.4 (0.5)	4.3 (0.5)	-0.59	.554	L Percent recorded	95.5% (11.2%)	116
P Interest in dreams	4.6 (0.7)	4.5 (0.8)	4.6 (0.6)	-0.64	.522			
P Need for cognition	28.3 (18.3)	25.9 (18.2)	30.1 (18.2)	-2.08	.037			

Note. Dream recall rates for nightmares, bad dreams, flying dreams and lucid dreams were prorated to monthly rates in all cases.

Correlations between retrospective and logbook measures of general dream recall are presented in Table 7.2. All three retrospective measures were strongly correlated with each other, with shared variance ranging from 48% to 70%. Correlations among logbook measures were mostly of a similar magnitude with shared variance ranging from 33% to 66%. However, correlations between retrospective measures and logbook measures were in most cases substantially smaller, ranging from 19% to 42% in shared variance. These findings demonstrate that retrospective and logbook measures of dream recall are not equivalent.

Table 7.2

Pearson correlations between retrospective and logbook measures of general dream recall.

	P DRF Schredl	P DRF last week	P DC weekly	L DRF	L DC	L DQ
P DRF last week	.84**	-	-	-	-	-
P DC weekly	.69**	.77**	-	-	-	-
L DRF	.49**	.51**	.44**	-	-	-
L DC	.43**	.45**	.52**	.71**	-	-
L DQ	.50**	.55**	.65**	.57**	.81**	-
L Recall rating	.51**	.53**	.47**	.73**	.62**	.81**

* *p* = <.05, ** *p* = <.01

Kruskal-Wallis tests were conducted to investigate whether logbook measures were influenced by the type of logbook used. These analyses are presented in Table 7.3. Five of the group differences were statistically significant at the .05 alpha level. Pairwise comparisons were conducted with adjusted significance values calculated by multiplying the unadjusted significance values for each pairwise comparison by the number of comparisons for each variable. It was found that participants in the Checklist group had significantly less flying dreams than those in the Quantity group (χ^2 = -14.84, p = .043). However, the differences between the Checklist and Narrative groups (χ^2 = 5.90, p = .931) and the Narrative and the Quantity groups (χ^2 = 8.94, p = .451) were not significant. Participants in the Checklist group reported significantly more bad dreams than those in the Narrative group (χ^2 = 20.88, p = .033), but there were no significant differences between the Narrative and Quantity groups (χ^2 = 9.30, p= .866) or between the Quantity and Checklist groups (χ^2 = 11.58, p = .529). Based on the p values in Table 7.3, it seems most likely that these findings are spurious. *L Mins to record dreams* was significantly higher in the Narrative group compared to both the Quantity (χ^2 = -72.21, p = <.001) and Checklist (χ^2 = 71.53, p = <.001) groups, with the difference between the Quantity and Checklist groups being non-significant (χ^2 = 0.68, p = .100). Similarly, *L Mins per log entry*, was significantly higher in the Narrative group compared to both the Quantity (χ^2 = -48.99, p = <.001) and Checklist (χ^2 = -36.55, p = <.001) groups, with the difference between Quantity and Checklist groups being non-significant (χ^2 = 12.45, p = .543). Finally, *L Mins recalling dreams* was significantly higher in the Narrative group compared to the Quantity group (χ^2 = -25.09, p = .035). However, the differences between the Narrative and the Checklist groups (χ^2 = -14.62, p = .350) and the Quantity and Checklist (χ^2 = 10.46, p = .846) groups were non-significant. Despite participants in the Narrative group spending substantially more time recalling and recording their dreams than participants in the other two groups, this does not seem to have resulted in higher dream recall rates. Indeed, dream recall was slightly (but not significantly) lower in the Narrative group compared to the other two groups for measures of general dream recall (*L DRF, L DC* and *L Recall rating*).

Table 7.3

Kruskal-Wallis tests for differences between the Checklist, Quantity and Narrative logbook groups on logbook measures of dream recall.

	Logbook type	*M* (*SD*)	Kruskal-Wallis test	
			χ^2	*p*
L Mins recalling dreams	Checklist	5.9 (6.0)	6.48	.039
	Quantity	4.8 (4.9)		
	Narrative	8.7 (11.5)		
L DRF	Checklist	5.4 (1.4)	1.53	.466
	Quantity	5.4 (1.6)		
	Narrative	5.3 (1.5)		
L DC	Checklist	12.9 (7.9)	2.54	.280
	Quantity	12.8 (8.6)		
	Narrative	10.5 (5.5)		
L Recall rating	Checklist	2.8 (0.7)	1.55	.462
	Quantity	3.0 (0.9)		
	Narrative	2.8 (0.8)		
L DC nightmares	Checklist	0.8 (2.0)	0.84	.657
	Quantity	1.5 (3.4)		
	Narrative	1.0 (2.2)		
L DC bad dreams	Checklist	4.0 (6.4)	6.53	.038
	Quantity	2.4 (3.7)		
	Narrative	2.3 (4.8)		
L DC flying	Checklist	0.4 (1.2)	5.99	.050
	Quantity	1.2 (2.2)		
	Narrative	1.2 (4.4)		
L DC lucid	Checklist	4.0 (9.4)	0.84	.657
	Quantity	2.7 (6.1)		
	Narrative	2.3 (6.3)		
L Mins to record dreams	Checklist	1.8 (1.3)	74.82	<.001
	Quantity	2.0 (1.7)		
	Narrative	8.0 (5.9)		
L Recall clarity	Checklist	2.5 (0.8)	1.32	.516
	Quantity	2.7 (0.9)		
	Narrative	2.5 (0.8)		
L Recall difficulty	Checklist	3.1 (0.8)	4.24	.120
	Quantity	2.9 (0.9)		
	Narrative	3.3 (0.8)		
L Recall improvement	Checklist	2.4 (1.1)	1.42	.491
	Quantity	2.3 (1.2)		
	Narrative	2.5 (1.0)		
L Mins per log entry	Checklist	6.0 (3.8)	29.52	<.001
	Quantity	5.0 (3.4)		
	Narrative	10.9 (7.3)		
L Days to complete log	Checklist	7.9 (5.1)	5.30	.071
	Quantity	7.1 (0.5)		
	Narrative	7.1 (0.3)		
L Total log entries	Checklist	7.0 (0.2)	2.17	.337
	Quantity	7.0 (0.2)		
	Narrative	7.0 (0.00)		

Note. Dream recall rates for nightmares, bad dreams, flying dreams and lucid dreams were prorated to monthly rates in all cases.

Pearson correlations were calculated to investigate whether logbook measures of dream recall changed over the course of keeping a logbook. Ascending consecutive numbers were assigned to each logbook day (from first to last) for each participant and this variable was then correlated with daily responses to logbook measures of dream recall. As can be seen in Table 7.4, for all participants combined, *L DRF*, *L DC*, *L Recall rating* and *L Recall clarity* decreased over time and *L Recall difficulty* increased. When changes over time were examined for participants in each logbook group separately, it was observed that these changes were strongest for participants in the Narrative group. One possible explanation for this is that the burden of having to provide written dream narratives caused participants in the Narrative group to lose motivation more quickly than participants in the other groups. No significant changes over time were observed for participants in the Quantity group. Changes in logbook dream recall measures are also graphically represented in Figure 7.1 for all participants combined and in Figures 7.2, 7.3 and 7.4 for participants in the Checklist, Narrative and Quantity groups respectively. In almost every case, dream recall was poorest on Day 5. The explanation for this is not clear.

Table 7.4

Pearson correlations between day of logbook entry and logbook measures of general dream recall for all participants combined and for participants in each logbook group.

	Logbook day			
	All participants	Logbook group		
		Checklist	Narrative	Quantity
L DRF	-.11**	-.11*	-.12**	-.10
L DC	-.12**	-.14**	-.13**	-.09
L DQ	-	-	-	-.03
L Recall rating	-.10**	-.08	-.15**	-.06
L Recall clarity	-.09**	-.06	-.16**	-.04
L Recall difficulty	.09**	.06	.13**	.06

* *p* = <.05, ** *p* = <.01

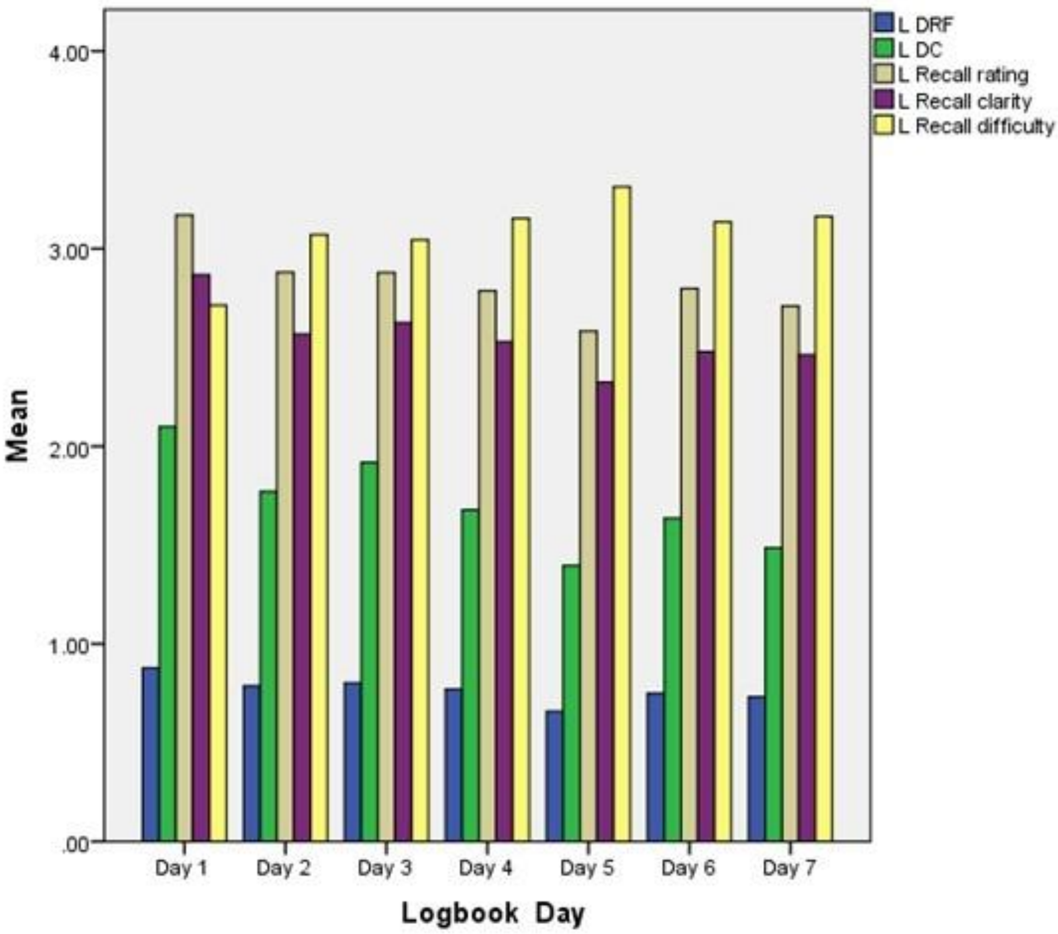

Figure 7.1. Changes in logbook measures of general dream recall for all participants combined.

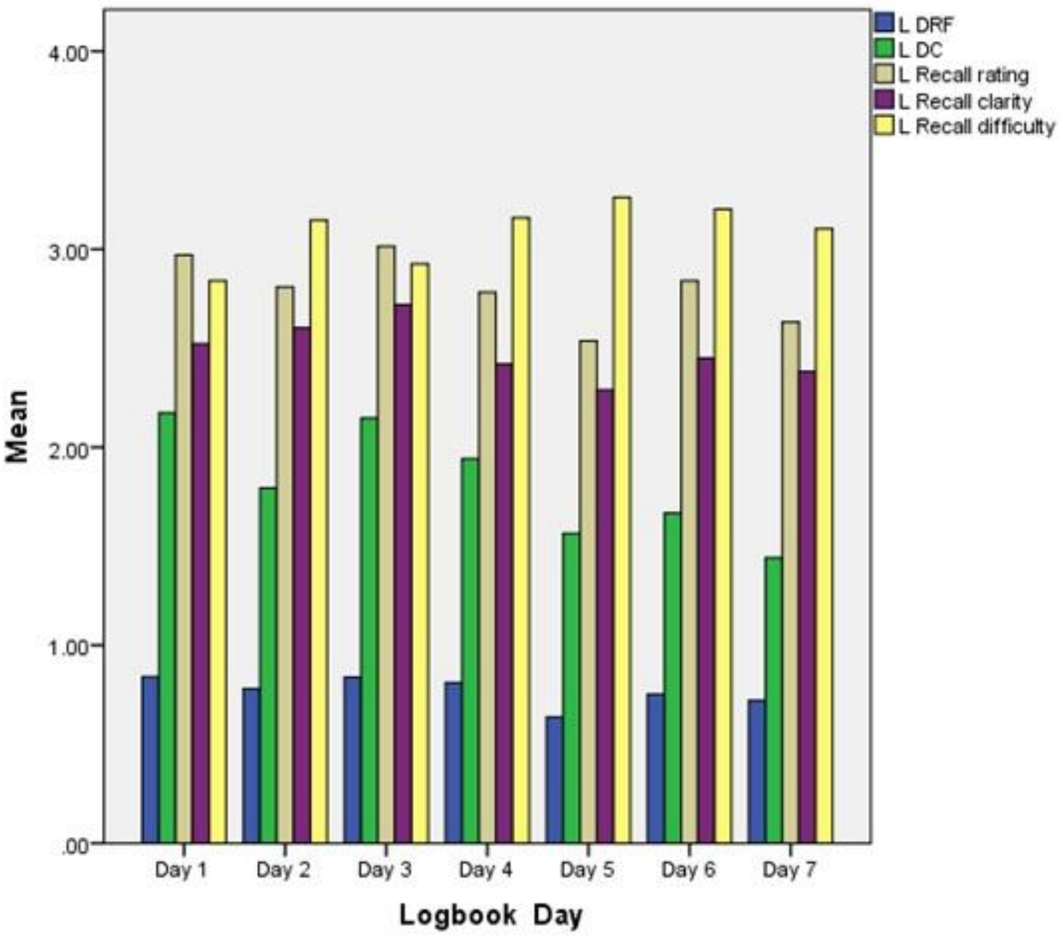

Figure 7.2. Changes in logbook measures of general dream recall for participants in the Checklist group.

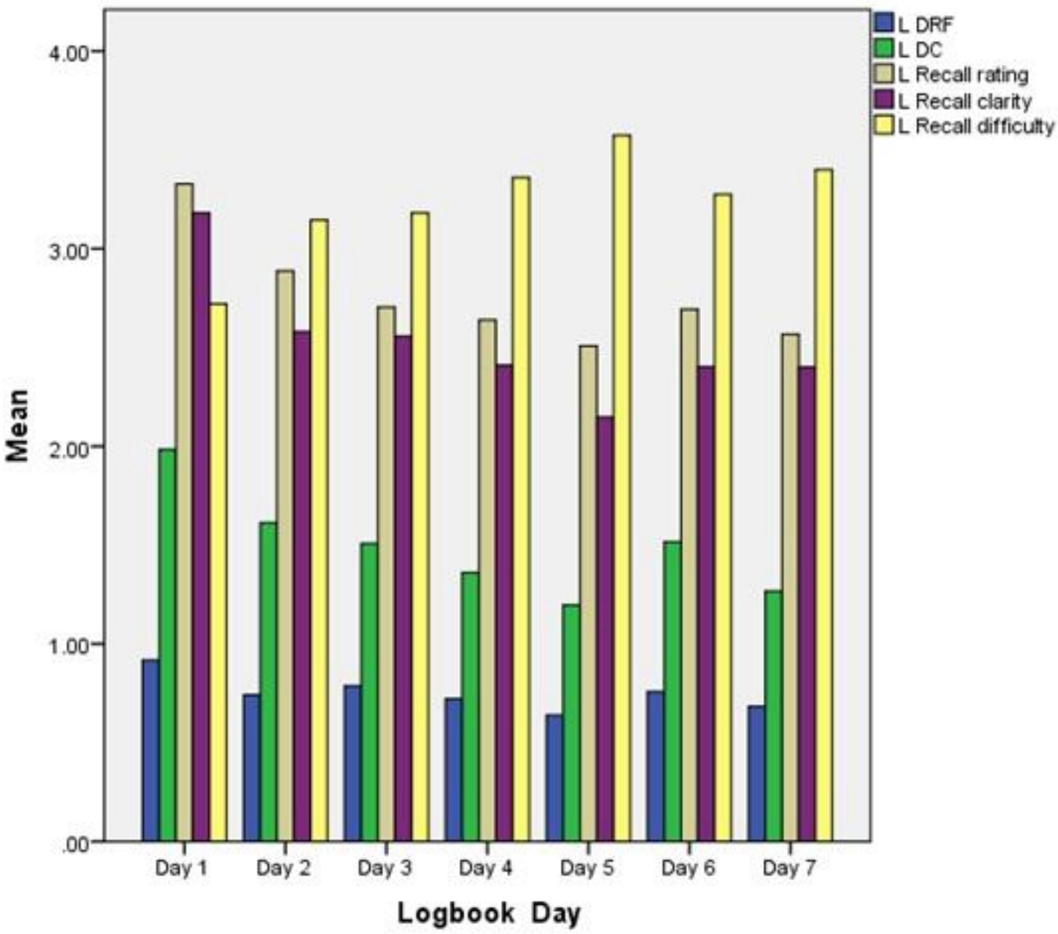

Figure 7.3. Changes in logbook measures of general dream recall for participants in the Narrative group.

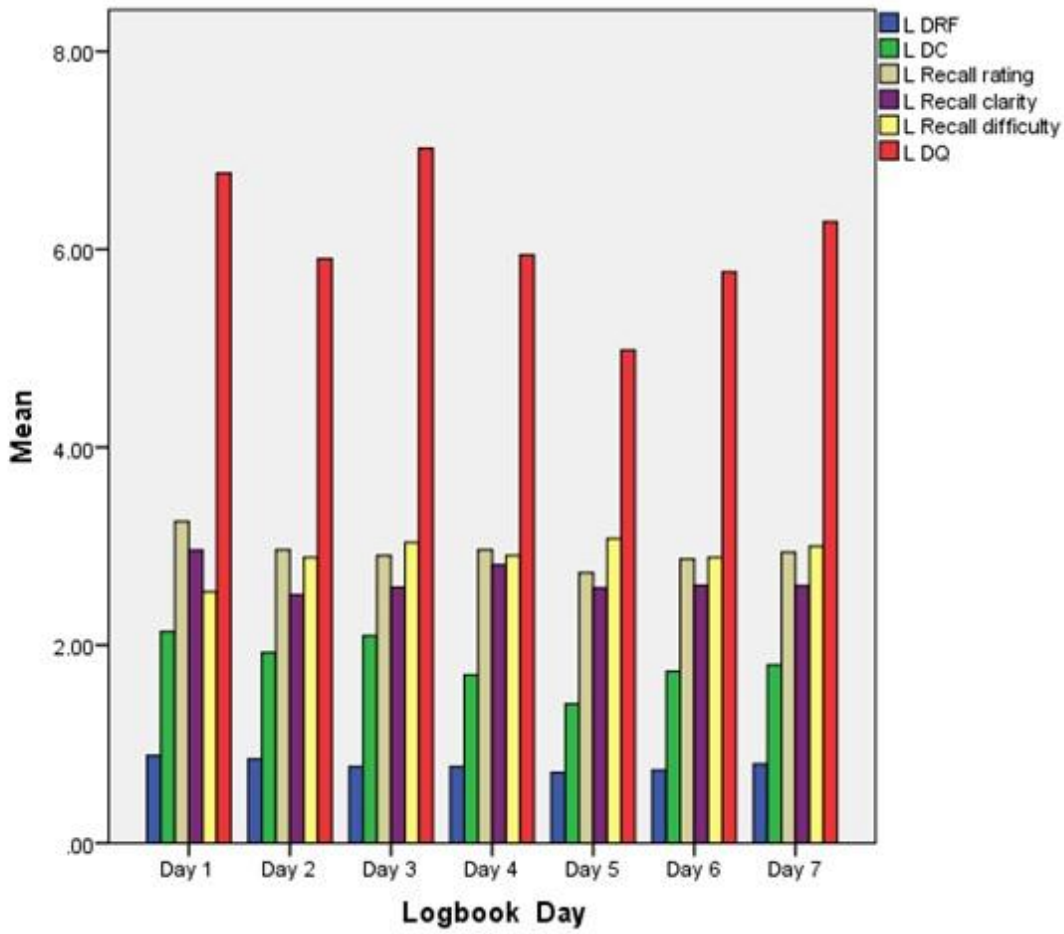

Figure 7.4. Changes in logbook measures of general dream recall for participants in the Quantity group.

To further investigate effects of different types of logbooks on measures of general dream recall, Chronbach's alpha reliability coefficients were calculated for all participants combined and for each logbook group separately. As can be seen in Table 7.5, reliability was highest in every case for measures presented in the Quantity logbook. *L DRF* and *L DC* showed the lowest reliability when presented in the Narrative logbook, while *L Recall rating* and *L Recall clarity* showed the lowest reliability in the Checklist logbook.

Table 7.5

Chronbach's alpha reliability coefficients for measures of general dream recall for all participants combined and for participants in each logbook group.

	All participants	Logbook group		
		Checklist	Narrative	Quantity
L DRF	.54	.52	.48	.61
L DC	.83	.84	.72	.86
L DQ	-	-	-	.92
L Recall rating	.69	.62	.68	.75
L Recall clarity	.73	.69	.71	.79
L Recall difficulty	.68	.65	.65	.73

7.3.3 The retrospective-logbook disparity

It was hypothesised that logbook measures of dream recall would yield significantly higher dream recall rates than comparable retrospective measures of dream recall. It was also hypothesised that retrospective-logbook disparities would be greatest for low recallers and smallest for high recallers. Wilcoxon matched-pair signed-ranks tests were conducted to investigate differences between comparable retrospective and logbook measures of dream recall for all participants combined and also for low, medium and high recallers. As can be seen in Table 7.6, all three retrospective-logbook disparities based on measures of general dream recall were statistically significant for all participants combined and also for low, medium and high recallers. Furthermore, these disparities were highest for low recallers and lowest for high recallers. These findings support both hypotheses. However, results for retrospective-logbook disparities based on measures of specific types of dreams only partially supported the hypotheses. Disparities were statistically significant for all participants combined for bad dreams and lucid dreams but not for nightmares or flying dreams. Despite being substantial in size in most cases, disparities were mostly non-significant for low, medium and high recaller groups. This is likely due to reduced statistical power for the three recaller groups compared to all participants combined. This issue is compounded by the fact that many participants had both retrospective and logbook DC of "0" for measures of specific types of dreams.

Table 7.6

Wilcoxon matched-pair signed-ranks tests for retrospective-logbook disparities.

Retrospective measure	Logbook measure	Recaller group	M (SD) Retrospective measure	M (SD) Logbook measure	Disparity	Wilcoxon test Z	Wilcoxon test p
P DRF Schredl	L DRF	All	3.05 (2.38)	5.39 (1.51)	76%	-10.30	<.001
		Low	0.18 (0.08)	3.88 (1.53)	2055%	-4.20	<.001
		Medium	0.83 (0.19)	4.75 (1.49)	472%	-6.41	<.001
		High	4.83 (1.50)	6.05 (1.10)	25%	-6.13	<.001
P DRF last week	L DRF	All	3.01(2.12)	5.39 (1.51)	79%	-10.49	<.001
		Low	0.52 (0.59)	3.88 (1.53)	646%	-4.21	<.001
		Medium	1.47 (0.79)	4.75 (1.49)	222%	-6.42	<.001
		High	4.34 (1.75)	6.05 (1.10)	39%	-6.97	<.001
P DC weekly	L DC	All	4.43 (4.35)	12.01 (7.44)	171%	-11.20	<.001
		Low	0.65 (0.65)	6.88 (3.83)	957%	-4.11	<.001
		Medium	1.91 (1.24)	9.55 (5.79)	400%	-6.28	<.001
		High	6.56 (4.58)	14.40 (7.84)	120%	-8.35	<.001
P DC nightmares (month)	L DC nightmares	All	0.73 (1.64)	1.07 (2.52)	47%	-1.88	.061
		Low	0.22 (0.52)	0.87 (2.40)	296%	-1.22	.223
		Medium	0.51 (0.86)	0.58 (1.62)	14%	-0.12	.908
		High	0.96 (2.02)	1.37 (2.88)	43%	-1.80	.071
P DC nightmares (year)	L DC nightmares	All	0.44 (1.43)	1.07 (2.52)	143%	-1.17	.240
		Low	0.14 (0.19)	0.87 (2.40)	521%	-0.85	.393
		Medium	0.26 (0.38)	0.58 (1.62)	123%	-2.04	.042
		High	0.60 (1.85)	1.37 (2.88)	128%	-0.07	.941
P DC bad dreams (month)	L DC bad dreams	All	1.81 (2.95)	2.95 (5.21)	63%	-2.83	.005
		Low	0.83 (1.19)	1.59 (2.37)	93%	-1.34	.180
		Medium	0.93 (1.18)	2.04 (3.60)	120%	-2.07	.038
		High	2.48 (3.62)	3.72 (6.17)	50%	-1.64	.101
P DC bad dreams (year)	L DC bad dreams	All	1.15 (2.80)	2.95 (5.20)	157%	-2.83	.005
		Low	0.48 (0.69)	1.59 (2.37)	233%	-0.85	.394
		Medium	0.55 (0.64)	2.04 (3.60)	271%	-0.74	.460
		High	1.61 (3.59)	3.72 (6.17)	130%	-2.63	.009
P DC flying (month)	L DC flying	All	0.75 (2.31)	0.85 (2.88)	13%	-0.65	.518
		Low	0.04 (0.21)	0.17 (0.83)	325%	-0.45	.655
		Medium	0.35 (0.78)	0.58 (1.62)	69%	-1.04	.297
		High	1.11 (2.94)	1.14 (3.57)	3%	-0.05	.959
P DC flying (year)	L DC flying	All	0.38 (1.12)	0.85 (2.88)	124%	-1.37	.172
		Low	0.06 (0.12)	0.17 (0.83)	183%	-1.19	.233
		Medium	0.18 (0.44)	0.58 (1.62)	222%	-0.77	.441
		High	0.56 (1.42)	1.14 (3.57)	104%	-0.91	.365
P DC lucid (month)	L DC lucid	All	1.45 (3.88)	2.99 (7.50)	106%	-3.20	.001
		Low	0.09 (0.29)	0.35 (1.52)	289%	-1.10	.285
		Medium	0.62 (1.05)	3.20 (7.71)	416%	-3.03	.002
		High	2.17 (4.94)	3.45 (8.09)	59%	-1.65	.099
P DC lucid (year)	L DC lucid	All	0.81 (3.00)	2.99 (7.50)	269%	-2.21	.027
		Low	0.07 (0.12)	0.35 (1.52)	400%	-0.42	.674
		Medium	0.24 (0.39)	3.20 (7.71)	1233%	-1.94	.053
		High	1.26 (3.89)	3.45 (8.09)	174%	-1.48	.140

Note. Dream recall rates for nightmares, bad dreams, flying dreams and lucid dreams were prorated to monthly rates in all cases. In all cases, group sizes were as follows: All participants, N = 183; low recallers, n = 22; medium recallers, n = 54; high recallers, n = 105. Descriptive statistics are provided to two decimal places due to the very low recall rates for some variables in some recaller groups.

To further investigate the hypothesis that retrospective-logbook disparities would be greatest for low recallers and smallest for high recallers, retrospective-logbook disparities for measures of general dream recall were calculated for each individual participant and then group differences between low, medium and high recallers were examined using Kruskal-Wallis tests. These general retrospective-logbook disparities were named after the dream recall operationalisation and the retrospective measure used as follows: *DISP DRF (Schredl)*, *DISP DRF (last week)* and *DISP DC (weekly)*. All three variables were non-normally distributed. For these variables there were 2, 19 and 10 cases respectively where a retrospective recall rate of “0” was converted to the low recaller mean value for that measure to permit calculating disparities. When the analyses were re-run with these cases excluded, the statistical significance (at the .05 alpha level) of all findings remained the same. As can be seen in Table 7.7, findings mostly supported the hypothesis. Note that retrospective-logbook disparities could not be calculated individually for each participant for nightmares, bad dreams, lucid dreams or flying dreams because in most cases participants responded “0” to the retrospective measures.

Table 7.7

Kruskal-Wallis tests for differences in general retrospective-logbook disparities between low, medium and high recaller groups.

Disparity	Kruskal-Wallis test		Post hoc pairwise comparison		
	χ^2	*p*	Recaller groups	χ^2	*p*
DISP DRF (Schredl)	133.60	<.001	Low-Med	34.94	.024
			Low-High	113.69	<.001
			Med-High	78.75	<.001
DISP DRF (last week)	82.42	<.001	Low-Med	22.24	.275
			Low-High	86.35	<.001
			Med-High	64.11	<.001
DISP DC (weekly)	43.60	<.001	Low-Med	14.01	.867
			Low-High	61.63	<.001
			Med-High	47.62	<.001

Note. Disparities are named after the retrospective measure they are based on: *DISP DRF (Schredl)* is the disparity between *P DRF Schredl* and *L DRF*; *DISP DRF (last week)* is the disparity between *P DRF last week* and *L DRF*; and *DISP DC (weekly)* is the disparity between *P DC weekly* and *L DC*. For post hoc pairwise comparisons, *p* values were adjusted by multiplying the unadjusted values for each comparison by the number of comparisons for each variable.

7.3.4 The retrospective underestimation hypothesis

It was hypothesised that retrospective measures of dream recall based on longer time periods would yield significantly lower dream recall rates than comparable retrospective measures based on shorter time periods. The findings presented in Table 7.6 provide some support for this hypothesis. With only one exception (flying dreams for low recallers), retrospective-logbook disparities were greater when retrospective measures of specific types of dream recall based on the past year were used than when measures based on the past month were used. To further investigate this hypothesis, differences between retrospective measures of both general and specific types of dream recall based on different time periods were investigated using Wilcoxon matched-pair signed-ranks tests. As can be seen in Table 7.8, the hypothesis was partially supported. Dream recall rates for nightmares, bad dreams, flying dreams and lucid dreams were significantly lower for the past year compared to the past month. However, the difference between the two measures of general dream recall was minimal and not statistically significant. This indicates that *P DRF Schredl* and *P DRF last week* are similar in the way that they measure dream recall. Indeed, the correlation between these two variables (r = .84) was higher than any of the other correlations between retrospective and logbook measures of dream recall reported in Table 7.2.

Table 7.8

Wilcoxon matched-pair signed-ranks tests for disparities between retrospective measures of dream recall based on different time periods.

Retrospective measure 1	Retrospective measure 2	Recaller group	*M* (*SD*)	*M* (*SD*)	Disparity	Wilcoxon test	
			Retrospective measure 1	Retrospective measure 2		*Z*	*P*
P DRF Schredl	P DRF last week	All	2.82 (2.31)	2.91 (2.01)	3%	-1.79	.073
		Low	0.18 (0.07)	0.72 (0.86)	300%	-3.56	<.001
		Medium	0.83 (0.19)	1.54 (0.95)	86%	-7.72	<.001
		High	4.72 (1.48)	4.30 (1.60)	-9%	-4.54	<.001
P DC nightmares (year)	P DC nightmares (month)	All	0.58 (1.93)	1.03 (2.32)	78%	-6.24	<.001
		Low	0.13 (0.18)	0.21 (0.50)	62%	-0.10	.921
		Medium	0.26 (0.33)	0.55 (0.95)	112%	-3.60	<.001
		High	0.89 (2.59)	1.52 (2.99)	71%	-5.32	<.001
P DC bad dreams (year)	P DC bad dreams (month)	All	1.12 (2.49)	2.05 (3.61)	83%	-10.52	<.001
		Low	0.39 (0.52)	0.62 (0.93)	59%	-2.09	.037
		Medium	0.57 (0.77)	1.22 (2.42)	114%	-5.60	<.001
		High	1.64 (3.26)	2.92 (4.34)	78%	-8.52	<.001
P DC flying (year)	P DC flying (month)	All	0.37 (1.30)	0.78 (2.48)	111%	-4.43	<.001
		Low	0.05 (0.11)	0.08 (0.27)	60%	-0.04	.972
		Medium	0.15 (0.34)	0.35 (0.78)	133%	-2.38	.018
		High	0.59 (1.73)	1.21 (3.27)	105%	-3.82	<.001
P DC lucid (year)	P DC lucid (month)	All	0.76 (2.65)	1.42 (3.81)	87%	-7.61	<.001
		Low	0.17 (0.41)	0.36 (1.33)	112%	-1.16	.247
		Medium	0.22 (0.34)	0.59 (1.07)	168%	-4.82	<.001
		High	1.25 (3.55)	2.20 (4.98)	76%	-5.82	<.001

Note. Dream recall rates for nightmares, bad dreams, flying dreams and lucid dreams were prorated to monthly rates in all cases. In all cases, group sizes were as follows: All participants, N = 420; low recallers, n = 53; medium recallers, n = 143; high recallers, n = 224. Descriptive statistics are provided to two decimal places due to the very low recall rates for some variables in some recaller groups.

It was hypothesised that there would be significant negative correlations between retrospective-logbook disparities and the following pre-test variables: self-rated confidence that responses to retrospective measures were correct, the frequency of thinking about dreams, the frequency of discussing dreams, the amount of attention paid to dreams, attitude toward dreams, interest in dreams and need for cognition. To test this hypothesis, general retrospective-logbook disparities were calculated for each participant as described in section 7.3.3 and correlated with the hypothesised predictor variables. Pearson correlations between predictor variables and both retrospective and logbook measures of general dream recall were also calculated and are presented in Table 7.9. Results partially supported the hypothesis. *P DRF Confidence*, *P Dream think freq*, *P*

Dream discuss freq and *P Dream attention* were all significantly correlated with all three general retrospective-logbook disparities. These findings support the retrospective underestimation hypothesis whereby participants who pay less attention to their dreams and are thus less aware of their dreaming patterns are more likely to underestimate their dream recall. An alternative explanation is that perhaps participants who spent less time thinking about, discussing and attending to their dreams had lower dream recall as a consequence and then experienced a relatively strong logbook enhancement effect because keeping a logbook caused them to spend more time attending to their dreams than usual. However, the pattern of correlations presented in Table 7.9 indicates that this does not explain the findings, at least not fully. This is because in every case, *P DRF Confidence*, *P Dream think freq*, *P Dream discuss freq* and *P Dream attention* were more strongly correlated with retrospective measures of dream recall than with logbook measures. If the correlations between these predictor variables and the general retrospective-logbook disparities were simply due to a logbook enhancement effect, one would expect them to be correlated at least as strongly with the logbook measures as with the retrospective measures. Furthermore, it was found that *P DRF Confidence* was significantly correlated with *P Dream think freq* (r = .35, p = <.001), *P Dream discuss freq* (r = .27, p = <.001) and *P Dream attention* (r = .25, p = <.001). Thus, these findings support the retrospective underestimation hypothesis. The remaining predictor variables (*P ATD*, *P Interest in dreams* and *P Need for cognition*) were not significantly correlated with general retrospective-logbook disparities. Excluding cases where retrospective dream recall values of “0” were converted to the low recaller mean value to permit calculation of disparities did not change the statistical significance of any of the findings.

Table 7.9

Pearson correlations between measures of general dream recall and selected pre-test variables.

Pre-test variable	Dream recall measure									
	DISP DRF (Schredl)	DISP DRF (last week)	DISP DC (weekly)	P DRF Schredl	P DRF last week	P DC weekly	L DRF	L DC	L DQ	L Recall rating
P DRF confidence	-.50**	-.41**	-.31**	.54**	.55**	.46**	.38**	.30**	.33*	.42**
P Dream think freq	-.35**	-.37**	-.31**	.52**	.56**	.44**	.28**	.25**	.23	.27**
P Dream discuss freq	-.23**	-.22**	-.26**	.29**	.30**	.25**	.18*	.07	.23	.25**
P Dream attention	-.22*	-.27**	-.24**	.37**	.37**	.33**	.25**	.23**	.30*	.28**
P ATD	-.05	-.12	-.07	.13	.17*	.14	.03	.09	.29*	.18*
P Interest in dreams	-.06	-.02	-.07	.21**	.18*	.21**	.11	.18	.18	.12
P Need for cognition	.05	.05	.12	-.07	-.07	-.07	.04	-.02	-.07	.05

Note. Disparities are named after the retrospective measure they are based on: *DISP DRF (Schredl)* is the disparity between *P DRF Schredl* and *L DRF*; *DISP DRF (last week)* is the disparity between *P DRF last week* and *L DRF*; and *DISP DC (weekly)* is the disparity between *P DC weekly* and *L DC.* All correlations are based on data from participants who completed the logbook only.

* *p* = <.05, ** *p* = <.01

7.3.5 The logbook enhancement hypothesis

It was hypothesised that retrospective-logbook disparities would be significantly greater for participants that recorded all of their dreams while keeping a logbook compared to participants that recorded only some of their dreams. As can be seen in Table 7.10, findings from Wilcoxon matched-pair signed-ranks tests did not support this hypothesis, suggesting that the general retrospective-logbook disparities were not related to whether participants reported all or only some of their dreams (note however that Narrative participants were excluded from this analysis). It was hypothesised that retrospective-logbook disparities would be significantly greater for participants that attempted to improve their dream recall while keeping a logbook compared to participants that did not attempt to improve their dream recall. As shown in Table 7.10, Wilcoxon matched-pair signed-ranks tests indicated that participants who attempted to improve their recall while keeping a logbook had significantly greater general retrospective-logbook disparities. These findings support the logbook enhancement hypothesis. It was hypothesised that retrospective-logbook disparities would be significantly greater for participants that reported improvement in dream recall while keeping a logbook compared to participants that did not report improvement. As can be seen in Table 7.10, Wilcoxon matched-pair signed-ranks tests indicated that participants that reported improvement in dream recall had significantly greater general retrospective-logbook disparities. Indeed, in every case the disparity was more than twice as large among participants that reported improvement in dream recall. These findings provide further support for the logbook enhancement hypothesis.

Table 7.10

Wilcoxon matched-pair signed-ranks tests for differences in general retrospective-logbook disparities between participants who reported all or only some of their dreams, who did or did not attempt to improve their dream recall, and who reported that their dream recall either was or was not better while keeping a logbook.

Retrospective measure	Logbook measure	Comparison variable	Comparison group	*n*	*M* (*SD*)		Disparity	Wilcoxon tests for each disparity		Wilcoxon tests for differences between disparities	
					Retrospective measure	Logbook measure		*Z*	*p*	*Z*	*p*
P DRF Schredl	L DRF	Percentage of dreams reported	All	22	3.3 (2.5)	5.5 (1.4)	67%	-2.71	.007	-0.36	.721
			Some	94	3.0 (2.3)	5.4 (1.6)	81%	-7.93	<.001		
P DRF last week	L DRF		All	22	3.2 (2.2)	5.5 (1.4)	73%	-3.05	.002	-0.39	.700
			Some	94	2.9 (2.2)	5.4 (1.6)	84%	-7.81	<.001		
P DC weekly	L DC		All	22	4.3 (3.7)	12.1 (5.6)	179%	-3.64	<.001	-0.58	.561
			Some	94	4.7 (4.7)	12.6 (8.6)	171%	-8.08	<.001		
P DRF Schredl	L DRF	Did the participant attempt to improve their dream recall?	Yes	70	2.4 (2.2)	5.3 (1.3)	117%	-6.83	<.001	-2.92	.003
			No	104	3.5 (2.5)	5.4 (1.6)	55%	-7.22	<.001		
P DRF last week	L DRF		Yes	70	2.6 (2.0)	5.3 (1.3)	101%	-6.82	<.001	-1.99	.046
			No	104	3.3 (2.2)	5.4 (1.6)	64%	-7.50	<.001		
P DC weekly	L DC		Yes	70	3.6 (3.2)	11.5 (6.4)	219%	-7.11	<.001	-2.14	.033
			No	104	5.0 (5.0)	11.9 (8.0)	136%	-8.19	<.001		
P DRF Schredl	L DRF	Was dream recall better during the logbook period?	Yes	106	3.9 (2.5)	5.2 (1.8)	32%	-4.73	<.001	-4.69	<.001
			No	69	2.5 (2.2)	5.5 (1.3)	118%	-8.60	<.001		
P DRF last week	L DRF		Yes	106	3.7 (2.3)	5.2 (1.8)	42%	-5.46	<.001	-4.21	<.001
			No	69	2.6 (2.0)	5.5 (1.3)	108%	-8.44	<.001		
P DC weekly	L DC		Yes	106	5.8 (5.0)	11.1 (7.9)	93%	-6.19	<.001	-5.19	<.001
			No	69	3.6 (3.8)	12.3 (7.2)	239%	-8.88	<.001		

Note. Narrative logbook participants were excluded from the comparison of participants who reported all or only some of their dreams because responses to this question from the Narrative logbook participants were not valid (see section 2.2.2).

It was hypothesised that there would be significant positive correlations between retrospective-logbook disparities and the amount of time spent trying to recall dreams while keeping a logbook. As shown in Table 7.11, this hypothesis was not supported. *L Mins recalling dreams* was only weakly correlated with one of the logbook dream recall variables (*L Recall rating*) and was not correlated with any of the general disparities (or pre-test dream recall variables). It may be the case that the amount of time participants spent recalling dreams was moderated by how much content was initially recalled. Participants may have tended to spend more time trying to recall dreams on mornings when recall was initially poor, which would have brought their recall rates closer to those that occurred on mornings when they were more easily able to recall dreams and likely to spend less time recalling dreams as a consequence. This would explain the lack of significant correlations between *L Mins recalling dreams* and logbook dream recall rates. This theory is supported by the significant correlation observed between *L Mins recalling dreams* and *L Recall difficulty* (r = .13, p = <.001). It was hypothesised that there would be significant positive correlations between retrospective-logbook disparities and participants' self-rated improvement in dream recall while keeping a logbook. As can be seen in Table 7.11, this hypothesis was supported. *L Recall improvement* was correlated with all three general retrospective-logbook disparities and was also correlated with retrospective measures of general dream recall. However, no significant correlations were observed between *L Recall improvement* and logbook measures of dream recall. These findings are best explained as being due to a logbook enhancement effect that was greatest for low recallers and smallest for high recallers. Unsurprisingly, *L Mins to record dreams* and to a lesser extent *L Mins per log entry* were positively correlated with both pre-test and logbook dream recall variables, suggesting that people with greater dream recall required more time to record their dreams and complete their logbooks. Removing cases where disparities were calculated by converting "0" to the low recaller mean value did not change the statistical significance of any of the findings.

Table 7.11

Pearson correlations between selected dream recall variables.

	L Mins recalling dreams	L Mins to record dreams	L Mins per log entry	L Recall improvement	L Percent recorded
L Mins to record dreams	.35**	-	-	-	-
L Mins per log entry	.38**	.80**	-	-	-
L Recall improvement	.08	.13	.16*	-	-
L Percent recorded	-.27**	-.00	-.27*	-.14	-
L DRF	-.05†	.32**†	.14	.11	-.02
L DC	-.03†	.33**†	.21**	.12	.04
L DQ	-.01†	.38**†	.45**	-.19	-.02
L Recall rating	-.06*†	.37**†	.23**	.08	-.08
DISP DRF (Schredl)	-.02	-.11	-.07	.31**	-.00
DISP DRF (last week)	-.07	-.13	-.13	.22**	-.02
DISP DC (weekly)	-.05	.05	.02	.27**	-.13
P DRF Schredl	.02	.20**	.10	-.30**	-.04
P DRF last week	.11	.25**	.17*	-.19*	-.04
P DC weekly	.02	.20**	.18*	-.22**	.07

Note. Disparities are named after the retrospective measure they are based on: *DISP DRF (Schredl)* is the disparity between *P DRF Schredl* and *L DRF*; *DISP DRF (last week)* is the disparity between *P DRF last week* and *L DRF*; and *DISP DC (weekly)* is the disparity between *P DC weekly* and *L DC.* All correlations with *L Percent recorded* are with Narrative participants excluded because responses to this question from the Narrative logbook participants were not valid (see section 2.2.2). All correlations with *L DQ* are for people in the Quantity logbook group only.

† These correlations were performed using observations from each individual logbook day for both variables. All other correlations were performed using weekly means for each participant or summary questions from the final page of the logbook.

* p = <.05, ** p = <.01

7.3.6 Multiple regression analysis

Multiple regression analysis was conducted to investigate the amount of variance that could be explained in retrospective-logbook disparities between measures of general dream recall, using variables theorised to be related to the retrospective underestimation and logbook enhancement effects. The following statistically significant correlates of general retrospective-logbook disparities (see Tables 7.9 and 7.11) were entered as predictors in forward linear multiple regression analyses: *P DRF confidence*, *P Dream think freq*, *P Dream discuss freq*, *P Dream attention* and *L Recall improvement*. Whether or not participants made a deliberate attempt to improve their dream recall during the logbook period was also included as a dichotomous predictor variable (see Table 7.10). Retrospective dream recall rates were not entered into regression analyses because this would not clarify whether disparities were due to underestimation or enhancement effects specifically. The reason for this is that although low recallers had the greatest disparities, this could be due to them underestimating their true dream recall the most, experiencing the greatest logbook enhancement effect, or both. As can be seen in Table 7.12, for all three general disparities *L Recall improvement* was a significant predictor, indicating that the disparities were partly due to a logbook enhancement effect. However, for all three disparities most of the variance was explained by *P DRF Confidence* and *P Dream think freq*, with *P Dream discuss freq* also being a significant predictor in one case. Thus, it appears that the retrospective-logbook disparities were mostly explained by retrospective underestimation. However, it is not possible to make firm conclusions about the relative strength of the retrospective underestimation effect and the logbook enhancement effect based on these findings. Furthermore, most of the variance in the retrospective-logbook disparities remained unexplained. Indeed, R^2 ranged from .32 to .20 in the final models for each disparity, with a mean of .26.

Table 7.12

Forward linear multiple regression analyses predicting general retrospective-logbook disparities from *P DRF confidence*, *P Dream think freq*, *P Dream discuss freq*, *P Dream attention*, *L Recall improvement* and whether or not participants made a deliberate attempt to improve their dream recall while keeping a logbook. Only statistically significant predictors are shown.

Outcome variable	Model				Predictors		
		R^2	*F* (df)	*p*		β	*P*
DISP DRF (Schredl)	1	.245	50.87	<.001	P DRF confidence	-.50	<.001
	2	.305	35.63	<.001	P DRF confidence	-.47	<.001
					L Recall improvement	.26	<.001
	3	.323	26.09	<.001	P DRF confidence	-.41	<.001
					L Recall improvement	.25	<.001
					P Dream think freq	-.16	.025
DISP DRF (last week)	1	.176	36.41	<.001	P DRF confidence	-.42	<.001
	2	.225	24.70	<.001	P DRF confidence	-.33	<.001
					P Dream think freq	-.24	.001
	3	.249	18.72	<.001	P DRF confidence	-.32	<.001
					P Dream think freq	-.23	.002
					L Recall improvement	.16	.020
DISP DC (weekly)	1	.090	17.00	<.001	P Dream think freq	-.30	<.001
	2	.145	14.36	<.001	P Dream think freq	-.27	<.001
					L Recall improvement	.23	.001
	3	.180	12.33	<.001	P Dream think freq	-.20	.011
					L Recall improvement	.22	.002
					P DRF confidence	-.20	.008
	4	.201	10.60	<.001	P Dream think freq	-.16	.044
					L Recall improvement	.23	.001
					P DRF confidence	-.19	.012
					P Dream discuss freq	-.15	.034

Note. Disparities are named after the retrospective measure they are based on: *DISP DRF (Schredl)* is the disparity between *P DRF Schredl* and *L DRF*; *DISP DRF (last week)* is the disparity between *P DRF last week* and *L DRF*; and *DISP DC (weekly)* is the disparity between *P DC weekly* and *L DC*.

7.4 Discussion

The purpose of the present study was to investigate the retrospective underestimation hypothesis and the logbook enhancement hypothesis as explanations for the retrospective-logbook disparity. Differences between a variety of retrospective and logbook dream recall measures and three different types of logbook were explored. As predicted, large and statistically significant disparities were observed between retrospective and logbook measures of general dream recall. Disparities were also observed for nightmares, bad dreams, flying dreams and lucid dreams, although these were not statistically significant in all cases (most likely due to low statistical power). In support of the retrospective underestimation hypothesis, retrospective measures based on longer time periods (the past year) yielded significantly lower dream recall rates than comparable retrospective measures based on shorter time periods (the past month). Furthermore, significant correlations were observed between general retrospective-logbook disparities and a range of variables theoretically related to the retrospective underestimation effect. In support of the logbook enhancement hypothesis, it was found that general retrospective-logbook disparities were significantly greater among participants that made a deliberate attempt to improve their dream recall and among participants that reported improved dream recall during the logbook period. These findings have important implications for the measurement of dream recall.

7.4.1 The retrospective underestimation hypothesis

Retrospective measures of nightmares, bad dreams, flying dreams and lucid dreams based on the past year yielded significantly lower recall rates than comparable measures based on the past month. It is important to note that the wording for the two versions of these measures was identical (except for the time period) and the order in which they were presented was randomised, controlling for order effects. Although these disparities were not statistically significant in all cases, their magnitude provides strong evidence that retrospective measures based on relatively long time periods underestimate dream recall. It is reasonable to assume that, to a lesser extent, measures based on shorter time periods will also tend to underestimate dream recall. These findings replicate those of previous studies by Zadra and Donderi (2000), Wood and Bootzin (1990), Pietrowsky and Köthe (2003) and Robert and Zadra (2008), which also investigated differences between retrospective measures of specific types of dream recall based on the past month and past year. The present study also investigated differences between two measures of general dream recall. Results showed that DRF for the previous week was only 3% higher than DRF measured using Schredl's

(2004) measure that includes multiple response options ranging from “never” and “less than once a month” to “almost every morning.” These two measures were selected because Schredl’s measure has been used widely in dream research and it is thus useful to compare it to another retrospective measure that should be minimally affected by retrospective underestimation. Findings indicate that the two measures are similarly robust to retrospective underestimation. A likely explanation for this is that the fixed response options of Schredl’s measure allow most participants to respond without considering their DRF beyond the past week. Indeed, most participants (72%) responded that their DRF was once per week or higher. However, it is possible that participants were motivated to ensure their answers to the two questions were consistent. Indeed, these two questions were separated by only one other question, which asked participants to rate how confident they were that their answers to Schredl’s measure were correct.

In addition to investigating mean disparities between different types of retrospective measures, the present study employed a novel approach to investigating the retrospective-logbook disparity that involved calculating disparities for each participant separately, and then examining correlations between this and other variables theoretically linked to the retrospective underestimation and logbook enhancement effects. Aspy et al. (2015) theorised that people who spend less time thinking about their dreams, discussing them with other people and paying attention to them are likely to have a poorer understanding of their dream recall patterns, and will be more prone to retrospective underestimation as a consequence. This is based on research into the availability heuristic (Tversky & Kahneman, 1973) that has shown frequency estimates to be lower when people have more difficulty recalling specific instances of an event (Buontempo & Brockner, 2008). Findings from the present study support this theory. It was found that less time spent thinking about, discussing and attending to dreams were all correlated with greater general retrospective-logbook disparities. Furthermore, participants that were less confident in their answers to Schredl’s (2004) retrospective dream recall measure had greater general retrospective-logbook disparities. These correlations were found to be statistically significant in every case and for all three general retrospective-logbook disparities. Two of these disparities operationalised dream recall as DRF, and one as DC, indicating that the findings are robust and likely to be generalisable to other types of dream recall measures. It was also found that greater self-rated confidence in the answers to Schredl’s measure was significantly correlated with greater time spent thinking about, discussing and attending to dreams. Taken together, these findings indicate that participants who were less aware of their dream recall were more prone to retrospective underestimation.

Contrary to predictions, attitude toward dreams and interest in dreams were not related to general retrospective-logbook disparities. A likely explanation is that more positive attitude toward and greater interest in dreams only result in greater awareness of one's own dreaming (and thus less retrospective underestimation) if they lead to increased frequency of dream-related behaviours such as thinking about, discussing and attending to dreams. It is also possible that there was restriction of range in both attitude toward dreams and interest in dreams in the present study (participants signed up based on their interest in learning to have lucid dreams). Aspy et al. (2015) suggested that retrospective underestimation may also be related to whether participants take a heuristic rather than an elaborative approach to estimating their dream recall. However, the results did not support this prediction as there was no significant correlation between need for cognition and the general retrospective-logbook disparities. A possible explanation for this is that few if any participants in the present study took an elaborative approach to estimating their dream recall. Indeed, as discussed above it is likely that most participants answered Schredl's (2004) DRF measure without any need to consider their dream recall beyond the past week and the other two retrospective measures of general dream recall were both open-ended and based on the past week.

7.4.2 The logbook enhancement hypothesis

Participants who reported improvement in their dream recall during the logbook period had significantly greater general retrospective-logbook disparities. For all three disparities, these were more than twice as large as those observed for participants who did not report improvement in their dream recall. Furthermore, the self-rated extent to which participants' dream recall improved during the logbook period was significantly correlated with all three general disparities. Of course, these findings may be partly due to participants underestimating their true dream recall prior to the logbook period and then incorrectly believing that their recall had improved when in fact it had not. However, because participants who simply *attempted* to improve their dream recall also had significantly higher disparities, it is very likely that the disparities were at least partly due to logbook enhancement effects. The present study thus provides the strongest evidence to date in support of the widely held belief that keeping a logbook tends to enhance dream recall. It is interesting to note that participants were explicitly instructed *not* to make any attempt to improve their dream recall during the first week. This indicates that participants of dream recall studies may attempt to improve their dream recall regardless of whether they are told to do so, and even if they are explicitly told *not* to.

As per the arousal retrieval model of dream recall (Koulack & Goodenough, 1976), it was expected that the logbook enhancement effect would be related to the amount of time spent on the retrieval process prior to making each logbook entry. However, the number of minutes spent recalling dreams prior to making logbook entries was not correlated with general retrospective-logbook disparities. Furthermore, the number of minutes spent recalling dreams was not correlated with any of the logbook measures of general dream recall. The most likely explanation for this is that although spending more time trying to recall dreams will almost certainly improve dream recall, the amount of time spent on this may largely be determined by the overall difficulty of recalling dreams. If a person is easily able to recall a large amount of dream content upon waking (perhaps due to waking directly from REM sleep), they may feel little need to spend much time trying to recall dreams. However, if a person recalls relatively little dream content upon waking (perhaps due to waking from non-REM sleep), they may be inclined to spend more time trying to retrieve dream content. Indeed, in the present study it was found that participants spent significantly more time trying to recall dreams when self-rated difficulty of recalling dreams was higher.

7.4.3 Comparisons between different types of logbooks

Participants in the Narrative logbook group took significantly longer to record their dreams and fill out their logbooks each morning than participants in the Checklist and Quantity groups. Furthermore, Narrative participants spent the most time each morning recalling dreams prior to making logbook entries. However, DRF was virtually identical in all three logbook groups and the number of dreams recalled each morning (DC) was only slightly (but not significantly) lower in the Narrative group than in the other two groups. This is at odds with studies in which Narrative logbooks yielded significantly lower dream recall rates than Checklist logbooks (Robert & Zadra, 2008; Zadra & Robert, 2012) and is also at odds with the observation by Aspy et al. (2015) that retrospective-logbook disparities tend to be smaller when Narrative logbooks are used. There are two likely explanations for these findings. One explanation is that Narrative logbooks caused a stronger logbook enhancement effect due to the greater amount of time participants had to spend thinking about their dreams while providing written narratives, but due to the burden of having to write out each dream recalled, participants in the Narrative group were more likely to underreport their true dream recall. An alternative explanation is that there was little if any difference between Narrative, Checklist and Quantity logbooks in their effects on overall weekly dream recall rates, perhaps because participants in the present study were participating in a larger study on lucid dream induction and were more likely to comply with the study requirements in the hopes that this would help them have lucid dreams. Unfortunately, due to an error in the preparation of the Narrative logbooks, the wording of the post-test question asking whether participants recorded all or only some of the dreams they recalled during the logbook period was not valid and so it was not possible to investigate underreporting in the Narrative group directly. It is thus unclear which of the two explanations account for the findings.

Although the three logbooks yielded similar weekly dream recall rates it was found that over the seven days of keeping a logbook, DRF, DC, self-rated recall and self-rated clarity declined the most, and self-rated recall difficulty increased the most, in the Narrative group. These changes were all smaller in the Checklist group and were the smallest and (in every case) non-significant in the Quantity group. It was also found that reliability coefficients for measures of general dream recall were all higher when presented in the Quantity logbook than in the Checklist and Narrative logbooks. These findings can be most easily explained by considering the major pros and cons of Checklist, Narrative and Quantity logbooks. Checklist logbooks can be completed quickly and easily, thereby minimising participant burden and the likelihood of underreporting. However, as a consequence some participants may fill in Checklist logbooks hastily and without taking the time to carefully think about how much dream content they can recall. Narrative logbooks address this issue by prompting participants to think carefully about the specific details of their dreams in order to provide written narratives, but this requires a large amount of time and participants may underreport their dream recall in order to minimise this burden. This could occur due to waning motivation (which might explain why dream recall rates declined most strongly in the Narrative group in the present study), or may occur when participants simply don't have the time required to make a complete Narrative logbook entry due to other time pressures such as having to get ready for work. Quantity logbooks combine the best attributes of Checklist and Narrative logbooks while avoiding those that are most problematic. Participants must think about the extent of their dream recall in order to provide DQ ratings, but this only takes slightly longer than making a Checklist logbook entry (12 seconds on average in the present study, see Table 7.3).

7.5 Strengths, limitations and future directions

A major strength of the present study is that it was based on a diverse sample of participants recruited from across the country using a wide variety of recruitment strategies, with only 27% being students. Furthermore, although only 44% of participants went on to complete the Week 1 logbook, results indicated that logbook completers were comparable to non-completers in most ways except for having lower need for cognition, being older (by 7.5 years on average) and possibly having slightly higher dream recall. However, it should be noted that participants signed up for the study out of interest in learning to have lucid dreams and future studies should attempt to replicate the present findings using participants with lower interest in dreaming. It is likely that such participants would be less motivated and less willing to fulfil the requirements of keeping a logbook. This may help clarify whether Narrative logbooks are more prone to underreporting than Checklist or Quantity logbooks, an issue that remains unclear at present. In future studies, participants should be asked to indicate if they reported all or only some of the dreams they recalled at post-test as per the approach outlined in section 2.2.2 above. Future studies should investigate differences between retrospective measures of general dream recall using measures based on different time periods. This could be done using questions that use the same wording but offer different sets of fixed response options or using open-ended questions involving different time periods (e.g. the past week vs. the past month). The order in which different retrospective measures of general dream recall are presented should be randomised and they should be separated by other questions that are unrelated.

In a recent publication, Zunker et al. (2015) outlined a promising approach for investigating the retrospective underestimation hypothesis. These authors suggested that after completing a dream recall logbook, research participants could be asked to complete a retrospective measure that enquires about dream recall during the logbook period specifically. Post-test retrospective dream recall rates could then be compared to logbook dream recall rates, which would reveal the extent to which the retrospective measure underestimated dream recall during the logbook period. This approach was employed by Zadra and Beaulieu-Prévost (2006), who found that post-test retrospective measures underestimated logbook recall rates by 9% for bad dreams and 21% for nightmares. However, this approach has not yet been used for measures of general dream recall. It would be important in such a study to ensure that participants do not have access to their logbooks when answering the post-test retrospective measure. A potential problem is that some participants may chose to keep their own dream journal in addition to completing logbooks provided by researchers (several participants of the present study reported doing this). It would be interesting to compare DRF and DC post-test retrospective measures and to ask some participants to answer them after a waiting period (e.g. one week) while asking others to answer them the day after completing their final logbook entry. As mentioned earlier, there are many inconsistencies and contradictory findings in the empirical literature on correlates of home dream recall and it would be of great value to the field if this literature were re-evaluated in light of the recommendations for the measurement of dream recall provided below. Specifically, previous studies could be sorted according to how valid the dream recall measures used are likely to have been. This might resolve some of the inconsistencies and contradictions in the literature.

7.6 Recommendations for the measurement of dream recall

In the present study, different retrospective measures of general dream recall were strongly correlated with each other and the same was true of different types of logbook measures. However, correlations between retrospective and logbook measures were much smaller, with shared variance ranging from only 19% to 42%. This demonstrates that retrospective and logbook measures are not equivalent and should not be used interchangeably. The choice between using retrospective and logbook measures involves a trade-off between ecological validity and internal validity, and will depend on the aims of the research being conducted.

7.6.1 Retrospective measures

Retrospective measures of general dream recall are likely to provide superior ecological validity compared to logbook measures because they assess typical (unaltered) dream recall rates. However, they are likely to provide poorer internal validity due to their tendency to underestimate dream recall and will tend to be confounded with variables related to this effect such as the frequency with which participants think about, discuss and attend to their dreams. These problems can be minimised by using retrospective measures based on relatively short time periods such as the past week. Retrospective measures offering fixed response options focussing on the recent past appear to be similarly valid, such as Schredl's (2004) measure. Retrospective measures of general dream recall based on longer time periods should be avoided. However, for retrospective measures of specific types of dreams that tend to occur infrequently (e.g. nightmares or lucid dreams), it will not be appropriate to limit the time period to the past week because this will only capture dream recall variation in the most frequent recallers. At this point, it seems the ideal approach is to either base such measures on the past month or to use fixed response options such as those provided by Schredl (2004). Another important consideration is the way in which retrospective measures operationalise dream recall, and it is important to not treat different operationalisations as interchangeable. For retrospective measures of general dream recall, DRF should be preferred over DC because participants that have a poor understanding of their dream recall are less likely to be able to provide an accurate estimation of their DC than their DRF. This is because DC measures require participants to recall many more instances of dream recall than DRF measures (i.e. the number of separate dreams recalled vs. the number of days when any amount of content was recalled). If retrospective DC measures of general dream recall *are* used, they should be limited to the past week at most. For retrospective measures of specific types of dreams that occur relatively infrequently, DC measures are likely to be less problematic.

7.6.2 Logbook measures

Logbook measures of dream recall are likely to provide superior internal validity compared to retrospective measures because dream recall is recorded immediately upon waking each morning. However, logbooks are likely to provide poorer ecological validity due to their tendency to enhance dream recall. This enhancement effect appears to be partly mediated by whether participants attempt to enhance their dream recall and it is important to note that participants may do this even if they are explicitly told not to. Narrative logbooks will tend to be more affected by time constraints and fluctuations in motivation that may lead participants to underreport their dream recall in order to reduce the substantial burden of providing written dream narratives. Narrative logbooks should thus be avoided except where dream content is of particular interest. Dream recall operationalised as DC, DQ and self-rated dream recall will be more sensitive to daily fluctuations in dream recall than DRF and are thus more appropriate for investigating correlates of dream recall on a day-to-day basis. Indeed, DRF will capture little or no variation in dream recall among high recallers who recall dream content on most or all mornings. In the present study, DQ and self-rated dream recall, but not DRF or DC, were significantly correlated with both age and attitude toward dreams, suggesting that DC is less likely to be confounded with other variables that may influence subjective judgments about dream recall. However, DC does not entirely avoid this problem – the tendency to count multiple scenes or dream fragments as one long dream or several shorter dreams may differ among participants, possibly in systematic ways. For example, people with a very strong interest in dreaming such as dedicated lucid dreaming practitioners might be more meticulous about counting multiple dream fragments as being part of the same dream. Notwithstanding, as long as this tendency remains fairly stable over time within individuals, DC is preferable to DRF for investigating daily correlates of dream recall. In contrast, DRF will be more robust to subjective bias and underreporting, and may be more appropriate for investigating absolute differences in dream recall between individuals and between different populations that might differ in their judgments about their DC dream recall. Regardless of how dream recall is operationalised, it seems that dream recall measures are most valid and reliable when Quantity logbooks are used. This type of logbook can be constructed using the information provided in section 2.2.2.

7.7 Conclusions

The present study provides the strongest evidence to date that dream recall is underestimated by retrospective measures and enhanced by logbooks. Many questions remain unanswered and it is still unclear whether retrospective underestimation effects are stronger than logbook enhancement effects or vice versa. Nonetheless, results from the present study permit a range of recommendations for the use of retrospective and logbook measures of dream recall. These recommendations can be used to guide future research on dream recall in the home setting and could also be used as a basis for re-evaluating the empirical literature on correlates of home dream recall.

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Chapter 8: The National Australian Lucid Dream Induction Study

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Abstract

Lucid dreaming is a learnable skill and has a wide range of potential applications. However, research in this area has been limited by a lack of effective and reliable lucid dream induction techniques. The present study provides a thorough investigation into two of the most promising cognitive lucid dream induction techniques – *reality testing* and the *Mnemonic Induction of Lucid Dreams* (MILD) technique. A sample of 169 Australian participants completed a pre-test questionnaire, provided baseline logbook data in Week 1, and practiced lucid dream induction techniques in Week 2. Results showed that the MILD technique was effective at inducing lucid dreams, but that reality testing alone was ineffective. Several factors that influenced the effectiveness of the MILD technique were identified, including general dream recall, prior sleep deprivation, and the amount of time taken to fall asleep after finishing the technique. Recommendations for future research on lucid dream induction are provided.

Reality testing and the mnemonic induction of lucid dreams: Findings from the National Australian Lucid Dream Induction Study

8.1 Introduction

A lucid dream is a dream in which the dreamer is aware that they are dreaming while the dream is still happening (LaBerge, 1985). In a recently published meta-analysis, Saunders, Roe, Smith and Clegg (2016) found that an estimated 55% of adults have experienced at least one lucid dream in their lives, with 23% of adults experiencing lucid dreaming regularly (once per month or more) and some rare individuals having spontaneous lucid dreams almost every night. Although references to lucid dreaming can be found from over 2000 years ago (LaBerge, 1985), it was not until 1975 that the phenomenon was confirmed empirically. Hearne (1978) reasoned that, if the eye movements that characterize *Rapid Eye Movement* (REM) sleep correspond to the gaze of the dreamer, it may be possible to signal to the outside world during a lucid dream using a series of pre-arranged left-right eye movements. Using electrooculography, he succeeded in recording such a signal that corresponded to the report of a lucid dream during unambiguous REM sleep. This was achieved independently by LaBerge (1980), and numerous other studies have since replicated these findings (e.g. Dane, 1984; Fenwick et al., 1984; Ogilvie, Hunt, Tyson, Lucescu, & Jeakins, 1982; Tholey, 1983). There was a subsequent surge of research into such topics as the phenomenology (see LaBerge & DeGracia, 2000), psychophysiology (see Schredl & Erlacher, 2011), and potential applications of lucid dreaming. Potential applications include treatment of nightmares (Holzinger, Klösch, & Saletu, 2015; Lancee, van den Bout, & Spoormaker, 2010; Spoormaker & Van Den Bout, 2006), improvement of physical skills and abilities through rehearsal in the lucid dream environment (Erlacher & Schredl, 2010; Stumbrys, Erlacher, & Schredl, 2016), creative problem solving (Stumbrys & Daniels, 2010), and research opportunities for exploring consciousness and mind-body relationships (see Hobson, 2009). However, research on lucid dreaming has been limited by a lack of effective and reliable lucid dream induction techniques.

8.1.1 Lucid dream induction techniques

A wide range of techniques have been developed for inducing lucid dreams (see LaBerge & Rheingold, 1991; Love, 2013; Stumbrys, Erlacher, Schädlich, & Schredl, 2012; Tholey, 1983). Some of these involve *Dream Induced Lucid Dreams* (DILDs), which occur when the dreamer realizes they are dreaming during a non-lucid dream (LaBerge & Rheingold, 1991). Other techniques are designed to help the practitioner enter a lucid dream directly from the waking state. These are known as *Wake Induced Lucid Dreams* (WILDs; LaBerge & Rheingold, 1991) and require a delicate balance of relaxation and unbroken conscious awareness during the transition into REM sleep. WILDs are considered more difficult to achieve, and WILD attempts carry an increased risk of experiencing sleep paralysis, which can be extremely unpleasant (Cheyne, 2003; Sharpless & Barber, 2011). DILD techniques are thus considered better suited to beginners and have been favored in lucid dream induction research. Stumbrys et al. (2012) further organized lucid dream induction techniques according to three broad categories. *Cognitive techniques* include all techniques that involve cognitive activities for inducing lucid dreams. These techniques do not require specialized equipment and are the most widely used for inducing lucid dreams. *External stimulation techniques* involve the presentation of stimuli such as flashing lights, acoustic stimuli, and mild electric shocks during REM sleep, which can be incorporated into the dream experience and serve as a cue to the dreamer that they are dreaming. *Miscellaneous techniques* cover techniques that do not fit into the other two categories such as the ingestion of specific substances that may promote lucid dreams (see LaBerge, 2004; see also Yuschak, 2006).

The two most widely studied cognitive techniques for inducing DILDs and the subjects of the present study are *reality testing* (LaBerge & Rheingold, 1991; Tholey, 1983) and the *Mnemonic Induction of Lucid Dreams* (MILD) technique (LaBerge, 1980; LaBerge & Rheingold, 1991). Reality testing involves examining one's surroundings multiple times throughout the day, questioning whether one is awake or dreaming, and then performing a reliable *reality test* to determine whether one is awake or dreaming. Reality testing is important because of the strong tendency for the dreaming mind to explain away even the most obvious indicators that one is dreaming. One of the most popular reality tests involves re-reading written text (written text tends to change upon second inspection in dreams; LaBerge & Rheingold, 1991). However, written text may not always be available, and some lucid dreamers favor the *inhalation test*, which involves closing one's lips and then attempting to inhale (see Love, 2013). Performing this action while dreaming can produce a contradictory sensation of air moving through one's closed mouth (presumably, this is because the muscles of the face and mouth but not those involved in respiration are inhibited during REM sleep). The rationale behind reality testing is that if it becomes habitual it will eventually be performed while dreaming, thereby leading to lucidity.

The MILD technique makes use of prospective memory, which is the ability to remember to perform planned actions in the future. While lying in bed and immediately prior to going to sleep, the practitioner repeats the phrase "next time I'm dreaming, I will remember that I'm dreaming" (or some variation) while imagining themselves becoming lucid in a dream. If successful, this intention will be remembered during subsequent REM sleep, and the dreamer will become lucid. The MILD technique is often combined with another lucid dream induction technique known as *Wake Back to Bed* (WBTB; LaBerge & Rheingold, 1991). This involves waking up after several hours of sleep (usually five to six hours) and remaining awake for a period of time (from as little as ten minutes to more than one hour) before returning to sleep. WBTB not only increases mental alertness, but also provides an ideal time to practice the MILD technique. This is because REM sleep is entered more quickly and for longer periods as sleep progresses, and most dreams (including lucid dreams) occur during REM sleep (Nielsen, 2000; Stumbrys & Erlacher, 2012). Thus, the intention to remember that one is dreaming is more likely to be retained during REM sleep if the MILD technique is practiced after five to six hours of sleep.

8.1.2 Research on lucid dream induction

Stumbrys et al. (2012) identified a total of 35 empirical studies in a recent systematic review of the lucid dream induction literature. Of these, 11 were conducted in sleep laboratories and 24 were field studies. Most studies (27) investigated cognitive techniques, with the majority (22) being field studies. A total of 10 studies investigated the MILD technique. One was a sleep laboratory study (Kueny, 1985), and the others were field studies conducted by LaBerge, Levitan and their colleagues (Edelstein & LaBerge, 1992; LaBerge, 1988; LaBerge, Phillips, & Levitan, 1994; Levitan, 1989, 1990a, 1990b, 1991; Levitan & LaBerge, 1994; Levitan, LaBerge, & Dole, 1992). Reality testing was investigated in nine studies. One of these was a sleep laboratory study (Dane, 1984), with the others being conducted in-field (LaBerge, 1988; Levitan, 1989; Levitan & LaBerge, 1994; Malamud, 1979; Purcell, 1988; Purcell, Mullington, Moffitt, Hoffmann, & Pigeau, 1986; Reis, 1989; Schlag-Gies, 1992). An additional field study investigating reality testing has been recently published (Taitz, 2011). Stumbrys et al. (2012) concluded that MILD and reality testing appear to be more effective than most other cognitive techniques. However, one study found that reality testing did not increase lucid dreaming frequency (LaBerge, 1988), as did the more recent study by Taitz (2011). It is unclear how reality testing compares to MILD. One study found that reality testing was more effective at inducing lucid dreams (Levitan, 1989), but another found that MILD was superior (LaBerge, 1988). Other than the study by Taitz (2011), only two other lucid dream induction studies have been published following the review by Stumbrys et al. (2012). One of these investigated visual (flashing lights) and tactile (vibration) external stimulation techniques (Franc, Schadlich, & Erlacher, 2014), and the other applied transcranial direct current stimulation (tDCS) to the dorsolateral prefrontal cortex (DLPFC) during REM sleep (Stumbrys, Erlacher, & Schredl, 2013). Both of these studies reported poor success rates.

Unfortunately, it is difficult to compare the effectiveness of lucid dream induction techniques across studies due to widespread methodological limitations. Stumbrys et al. (2012) evaluated the studies included in their review using a methodological quality checklist, developed by Downs and Black (1998) that assesses quality of reporting, external and internal validity, and statistical power. Most (60%) studies were classified as poor quality, with the rest (40%) classified as moderate quality. Just over half of the studies were either unpublished Ph.D. dissertations or were otherwise not published in academic journals. The average score for all studies was 9.1 out of a maximum of 28, with no substantial difference between laboratory and field studies. Field studies investigating reality testing scored slightly higher at 11.5. Field studies investigating the MILD technique scored below average at 5.9 and were all published in a non-academic magazine targeted to lucid dreaming enthusiasts. All 35 studies included in the review scored poorly on external validity, with participants mostly consisting of self-selected lucid dream enthusiasts or university students. Other common issues included insufficient statistical power (due to small sample sizes), lack of random allocation, and invalid or unreliable outcome measures.

Inconsistent operationalization of lucid dreaming rates is another problem in the empirical lucid dream induction literature, as well as the broader empirical literature on general dream recall (see Aspy, 2016; Aspy, Delfabbro, & Proeve, 2015). A common operationalization is the mean number of lucid dreams reported in a given period (*Dream Count*, DC). However, lucidity is often lost and regained within a single dream and may be attained in multiple separate dreams, especially among proficient lucid dreamers. This makes it hard to compare studies of proficient lucid dreamers with studies involving less proficient participants. Another operationalization is the percentage of all reported dreams that are lucid. This suffers the same limitations as DC but is also confounded with general (non-lucid) dream recall rates. The percentage of participants that experience lucid dreaming at least once while trialing a technique avoids the aforementioned problems, but is too insensitive to provide much insight into technique effectiveness on its own. A more suitable operationalization is lucid *Dream Recall Frequency* (DRF; see Aspy et al., 2015), which is the proportion of days in a given period on which lucid dreaming is experienced irrespective of how many lucid dreams are reported. Mean DRF rates are less prone to being inflated by participants who have multiple lucid dreams within the same night or who are more likely to lose and then regain lucidity in the same dream, thus making it easier to compare findings from studies that have different sample characteristics.

One of the biggest limitations in the empirical lucid dream induction literature is the near-ubiquitous failure to measure variables related to how lucid dream induction techniques were practiced. Only one study (LaBerge, 1988), which investigated both MILD and reality testing in different experimental groups, reported correlations between the number of technique repetitions and lucid dreaming rates. This study found that the number of times the MILD phrase was repeated each night was correlated with lucid dreaming (r = .12). In contrast, the correlation between lucid dreaming and the number of reality tests performed was very small and non-significant (r = .04). However, it is difficult to interpret these findings because essential statistical and methodological information was not reported. More recently, Taitz (2011) reported having measured the number of reality tests performed by participants but provided no descriptive statistics, and this variable was not included in analyses. In order to properly assess lucid dream induction techniques and maximize their effectiveness, it is essential that variables related to technique practice are examined in addition to overall lucid dreaming rates.

8.1.3 Aims and hypotheses

The present study forms part of a larger research project that also investigated issues related to the measurement of dream recall (see Aspy, 2016). The aim of the present study was to provide a thorough investigation into reality testing and the MILD technique. Baseline logbook data were collected during Week 1 of the study and then participants were randomly allocated to one of three experimental groups for Week 2. Because reality testing, WBTB and MILD are often used in combination, and in the interests of identifying a maximally effective approach to lucid dream induction, groups involving reality testing only (*RT only* group), reality testing and WBTB (*RT + WBTB* group) and reality testing, WBTB and MILD (*RT + WBTB + MILD* group) were compared. The *RT + WBTB* condition involved reading a document about lucid dreaming (see Section 8.2.2.3), which controlled for the effects of thinking about lucid dreaming that are inherent to the MILD technique.

Hypotheses were as follows:

- Because the relationship between lucid dreaming and general dream recall rates is one of the most robust relationships observed in the empirical lucid dreaming literature (see Erlacher, Schädlich, Stumbrys, & Schredl, 2014), it was hypothesized that there would be significant positive correlations between general dream recall rates and lucid dreaming rates at both pre-test and during Week 2.

- It was hypothesized that lucid dreaming rates would be significantly higher in Week 2 compared to Week 1 for all participants combined and for participants in each of the three Week 2 groups.

Exploratory analyses were also conducted to investigate relationships between lucid dreaming rates and a range of other variables described in Section 8.2.2, including variables that operationalize the way in which lucid dream induction techniques were practiced.

8.2 Method

8.2.1 Participants

A total of 420 participants who passed the exclusion criteria (below) signed up for the study and completed the pre-test questionnaire. A total of 169 participants went on to complete the full study. This final sample consisted of 94 (55.6%) females, 73 (43.2%) males and 2 (1.2%) participants who identified their gender as "other". The mean age was 38.3 (*SD* = 15.0) and ranged from 18 to 75. Most of the participants were employed non-students (*n* = 116, 68.6%), with 36 (21.3%) participants being students and 17 (10.1%) being unemployed or retired. Most participants (63.9%) had no prior experience with lucid dream induction techniques. Participants in the final sample heard about the study from a range of recruitment sources: 54 (32.0%) from physical posters or flyers (see Appendix B for copies of promotional materials) distributed in public locations across the Australian states of South Australia, Victoria, and New South Wales; 32 (18.9%) from word of mouth; 24 (14.2%) from nationally televised news interviews with the first author; 23 (13.6%) from newspaper articles; 15 (8.9%) from radio interviews; 12 (7.1%) from social media; and 9 (5.3%) from other internet sources. Participants were excluded from the study if they had been diagnosed with any kind of mental health disorder, sleep disorder, or neurological disorder; suspected they *might* have one of these disorders; were experiencing a traumatic or highly stressful life event that was interfering with their sleep; suffered from persistent insomnia or were unable to keep a regular sleep schedule; had experienced sleep paralysis more than once in the past 6 months; found it unpleasant to think about their dreams; or were under 18 years of age. All participants who completed the study entered a raffle to win one of five $200 gift vouchers or one of ten $50 gift vouchers.

8.2.2 Materials

Materials included an online pre-test questionnaire and physical packages that contained an instructions sheet, Week 1 logbook, and a sealed envelope containing materials for Week 2. This envelope had the words “Week 2 materials – do not open until Week 1 is complete” printed on the front to discourage participants from attempting the lucid dream induction techniques prematurely. All participants reported that they complied with these instructions. The Week 2 envelopes contained another instructions sheet, lucid dream induction technique documents, and a Week 2 logbook. Some of these materials are described in greater detail by Aspy (2016). In the present paper, pre-test variables are identified by a capital “P” and logbook variables by a capital “L.”

8.2.2.1 Pre-test questionnaire

Demographic questions. Participants were asked to indicate their age, gender, occupation, and how they heard about the study.

General dream recall. Two retrospective measures of general dream recall were used. The first assessed DRF over the last week (*P DRF*; the percentage of days on which there was dream recall) by asking “How many days during the last week did you remember your dreams from the previous night?” Participants selected one of eight options from a drop-down menu ranging from “0 days” to “7 days.” Following this, the number of separate dreams recalled over the past week was assessed by asking “On average, how many separate dreams do you usually remember per week?” Participants could select any whole number between 0 and 50 or “more than 50” from a drop-down menu. The mean number of dreams recalled per day (*P DC per day*) was attained by dividing responses by seven.

Lucid dream recall. A question adapted from Brown and Donderi’s (1986) *Sleep and Dream Questionnaire* (SDQ) assessed retrospective DC dream recall for lucid dreams (*P DC Lucid per month*): “Lucid dreams are those in which a person becomes aware of the fact that he or she is dreaming while the dream is still ongoing. For example: ‘I was in England talking to my grandfather when I remembered that (in real life) he had died several years ago and that I had never been to England. I concluded that I was dreaming and decided to fly to get a bird's eye view of the countryside…’ Please estimate the number of lucid dreams you have had in the past month.” Participants answered by selecting any whole number from 0 to 30 or “more than 30” from a drop-down menu.

Prior lucid dream induction technique practice. Participants were asked “Have you ever tried to have lucid dreams by learning and then practicing a lucid dreaming technique?” (*P Lucid tech prior*;

"Yes" or "No"). Participants were then asked "How often have you practiced a lucid dreaming technique recently (in the past several months)?" (*P Lucid tech freq*). Response options from Schredl's (2004) widely used dream recall measure were used (0 = "never", 1 = "less than once a month", 2 = "about once a month", 3 = "two or three times a month", 4 = "about once a week", 5 = "several times a week" and 6 = "almost every morning"). Responses were converted to the approximate number of days per week using the following class means: 0 = 0, 1 = 0.125, 2 = 0.25, 3 = 0.625, 4 = 1.0, 5 = 3.5, 6 = 6.5.

8.2.2.2 Logbooks

Three different Week 1 logbooks were used. They each used a different primary measure of general dream recall but were otherwise identical. The Checklist logbook elicited brief titles for each dream recalled. The Narrative logbook elicited detailed written narratives of each dream recalled. The Quantity logbook (see Appendix G for a sample logbook page) prompted participants to rate the extent to which each dream was recalled. Aspy (2016) provided a detailed comparison of these three types of logbooks and found that measures of general dream recall were most stable and reliable when presented in the Quantity logbook, with no differences in overall dream recall rates. These findings were anticipated prior to conducting the study, and the Quantity logbook was used in all three of the Week 2 groups (with additional questions related to lucid dream induction techniques).

Preliminary questions. Participants indicated the date of each logbook entry, allowing the number of days taken to complete all seven entries to be calculated (*L Days to complete log*). The total number of logbook entries made by each participant was also counted (*L Total log entries*).

General dream recall. Participants were asked if they could recall anything specific about their dreams from the previous night and were asked to provide brief titles for each dream recalled. This allowed dream recall to be operationalized as both *Dream Recall Frequency* (*L DRF*; the percentage of days on which there was dream recall) and *Dream Count* (*L DC per day*; the number of dreams recalled each day). Participants were also asked to rate the amount of content recalled from each dream using four categories provided. This operationalization is referred to as *Dream Quantity* (*L DQ*) and was developed by Aspy (2016) based on an earlier measure developed by Reed (1973). Category ratings are converted to numerical values ("Fragmentary" = 1, "Partial" = 2, "Majority" = 4, "Whole" = 8) and summed (higher scores indicate superior dream recall). Three additional questions were used to assess overall self-rated general dream recall quantity ("how much do you recall of your dreams from last night?"; *L Recall rating*), general recall difficulty ("how difficult was it for you to remember your dreams from last night?"; *L Recall difficulty*), and general recall clarity ("how clear are your memories of your dreams from last night?"; *L Recall clarity*), using Likert-type scales ranging from 1 to 5 (see Aspy, 2016).

Lucid dream recall. Lucid dreaming was operationalized as DRF (the percentage of mornings when lucid dreaming was reported) because in many cases participants were unsure of how many lucid dreams they had, and in some cases lost lucidity and then regained it within the same dream. The following question was used: "Did you have any lucid dreams last night? (Lucid dreams are those in which a person becomes aware of the fact that he or she is dreaming while the dream is still ongoing)" ("yes" or "no") (*L DRF Lucid*). Days when participants did not practice lucid dream induction techniques were excluded when calculating Week 2 *L DRF Lucid* rates. The percentage of participants that experienced lucid dreaming at least once during Week 1 and during Week 2 was included as a second operationalization of lucid dreaming (*L Lucid participants*). Participants were also asked "How long (approximately) do you think you were lucid dreaming?......minutes" (*L Lucid duration mins*).

Sleep-related questions. Participants were asked to estimate how much time they had spent sleeping (*L Time asleep*): "How much time in total do you think you spent sleeping last night?......hours,......minutes". Participants also rated their subjective *sleep quality* (*L Sleep quality*): "On a scale of 1 to 5, what was the overall quality of your sleep last night?" (1 = "terrible", 2 = "poor", 3 = "okay", 4 = "good", 5 = "excellent"). Participants indicated how tired they felt upon waking (*L Tiredness on waking*) with the following question: "On a scale of 1 to 5, how tired do you feel this morning?" (1 = "not at all tired", 2 = "slightly tired", 3 = "somewhat tired", 4 = "quite tired", 5 = "very tired"). Finally, participants indicated how sleep deprived they were the previous day (*L Sleep dep yesterday*): "On a scale of 1 to 5, how sleep deprived were you yesterday?" (1 = "not at all", 2 = "slightly", 3 = "somewhat", 4 = "quite", 5 = "very").

Lucid dream induction technique practice questions. The following question was used in all three Week 2 logbooks: "How many reality tests did you perform yesterday?" (blank space provided) (*L Reality tests*). In the *RT + WBTB* and *RT + WBTB + MILD* groups, the following additional questions were included: "Were you in the middle of a dream when the alarm woke you up to do the technique? ("yes", "no" or "unsure") (*L Awoke while dreaming*); "On a scale of 1 to 5, how motivated did you feel about doing the technique after the alarm went off?" (1 = "not at all motivated", 2 = "slightly motivated", 3 = "somewhat motivated", 4 = "quite motivated", 5 = "very motivated") (*L Technique motivation*); "On a scale of 1 to 5, how difficult was it to focus on the technique?" (1 = "not at all difficult", 2 = "slightly difficult", 3 = "somewhat difficult", 4 = "quite difficult", 5 = "very difficult") (*L Difficulty focusing*); "How long (approximately) did it take for you to get to sleep after you did the technique?......minutes." (*L Mins back to sleep*). The following questions specific to the

MILD technique were included for participants in the *RT + WBTB + MILD* group: "Did you fall asleep while you were still trying to do the technique?" ("yes" or "no") (*L Asleep during technique*); "If you answered "no" to the above question, how long (approximately) did it take for you to get to sleep after you stopped doing the technique?......minutes." (*L Mins back to sleep*); "How long (approximately) did you spend on doing the technique?......minutes." (*L Technique mins*); and "How many times (approx) did you repeat 'next time I'm dreaming, I will remember I'm dreaming'?" (blank space provided) (*L Technique repetitions*).

8.2.2.3 Lucid dream induction technique documents

RT only group. The "Daytime Lucid Dreaming Technique" document (see Appendix F) instructed participants to perform a minimum of 10 reality tests per day by first asking themselves "Am I dreaming?" The importance of genuinely considering the possibility that they are dreaming was emphasized. They were instructed to examine their surroundings for anything strange or inconsistent. They were then instructed to perform an inhalation reality test (see Section 8.1.1). Participants were asked to count the number of reality tests performed each day using one of several free tally counter apps available for iPhone and Android smartphones or by making marks on a piece of paper or the back of their hand. Participants were told that reality testing is most effective when practiced frequently and carefully, and that reality tests should be performed at a range of times and settings throughout the day (especially when something unusual or unexpected happens).

RT + WBTB group. In addition to the "Daytime Lucid Dreaming Technique" document, these participants were given a "Nighttime Lucid Dreaming Technique" document (see Appendix F) that outlined the WBTB technique. It instructed participants to set an alarm for five hours after going to bed and place it somewhere where they would have to get out of bed to turn it off. They were instructed to put a light on when their alarm went off, go to the bathroom if necessary, return to bed and then read a document entitled "what to do if you have a lucid dream" (see Appendix F) before returning to sleep as they normally would. This document – which was given to participants in all three Week 2 groups – was approximately 700 words long and began by explaining several ways that lucid dreams can happen. It advised participants that if they became lucid, they should stay calm to avoid waking, perform a reality test, then stabilize the dream by rubbing the palms of their hands together vigorously and focusing on the physical sensations while repeating "this is a lucid dream" (LaBerge & Rheingold, 1991). Participants were asked to perform a reality test upon reaching the end of the document.

RT + WBTB + MILD group. Participants in this group were given the “Daytime Lucid Dreaming Technique” and “what to do if you have a lucid dream” documents, as well as a “Nighttime Lucid Dreaming Technique” document (see Appendix F) that outlined the MILD technique (LaBerge, 1980; LaBerge & Rheingold, 1991). Participants were instructed to set an alarm for five hours after going to bed, put a light on when their alarm went off and then sit upright in bed and try to remember a dream from just before they woke up (or any recent dream if they were unable to recall one). They were then told to go to the bathroom if necessary before turning off the light, lying down comfortably and repeating the phrase “next time I’m dreaming, I will remember that I’m dreaming”. The importance of putting meaning into the words was emphasized. Participants were told to simultaneously imagine themselves back in the dream they had recalled and noticing something unusual or bizarre that makes them realize they are dreaming. Participants were told to repeat these steps until they either fell asleep or their intention was set. If their mind wandered, they were told to repeat the procedure so that the last thing they thought about was their intention to remember to recognize the next time they are dreaming. Participants were told that the longer they spend doing the technique the more effective it would be, and not to worry if it took a long time to fall asleep.

8.2.3 Procedure

Participants accessed the online pre-test questionnaire using a web URL included in all promotional materials and media items. The questionnaire was hosted by the survey management website *Survey Monkey* and was configured so that participants could not navigate back to change their answers. Participants provided postal details so they could be sent materials via post. Participants thus completed the study in their own homes. Participants were randomly allocated to the nine possible combinations of the three Week 1 and three Week 2 groups. There was no significant difference between the number of participants in these nine combinations: $\chi^2(4, N = 169) = 1.89$, $p = .756$. Participants were told that the purpose of Week 1 was to gather baseline information about normal sleeping patterns and dream recall ability, and were asked not to attempt any lucid dream induction techniques or to improve their dream recall during this period (see Appendix D for a copy of the Week 1 instructions sheet). Participants filled in their logbooks immediately upon waking and were urged to complete all seven logbook days consecutively if possible. However, during Week 2 they were told that it is better to skip a day if they were feeling sleep deprived and to make up for it at the end (see Appendix E for a copy of the Week 2 instructions sheet). During Week 2, participants practiced lucid dream induction techniques as per the instructions described in Section 8.2.2.3. Participants returned their completed logbooks using pre-paid envelopes provided.

8.3 Results

8.3.1 Preliminary analyses and descriptive statistics

Most variables were not normally distributed and non-parametric tests were used in all cases. Independent samples Kruskal-Wallis tests indicated that the three Week 2 lucid dreaming groups did not differ on any of the pre-test or Week 1 variables (for the sake of brevity, these analyses are not reported here). The ratio of males to females did not differ between participants who did and did not complete the full study: $\chi^2(1, N = 418) = 1.30$, $p = .254$. The proportions of participants who were employed non-students, students, and unemployed or retired did not differ among participants who did and did not complete the full study: $\chi^2(2, N = 420) = 4.30$, $p = .117$. Independent samples Wilcoxon tests indicated that participants who went on to complete the full study were not significantly different from those who did not on any pre-test variables except for being 6.4 years older on average. In Week 2 of the study, participants spent (slightly) more time asleep, took longer to complete their logbooks, and made (slightly) fewer logbook entries compared to Week 1. These findings are presented with descriptive statistics in Table 8.1.

Table 8.1

Descriptive statistics for pre-test, Week 1 and Week 2 variables with Wilcoxon signed-ranks tests for pre-test differences between participants who did and did not complete the full study and between Week 1 and Week 2 logbook variables.

Pre-test variable					Logbook variable				
	M (*SD*)		Wilcoxon test			*M* (*SD*)		Wilcoxon test	
	Completed full study (*N* = 169)	Did not complete full study (*N* = 251)	*Z*	*p*		Week 1 (*N* = 169)	Week 2 (*N* = 169)	*Z*	*p*
P DRF	44.3% (30.0%)	40.0% (27.1%)	1.17	.244	L DRF	77.1% (21.4%)	77.1% (22.9%)	0.11	.912
P DC (per day)	0.6 (0.6)	0.6 (0.6)	1.61	.108	L DC (per day)	1.7 (1.1)	1.8 (1.2)	0.27	.791
P DC Lucid (per month)	1.5 (4.0)	1.4 (3.7)	0.34	.738	L Recall rating	2.8 (0.8)	2.8 (0.8)	0.08	.940
P Lucid tech prior	36.1% (48.2%)	30.7% (46.2%)	1.16	.247	L Recall clarity	2.5 (0.9)	2.5 (0.8)	0.02	.983
P Lucid tech freq	0.3 (0.9)	0.3 (1.0)	0.36	.719	L Recall difficulty	3.1 (0.9)	3.2 (0.8)	1.22	.223
P Age	38.3 (15.0)	31.9 (13.0)	4.39	<.001	L Time asleep	7.5 (0.8)	7.6 (0.8)	3.12	.002
					L Sleep quality	3.5 (0.5)	3.5 (0.5)	1.67	.095
					L Tiredness on waking	2.4 (0.7)	2.4 (0.8)	0.87	.386
					L Sleep dep yesterday	1.9 (0.6)	1.9 (0.7)	0.48	.634
					L Days to complete log	7.1 (0.5)	7.8 (1.8)	4.79	<.001
					L Total log entries	7.0 (0.1)	6.8 (0.9)	2.66	.008

Note. P = pre-test variable, L = logbook variable.

Independent samples Kruskal-Wallis tests were conducted to investigate group differences in Week 2 logbook variables and are presented with descriptive statistics in Table 8.2. Group differences reached statistical significance for five variables: *L Recall clarity*, *L Time asleep*, *L Tiredness on waking*, *L Days to complete log* and *L Total log entries*. Post-hoc pairwise comparisons were calculated for these variables and are presented in Table 8.3. Participants in the *RT + WBTB + MILD* group had significantly higher *L Recall clarity* than participants in the *RT + WBTB* group, perhaps because the *RT + WBTB + MILD* condition involved recalling dreams before practicing the MILD technique. Participants in the *RT + WBTB + MILD* group had significantly lower *L Time asleep* than participants in the *RT + WBTB* group and participants in the *RT + WBTB* and *RT + WBTB + MILD* groups had significantly lower *L Tiredness on waking*. This is most likely because the *RT + WBTB* and *RT + WBTB + MILD* conditions but not the *RT only* condition involved disruption to sleep. Participants in the *RT + WBTB + MILD* group made significantly fewer logbook entries than participants in the *RT only* group, which may reflect greater participant burden in the *RT + WBTB + MILD* group.

Table 8.2

Kruskal-Wallis tests for differences between the *RT only*, *RT + WBTB* and *RT + WBTB + MILD* groups in Week 2 logbook variables.

Logbook variable	*M* (*SD*)				Kruskal-Wallis test	
	All participants (*N* = 169)	RT only (*n* = 68)	RT + WBTB (*n* = 54)	RT + WBTB + MILD (*n* = 47)	χ^2	*p*
L Lucid duration mins	11.3 (15.6)	9.2 (8.6)	13.0 (14.9)	11.6 (20.8)	1.96	.376
L Reality tests	10.1 (4.5)	10.6 (5.6)	10.2 (3.7)	9.2 (3.5)	1.69	.429
L DRF	77.1% (22.9%)	75.7% (24.3%)	75.7% (25.7%)	81.4 (18.6)	0.41	.815
L DC (per day)	1.8 (1.2)	1.7 (1.2)	1.8 (1.2)	1.8 (1.1)	0.81	.668
L DQ	5.6 (5.7)	5.3 (5.8)	5.0 (4.4)	6.6 (6.7)	3.26	.196
L Recall rating	2.8 (0.8)	2.8 (0.8)	2.7 (0.9)	3.1 (0.7)	4.92	.085
L Recall clarity	2.5 (0.8)	2.5 (0.8)	2.4 (0.8)	2.8 (0.8)	6.79	.034
L Recall difficulty	3.2 (0.8)	3.2 (0.8)	3.3 (0.9)	3.0 (0.7)	2.60	.273
L Time asleep	7.6 (0.8)	7.6 (0.9)	7.9 (0.8)	7.4 (0.7)	7.33	.026
L Sleep quality	3.5 (0.5)	3.5 (0.5)	3.4 (0.5)	3.4 (0.6)	3.68	.159
L Tiredness on waking	2.4 (0.8)	2.2 (0.7)	2.5 (0.7)	2.5 (0.8)	9.08	.011
L Sleep dep yesterday	1.9 (0.7)	1.8 (0.6)	1.9 (0.7)	1.9 (0.8)	0.90	.638
L Days to complete log	7.8 (1.8)	7.5 (1.0)	8.3 (2.7)	7.7 (1.6)	6.14	.046
L Total log entries	6.8 (0.9)	7.0 (0.1)	6.8 (0.8)	6.5 (1.3)	6.16	.046

Note. L = logbook variable, RT = reality testing, WBTB = Wake Back to Bed, MILD = Mnemonic Induction of Lucid Dreams.

Table 8.3

Post-hoc pairwise comparisons for differences between the *RT only*, *RT + WBTB* and *RT + WBTB + MILD* groups in Week 2 logbook variables.

Logbook variable	Pairwise comparison	χ^2	*P*
L Recall clarity	RT only – RT + WBTB	6.90	>.999
	RT only – RT + WBTB + MILD	17.81	.164
	RT + WBTB – RT + WBTB + MILD	24.81	.034
L Time asleep	RT only – RT + WBTB	20.09	.073
	RT only – RT + WBTB + MILD	3.72	>.999
	RT + WBTB – RT + WBTB + MILD	23.81	.044
L Tiredness on waking	RT only – RT + WBTB	23.09	.028
	RT only – RT + WBTB + MILD	23.07	.038
	RT + WBTB – RT + WBTB + MILD	0.02	>.999
L Days to complete log	RT only – RT + WBTB	16.37	.074
	RT only – RT + WBTB + MILD	0.45	>.999
	RT + WBTB – RT + WBTB + MILD	16.82	.121
L Total log entries	RT only – RT + WBTB	4.99	.572
	RT only – RT + WBTB + MILD	9.78	.041
	RT + WBTB – RT + WBTB + MILD	4.79	.753

Note. L = logbook variable, RT = reality testing, WBTB = Wake Back to Bed, MILD = Mnemonic Induction of Lucid Dreams. Significance values were adjusted by multiplying the unadjusted values for each pairwise comparison by the number of comparisons made.

8.3.2 Relationships with overall lucid dreaming rates

Spearman rho non-parametric correlations were calculated to investigate relationships between both pre-test and Week 2 lucid dreaming rates and other pre-test and Week 2 variables. Correlations between Week 2 variables based on both mean values for the week and individual daily observations are presented in Table 8.4. It was hypothesized that there would be significant positive correlations between general dream recall rates and lucid dreaming rates at both pre-test and during Week 2. This hypothesis was supported. All pre-test dream recall variables were related to *P Lucid DC (per month)*. Correlations between these pre-test variables and *L DRF Lucid* were weaker and in most cases non-significant. This pattern was reversed for Week 2 general dream recall variables, which were more strongly and consistently correlated with *L DRF Lucid* than with *P Lucid DC (per month)*. Note that the correlations between Week 2 variables tended to be stronger when they were based on daily observations rather than mean values for the week. This highlights the advantage of using daily observations, as much variance and statistical power is lost when correlations are based on mean values for the week. *P Lucid tech prac* was weakly correlated with *P Lucid DC (per month)* but not with Week 2 *L DRF Lucid*, indicating that prior experience with lucid dream induction techniques did not influence the effectiveness of the techniques used in the present study. There was a significant positive correlation between pre-test and Week 2 lucid dreaming rates. However, shared variance was only 9.6%. Age was positively correlated with both pre-test and Week 2 lucid dreaming rates.

Table 8.4

Spearman rho non-parametric correlations between pre-test and Week 2 lucid dreaming rates and other pre-test and Week 2 variables.

	P DC Lucid (per month)	Week 2 L DRF Lucid	
		Correlation based on mean of Week 2 observations	Correlation based on daily Week 2 observations
P DC Lucid (per month)	-	.31**	-
P Lucid tech freq	.11*	-.10	-
P Age	.10*	.31**	-
P DRF	.28**	.15	-
P DC (per day)	.27**	.21**	-
L DRF	-.04	.08*	-
L DC (per day)	.07	.20**	.22**
L DQ	.21**	.25**	.30**
L Recall rating	.19*	.15*	.28**
L Recall clarity	.18*	.12*	.26**
L Recall difficulty	-.22**	-.20**	-.29**

Note. P = pre-test variable, L = logbook variable. Correlations between Week 2 *L DRF Lucid* and other Week 2 variables based on daily observations are point-biserial.

* p = <.05, ** p = <.01

Correlations between *L DRF Lucid* and Week 2 measures of sleep quality were calculated for participants in each group separately as well as for all participants combined. This is because the three experimental conditions had different effects on sleep (participants in the *RT + WBTB* and *RT + WBTB + MILD* groups woke up after 5 hours of sleep, and the MILD technique may have made it especially difficult to return to sleep). As can be seen in Table 8.5, *L DRF Lucid* was higher when participants in the *RT + WBTB* and *RT + WBTB + MILD* groups were less sleep deprived the day before and when sleep quality was superior.

Table 8.5

Spearman rho non-parametric correlations between Week 2 lucid dreaming rates and measures of sleep quality for all participants combined and for participants in each Week 2 group.

	Week 2 L DRF Lucid			
	All participants	RT only group	RT + WBTB group	RT + WBTB + MILD group
L Sleep dep yesterday	-.03	.15**	-.12*	-.16**
L Time asleep	.03	.05	.00	.07
L Sleep quality	.05	-.05	.11*	.11*
L Tiredness on waking	-.09**	-.02	-.09	-.22**

Note. L = logbook variable, RT = reality testing, WBTB = Wake Back to Bed, MILD = Mnemonic Induction of Lucid Dreams. All correlations are point-biserial and based on daily observations.

* p = <.05, ** p = <.01

8.3.3 Lucid dream induction

It was hypothesized that lucid dreaming rates would be significantly higher in Week 2 compared to Week 1 for all participants combined and for participants in each of the three Week 2 groups. This hypothesis was partially supported. As can be seen in Table 8.6, dependent samples Wilcoxon tests showed that *L DRF Lucid* was significantly higher in Week 2 than in Week 1 for all participants combined. The same was true for participants in the *RT + WBTB + MILD* group. *L DRF Lucid* was higher in the *RT + WBTB* group in Week 2 compared to Week 1, but this difference was not statistically significant. *L DRF Lucid* was slightly *lower* in Week 2 for participants in the *RT only* group, indicating that reality testing on its own was not effective at inducing lucid dreams. An independent samples Kruskal-Wallis test indicated that there were significant group differences in Week 2 *L DRF Lucid* (χ^2 = 6.35, p = .042). Post-hoc pairwise comparisons revealed that the difference between the *RT only* and *RT + WBTB + MILD* groups was significant (χ^2 = 21.10, p = .035). However, the differences between the *RT only* and *RT + WBTB* groups (χ^2 = 8.84, p = .816) and the *RT + WBTB* and *RT + WBTB + MILD* groups (χ^2 = 12.26, p = .492) were non-significant.

Table 8.6

Improvements in lucid dreaming rates in Week 2 compared to Week 1 for all participants combined and for participants in each Week 2 group.

Week 2 group	L DRF Lucid			Wilcoxon test	
	Week 1 M (SD)	Week 2 M (SD)	Improvement	Z	P
All participants (N = 169)	8.1% (17.8%)	11.3% (17.3%)	39.0%	2.27	.023
RT only (n = 68)	8.1% (17.8%)	7.6% (13.0%)	-6.8%	0.27	.786
RT + WBTB (n = 54)	6.9% (15.7%)	10.7% (16.3%)	54.1%	1.04	.301
RT + WBTB + MILD (n = 47)	9.4% (20.0%)	17.4% (22.0%)	84.5%	2.94	.003

Note. L = logbook variable, RT = reality testing, WBTB = Wake Back to Bed, MILD = Mnemonic Induction of Lucid Dreams.

In addition to *L DRF Lucid*, lucid dreaming was also operationalized as *L Lucid participants*. A McNemar's test showed that for all participants combined, the proportion of participants that experienced lucid dreaming at least once during Week 2 (*L Lucid participants* = 44.6%) was significantly higher than in Week 1 (*L Lucid participants* = 27.7%): $\chi^2(1, N = 166) = 13.50$, p = <.001. A binomial test – used because cell counts did not permit McNemar's test – showed that the increase in *L Lucid participants* was significant in the *RT + WBTB + MILD* group (Week 1 = 27.7%, Week 2 = 53.2%, p = .012). The increases in *L Lucid participants* were smaller and did not reach statistical significance in the *RT only* (Week 1 = 25.4%, Week 2 = 36.8%, p = .077) and the *RT + WBTB* (Week 1 = 30.8%, Week 2 = 46.3%, p = .096) groups. These findings provide partial support for the hypothesis that lucid dreaming rates would be significantly higher in Week 2 compared to Week 1 for all participants combined and for participants in each of the three Week 2 groups. A 3 x 2 Chi^2 test was performed to explore group differences in *L Lucid participants*. Results indicated that there were no statistically significant group differences, $\chi^2(2, N = 169) = 3.16$, $p = .206$.

8.3.4 Relationships with technique practice variables

A Spearman rho non-parametric correlation using data from each individual logbook day indicated that, for all participants combined, the number of reality tests performed was not related to whether participants experienced lucid dreaming ($r_s = .05$, $p = .078$, $N = 1087$). This was also the case for participants in the *RT only* group ($r_s = .03$, $p = .501$, $n = 445$) and the *RT + WBTB + MILD* group ($r_s = -.02$, $p = .792$, $n = 281$). However, a significant correlation was observed for participants in the *RT + WBTB* group ($r_s = .17$, p = <.001, $n = 361$). These findings are given greater consideration in Section 8.4.1. Spearman rho non-parametric correlations between *L DRF Lucid* and variables that operationalize the way in which the WBTB and MILD techniques were practiced are presented with descriptive statistics in Table 8.7. In both the *RT + WBTB* and *RT + WBTB + MILD groups*, *L DRF Lucid* was higher when participants had less difficulty focusing. *L DRF Lucid* was also positively correlated with motivation to practice the technique, but only in the *RT + WBTB* group. Participants fell asleep while performing the MILD technique in the majority (79.9%) of cases. A 2 x 2 Chi^2 test indicated that this was not related to the likelihood of experiencing lucid dreaming: $\chi^2(1, n = 293) = 0.48, p = .487$. However, a significant negative correlation was observed between *L Mins back to sleep* and *L DRF Lucid* (see Table 8.7). Indeed, this relationship is stronger than any of the other relationships with *L DRF Lucid* observed in the present study. To further explore this relationship, occasions when participants did not fall asleep while performing the MILD technique and then took five minutes or less to fall asleep afterward were examined. This was achieved a total of 24 times by 14 participants. For these 24 occasions, Week 2 *L DRF Lucid* (M = 45.8%, SD = 50.9%) was much higher than for all the other nights on which these participants practiced MILD (M = 24.6%, SD = 43.4%), suggesting that the MILD technique is most effective when sleep is achieved within five minutes of completing the technique. However, it should be noted that the baseline *L DRF Lucid* rate for these participants during Week 1 was higher than average at M = 20.4% (SD = 29.5%), which limits the generalizability of these findings. Notwithstanding, completing the technique and then falling asleep within five minutes was associated with an increase in *L DRF Lucid* of 86.2% compared to all other MILD attempts for these 14 participants. Week 2 *L DRF Lucid* was significantly lower when participants performed more MILD technique repetitions and spent longer doing so. However, when participants who fell asleep while performing the technique were excluded, the correlations with *L Technique repetitions* ($r_s = -.09, p = .168, n = 223$) and *L Technique mins* ($r_s = -.13, p = .057, N = 234$) became smaller and non-significant. This is given greater consideration in Section 8.4.2.3.

Table 8.7

Spearman rho non-parametric correlations between Week 2 lucid dreaming rates and variables that operationalize the way in which the WBTB and MILD techniques were practiced.

	RT + WBTB group		RT + WBTB + MILD group	
	M (*SD*)	Correlation (r_s) with L DRF Lucid	*M* (*SD*)	Correlation (r_s) with L DRF Lucid
L Difficulty focusing	2.7 (1.0)	-.11*	3.0 (0.9)	-.12*
L Technique motivation	2.8 (1.0)	.11*	3.0 (1.0)	-.03
L Mins back to sleep	18.6 (14.3)	.11*	24.0 (25.7)	-.44**
L Technique repetitions	-	-	17.4 (16.1)	-.12*
L Technique mins	-	-	8.5 (5.3)	-.16**

Note. L = logbook variable, RT = reality testing, WBTB = Wake Back to Bed, MILD = Mnemonic Induction of Lucid Dreams. All correlations are point-biserial and based on daily observations.
* p = <.05, ** p = <.01

8.3.5 Additional exploratory analyses

An independent samples Kruskal-Wallis test indicated that the type of logbook used in Week 1 was not related to Week 2 *L DRF Lucid*: $\chi^2(2, N = 169) = 0.89$, $p = .641$. Similarly, a 3 x 2 Chi^2 test indicated that there was no significant difference in the proportion of participants in each Week 1 logbook group that experienced lucid dreaming during Week 2: $\chi^2(2, N = 169) = 1.18$, $p = .554$. Thus, writing out one's dreams for a week prior to practicing lucid dreaming techniques did not appear to be advantageous.

As noted in Section 8.3.2, for all participants combined *P Lucid tech freq* was not significantly correlated with Week 2 *L DRF Lucid*. The same was true for participants in the *RT + WBTB + MILD* group ($r_s = -.21$, $p = .159$). A 2 x 2 Chi^2 test indicated that whether participants experienced lucid dreaming during Week 2 was also not significantly related to whether they had attempted to practice lucid dream induction techniques previously (*L Lucid participants* = 39.3%) or not (*L Lucid participants* = 47.2%): $\chi^2(1, N = 169) = 0.98$, $p = .322$. The same was true for participants in the *RT + WBTB + MILD* group (previous experience: *L Lucid participants* = 50.0%; no previous experience: *L Lucid participants* = 54.3%): $\chi^2(1, N = 47) = 0.07$, $p = .797$. An independent samples Wilcoxon test indicated that Week 2 *L DRF Lucid* did not differ between participants with previous experience (M = 9.4%, SD = 16.5%) and without previous experience (M = 12.4%, SD = 17.7%): $Z(169) = 0.51$, $p = .692$. The same was true for participants in the *RT + WBTB + MILD* group (previous experience: M = 9.5%, SD = 11.2%; no previous experience: M = 20.1%, SD = 24.2%): $Z(1, N = 47) = 0.81$, $p = .480$.

A 2 x 2 Chi^2 test indicated that in the *RT + WBTB + MILD* group, lucid dreaming was associated with whether or not participants reported that they were dreaming when they were awakened by their alarm to perform the technique, $\chi^2(2, n = 285) = 7.16$, $\phi = .16$, $p = .028$. Lucid dreaming was most likely when participants reported that they were not dreaming ($n = 75$, *L DRF Lucid* = 25.3%), was less likely when participants were awakened while dreaming ($n = 96$, *L DRF Lucid* = 17.7%), and was least likely when participants were unsure of whether or not they were dreaming ($n = 114$, *L DRF Lucid* = 10.5%). However, because of the disproportionately large number of occasions when participants were unsure, it remains unclear whether or not waking from a dream before performing lucid dream induction techniques was related to lucid dreaming. This issue is given greater consideration in Section 8.4.2.2. The same pattern of findings was observed for the *RT + WBTB* group, but was not statistically significant, $\chi^2(2, n = 358) = 2.53$, $\phi = .08$, $p = .282$.

To further investigate factors that influenced the success rate of the MILD technique, differences in logbook variables between nights when MILD was and was not followed by lucid dreaming were investigated. These are presented in Table 8.8. No significant differences were found for *L Reality tests* and *L Technique motivation*. When MILD was followed by lucid dreaming, participants had significantly less difficulty focusing, took less time to get back to sleep once they finished the technique, performed fewer technique repetitions, and spent slightly less time on the technique overall. When MILD was followed by lucid dreaming, participants were significantly less sleep deprived the previous day, had marginally better sleep quality, and were significantly less tired the next morning. *L Time asleep* was also slightly higher, but this finding was not statistically significant. These findings indicate that successful induction of lucid dreaming using the MILD technique did not compromise sleep quality. General dream recall was superior according to every measure used.

Table 8.8

Wilcoxon signed-ranks tests for differences in Week 2 logbook variables between nights when lucid dreaming did and did not occur following practice of the MILD technique.

Logbook variable	*M* (*SD*)		Wilcoxon test	
	Lucid dreaming reported (n = 52)	No lucid dreaming reported (n = 251)	*Z*	*p*
L Reality tests	9.3 (5.8)	9.5 (3.8)	0.26	.792
L Difficulty focusing	2.6 (1.3)	3.0 (1.2)	2.08	.038
L Technique motivation	3.1 (1.3)	3.0 (1.4)	0.57	.572
L Mins back to sleep	10.6 (21.1)	26.7 (27.4)	3.34	.001
L Technique repetitions	13.9 (16.9)	18.7 (22.1)	2.05	.040
L Technique mins	7.7 (10.2)	8.8 (7.6)	2.76	.006
L DC (per day)	2.9 (2.1)	1.7 (1.4)	3.74	<.001
L DQ	14.4 (15.9)	5.3 (5.7)	4.92	<.001
L Recall rating	3.9 (1.1)	2.9 (1.4)	4.68	<.001
L Recall clarity	3.6 (1.3)	2.7 (1.4)	4.47	<.001
L Recall difficulty	1.9 (1.2)	3.1 (1.5)	5.73	<.001
L Time asleep	7.6 (1.4)	7.4 (1.1)	1.13	.260
L Sleep quality	3.7 (0.8)	3.4 (0.9)	1.96	.050
L Tiredness on waking	2.0 (0.9)	2.6 (1.1)	3.77	<.001
L Sleep dep yesterday	1.6 (0.8)	2.0 (1.1)	2.73	.006

Note. L = logbook variable.

8.4 Discussion

The purpose of the present study was to provide a thorough empirical investigation into the effectiveness of two widely used cognitive lucid dream induction techniques – reality testing and the MILD technique. A pre-test questionnaire was administered, and baseline logbook data were collected during Week 1. In Week 2, participants were randomly allocated to conditions that involved reality testing only (*RT only*), reality testing and WBTB, and reality testing, WBTB and the MILD technique (*RT + WBTB + MILD*). Results showed that the *RT + WBTB + MILD* condition was the most effective at inducing lucid dreams. Results showed that the effectiveness of the MILD technique was influenced by several factors, including general dream recall, prior sleep deprivation and the amount of time taken to fall asleep after finishing the technique.

8.4.1 Group differences in lucid dream induction

The *RT + WBTB + MILD* condition was clearly the most effective at inducing lucid dreams. Participants in this group had a mean *L DRF Lucid* of 17.4%, which is 84.5% higher than in Week 1. Furthermore, just over half of these participants (53.2%) experienced lucid dreaming at least once during Week 2, which is nearly twice as many as in Week 1. In the *RT + WBTB* group, mean *L DRF Lucid* in Week 2 was 10.7%, which is 54.1% higher than in Week 1. However, this increase was less than that observed in the *RT + WBTB + MILD* group and was not statistically significant. The purpose of the *RT + WBTB* group was to control for the effects of waking up after five hours of sleep, thinking about lucid dreaming, and expecting that one might have a lucid dream as a consequence of practicing a lucid dream induction technique. Findings indicate that these effects are at most only partly responsible for the effectiveness of the MILD technique and thus support the theory that the MILD technique works by creating a mnemonic intention to remember that one is dreaming that is then later recalled during a non-lucid dream. The present study replicates several earlier field studies that have shown the MILD technique to be effective for inducing lucid dreams (Edelstein & LaBerge, 1992; LaBerge, 1988; LaBerge et al., 1994; Levitan, 1989, 1990a, 1990b, 1991; Levitan & LaBerge, 1994; Levitan et al., 1992). With the exception of one laboratory study (Kueny, 1985), the present study is the first investigation of the MILD technique that was not conducted by the creator of the MILD technique Dr Stephen LaBerge or any of his research associates. Because it was clearly the most effective, the MILD technique is given in-depth consideration in Section 8.4.2.

Contrary to hypotheses, reality testing on its own was not effective at inducing lucid dreams. Mean *L DRF Lucid* in the *RT only* group was only 7.6% in Week 2, which was lower than the rate observed in Week 1. The percentage of participants that experienced lucid dreaming at least once during Week 2 was the lowest in this group at 36.8%, and was not significantly higher than in Week 1. These findings are consistent with those of Taitz (2011) and LaBerge (1988), who also found that reality testing on its own was ineffective. However, the present findings are at odds with other studies that have found reality testing to be effective (Levitan, 1989; Purcell, 1988; Purcell et al., 1986; Schlag-Gies, 1992). One possible explanation for the diversity in findings is that reality testing is only effective if combined with other activities that assist with lucid dream induction. For example, Purcell (1988) observed significantly higher lucid dreaming rates in an experimental condition that involved reality testing, reading over written dream narratives and becoming familiar with recurring anomalies that may serve as triggers for lucidity. Similar results were reported by Paulson and Parker (2006), who asked participants to form the intention to have a lucid dream directly before going to sleep in addition to practicing reality testing throughout the day. This explanation is also supported by findings from the present study. The correlation between *L DRF Lucid* and the number of reality tests performed was non-significant in the *RT only* group. However, the correlation was highly significant in the *RT + WBTB* group, which involved reality testing as well as waking up after five hours of sleep, reading about lucid dreaming and then performing a reality test before returning to sleep (see Section 8.2.2.3). This may have primed participants to perform reality tests shortly before REM sleep. In the *RT + WBTB + MILD* group, this priming effect may have been negated by practicing the MILD technique. This might explain why the number of reality tests performed was not correlated with *L DRF Lucid* in this group.

8.4.2 Findings related to the MILD technique

8.4.2.1 General dream recall

General dream recall was correlated with *L DRF Lucid* and was significantly higher on occasions when practicing the MILD technique was followed by lucid dreaming. There are two likely explanations for this. The first is that physiological factors that cause increased dreaming activity are conducive to lucid dream induction. The other is that the occurrence of lucid dreams simply inflates general dream recall rates due to them being more vivid and memorable than most non-lucid dreams. Participants recalled 1.2 more dreams on average when practicing the MILD technique led to lucid dreaming, which at first glance appears consistent with the explanation that general dream recall rates were simply inflated by the occurrence of highly memorable lucid dreams. However, most lucid dreams occur during the course of non-lucid dreams and it is likely that at least a substantial portion of these dreams would have been recalled even if lucidity had not been attained. In light of this, the finding that participants recalled 1.2 more dreams on average when they experienced lucid dreaming tentatively suggests that there is indeed an effect whereby physiological conditions that give rise to superior general dream recall are conducive to lucid dream induction. If this is correct, it may be possible to increase the effectiveness of cognitive lucid dream induction techniques such as the MILD technique by enhancing dreaming activity during the night. This is given further consideration in Section 8.6.

8.4.2.2 Sleep stage awakening

Lucid dreaming was most likely when participants reported that they were not dreaming when they were awakened by their alarm to perform the MILD technique. Lucid dreaming was less likely if participants reported that they were dreaming and least likely when they were unsure of whether or not they had been dreaming. However, it remains uncertain whether waking up during a dream influences the effectiveness of the MILD technique. This is because participants were unsure of whether they had been dreaming in the majority of cases. If participants were not dreaming on most of the occasions when they were unsure, this would mean that lucid dreaming was less likely following awakening from dreamless sleep than the results indicate. On the other hand, the fact that self-reported sleep stage awakening was significantly related to *L DRF Lucid* in the *RT + WBTB + MILD* group but not the *RT + WBTB* group suggests that sleep stage awakening may indeed influence the effectiveness of the MILD technique in some way. This is given further consideration in Section 8.6.

8.4.2.3 Technique repetitions and time spent on the technique

On occasions when performing the MILD technique was followed by lucid dreaming, participants performed fewer technique repetitions and spent less time on the technique. Furthermore, significant negative correlations were observed between *L DRF Lucid* and both the number of technique repetitions and the amount of time spent on the technique. These findings appear counterintuitive, as one would expect that more technique repetitions and more time spent on the technique would assist in creating a strong mnemonic intention to remember that one is dreaming. However, upon closer inspection it was found that difficulty falling asleep after completing the technique was strongly related to both the number of technique repetitions (r_s = .48, p = <.001) and the amount of time spent on the technique (r_s = .67, p = <.001). Furthermore, the correlations between *L DRF Lucid* and both technique repetitions and time spent on the technique became smaller and non-significant when they were recalculated using only occasions when participants fell asleep before completing the technique. These findings are consistent with the theory that the effectiveness of the MILD technique is highly dependent on being able to fall asleep quickly after creating a strong mnemonic intention to remember that one is dreaming. It appears that this mnemonic intention tends to become weaker when one takes longer to fall asleep after completing the technique.

8.4.2.4 Time taken to return to sleep

The strongest predictor of lucid dreaming following practice of the MILD technique was the amount of time it took for participants to fall asleep after they finished the technique. On occasions when participants were able to fall asleep in less than five minutes, *L DRF Lucid* was very high at *M* = 45.8%. This rate is 86.2% higher than the mean *L DRF Lucid* rate for all other nights on which these participants attempted the MILD technique (*M* = 24.6%). It should be noted that the Week 1 base rate for the 14 participants who managed to achieve this (*M* = 20.4%) was substantially higher than for all participants in the *RT + WBTB + MILD* group (*M* = 9.4%), which calls into question the generalizability of this finding. Notwithstanding, if this amount of improvement (86.2%) were extrapolated to all participants in the *RT + WBTB + MILD* group, this would yield a mean *L DRF Lucid* rate of 32.4%. This is an exciting possibility because a lucid dream induction rate of this magnitude would make research into the potential applications of lucid dreaming highly feasible. A potential problem is that it may be difficult to fall asleep within five minutes of completing the MILD technique. Indeed, participants fell asleep before finishing the technique in the majority (79.9%) of cases. However, participants were told that it did not matter if they fell asleep while practicing the MILD technique or how long it took to fall asleep afterwards. With altered instructions it may be possible to reduce both the likelihood of falling asleep prematurely and the amount of time required to fall asleep after completing the technique. This is given further consideration in Section 8.6.

8.4.2.5 Relationships with sleep quality

On occasions when practicing the MILD technique was followed by lucid dreaming, participants reported being significantly less sleep deprived the previous day. This suggests that the MILD technique is more likely to be effective if one is well-rested. Participants in the *RT + WBTB + MILD* group reported significantly less time asleep and significantly more tiredness on waking than participants in the other two groups, suggesting that the MILD technique had a negative effect on sleep quality overall. However, group differences were very small, and on closer inspection it was found that on occasions when MILD led to lucid dreaming, all sleep quality variables were either as good as or better than Week 2 means for the *RT only* group (the *RT only* condition did not involve any interruption to sleep). Therefore, it appears that only unsuccessful attempts at inducing lucid dreams using the MILD technique had a detrimental effect on sleep quality. Successful lucid dream induction using the MILD technique does not appear to be detrimental to sleep quality.

8.4.2.6 Accessibility of the MILD technique

Participants with prior lucid dreaming experience were no more likely to experience lucid dreaming and did not have higher mean *L DRF Lucid* during Week 2 compared to participants with no prior experience, nor was *L DRF Lucid* correlated with the frequency of previous lucid dream induction technique practice. This was the case for all participants combined and for participants in the *RT + WBTB + MILD* group specifically. Pre-test lucid dreaming rates were significantly correlated with Week 2 *L DRF Lucid*, but shared variance was only 9.6%. Shared variance was similarly low for participants in the *RT + WBTB + MILD* group at 11.2% (r_s = .33, p = .022). These findings indicate that it is not necessary to have prior experience with lucid dream induction techniques in order for the MILD technique to be effective, nor is it necessary to be a naturally prolific lucid dreamer. Thus, the MILD technique appears to be appropriate for people who are naive to lucid dreaming and effective within a short period of time.

8.5 Strengths and limitations

The present study is the most methodologically rigorous lucid dream induction field study ever conducted and is based on a relatively large and highly diverse sample of participants from across Australia. The majority of previous lucid dream induction studies have used participants that were either self-selected lucid dreamers or undergraduate students. In contrast, the majority of (63.9%) participants in the present study had never attempted a lucid dream induction technique before and only 21.3% of participants were students. Although most participants who completed the pre-test questionnaire did not go on to complete the full study, those who did were comparable to those who did not on all pre-test variables, except for being significantly older (by 6.4 years on average). Thus, it appears that findings from the present study are generalizable to a wide range of people that are interested in learning to have lucid dreams. The present study has high ecological validity because participants trialed the techniques in their own homes using written instructions and without any contact from the experimenters, which reflects how people typically learn lucid dream induction techniques. A limitation of the present study is that the MILD technique was not trialed in isolation from reality testing. This was done in the interests of identifying a maximally effective approach to lucid dream induction. Although reality testing on its own was found to be ineffective in the *RT only* group, the possibility that reality testing contributed to the *L DRF Lucid* rate observed in the *RT + WBTB + MILD* group cannot be ruled out. Further research comparing MILD on its own to MILD combined with reality testing would shed light on this.

8.6 Directions for future research

Findings from the present study indicate that the effectiveness of the MILD technique could be improved with strategies designed to help participants develop a strong mnemonic intention to remember that they are dreaming and then fall asleep quickly without losing this intention. A one-size-fits-all approach is not likely to be effective and participants will probably need to be given a range of strategies for achieving an ideal level of wakefulness. For participants who are prone to falling asleep prematurely, turning on lights, spending more time reading about lucid dreaming, getting out of bed for a short period of time, or even writing out the phrase “next time I’m dreaming, I will remember that I’m dreaming” multiple times on paper may be helpful. In contrast, for participants who find it difficult to fall asleep after completing the technique, it will be important to minimize such stimulation. It remains unclear whether sleep stage awakening influences the effectiveness of the MILD technique. This issue is worth further investigation and this could be done in a sleep laboratory by comparing the effectiveness of the MILD technique following awakenings from various sleep stages. If there is indeed a sleep stage awakening that is most conducive to lucid dream induction, practitioners of lucid dream induction techniques could take advantage of this knowledge in the home setting using recently developed software applications that track sleep activity using the accelerometers in smartphones. Although these software applications are less accurate than the equipment used in sleep laboratories, they permit users to set alarms that go off when a specific sleep stage is detected. Users could set an alarm to wake them up during a sleep stage that is most conducive to lucid dreaming, thus increasing the effectiveness of cognitive lucid dream induction techniques that involve an awakening such as the MILD technique.

In the present study, general dream recall was higher when practicing the MILD technique was followed by lucid dreaming and was also correlated with overall *L DRF Lucid* rates. It appears that it is the physiological conditions that give rise to superior general dream recall that are conducive to lucid dreaming rather than general dream recall per se. There is an abundance of anecdotal reports on the extensive online lucid dreaming forums (e.g. “Dream Views”, “LD4all”, “World of Lucid Dreaming”) indicating that certain substances are highly effective for increasing dreaming activity and also for inducing lucid dreams (see also Yuschak, 2006). Some of these substances influence the REM-on neurotransmitter acetylcholine and include acetylcholine esterase inhibitors such as Galantamine, Huperzine-A and Donepezil. To date, three studies have investigated the use of such substances for inducing lucid dreams. In a pilot study by LaBerge (2004), it was found that the odds ratio of experiencing lucid dreaming was extremely high at 0.75 on nights when 10mg of Donepezil was administered, compared to only 0.03 for participants in a placebo condition. However, adverse effects including insomnia, sleep paralysis, and gastrointestinal symptoms were reported in some cases. In an unpublished study by LeMarca and LaBerge (2012, as cited in Sparrow, Hurd, & Carlson, 2016), participants who ingested Galantamine during a brief awakening (dose not specified) purportedly experienced a five-fold increase in lucid dreaming compared to participants in a placebo condition. Most recently, participants in a survey of 19 lucid dreaming enthusiasts who used Galantamine for inducing lucid dreams reported that their Galantamine-induced lucid dreams were significantly longer and more vivid than their other lucid dreams and contained significantly less fear, threatening dream characters, violence and darkness, with no increase in sleep paralysis (Sparrow, Hurd, & Carlson, 2016). Another potential dream-enhancing substance with less risk of adverse side effects is vitamin B6. Ebben, Lequerica, & Spielman (2002) found that 240mg of vitamin B6 (pyridoxine hydrochloride) increased the vividness, emotionality, bizarreness, and color of dreams when consumed before bed. However, this was only a small pilot study, and effects on lucid dreaming were not reported. It may be possible to combine acetylcholine esterase inhibitors, vitamin B6, or other potential dream-enhancing substances (see Yuschak, 2006) with cognitive lucid dream induction techniques such as the MILD technique to great effect, and research into this is certainly warranted.

External stimulation techniques represent another promising approach for increasing the effectiveness of cognitive techniques. Light stimulation appears to be the most effective (Stumbrys et al., 2012) and has been used in combination with the MILD technique in four studies. Findings from these studies indicate that this combination is more effective than the MILD technique on its own (LaBerge, 1988; LaBerge & Levitan, 1995; LaBerge, Levitan, Rich, & Dement, 1988; Levitan & LaBerge, 1994). Several commercially available devices designed to induce lucid dreams in this way have been created by LaBerge's research group, such as the *DreamLight*, *DreamLink,* and *NovaDreamer*, and various generic versions exist. These devices are designed to be used in the home setting and include an eye-mask with sensors that detect the eye movements that characterize REM sleep. Once REM sleep is detected, the device produces a series of flashing LED lights within the mask that are incorporated into the dream experience and serve as a cue that one is dreaming. With further research, the MILD technique in conjunction with light stimulation and the administration of a dream-enhancing substance could prove to be a highly effective approach to lucid dream induction.

8.7 Conclusions

The present study indicates that the MILD technique is effective for inducing lucid dreams within a short period of time and is suitable for a wide range of people, including people that are naive to lucid dreaming. Based on the present findings, several strategies for improving the effectiveness of the MILD technique were identified. Combining the MILD technique with substances that may enhance dreaming activity and with external stimulation may further enhance the effectiveness of the MILD technique. Lucid dreaming has a wide range of potential benefits and applications, and the only impediment to research in this area is the lack of effective and reliable lucid dream induction techniques. Thus, high quality empirical research on lucid dream induction should be considered a high priority among dream researchers.

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Chapter 9: Additional Findings from the National Australian Lucid Dream Induction Study

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Abstract

The present study investigated a novel cognitive lucid dream induction technique: the *Senses Initiated Lucid Dream* (SSILD) technique. Participants were 21 people who agreed to participate in a trial of an additional technique after completing the National Australian Lucid Dream Induction Study (NALDIS; see Chapter 8). After completing the pre-test questionnaire, Week 1 baseline logbook period and Week 2 experimental period of the NALDIS, participants practiced the SSILD technique for one week. Results indicated that the SSILD technique was effective for inducing lucid dreams. Participants experienced lucid dreaming on 14.7% of nights during Week 3, which was 54.1% higher than in Week 1. Findings provide further evidence that the conditions that give rise to superior general dream recall are conducive to lucid dreaming. Avenues for future research are discussed.

The Senses Initiated Lucid Dream (SSILD) technique: Additional findings from the National Australian Lucid Dream Induction Study

9.1 Introduction

Lucid dreams are dreams in which the dreamer is aware that they are dreaming while the dream is still happening (LaBerge, 1985). Lucid dreaming was confirmed empirically by Hearne (1978; see also LaBerge, 1980), who asked a proficient lucid dreamer to perform a series of pre-arranged left-right eye movements when they became lucid (physical eye movements during REM sleep correspond with the gaze of the dreamer). Several such signals were recorded using electrooculography and were followed by reports of lucid dreaming. These signals occurred during unambiguous REM sleep, and numerous studies have since replicated these findings (e.g. Dane, 1984; Fenwick et al., 1984; Ogilvie, Hunt, Tyson, Lucescu, & Jeakins, 1982; Tholey, 1983). In a recent meta-analysis by Saunders, Roe, Smith and Clegg (2016), it was found that an estimated 55% of adults have experienced at least one lucid dream in their lives, with an estimated 23% of adults experiencing lucid dreaming regularly (once per month or more). Lucid dreams tend to be highly vivid and realistic, and it is possible to exert control in lucid dreams. Examples include changing to a new location, stabilizing a dream that is beginning to fade, and deliberately waking up (LaBerge & DeGracia, 2000; LaBerge & Rheingold, 1991; Love, 2013). Lucid dreaming has a wide range of potential benefits and applications, such as treatment for nightmares (Holzinger, Klösch, & Saletu, 2015; Lancee, van den Bout, & Spoormaker, 2010; Spoormaker & Van Den Bout, 2006), improvement of physical skills and abilities through dream rehearsal (Erlacher & Schredl, 2010; Stumbrys, Erlacher, & Schredl, 2016), creative problem solving (Stumbrys & Daniels, 2010), and research opportunities for exploring mind-body relationships and consciousness (see Hobson, 2009).

9.1.1 Lucid dream induction techniques

Lucid dreaming is a learnable skill and a wide variety of techniques for inducing lucid dreams exist (see LaBerge & Rheingold, 1991; Love, 2013; Stumbrys, Erlacher, Schädlich, & Schredl, 2012; Tholey, 1983). Lucid dream induction techniques have recently been organized by Stumbrys et al. (2012) according to three broad categories. *Cognitive techniques* encompass a wide range of cognitive activities designed to increase the likelihood of lucid dreaming. Two of the most widely used and researched cognitive techniques are *reality testing* (LaBerge & Rheingold, 1991; Tholey, 1983) and the *Mnemonic Induction of Lucid Dreams* (MILD) technique (LaBerge, 1980; LaBerge &

Rheingold, 1991). Reality testing involves examining one's environment several times per day, questioning whether or not one is awake or dreaming, and then performing a reliable test that differentiates between waking and dreaming. The rationale is that if reality testing becomes habitual, it will eventually be performed while dreaming, triggering lucidity. The MILD technique makes use of prospective memory and involves creating an intention to remember that one is dreaming by repeating the phrase "next time I'm dreaming, I will remember that I'm dreaming" (or some variation). Timing is important, and the technique is best performed during a brief awakening after five or so hours of sleep. This is because most dreams are experienced in the last few hours of sleep. Indeed, waking up after several hours of sleep for the purpose of lucid dreaming induction is considered a lucid dream induction technique in its own right, known as *Wake Back to Bed* (WBTB; LaBerge & Rheingold, 1991). If the MILD technique is successful, the intention to remember that one is dreaming will be remembered while dreaming, leading to lucidity. *External stimulation techniques* involve the presentation of stimuli such as flashing lights and mild electric shocks during REM sleep that can be incorporated into dreams, serving as cues that trigger lucidity. *Miscellaneous techniques* are those that do not fit into the other two categories, such as the use of drugs and supplements that influence sleep and dreaming (see LaBerge, 2004; see also Yuschak, 2006). Cognitive techniques have been favored in both research and by lucid dreaming enthusiasts because they do not require specialized equipment and do not carry the potential side effects associated with ingesting drugs and supplements.

9.1.2 Research on lucid dream induction

In a recent systematic review, Stumbrys et al. (2012) identified 35 empirical studies that investigated various lucid dream induction techniques. Most of these (24) were conducted as field studies, with the others conducted in sleep laboratories (11). Stumbrys et al. (2012) evaluated these studies using a methodological quality checklist developed by Downs and Black (1998) and found that most studies (60%) were of poor methodological quality, with the others classified as moderate quality. More than half of the studies were unpublished Ph.D. dissertations or otherwise not published in peer-reviewed journals. All of the studies showed poor external validity. Participants were mostly university students or self-selected lucid dreaming enthusiasts. Other widespread methodological limitations include small sample sizes, lack of random allocation, inconsistent operationalization of lucid dreaming rates, and failure to investigate variables that operationalize the way in which techniques were practiced (e.g. number of technique repetitions). The widespread methodological limitations in the lucid dream induction literature make it difficult to compare the effectiveness of techniques across studies, and although some techniques have been shown to significantly increase lucid dreaming rates, none of them have been shown to be highly effective and reliable. Following the systematic review by Stumbrys et al. (2012), four additional lucid dream induction studies have been published. Success rates were poor in a field study of reality testing by Taitz (2011), and in laboratory studies of external stimulation (flashing lights and vibration; Franc, Schadlich, & Erlacher, 2014) and transcranial direct current stimulation (tDCS) to the dorsolateral prefrontal cortex (DLPFC) during REM sleep (Stumbrys, Erlacher, & Schredl, 2013). The fourth and most recent study of lucid dream induction is the National Australian Lucid Dream Induction Study (NALDIS; see Chapter 8).

9.1.3 The National Australian Lucid Dream Induction Study (NALDIS)

The NALDIS compared the effectiveness of reality testing with the combination of the MILD and WBTB techniques using a highly diverse sample of Australian residents. A third experimental condition that involved WBTB and reading about lucid dreaming was also included, which controlled for the effects inherent in the MILD technique of thinking about lucid dreaming. In the interests of finding a maximally effective approach to lucid dream induction, and because reality testing is often considered a supporting technique that helps with other lucid dream induction techniques, reality testing was practiced in all three groups. During Week 1, participants recorded baseline dream recall rates and were then randomly allocated to one of the three experimental groups for Week 2. A significant increase in lucid dreaming was observed in the MILD group, with lucid dreaming reported on 17.4% of nights in Week 2 compared to 9.4% of nights in Week 1. In contrast, the other two conditions did not have a significant effect on lucid dreaming rates. Indeed, the Week 2 lucid dreaming rate was slightly *lower* than the Week 1 rate in the reality testing only condition, indicating that reality testing alone was not effective. Pre-test general dream recall was positively correlated with Week 2 lucid dreaming, and general dream recall was significantly higher on nights when participants experienced lucid dreaming following practice of the MILD technique. Results showed that more MILD technique phrase repetitions and more time spent on the technique were associated with a lower likelihood of lucid dreaming. Upon closer inspection it was found that these two variables were strongly correlated with greater self-rated difficulty falling asleep after completing the technique, and the strongest predictor of lucid dreaming in the MILD group was the amount of time taken to fall back asleep after completing the technique. Indeed, lucid dreaming was experienced on a massive 45.8% of occasions when participants were able to complete the technique and then fall asleep within five minutes. However, generalizability is limited because this was only achieved by 14 participants, who had higher Week 1 baseline lucid dreaming rates than the other participants.

9.1.4 The present research

The biggest impediment to research into the potential benefits and applications of lucid dreaming is the lack of effective and reliable lucid dream induction techniques. Despite a reduction of research interest in lucid dream induction over the past few decades (Stumbrys et al., 2012), many promising avenues for research remain. For example, numerous lucid dream induction techniques have been developed by lucid dreaming enthusiasts, but have never been investigated scientifically. The aim of the present study was to investigate the effectiveness of a novel cognitive lucid dream induction technique that has received anecdotal support in the online lucid dream induction forums (e.g. "Dream Views", "LD4all", "World of Lucid Dreaming") known as the *Senses Initiated Lucid Dream* (SSILD) technique (the double "S" in the acronym is intentional). This technique was developed by Gary Zhang (2013), a prominent figure in the online lucid dreaming community who is also known by the pseudonym "CosmicIron". The technique is performed in conjunction with WBTB (as with the MILD technique) and involves repeatedly focusing one's attention on visual, auditory and somatosensory perceptions (see Section 9.2.2.3 for greater detail). The present study was conducted using participants from the NALDIS who agreed to participate in a trial of an additional technique ("Week 3"). For the sake of consistency with the NALDIS, the SSILD technique was practiced in conjunction with reality testing. In addition to a range of exploratory analyses involving variables described in Section 9.2.2, the following hypotheses were tested:

- It was hypothesized that lucid dreaming during Week 3 would be associated with superior general dream recall according to all Week 3 general dream recall measures.
- It was hypothesized that the lucid dreaming rate in Week 3 would be significantly higher than in Week 1.
- It was hypothesized that there would be a significant negative correlation between the lucid dreaming rate in Week 3 and the number of minutes taken to fall asleep after completing the SSILD technique.

9.2 Method

9.2.1 Participants

All participants who completed the NALDIS (*N* = 169) were invited to participate in a trial of an additional lucid dream induction technique (see Appendix H for a copy of the email invitation). The gender ratio of females (*n* = 11) to males (*n* = 10) who participated in the present study (*N* = 21) was not significantly different from in the NALDIS: $\chi^2(1, N = 167) = 0.15$, $p = .700$. The mean age was 44.6 (*SD* = 15.1) and ranged from 21 to 72. Most participants were employed non-students (*n* = 18), with one participant being a student and two participants being unemployed or retired. Participants were recruited from across Australia using a range of recruitment strategies including posters and flyers, nationally televised news interviews with the author, newspaper articles, radio interviews, social media and other internet sources. Participants were excluded from the study if they had been diagnosed with any kind of mental health disorder, sleep disorder, or neurological disorder; suspected they *might* have one of these disorders; were experiencing a traumatic or highly stressful life event that was interfering with their sleep; suffered from persistent insomnia or were unable to keep a regular sleep schedule; had experienced sleep paralysis more than once in the past 6 months; found it unpleasant to think about their dreams; or were under 18 years of age. Participants were not offered any incentive for participating in the trial the SSILD technique.

9.2.2 Materials

Materials for the NALDIS included an online pre-test questionnaire and physical packages that contained an instructions sheet, Week 1 logbook, and an envelope containing materials for Week 2 (this envelope was kept sealed until Week 1 was complete). The Week 2 envelopes contained another instructions sheet, lucid dream induction technique documents, and a Week 2 logbook (see Chapter 8). Participants who agreed to participate in the trial of the SSILD technique were sent an additional package containing an instructions sheet (see Appendix I), a document outlining the SSILD technique (see Appendix J), and a Week 3 logbook. In the present paper, pre-test variables are identified by a capital "P" and logbook variables by a capital "L."

9.2.2.1 Pre-test questionnaire

Demographic questions. Participants were asked to indicate their age, gender, occupation, and how they heard about the study.

General dream recall. Dream Recall Frequency (DRF; the percentage of days on which there was dream recall) was assessed by asking “How many days during the last week did you remember your dreams from the previous night?” (*P DRF*). Response options ranged from “0 days” to “7 days.” The number of dreams recalled over the past week (*Dream Count*, DC; see Aspy, 2016) was assessed by asking “On average, how many separate dreams do you usually remember per week?” Response options ranged from 0 to 50 or “more than 50”. Responses were divided by seven to obtain the mean number of dreams recalled per day (*P DC per day*).

Lucid dream recall. The number of lucid dreams recalled over the past month (*P DC Lucid per month*) was assessed using a question adapted from Brown and Donderi’s (1986) *Sleep and Dream Questionnaire* (SDQ): “Lucid dreams are those in which a person becomes aware of the fact that he or she is dreaming while the dream is still ongoing. For example: ‘I was in England talking to my grandfather when I remembered that (in real life) he had died several years ago and that I had never been to England. I concluded that I was dreaming and decided to fly to get a bird's eye view of the countryside…’ Please estimate the number of lucid dreams you have had in the past month.” Response options ranged from 0 to 30 or “more than 30”.

9.2.2.2 Logbooks

Preliminary questions. Participants indicated the date of each logbook entry, allowing the number of days taken to complete all seven entries to be calculated (*L Days to complete log*). The total number of logbook entries made by each participant was also counted (*L Total log entries*).

General dream recall. Participants were asked if they could recall anything specific about their dreams from the previous night and were asked to provide brief titles for each dream recalled. This allowed dream recall to be operationalized as both *Dream Recall Frequency* (*L DRF*; the percentage of days on which there was dream recall) and *Dream Count* (*L DC per day*; the number of dreams recalled each day). Participants were also asked to rate the amount of content recalled from each dream using four categories provided.[1] This operationalization is referred to as *Dream Quantity* (*L DQ*) and was developed by Aspy (2016) based on an earlier measure developed by Reed (1973).

[1] Only some of the Week 1 logbooks included the *L DQ* measure (see Aspy, 2016).

Category ratings are converted to numerical values ("Fragmentary" = 1, "Partial" = 2, "Majority" = 4, "Whole" = 8) and summed (higher scores indicate superior dream recall). Three additional questions were used to assess overall self-rated dream recall quantity ("how much do you recall of your dreams from last night?"; *L Recall rating*), recall difficulty ("how difficult was it for you to remember your dreams from last night?"; *L Recall difficulty*), and recall clarity ("how clear are your memories of your dreams from last night?"; *L Recall clarity*), using Likert-type scales ranging from 1 to 5 (see Aspy, 2016).

Lucid dream recall. Lucid dreaming was operationalized as DRF (*L DRF Lucid* ; the percentage of mornings on which lucid dreaming was reported) using the following question: "Did you have any lucid dreams last night? (Lucid dreams are those in which a person becomes aware of the fact that he or she is dreaming while the dream is still ongoing)" ("yes" or "no"). DRF was used instead of DC because participants were unsure of how many lucid dreams they had in some cases, and in other cases lost and regained lucidity within the same dream. The percentage of participants that experienced lucid dreaming at least once during Week 2 was included as a second operationalization of lucid dreaming (*L Lucid participants*).

Sleep-related questions. Participants were asked to estimate how much time they had spent sleeping (*L Time asleep*): "How much time in total do you think you spent sleeping last night?......hours,......minutes". Participants also rated their subjective sleep quality (*L Sleep quality*): "On a scale of 1 to 5, what was the overall quality of your sleep last night?" (1 = "terrible", 2 = "poor", 3 = "okay", 4 = "good", 5 = "excellent"). Participants indicated how tired they felt upon waking (*L Tiredness on waking*) with the following question: "On a scale of 1 to 5, how tired do you feel this morning?" (1 = "not at all tired", 2 = "slightly tired", 3 = "somewhat tired", 4 = "quite tired", 5 = "very tired"). Finally, participants indicated how sleep deprived they were the previous day (*L Sleep dep yesterday*): "On a scale of 1 to 5, how sleep deprived were you yesterday?" (1 = "not at all", 2 = "slightly", 3 = "somewhat", 4 = "quite", 5 = "very").

Lucid dream induction technique practice questions. The following questions appeared in the Week 3 logbooks only. Participants were asked "How many reality tests did you perform yesterday?" (blank space provided) (*L Reality tests*). The following questions operationalized the way in which the SSILD technique was practiced: "Were you in the middle of a dream when the alarm woke you up to do the technique? ("yes", "no" or "unsure") (*L Awoke while dreaming*); "On a scale of 1 to 5, how motivated did you feel about doing the technique after the alarm went off?" (1 = "not at all motivated", 2 = "slightly motivated", 3 = "somewhat motivated", 4 = "quite motivated", 5 = "very motivated") (*L Technique motivation*); "How many fast and slow cycles did you do? Fast:......,Slow:......" (*L Fast cycles* and *L Slow cycles*); "How long (approximately) did you spend on doing the technique?......minutes." (*L Technique mins*); "On a scale of 1 to 5, how difficult was it to focus on the technique?" (1 = "not at all difficult", 2 = "slightly difficult", 3 = "somewhat difficult", 4 = "quite difficult", 5 = "very difficult") (*L Difficulty focusing*); "Did you fall asleep while you were still trying to do the technique?" ("yes" or "no") (*L Asleep during technique*); "If you answered "no" to the above question, how long (approximately) did it take for you to get to sleep after you stopped doing the technique?......minutes." (*L Mins back to sleep*).

Summary questions. At the end of the Week 3 logbook, participants were also asked "After you completed Week 2 of the main study, did you continue practicing lucid dreaming techniques?" ("yes" or "no"). Because anecdotal evidence from online lucid dream induction forums (e.g. "Dream Views", "LD4all", "World of Lucid Dreaming") suggests that the SSILD technique may increase the likelihood of experiencing sleep paralysis (Cheyne, 2003), participants were also asked if they had any sleep paralysis during the study, and if so, to provide a written description of what happened.

9.2.2.3 Lucid dream induction technique documents

The "Daytime Lucid Dreaming Technique" document (see Chapter 8 for greater detail; see also Appendix F) outlined the rationale for reality testing and instructed participants to perform a minimum of 10 reality tests per day by asking themselves "Am I dreaming?" while examining their surroundings for anomalies, and to then perform an inhalation reality test (this involves closing one's lips and then attempting to inhale, which is possible in dreams but not while awake; see Chapter 8). Participants were asked to keep count of their reality tests using a smartphone application or by making marks on paper or the back of their hand. The "Nighttime Lucid Dreaming Technique" document (see Appendix J) was created in consultation with the creator of the SSILD technique. Participants were instructed to set an alarm for five hours after going to bed and to put the alarm where they would have to get out of bed to turn it off. They were instructed to turn a light on when their alarm went off, go to the bathroom if necessary, return to bed, and then perform the technique. It was explained that the technique works by conditioning the mind and body into a subtle state that is optimized for lucid dreams to occur, and that it involves performing a number of "cycles" that each involve the following three steps:

> *Step 1. Focus on Vision*: Close your eyes and focus all your attention on the darkness behind your closed eyelids. Keep your eyes completely still and totally relaxed. You might see colored dots, complex patterns, images, or maybe nothing at all. It doesn't matter what you

can or cannot see – just pay attention in a passive and relaxed manner and don't "try" to see anything.

Step 2. Focus on Hearing: Shift all of your attention to your ears. You might be able to hear the faint sounds of traffic or the wind from outside. You might also be able to hear sounds from within you, such as your own heartbeat or a faint ringing in your ears. It doesn't matter what, if anything, you can hear – just focus all of your attention on your hearing.

Step 3. Focus on Bodily Sensations: Shift all of your attention to sensations from your body. Feel the weight of the blanket, your heartbeat, the temperature of the air, etc. You might also notice some unusual sensations such as tingling, heaviness, lightness, spinning sensations, and so on. If this happens simply relax, observe them passively and try not to get excited.

Participants were instructed to begin by performing four fast cycles, spending two or three seconds on each step. They were then instructed to perform between four and six slow cycles, spending about 20 seconds on each step. They were told that this is the most important part of the technique, that they should not to count the number of seconds, and that it is good if they fall asleep while still doing the technique, but that it is important to complete at least four cycles. Participants were instructed that they should simply fall asleep as they normally would after completing six slow cycles. Participants were also given a document (see Appendix K) that explained sleep paralysis and provided advice on what to do if it occurs (see LaBerge & Rheingold, 1991; Sleep Paralysis Information Service, 2013; University of Waterloo, 2013).

9.2.3 Procedure

Participants accessed the online pre-test questionnaire and an information sheet outlining the NALDIS using a web URL that was included in all promotional materials and media items. The questionnaire was hosted by the survey management website *Survey Monkey*. Participants provided postal details so they could be sent the materials via post, allowing participants from anywhere in Australia to complete the study in their own homes. Participants were randomly allocated to the three Week 2 experimental conditions. Once data collection was complete, participants were invited via email to trial an additional lucid dream induction technique. Participants were not told the name of the SSILD technique at any point. There was no significant difference between the number of participants in the three Week 2 experimental groups who went on to participate in the trial of the SSILD technique: $\chi^2(2, N = 169) = 4.61, p = .100$. Participants were told that the purpose of Week 1 was to gather baseline information about normal sleeping patterns and dream recall, and were asked not to attempt any lucid dream induction techniques or to improve their dream recall during this period. For all logbook periods, participants filled out their logbook immediately upon waking and were urged to complete all seven logbook days consecutively if possible. However, while practicing the SSILD technique during Week 3, participants were told that it was better to skip a day if they were feeling sleep deprived and to make up for it at the end. Completed logbooks were returned using pre-paid envelopes provided.

9.3 Results

9.3.1 Preliminary analyses and descriptive statistics

Participants performed the SSILD technique on a total of 135 nights (12 nights were excluded due to participants not practicing the technique properly, defined as less than two slow cycles). Most variables were not normally distributed and non-parametric tests were used in all cases. Independent samples Wilcoxon tests indicated that participants from the NALDIS who participated in the trial of the SSILD technique had superior general dream recall according to most pre-test and Week 1 logbook measures. They were also significantly older (by 7.2 years). These findings are presented with descriptive statistics in Table 9.1.

Table 9.1

Descriptive statistics and Wilcoxon signed-ranks tests for pre-test and Week 1 differences between participants from the NALDIS who did and did not participate in the trial of the SSILD technique.

	M (*SD*)		Wilcoxon test	
	Completed NALDIS and SSILD (*N* = 21)	Completed NALDIS only (*N* = 148)	*Z*	*p*
P DC Lucid (per month)	1.8 (4.4)	1.4 (4.0)	0.63	.540
P Age	44.6 (15.1)	37.4 (14.8)	2.16	.030
P DRF	54.4% (29.8%)	42.3% (30.2%)	1.82	.069
P DC (per day)	1.0 (0.8)	0.6 (0.6)	2.57	.009
L DRF	86.4% (34.4%)	76.2% (21.2%)	2.38	.016
L DC (per day)	2.5 (1.8)	1.6 (0.9)	2.27	.023
L Recall rating	3.2 (0.8)	2.8 (0.8)	2.11	.034
L Recall clarity	3.0 (1.0)	2.5 (0.8)	2.11	.034
L Recall difficulty	2.8 (0.8)	3.1 (0.9)	1.70	.090
L Sleep dep yesterday	2.0 (0.7)	1.9 (0.6)	0.38	.707
L Time asleep	7.6 (0.8)	7.5 (0.8)	0.48	.638
L Sleep quality	3.5 (0.7)	3.5 (0.5)	0.22	.829
L Tiredness on waking	2.4 (0.8)	2.4 (0.7)	0.57	.574
L Days to complete log	7.1 (0.3)	7.1 (0.5)	0.31	>.999
L Total log entries	7.0 (0.0)	7.0 (0.1)	0.63	>.999

Note. P = pre-test variable, L = logbook variable, NALDIS = National Australian Lucid Dream Induction Study, SSILD = Senses Initiated Lucid Dream.

Dependent samples Wilcoxon tests were conducted to assess differences in logbook variables between Week 1 and Week 3 and are presented with descriptive statistics in Table 9.2. Participants took significantly longer to complete Week 3 compared to Week 1, and the difference in *L Total log entries* was approaching significance.

Table 9.2

Descriptive statistics and Wilcoxon signed-ranks tests for differences between Week 1 and Week 3 logbook variables.

Logbook variable	*M* (*SD*)		Wilcoxon test	
	Week 1 (*N* = 21)	Week 3 (*N* = 21)	*Z*	*p*
L DQ†	-	9.1 (8.5)	-	-
L DRF	86.4% (34.4%)	85.2% (20.9%)	0.09	.940
L DC (per day)	2.5 (1.8)	2.6 (1.7)	0.61	.560
L Recall rating	3.2 (0.8)	3.2 (0.8)	0.41	.694
L Recall clarity	3.0 (1.0)	2.9 (0.9)	0.00	>.999
L Recall difficulty	2.8 (0.8)	3.0 (0;8)	1.21	.240
L Sleep dep yesterday	2.0 (0.7)	1.8 (0.7)	1.53	.130
L Time asleep	7.6 (0.8)	7.8 (0.8)	1.86	.065
L Sleep quality	3.5 (0.7)	3.5 (0.7)	0.62	.552
L Tiredness on waking	2.4 (0.8)	2.4 (1.0)	0.32	.763
L Days to complete log	7.1 (0.3)	9.3 (8.5)	2.23	.031
L Total log entries	7.0 (0.0)	6.5 (1.0)	2.07	.063

Note. L = logbook variable.

† Most of the Week 1 logbooks did not include the L DQ measure (see Aspy, 2016).

9.3.2 Relationships with lucid dreaming

Spearman rho non-parametric correlations were calculated to investigate relationships between Week 3 *L DRF Lucid* and pre-test and other Week 3 logbook variables. These are presented in Table 9.3. The hypothesis that lucid dreaming during Week 3 would be associated with superior general dream recall according to all Week 3 general dream recall measures was supported. Week 3 *L DRF Lucid* was also correlated with *L Tiredness on waking*.

Table 9.3

Spearman rho non-parametric correlations between Week 3 lucid dreaming and pre-test and other Week 3 logbook variables.

	Week 3 L DRF Lucid
P DC Lucid (per month)	.28
P Age	-.11
P DRF	.22
P DC (per day)	.10
L DRF	.32
L DC (per day)	.36**
L Recall rating	.31**
L Recall clarity	.46**
L Recall difficulty	-.38**
L Sleep dep yesterday	-.10
L Time asleep	.03
L Sleep quality	.16
L Tiredness on waking	-.20*

Note. P = pre-test variable, L = logbook variable. Correlations with pre-test variables and *L DRF* were calculated using mean *L DRF Lucid* values for each participant. Correlations with all other logbook variables were calculated using individual daily observations and are point-biserial.
* p = <.05, ** p = <.01

9.3.3 Lucid dream induction

It was hypothesized that the lucid dreaming rate in Week 3 would be significantly higher than in Week 1. Results supported the hypothesis. An exact one-tailed dependent samples Wilcoxon test was conducted and showed that *L DRF Lucid* was 54.1% higher in Week 3 (M = 14.7%, SD = 23.1%) than in Week 1 (M = 9.5%, SD = 24.5%): Z = 1.69, p = .049. Several tests were conducted to investigate whether this increase could be attributed to the lucid dream induction techniques practiced in Week 2. An independent samples Kruskal Wallis test showed that Week 3 *L DRF Lucid* was not related to the experimental condition that participants were assigned to in Week 2: $\chi^2(2, N = 21) = 1.39$, p = .499. An independent samples Wilcoxon test showed that Week 3 *L DRF Lucid* was not related to whether or not participants continued practicing the techniques from Week 2 (Z = 0.86, p = .412). The number of days between the final Week 2 logbook entry and the first Week 3 logbook entry (M = 136.9, SD = 55.1, range: 30-221) was not correlated with Week 3 mean *L DRF Lucid* (r_s = -

.06, p = .796). In addition to *L DRF Lucid*, lucid dreaming was also operationalized as *L Lucid participants*. An exact one-tailed McNemar's test showed that the proportion of participants that experienced lucid dreaming at least once during Week 3 (*L Lucid participants* = 47.6%) was not significantly higher than in Week 1 (*L Lucid participants* = 23.8%): $\chi^2(1, N = 21) = 1.78$, $p = .090$. However, it should be noted that the difference was substantial in size (twice as many participants experienced lucid dreaming in Week 3 than in Week 1) and was approaching statistical significance.

9.3.4 Relationships with technique practice variables

Spearman rho non-parametric correlations between *L DRF Lucid* and the number of reality tests performed and variables that operationalized the way in which the SSILD technique was practiced were calculated and are presented with descriptive statistics in Table 9.4. All correlations were weak and non-significant. The hypothesis that there would be a significant negative correlation between the lucid dreaming rate in Week 3 and the number of minutes taken to fall asleep after completing the SSILD technique was not supported. A 2 x 3 Chi^2 test indicated that lucid dreaming was not associated with whether participants reported that they were dreaming, not dreaming, or unsure of whether they were dreaming when they were awakened by their alarm to perform the SSILD technique, $\chi^2(2, N = 130) = 3.58$, $p = .168$. Participants fell asleep while practicing the SSILD technique on 48.2% of occasions. A 2 x 2 Chi^2 test indicated that this was not related to whether or not participants experiencing lucid dreaming: $\chi^2(1, n = 135) = 0.01$, $p = .942$.

Table 9.4

Spearman rho non-parametric correlations between Week 3 lucid dreaming and variables that operationalized the way in which the SSILD technique was practiced.

	M (*SD*)	Correlation (r_s) with L DRF Lucid
L Reality tests	10.7 (4.1)	.12
L Technique motivation	3.0 (1.5)	-.12
L Fast cycles	3.9 (0.9)	.02
L Slow cycles	5.0 (2.8)	.03
L Technique mins	10.1 (7.1)	-.04
L Difficulty focusing	3.2 (1.2)	-.02
L Mins back to sleep	16.5 (16.3)	.05

Note. L = logbook variable, SSILD = Senses Initiated Lucid Dream. All correlations are point-biserial and were calculated using individual daily observations.

* p = <.05, ** p = <.01

9.3.5 Additional exploratory analyses

Differences in logbook variables between nights when SSILD was and was not followed by lucid dreaming were assessed to further investigate factors related to successful induction of lucid dreams. These are presented in Table 9.5. When SSILD was followed by lucid dreaming, general dream recall was superior according to all general dream recall measures. Participants reported significantly lower *L Tiredness on waking* and the difference *in L Sleep quality* was approaching significance, indicating that successful induction of lucid dreaming using the SSILD technique did not compromise sleep quality. There were no significant differences in variables that operationalized the way in which the SSILD technique was practiced or *L Reality tests*.

Table 9.5

Wilcoxon signed-ranks tests for differences in Week 3 logbook variables between nights when practice of the SSILD technique was and was not followed by lucid dreaming.

Logbook variable	*M* (*SD*)		Wilcoxon test	
	Lucid dreaming reported (n = 19)	No lucid dreaming reported (n = 116)	Z	p
L Reality tests	12.3 (4.6)	10.4 (4.0)	1.41	.160
L Technique motivation	2.7 (1.5)	3.1 (1.1)	1.37	.174
L Fast cycles	3.9 (1.1)	3.9 (0.9)	0.17	.959
L Slow cycles	5.0 (1.1)	5.0 (3.0)	0.35	.732
L Technique mins	8.0 (2.7)	10.4 (7.5)	0.45	.659
L Difficulty focusing	3.1 (1.2)	3.2 (1.2)	0.25	.800
L Mins back to sleep	18.7 (16.6)	16.1 (16.3)	0.37	.717
L DQ	17.6 (8.0)	8.0 (10.1)	4.56	<.001
L DC (per day)	4.5 (1.5)	2.4 (2.0)	4.16	<.001
L Recall rating	4.2 (0.8)	3.1 (1.3)	3.58	<.001
L Recall clarity	4.4 (0.7)	2.7 (1.3)	5.26	<.001
L Recall difficulty	1.7 (0.8)	3.1 (1.3)	4.40	<.001
L Sleep dep yesterday	1.6 (1.1)	1.8 (1.0)	1.11	.270
L Time asleep	8.1 (1.7)	7.7 (1.0)	0.36	.726
L Sleep quality	3.9 (1.2)	3.5 (0.8)	1.83	.066
L Tiredness on waking	2.0 (1.4)	2.4 (1.1)	2.30	.021

Note. L = logbook variable, SSILD = Senses Initiated Lucid Dream.

Additional analysis revealed that although *L DRF Lucid* during Week 3 was not correlated with *L DRF Lucid* during Week 1 (r_s = .14, p = .578), *L DRF Lucid* during week 3 was strongly correlated with *L DRF Lucid* during Week 2 (r_s = .69, p = <.001). Furthermore, a 2 x 2 Chi^2 test indicated that whether or not participants experienced lucid dreaming during Week 3 was significantly related to whether they experienced lucid dreaming during Week 2: $\chi^2(1, N = 21) = 8.42$, p = .004. These findings suggest that some people are more responsive to lucid dream induction techniques regardless of their baseline lucid dreaming rate. To further investigate this notion, correlations with baseline general dream recall rates were examined. As shown in Table 9.3, Week 3 *L DRF Lucid* was not correlated with pre-test general dream recall measures. However, correlating retrospective (questionnaire) measures of dream recall with logbook measures is problematic because retrospective measures are less valid and tend to underestimate true dream recall rates (see Aspy, 2016; Aspy, Delfabbro, & Proeve, 2015). Additional analyses revealed that Week 3 *L DRF Lucid* was strongly correlated with most Week 1 general dream recall measures: *L DRF*: r_s = .25, *p* = .277; *L DC*: r_s = .46, *p* = .038; *L Recall rating*: r_s = .42, *p* = .060; *L Recall clarity*: r_s = .53, *p* = .014; *L Recall difficulty*: r_s = -.55, *p* = .010. These findings are given further consideration in Section 9.4.2.

9.4 Discussion

The present study investigated the effectiveness of a previously untested cognitive lucid dream induction technique; the Senses Initiated Lucid Dream (SSILD) technique (Zhang, 2013). After completing the pre-test questionnaire, Week 1 baseline logbook period and Week 2 experimental period of the National Australian Lucid Dream Induction Study (NALDIS; see Chapter 8), participants were invited to participate in a trial of an additional technique. A total of 21 participants completed the trial of the SSILD technique (Week 3). Results indicated that the SSILD technique was effective for inducing lucid dreams.

9.4.1 Lucid dream induction

Participants experienced lucid dreaming on 14.7% of nights on average during Week 3, which was 54.1% higher than in Week 1. Findings indicated that this increase was not due to the lucid dream induction techniques practiced in Week 2. The number of days between the last Week 2 logbook entry and the first Week 3 logbook entry (*M* = 136.9) was not correlated with Week 3 lucid dreaming. Furthermore, Week 3 lucid dreaming was not related to the type of technique practiced in Week 2 or whether participants continued practicing the Week 2 techniques after completing the NALDIS. In the present study, participants performed reality tests in addition to practicing the SSILD technique. However, findings from both the NALDIS and the present study indicate that performing reality tests was unlikely to have had a substantial effect on Week 3 lucid dreaming. In the NALDIS, the reality testing only condition was found to be ineffective for inducing lucid dreams. Furthermore, the number of reality tests performed was not correlated with lucid dreaming in either the reality testing only or the MILD technique groups. The present study replicates these findings, with the number of reality tests showing no correlation with Week 3 lucid dreaming. The most likely explanation for the significantly increased Week 3 lucid dreaming rate is that the SSILD technique was effective for inducing lucid dreams. There are several possible explanations for how the SSILD technique may induce lucid dreams. One explanation is that it causes an increased awareness of perceptual stimuli that persists into REM sleep, making it more likely that the practitioner will notice anomalies within the dream that trigger lucidity. This might also occur if the practitioner continues to practice the SSILD technique after they enter REM sleep. Indeed, one participant reported: “as I was drifting off to sleep, I found myself continuing to do the technique, even though I wasn’t trying to.” Another possible explanation is that repeatedly refocusing one’s attention on different types of perceptual stimuli causes a general increase in cortical activation that increases the likelihood of lucid dreaming.

9.4.2 Predictors of lucid dreaming

Week 3 lucid dreaming was not related to motivation, the number of fast or slow cycles performed, the amount of time spent on the technique, self-rated difficulty focusing on the technique, or whether or not participants fell asleep while practicing the technique. In the NALDIS, it was found that taking less time to fall asleep after completing the MILD technique was a strong predictor of greater technique effectiveness. However contrary to expectations, no such relationship was observed in the present study. Week 3 lucid dreaming rate was not related to pre-test or Week 1 lucid dreaming rates. However, Week 3 lucid dreaming was strongly correlated with Week 2 lucid dreaming. Furthermore, participants who experienced lucid dreaming at least once during Week 2 had a greater likelihood of experiencing lucid dreaming in Week 3. These findings indicate that some people are more responsive to lucid dream induction techniques than others. General dream recall appears to be a strong predictor of this. Week 3 lucid dreaming was correlated with both Week 1 and Week 3 general dream recall measures, with participants experiencing 2.1 more dreams on average on nights when practice of the SSILD technique was followed by lucid dreaming. It should be noted that general dream recall was not significantly different in Week 3 compared to Week 1. Therefore, the increased lucid dreaming rate observed in Week 3 compared to Week 1 cannot be attributed to improved general dream recall. Taken together, these findings provide further support for the theory that the conditions that give rise to superior dream recall are also conducive to lucid dreaming (see Chapter 8).

9.4.3 Effects of the SSILD technique on sleep

Sleep quality was not significantly different in Week 3 compared to Week 1, and the only significant difference in sleep quality between nights when practice of the SSILD technique was and was not followed by lucid dreaming is that participants reported significantly less tiredness on waking following lucid dreaming. These findings indicate that sleep quality was not adversely affected by practicing the SSILD technique or by experiencing lucid dreaming. This is consistent with findings from the NALDIS, whereby successful lucid dream induction using the MILD technique did not adversely affect sleep quality. In the present study, sleep paralysis was experienced on two of the 135 nights on which the SSILD technique was attempted. Only one of these episodes appears to have been caused by the SSILD technique, and it appears that this did not cause significant distress. The participant described the episode as follows: “At one stage during the auditory section [of the SSILD technique], I thought I heard someone in the house. They then came into the room. I think they held me down. I couldn’t move. A little bit scary, but I realized it was sleep paralysis, so I relaxed and it went away. No problem.” Being given information about what to do if sleep paralysis occurs may have been beneficial in this case (see Section 9.2.2.3; see also Appendix K). The other episode of sleep paralysis occurred upon waking from a highly distressing dream, and was most likely due to increased physiological arousal associated with the distressing dream. The participant reported that the sleep paralysis “lasted for 10-15 seconds” before they could move again, and said “it shocked me quite a bit”. The frequency of SSILD-related sleep paralysis (0.7%) thus appears to have been equal to the frequency of sleep paralysis that was unrelated to the SSILD technique. Therefore, findings from the present study do not support the notion that the SSILD technique increases the risk of sleep paralysis. However, this possibility cannot be ruled out.

9.4.4 Lucid dreaming and nightmares

Of the 12 written reports of lucid dreaming that described the moment when the participant became lucid, lucidity occurred during an acute state of emotional distress in four cases. In three of these cases, the participant reported that lucidity brought immediate relief. This involved deliberately waking up in two cases (details on how this was achieved were not provided) and running away from an aggressor in the other case. In the final case of lucidity occurring during acute emotional distress, the participant attempted to lock their aggressors behind a door. However, the aggressors continued to taunt them from behind the door. The participant then flew away in an attempt to escape, but was pursued. Finally, the participant yelled “wake up!” Upon doing so, the dream faded to white and the participant woke up. Thus, although lucidity did not bring immediate relief in this case, it did eventually allow the participant to wake up. These findings provide further evidence that lucid dreaming can bring relief from emotionally distressing dreams, and are consistent with previous case studies (Been & Garg, 2010; Spoormaker, Van Den Bout, & Meijer, 2003; Zadra & Pihl, 1997) and experimental studies (Holzinger et al., 2015; Lancee et al., 2010; Spoormaker & Van

Den Bout, 2006) indicating that lucid dreaming may be effective for treating nightmares. These findings also provide additional evidence that emotionally distressing experiences in dreams are a common trigger for lucidity (Stumbrys, Erlacher, Johnson, & Schredl, 2014).

9.5 Strengths and limitations

Strengths of the present study include the wide range of measures used, the use of measures that operationalize the way in which the SSILD technique was practiced, and a sample of participants recruited from the general Australian population that were mostly employed non-students (85.7%) and mostly (66.9%) naive to lucid dream induction techniques (prior to participating in the NALDIS). As with the NALDIS, the present study has high ecological validity – participants practiced the SSILD technique in their own homes using written instructions, which reflects how cognitive lucid dream induction techniques are usually practiced. The greatest limitation of the present study is that the sample was small and self-selected. Only 12.4% of participants from the NALDIS agreed to trial the SSILD technique, and these participants had superior baseline (Week 1) general dream recall, which is a strong predictor of lucid dreaming as discussed in Section 9.4.2. Participants were also significantly older (by 7.2 years). Thus, it is not possible to compare the effectiveness of the SSILD technique in the present study to the effectiveness of the MILD technique in the NALDIS, and it remains uncertain which of the two techniques is more effective.

9.6 Directions for future research

Further research is needed to replicate the present findings using a larger sample of participants. Ideally, this should involve comparing the effectiveness of the SSILD technique with the MILD technique. This should be done in the absence of reality testing to confirm that the MILD and SSILD techniques are effective on their own. A third experimental condition that combines the MILD and SSILD techniques could be a valuable addition to such a study. In the NALDIS, the effectiveness of the MILD technique was strongly correlated with the amount of time required for participants to fall asleep after completing the technique. In contrast, Week 3 lucid dreaming in the present study was not correlated with the amount of time required to return to sleep. Thus, it may be useful to practice the SSILD technique on occasions when one is unable to fall asleep within five to ten minutes of completing the MILD technique. Alternatively, it may be possible to combine the MILD and SSILD techniques into a single technique, by repeating the MILD phrase each time attention is focused on a new sensory modality while practicing the SSILD technique. Both of these approaches may be more effective than the MILD and SSILD techniques on their own.

The present study provides further evidence that the conditions that give rise to superior dream recall are conducive to lucid dreaming. Thus, it may be possible to increase the effectiveness of cognitive lucid dream induction techniques using drugs and supplements that enhance dream recall. Preliminary research indicates that acetylcholine esterase inhibitors such as Galantamine, Huperzine-A and Donepezil that influence the REM-on neurotransmitter acetylcholine may be effective for this (LaBerge, 2004; Sparrow, Hurd, & Carlson, 2016; Yuschak, 2006). Preliminary research by Ebben, Lequerica and Spielman (2002) indicates that taking vitamin B6 prior to sleep may also enhance dream recall. The effectiveness of cognitive lucid dream induction techniques could also be enhanced with the addition of external stimulation techniques. Indeed, several studies have shown that combining the MILD technique with light stimulation is more effective than MILD by itself (LaBerge, 1988; LaBerge & Levitan, 1995; LaBerge, Levitan, Rich, & Dement, 1988; Levitan & LaBerge, 1994). Light stimultion may also increase the effectivenes of the SSILD technique. It is important that future lucid dream induction studies operationalize the way in which lucid dream induction techniques are practiced, use valid and reliable measures of dream recall, and avoid the many methodological limitations of prior lucid dream induction studies (see Chapter 8).

9.7 Conclusions

Findings from the present study indicate that the SSILD technique was effective for inducing lucid dreams. Further research is needed to replicate the present findings using a larger participant sample. Although research on lucid dream induction has declined in recent decades, there are still many promising avenues for research. If more effective approaches to lucid dream induction could be developed, research into the potential benefits and applications of lucid dreaming would become more feasible. Further research on lucid dream induction is certainly warranted.

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Chapter 10: Empirical Investigation into the Effects of B Vitamins on Dreaming and Sleep

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Abstract

Anecdotal evidence indicates that supplementation with vitamin B6 (pyridoxine) before bed can enhance dream vividness and recall. In a single pilot study by Ebben et al. (2002), it was found that vitamin B6 had a dose-dependent effect of increasing scores on a composite measure of dream vividness, bizarreness, emotionality and colour. The present research replicates this study using a larger and more diverse sample of 100 participants from across Australia. A randomised, double-blind, placebo-controlled experiment was conducted to investigate the effects of ingesting 240mg vitamin B6 (pyridoxine hydrochloride) before bed for five consecutive days on dreaming and sleep. An exploratory condition that involved a B complex preparation containing a range of B vitamins was also included. Results indicated that vitamin B6 significantly increased the amount of content that participants recalled from their dreams, but did not have a significant effect on dream vividness, bizarreness, colour, or the presence of positive or negative emotion. Vitamin B6 did not have any significant effects on sleep-related variables. In contrast, participants in the B complex group showed significantly lower self-rated sleep quality and significantly higher tiredness on waking. The potential for using vitamin B6 in research on lucid dreaming is discussed.

Effects of vitamin B6 (pyridoxine) and a B complex preparation on dreaming and sleep

10.1 Introduction

Vitamin B6 refers to a group of closely related water-soluble compounds that are essential for human health and involved in a wide range of human biochemical processes (Peuhkuri, et al., 2012; "Vitamin B6: Physiology," 2013). Vitamin B6 occurs naturally in a variety of foods, including whole grain cereals, legumes, fruits (such as banana and avocado), vegetables (such as spinach and potato), milk, cheese, eggs, red meat, liver and fish (Natural Medicines, 2015). Anecdotal evidence indicates that moderate to high doses of vitamin B6 can enhance dreaming (Ebben et al., 2002; Fredericks, 1983; Pfeiffer, 1975). For example, the Natural Medicines database lists improving dream recall as one of the reasons people supplement with vitamin B6 (Natural Medicines, 2015), and it has been suggested that poor dream recall may be a sign of vitamin B6 deficiency (Pfeiffer, 1975). Kellogg (2005) recommends taking 100-250mg of vitamin B6 before bed as one of a number of miscellaneous aids to increase dream vividness and recall, and it has been claimed that vitamin B6 can also make dreams appear more colourful (Hastings, 1997, as cited in Ebben et al., 2002).

To date, only one study has investigated the effects of vitamin B6 (in the form of pyridoxine hydrochloride) on dreaming specifically. In a small double-blind, within-subjects experiment conducted by Ebben et al. (2002), 12 participants ingested capsules containing an inactive placebo, 100mg or 250mg of pyridoxine hydrochloride five minutes before going to bed. The three conditions were fully counterbalanced, lasted for five days each, and had a two-day washout period between them. Analyses were conducted using a composite measure of dream salience based on daily ratings of dream vividness, bizarreness, emotionality and colour. Results showed that dream salience scores were 30% higher in the 100mg condition and 50% higher in the 250mg condition compared to the placebo condition. Only the latter comparison was statistically significant, but this is likely due to the study being underpowered. The authors concluded that vitamin B6 supplementation before bed had a dose-dependent effect of increasing dream salience.

As Ebben et al. (2002) theorised, the effects of vitamin B6 on dreaming may be due to its role as a cofactor in converting L-Tryptophan to 5-Hydroxytryptophan (5-HTP), and in converting 5-Hydroxytrptophan to serotonin (5-Hydroxytryptamine, 5-HT; Luboshitzky et al., 2002; Peuhkuri et al., 2012). As per the reciprocal interaction hypothesis of REM sleep neurobiology (Hobson et al., 1975; Hobson et al., 1998; McCarley & Hobson, 1975), elevated serotonin in the brain during the first few hours of sleep suppresses REM sleep, the sleep stage in which most dreams occur (Gaillard et al., 1994; Nicholson et al., 1989; Trivedi et al., 1999; Vogel et al., 1990). This can cause a subsequent REM-rebound effect in the last few hours of sleep, characterised by greater REM sleep and intensified dreaming activity (Goodenough, 1991; Manfridi & Kales, 1987). In support of this theory, acute administration of vitamin B6 has been shown to cause increased serotonin synthesis in the primate brain (Hartvig et al., 1995). Furthermore, Luboshitzky et al. (2002) found that participants given 100mg vitamin B6 (pyridoxine hydrochloride) at 5pm subsequently spent 33% more time in REM sleep compared to participants given a placebo, although this difference did not reach statistical significance (possibly due to the small sample size of $N = 12$).

An alternative to the serotonin synthesis theory is that vitamin B6 causes disrupted sleep and more frequent awakenings that provide opportunities for dream content to be recalled and consolidated into long-term memory, as per the arousal retrieval model of dream recall (Goodenough, 1991; Koulack & Goodenough, 1976). However, although Ebben et al. (2002) measured a range of sleep-related variables, these were not included in analyses, and thus it remains unclear whether vitamin B6 enhanced dream salience through disrupted sleep and more frequent awakenings. Because only a single composite measure of dream salience was used in statistical analyses, it is also unclear what effects vitamin B6 had on dream vividness, bizarreness, emotionality and colour, specifically. Furthermore, although general dream recall rates were measured, they were not reported or included in analyses. It is thus unclear whether vitamin B6 increases the amount of content recalled from dreams, or only affects the quality of dream recall.

The primary aim of the present research was to further investigate the effects of vitamin B6 supplementation on dreaming and sleep. A secondary aim was to explore the possibility that other B vitamins may work synergistically with vitamin B6 to enhance dreaming. Indeed, the B vitamins all perform closely inter-related roles in a vast array of biochemical processes; including the synthesis of neurotransmitters (see Kennedy, 2016). A randomised, double-blind, placebo-controlled experiment was conducted in which participants were randomly allocated to groups that involved ingesting either a placebo, 240mg of vitamin B6 (pyridoxine hydrochloride), or a B complex preparation that contained 240mg of vitamin B6 and a range of other B vitamins. It was hypothesised that participants in the B6 only group would have significantly greater general dream recall than participants in the placebo group. It was also hypothesised that participants in the B6 only group would have significantly greater self-rated dream colour, vividness and bizarreness than participants in the placebo group. In contrast to the single emotionality scale used by Ebben et al. (2002), separate scales for positive and negative emotion were used. Analyses for these variables were exploratory and no specific hypotheses were made. All analyses involving sleep-related variables and the B complex group were exploratory.

10.2 Method

10.2.1 Participants

A total of 100 participants (68 females, 31 males, 1 "other") who met the inclusion criteria (below) completed the study. The mean age was 27.5 (*SD* = 6.8). Most of the participants were employed non-students (*n* = 50), with 42 participants being students and 8 being unemployed. Participants in the final sample learnt of the study from a range of recruitment sources: 41 from social media; 12 from other internet sources; 22 from word of mouth; 16 from posters or flyers (see Appendix O for copies of promotional materials); 5 from radio interviews with the first author; 3 from newspaper articles; and 1 from nationally televised news interviews with the first author. Participants were excluded from the study if they were under the age of 18 or over the age of 40; had any significant medical problems including diabetes, epilepsy, low blood pressure, heart disease, liver disease, kidney disease or a sleep disorder; were currently pregnant or breast-feeding; napped during the day or were unable to keep a regular sleep schedule; drank more than seven alcoholic drinks per week; or had been advised by a doctor or other health care practitioner to take a supplement or medication that contained B vitamins. All participants who completed the study were given a $50 gift voucher. Ethics approval was granted by the University of Adelaide Human Research Ethics Committee (approval number: H-2015-077, see Appendix N; see also Appendix M for Adverse Events Procedure).

10.2.2 Materials

Participants were given 10-day logbooks containing questions related to general dream recall and sleep quality. Participants were asked if they could recall anything specific about their dreams from the previous night and were asked to provide brief titles for each dream recalled. This allowed dream recall to be operationalised as both *Dream Recall Frequency* (the percentage of days on which there was dream recall) and *Dream Count* (the number of dreams recalled each day; see Aspy 2016). Participants were also asked to rate the amount of content recalled from each dream using four categories provided. This operationalisation is referred to as *Dream Quantity* and provides a more sensitive measure of dream recall than Dream Recall Frequency or Dream Count. The measure was developed by Aspy (2016) and is based on an earlier measure developed by Reed (1973). Category ratings are converted to numerical values ("Fragmentary" = 1, "Partial" = 2, "Majority" = 4, "Whole" =

8) and summed (higher scores indicate superior dream recall). Participants rated how vivid, bizarre and colourful their dreams were using Likert-type scales ranging from 1 (“not at all”) to 10 (“extremely”). The amount of positive and negative emotion experienced was also rated (1 = “none at all”, 10 = “an extremely large amount”). Participants were asked to estimate how many times they woke during the night, how much time in total they spent awake during the night, and the total amount of time they spent sleeping. Overall self-rated sleep quality was assessed with the following question: “On a scale of 1 to 5, what was the overall quality of your sleep last night?” (1 = “terrible”, 2 = “poor”, 3 = “okay”, 4 = “good”, 5 = “excellent”). Participants also indicated how tired they felt upon waking: “On a scale of 1 to 5, how tired do you feel this morning?” (1 = “not at all tired”, 2 = “slightly tired”, 3 = “somewhat tired”, 4 = “quite tired”, 5 = “very tired”).

The capsules were prepared for the present study by a compounding pharmacy. They were made of gelatine and were opaque. In the B6 only group, the dose of vitamin B6 (pyridoxine hydrochloride) was 240mg. This dose was used because 240mg pyridoxine hydrochloride is equivalent to 197mg of pyridoxine, which is slightly below the No Observed Adverse Effects Level (NOAEL) of 200mg pyridoxine established in the Nutrient Reference Values for Australia and New Zealand (National Health and Medical Research Council, 2006). In the B complex group, dosages for the following B vitamins were used: vitamin B1 (thiamine hydrochloride) 75mg; vitamin B3 (nicotinamide) 200mg; vitamin B5 (calcium pantothenate) 150mg; vitamin B6 (pyridoxine hydrochloride) 240mg; vitamin B7 (biotin) 40µg; vitamin B9 (folic acid) 400µg; vitamin B12 (cyanocobalamin) 500µg; inositol 25mg; and choline bitartrate 100mg. All of these dosages are at the upper end of what can be found in over the counter B complex supplement preparations in Australia (see Appendix L for a safety review of B vitamins used in the present study). Note that vitamin B2 (riboflavin) was not included. Vitamin B2 causes urine to become brightly coloured, which could have revealed to participants that they were in the B complex group. Dosages were split over two capsules in all three groups. I.e., each capsule contained a half-dose, and participants were instructed to consume two capsules at a time. The placebo capsules contained microcrystalline cellulose.

10.2.3 Procedure

Participants were presented with an information sheet (see Appendix P), confirmed participation and provided demographic and postal details via a web URL that was included in all promotional materials and media items. The information sheet explained that the purpose of the study was to investigate the effects of B vitamins on dreaming. Participants were sent packages via post that contained a logbook, packet of capsules, and an instructions sheet (see Appendix Q for a copy of the instructions sheet). Participants thus completed the study in their own homes without direct contact with the experimenters. The study involved a five-day baseline period followed by a five day experimental period. Both periods were from Monday to Friday on consecutive weeks. Participants were randomly allocated to experimental groups, and were blind to the group they were in. Participants were asked to make logbook entries immediately upon waking each morning. For the experimental period, participants were asked to consume two capsules directly before bed each night from Sunday to Thursday. Throughout the entire study period, participants were instructed to check the ingredients lists of food, beverage and supplement products and to avoid consuming products that contained added B vitamins. However, participants were told that they could continue to consume basic food products that are routinely fortified with vitamin B6 in Australia (such as bread and cereals). Participants returned their completed logbooks using pre-paid envelopes provided.

10.3 Results

Because participants were randomly assigned to groups, post-test only comparisons were conducted. Mean values for all logbook variables over the five-day experimental period were calculated and are presented in Table 1. Planned contrasts were conducted for all variables and between all combinations of the placebo, B6 only and B complex groups to explore group differences. The hypothesis that participants in the B6 only group would have significantly greater general dream recall than participants in the placebo group was partially supported. Although the differences in Dream Recall Frequency and Dream Count were non-significant, the more sensitive measure of Dream Quantity was significantly higher in the B6 only group compared to the placebo group ($t(97) = 2.19$, $p = .032$, $d = 0.55$). There were no other significant differences between the B6 only and the placebo groups, and the hypothesis that participants in the B6 only group would have significantly greater self-rated dream colour, vividness and bizarreness than participants in the placebo group was not supported. Self-rated sleep quality was significantly lower ($t(97) = 2.51$, $p = .014$, $d = 0.61$) and tiredness on waking was significantly higher ($t(97) = 2.11$, $p = .037$, $d = 0.43$) in the B complex group compared to the B6 only group. With the exception of the difference in tiredness on waking between the B6 only and the B complex groups, findings remained statistically significant when analyses were repeated using mean values for only the first three days of the experimental period as per the procedure used by Ebben et al. (2002).

Table 10.1

Descriptive statistics for all participants combined and for participants in the placebo, B6 only and B complex groups.

Logbook variable	*M* (*SD*)			
	All participants (*N* = 100)	Placebo (*n* = 35)	B6 only (*n* = 33)	B complex (*n* = 32)
Dream Recall Frequency	69.4% (27.9%)	72.6% (26.6%)	72.1% (30.0%)	63.1% (26.9%)
Dream Count	1.2 (0.8)	1.1 (0.6)	1.5 (1.0)	1.2 (0.8)
Dream Quantity	3.5 (3.3)	2.7 (2.1)	4.5 (4.1)	3.5 (3.5)
Vividness	4.7 (2.1)	4.8 (1.8)	4.9 (2.2)	4.4 (2.2)
Bizarreness	4.1 (1.9)	4.4 (1.9)	4.1 (2.0)	3.8 (1.7)
Colour	4.4 (2.0)	4.3 (1.9)	4.5 (2.2)	4.3 (2.1)
Positive emotion	4.0 (1.9)	4.0 (1.7)	4.2 (2.0)	3.9 (1.9)
Negative emotion	3.3 (1.7)	3.2 (1.5)	3.7 (1.9)	3.1 (1.5)
Number of awakenings	1.0 (0.9)	0.9 (0.7)	0.9 (0.8)	1.1 (1.2)
Time awake during the night (minutes)	13.8 (23.1)	10.1 (10.7)	10.0 (14.6)	21.8 (35.5)
Total time asleep (hours)	7.7 (0.9)	7.8 (0.9)	7.8 (0.8)	7.5 (0.9)
Self-rated sleep quality	2.8 (0.7)	2.9 (0.7)	3.0 (0.7)	2.6 (0.6)
Tiredness on waking	2.6 (0.7)	2.6 (0.7)	2.4 (0.7)	2.7 (0.7)
Dream recall improvement rating	2.5 (1.2)	2.6 (1.3)	2.4 (1.0)	2.4 (1.2)

10.4 Discussion

The present study investigated the effects of vitamin B6 and a B complex preparation ingested before bed on dreaming and sleep in a randomised, double-blind, placebo-controlled experiment. The hypothesis that participants in the B6 only group would have significantly greater general dream recall than participants in the placebo group was partially supported. Dream Recall Frequency was virtually identical in the B6 only group compared to the placebo group. Using the more sensitive Dream Count measure of dream recall, results showed that participants recalled 32.7% more dreams on average compared to placebo, although this finding did not reach statistical significance. Using the most sensitive measure of dream recall – the Dream Quantity measure that quantifies the amount of content recalled from each individual dream – it was found that participants in the B6 only group recalled a substantial and statistically significant 64.1% more dream content than participants in the placebo group. These findings indicate that supplementation with 240mg of vitamin B6 before bed enhanced dream recall, and are consistent with anecdotal reports that vitamin B6 can be used for this purpose (Ebben et al., 2002; Fredericks, 1983; Pfeiffer, 1975).

These findings also highlight the importance of using dream recall measures that are sensitive enough to reveal statistically significant effects (see Aspy, 2016).

The hypothesis that participants in the B6 only group would have significantly greater self-rated dream colour, vividness and bizarreness than participants in the placebo group was not supported. There were also no significant differences in positive or negative emotion. These findings are at odds with those of Ebben et al. (2002), who found that participants given 250mg of vitamin B6 before bed scored higher on a composite measure of dream colour, vividness, bizarreness and emotionality compared to placebo. The explanation for these findings is not clear, although one possibility is that participants of the present study had sufficiently high dietary intake of vitamin B6 that supplementation affected only the quantity of dream recall, and did not have any detectable effects on the overall quality of dreaming. Poor dream recall has been described as a symptom of vitamin B6 deficiency (Pfeiffer, 1975), and the dream enhancing effects of vitamin B6 supplementation may be weaker or non-existent for people who have sufficient intake. Although participants of the present study were asked to avoid a range of foods, beverages and supplements that contain added vitamin B6, many other basic foods such as bread and cereals are fortified with vitamin B6 in Australia, where vitamin B6 deficiency is rare.

Results indicated that the B complex preparation did not have any significant effects on dreaming, despite the fact that the same dosage of vitamin B6 was used in the B complex preparation as in the B6 only group. It appears that one or more of the other B vitamins counteracted the effects of vitamin B6 on dreaming, or otherwise inhibited dream activity or dream recall. Due to the range of B vitamins included in the B complex preparation and the paucity of research on the effects of B vitamins on dreaming and sleep, it is impossible to tell which B vitamins were responsible for these effects. Notwithstanding, the possibility remains that some B vitamins may work synergistically with vitamin B6 to enhance dream recall. For example, vitamins B1, B3, B5 and B9 play important roles in the synthesis of serotonin, and limited clinical evidence indicates that vitamin B1 may increase REM sleep, possibly by reducing the amount of tryptophan needed for conversion into niacin and thereby leaving more tryptophan available for serotonin synthesis (see Kennedy, 2016; Peuhkuri et al., 2012).

There were no significant differences in the B6 only group compared to the placebo group in total sleep time, number of awakenings, time awake during the night, sleep-quality, or tiredness on waking. These findings indicate that vitamin B6 supplementation did not have any detrimental effects on sleep quality, and are consistent with findings from Luboshitzky et al. (2002), whereby supplementation with 100mg of vitamin B6 at 5pm did not have any significant effect on total time asleep or sleep efficiency. Participants in the B complex group showed significantly lower self-rated sleep quality and significantly higher tiredness on waking compared to the B6 only group. These participants also spent more than twice as much time awake during the night compared to both the B6 only and placebo groups, although these differences did not reach statistical significance. These findings suggest that the B complex preparation had a detrimental effect on sleep quality, and are consistent with a study by Lichstein et al. (2007) in which participants taking a multi-vitamin containing a range of B vitamins (among other things) showed poorer sleep quality and more frequent awakenings.

Strengths of the present study include the wide range of dreaming and sleep-related variables included in analyses, and the use of a large and highly diverse sample of participants from across Australia. A limitation of the study is that the B complex preparation contained a range of B vitamins, making it impossible to distinguish the effects of individual B vitamins other than B6 on dreaming and sleep. Findings from the present study discount the theory that vitamin B6 enhances dream recall by disrupting sleep and causing more frequent awakenings as per the arousal retrieval theory of dream recall. More research is needed to investigate the theory that vitamin B6 increases serotonin levels in the brain and causes a REM-rebound effect later in the night. This could be done in a sleep laboratory study that compares the sleep architecture of participants given vitamin B6 compared to placebo using polysomnography. Such a study could also measure blood serum levels of vitamin B6, which may help identify the ideal time to ingest vitamin B6 for enhancing dreaming. If the serotonin synthesis theory is correct, dream enhancement effects should be greatest if vitamin B6 ingestion is timed so that the increase in serotonin peaks during the first four to six hours of sleep and then declines during the final few hours of sleep, allowing a strong REM rebound effect to occur. Further research is also needed to investigate whether the effects of vitamin B6 vary according to how much vitamin B6 is being obtained from the diet. If vitamin B6 is only effective for people with low dietary intake, its effects on dreaming may diminish with prolonged supplementation. Future studies should investigate the effects of vitamin B6 over longer periods of time.

Findings from the recently published National Australian Lucid Dream Induction Study (NALDIS; see Chapter 8) indicate that the physiological conditions that give rise to superior general dream recall are conducive to inducing lucid dreams, which are dreams in which the dreamer is aware that they are dreaming while the dream is still happening (LaBerge & Rheingold, 1991). Indeed, vitamin B6 has been described as an “extremely useful” aid for inducing lucid dreams (FitzGerald, 2014), and there are many anecdotal reports on the various online lucid dreaming forums (e.g. “Dream Views”, “LD4all”, “World of Lucid Dreaming”) of vitamin B6 being used for this purpose. Lucid dreaming has a wide range of potential benefits and applications in areas such as scientific dream research (Hobson, 2009), the treatment of nightmares (Holzinger et al., 2015), improvement of skills through rehearsal in the lucid dream environment (Stumbrys et al., 2016), recreation (Schädlich & Erlacher, 2012), and creative problem solving (Stumbrys & Daniels, 2010). However, research in this area has been limited by a lack of effective and reliable lucid dream induction techniques. Vitamin B6 may provide a simple, inexpensive and low-risk means to enhance the effectiveness of lucid dream induction techniques (see Stumbrys et al., 2012; Chapter 8), and could thus make further research on the potential applications of lucid dreaming more feasible. Further research on the effects of vitamin B6 and other B vitamins on dreaming is warranted.

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Chapter 11: General Discussion

11.1 Overview

The primary objective of the present thesis was to address the current lack of effective and reliable lucid dream induction techniques by conducting methodologically rigorous experimental research on lucid dream induction. The thesis began with five chapters, which provided: general introductory content (Chapter 1); a brief overview of the history of lucid dreaming (Chapter 2); a discussion of the phenomenology of lucid dreams (Chapter 3); a review of research on psychophysiological correlates of actions and experiences in lucid dreams (Chapter 4); and a discussion of the potential benefits and applications of lucid dreaming (Chapter 5). Chapters 6, 7, 8, 9 and 10 presented original research in the form of manuscripts that have been prepared for, submitted to or published by peer-reviewed academic journals. Chapter 6 presented a published review paper that investigated psychometric issues related to the measurement of dream recall. Chapter 7 presented a published empirical study that addressed many of the psychometric issues raised in Chapter 6. Chapter 8 presented findings from an experimental study on lucid dream induction; the National Australian Lucid Dream Induction Study (NALDIS). Chapter 9 presented findings from an extension of the NALDIS that investigated a novel lucid dream induction technique known as the *Senses Initiated Lucid Dream* (SSILD) technique (Zhang, 2013). Chapter 10 presented findings from a randomised, double-blind, placebo-controlled experiment that investigated the effects of B vitamins on dreaming and sleep. The original research presented in Chapters 6, 7, 8, 9 and 10 is summarised and discussed below. In the section that follows, methodological limitations of this research are considered. Directions for future research are then provided, including a series of three additional studies that could potentially yield a highly effective and reliable approach to lucid dream induction.

11.2 Summary of original research

11.2.1 Review paper on the measurement of dream recall

The relationship between general dream recall and lucid dreaming is one of the most robust relationships observed in the empirical lucid dreaming literature (see Erlacher, Schädlich, Stumbrys, & Schredl, 2014). However, while reviewing the literature on measures of dream recall in preparation for conducting lucid dream induction research, it became apparent that retrospective measures (which involve estimating one's dream recall retrospectively) typically yield substantially lower dream recall rates than logbook measures (which involve recording one's dream recall each morning). This was termed the *retrospective-logbook disparity*, and raised concerns about the valid measurement of dream recall. Thus, it was considered essential to further investigate this phenomenon before proceeding with lucid dream induction research in order to ensure that valid and reliable measures of dream recall were used. An extensive literature search was conducted in order to identify studies in which a retrospective-logbook disparity was reported or could be calculated. This formed the basis of the published review paper presented in Chapter 6. Out of 1933 initial search results, a total of 17 studies were ultimately included in the review. The majority of these studies yielded a retrospective-logbook disparity of between 10% and 610%, with an unweighted mean of 115%. This confirmed that the retrospective-logbook disparity is a widespread phenomenon.

Two principal explanations were proposed for the retrospective-logbook disparity. According to the *retrospective underestimation hypothesis*, retrospective measures tend to underestimate true dream recall rates. According to the *logbook enhancement hypothesis*, keeping a dream recall logbook tends to enhance dream recall. It was argued that if retrospective measures underestimate dream recall, the dream recall rates they yield may be a poor reflection of true dream recall rates, and may be confounded with variables related to the underestimation effect. Similarly, it was argued that if logbooks tend to enhance dream recall, they too may fail to provide an accurate measure of typical dream recall rates, and may be confounded with variables related to the enhancement effect. The retrospective underestimation hypothesis and the logbook enhancement hypothesis were given in-depth consideration in relation to theoretical considerations and existing empirical research. It was concluded that the retrospective-logbook disparity is most likely due to a combination of both retrospective underestimation and logbook enhancement effects, and that both types of measures are likely to be confounded with variables that have little or no direct relationship with true dream recall rates. Many questions surrounding the valid measurement of dream recall remained unanswered, and a range of recommendations for further research were provided.

11.2.2 Empirical investigation into measures of dream recall

Chapter 7 presented a published empirical study that addressed many of the questions regarding the measurement of dream recall that were raised in the review paper presented in Chapter 6. The study was incorporated into the larger lucid dream induction study presented in

Chapter 8, and investigated multiple different types of retrospective and logbook measures of both general dream recall and the recall of nightmares, bad dreams, lucid dreams and flying dreams. The study also investigated several different operationalisations of dream recall, including *Dream Recall Frequency* (DRF; the number of mornings on which any amount of dream content is recalled), *Dream Count* (DC; the number of separate dreams recalled each morning), and a novel and more sensitive operationalisation of dream recall termed *Dream Quantity* (DQ) that involved participants providing ratings for how much content they could recall from each individual dream. The DQ measure was developed by the present author based on a previous measure developed by Reed (1973). Three different types of logbook were compared: a *Checklist logbook* that involved providing brief titles of all dreams recalled; a *Narrative logbook* that elicited written narratives of dream content; and a *Quantity logbook* that included the DQ measure.

Data were collected from 420 participants who completed a pre-test questionnaire and 187 participants who went on to complete their logbooks. As hypothesised, large and statistically significant retrospective-logbook disparities were observed. Strong correlations were observed among different types of retrospective measures, and also among different types of logbook measures. However, correlations between retrospective and logbook measures were much weaker, demonstrating that retrospective and logbook measures are not equivalent and should not be used interchangeably. Retrospective-logbook disparities were calculated for each participant individually, and then correlated with other variables theoretically linked to the retrospective underestimation and logbook enhancement effects. Findings provided strong evidence that retrospective measures underestimate true dream recall and that logbooks enhance it. Logbook measures of dream recall were most stable over time when presented in the Quantity logbook and least stable when presented in the Narrative logbook. There were no significant differences in overall dream recall rates between the three types of logbooks, and it was concluded that Quantity logbooks should be preferred except where written descriptions of dream content are of interest to researchers. A range of other recommendations for the valid measurement of dream recall were provided (see Section 6.6). These were used when conducting the experimental research presented in Chapters 8, 9 and 10.

11.2.3 The National Australian Lucid Dream Induction Study

Having addressed a range of concerns regarding the valid measurement of dream recall, the present author proceeded with research on lucid dream induction. The National Australian Lucid Dream Induction Study (NALDIS) was conducted, and was presented in Chapter 8. This study investigated two of the most promising and widely studied cognitive lucid dream induction techniques: *Reality testing* (LaBerge & Rheingold, 1991; Tholey, 1983), and the *Mnemonic Induction of Lucid Dreams* (MILD) technique (LaBerge, 1980; LaBerge & Rheingold, 1991). Participants completed a pre-test questionnaire, provided baseline logbook data in Week 1, and were then randomly assigned to one of three lucid dream induction groups in Week 2. These groups involved: reality testing throughout the day only; reality testing throughout the day and practising the MILD technique at night after five hours of sleep; and a third group that involved reality testing throughout the day and then waking up after five hours of sleep to simply read about lucid dreaming. This third group helped to control for the priming effects inherent in the MILD technique of thinking about lucid dreaming. It was anticipated that the Quantity logbook would be psychometrically superior to the Checklist and Narrative logbooks prior to conducting the study, and so Quantity logbooks were used in all Week 2 groups. The NALDIS generated substantial media interest, including two nationally televised TV interviews with the present author and numerous radio interviews and news articles. This assisted greatly in recruiting a highly diverse sample of participants from across Australia that were mostly naive to lucid dreaming (63.9%), with only 21.3% of participants being students.

A significant increase in lucid dreaming was observed for participants who practised the MILD technique – lucid dreaming was reported on 17.4% of nights in Week 2 compared to 9.4% of nights in Week 1; an increase of 84.5%. These findings replicate those of several earlier studies in which the MILD technique was found to be effective for inducing lucid dreams (Edelstein & LaBerge, 1992; LaBerge, 1988; LaBerge, Phillips, & Levitan, 1994; Levitan, 1989, 1990a, 1990b, 1991; Levitan & LaBerge, 1994; Levitan, LaBerge, & Dole, 1992). There was no significant increase in lucid dreaming in the control group, indicating that waking up and thinking about lucid dreaming at a time when REM sleep was likely to occur did not explain the significantly increased lucid dreaming rate observed for participants who practised the MILD technique. The present study is the first that has attempted to control for these effects inherent in the MILD technique, and provides the strongest evidence to date that the MILD technique is effective for inducing lucid dreams.

Lucid dreaming was more likely to occur following practice of the MILD technique on nights when general dream recall was superior. However, mean general dream recall rates during Week 2 were virtually identical to those observed during Week 1, despite participants being given instructions for improving their dream recall during Week 2. Furthermore, participants who wrote out their dreams while keeping a Narrative logbook during Week 1 of the NALDIS were no more responsive to the lucid dream induction techniques in Week 2 than participants assigned to the Checklist or Quantity logbook groups in Week 1. These findings suggest that it is the physiological conditions that give rise to superior dream recall that are conducive to lucid dream induction.

Activities such as writing out one's dreams each morning and using techniques for improving dream recall such as those provided to participants in Week 2 (see Appendix E) may have relatively little impact on the effectiveness of lucid dream induction techniques.

The strongest predictor of lucid dreaming was being able to fall asleep quickly after completing the MILD technique. Similarly, participants were more likely to experience lucid dreaming when they reported less difficulty falling asleep. In contrast, participants' motivation to practise the MILD technique was not a significant predictor, and the amount of technique repetitions and time spent on the MILD technique were not related to lucid dreaming when the amount of time required to fall asleep was controlled for. Taken together, these findings provide the strongest support to date for the theory that the MILD technique works by creating a mnemonic intention to remember that one is dreaming, and indicates that its effectiveness is heavily dependent on being able to enter REM sleep quickly without losing this intention. Week 2 lucid dreaming was not related to prior experience with lucid dream induction techniques, and shared variance between pre-test and Week 2 lucid dreaming rates was only 10.9%. These findings indicate that the MILD technique is effective for a wide range of people within a short period of time (one week in the NALDIS), including people who are naive to lucid dreaming and who have low baseline lucid dreaming frequency.

Reality testing on its own was not effective for inducing lucid dreams. Indeed, the lucid dreaming rate for participants who practised reality testing only was slightly *lower* in Week 2 (7.6%) compared to Week 1 (8.1%). This finding replicates those of two previous studies that also found reality testing to be ineffective (LaBerge, 1988; Taitz, 2011). However, this finding is inconsistent with other studies in which reality testing was shown to be effective (Levitan, 1989; Purcell, 1988; Purcell, Mullington, Moffitt, Hoffmann, & Pigeau, 1986; Schlag-Gies, 1992). As discussed in Section 8.4.1, a possible explanation for these mixed findings is that the studies in which reality testing was effective involved other activities that may have enhanced the effectiveness of reality testing. In the study by Purcell (1988), participants were instructed to read over their dream narratives and familiarise themselves with recurring anomalies. This may have worked synergistically with reality testing to increase the likelihood that participants would notice idiosyncratic anomalies while dreaming that triggered lucidity. In the study by Paulson and Parker (2006), participants were instructed to form the intention to have a lucid dream directly before going to bed in addition to practising reality testing throughout the day, which may have primed participants to perform reality tests in subsequent REM sleep.

11.2.4 Additional findings from the National Australian Lucid Dream Induction Study

Chapter 9 presented an extension of the NALDIS that investigated the effectiveness of a previously untested lucid dream induction technique; the SSILD technique. Participants were 21 people who completed the NALDIS and then agreed to trial an additional lucid dream induction technique each night for one week (Week 3). Participants also practised reality testing throughout the day for the sake of consistency with the NALDIS. Results showed that participants experienced lucid dreaming on 14.7% of nights while practising the SSILD technique, which was 54.1% higher than the Week 1 baseline rate; a statistically significant difference. Analyses indicated that this increase in lucid dreaming could not be attributed to practising lucid dream induction techniques in Week 2 of the NALDIS. Furthermore, and as with the MILD technique in the NALDIS, results indicated that the significantly increased lucid dreaming rate while practising the SSILD technique was not likely due to performing reality tests throughout the day. Thus, it was concluded that the SSILD technique was effective for inducing lucid dreams.

Lucid dreaming in Week 3 was strongly correlated with lucid dreaming in Week 2, but was not correlated with lucid dreaming in Week 1. These findings indicated that some participants were more responsive than others to lucid dream induction techniques, irrespective of their baseline lucid dreaming rates. This seems to be at least partly explained by general dream recall – Week 3 lucid dreaming was strongly correlated with Week 1 general dream recall, and as with the MILD technique in the NALDIS, lucid dreaming was more likely to occur following practice of the SSILD technique on nights when general dream recall was superior. These findings provide further evidence for the theory that the physiological conditions that give rise to superior general dream recall are conducive to lucid dream induction.

Contrary to expectations, and unlike findings for the MILD technique in the NALDIS, the amount of time required to return to sleep after completing the SSILD technique was not related to lucid dreaming. Lucid dreaming was also not related to motivation to practise the technique, the number of technique repetitions, self-rated difficulty focussing on the technique, or whether or not participants fell asleep while practising the technique. Further research is needed to establish the mechanisms through which the SSILD technique induces lucid dreams. One possibility is that it causes a general increase in awareness of perceptual stimuli that persists into subsequent REM sleep. This may increase the likelihood of noticing dream anomalies that trigger lucidity. Similarly, the likelihood of noticing that one is dreaming may be increased if the practitioner continues to perform the SSILD technique after falling asleep, as was reported by one participant (see Section 9.4.1).

11.2.5 Empirical investigation into the effects of B vitamins on dreaming and sleep

Findings from both the NALDIS and the investigation of the SSILD technique supported the theory that the physiological conditions that give rise to superior dream recall are conducive to lucid dream induction. In both studies, it was suggested that drugs and supplements that enhance dream recall could potentially be used to increase the effectiveness of cognitive lucid dream induction techniques such as the MILD technique and the SSILD technique. Based on this theory, a randomised, double-blind, placebo-controlled experiment was conducted to investigate whether supplementation with vitamin B6 (pyridoxine hydrochloride) directly before bed enhances dream recall. This study was presented in Chapter 10, and replicated a small within-subjects pilot study (*N* = 12) by Ebben, Lequerica and Spielman (2002) in which vitamin B6 ingested before bed was shown to significantly increase the colour, vividness, emotionality and bizarreness of dreams. For the present study, a much larger and more diverse sample of participants from across Australia (*N* = 100) was recruited. As with the NALDIS, this study generated substantial media attention. Participants completed a pre-test questionnaire and were then randomly allocated to groups that involved ingesting either vitamin B6 or a placebo directly before bed for five days after an initial five day baseline logbook period. A third group that involved ingesting a B complex preparation containing a range of B vitamins was also included.

Vitamin B6 supplementation was not shown to have any significant effects on the colour, vividness, bizarreness or positive or negative emotion of dreams compared with placebo. Similarly, DRF was virtually identical in the B6 group compared to the placebo group. Using the more sensitive DC operationalisation of dream recall, it was found that participants reported 32.7% more dreams in the B6 group than those in the placebo group, although this finding did not reach statistical significance. However, for the most sensitive measure of dream recall used – the DQ measure developed in the study presented in Chapter 7 – a significant difference was observed: participants recalled 64.1% more dream content in the B6 group compared to the placebo group. This finding indicates that vitamin B6 supplementation enhanced dream recall, and also highlights the importance of using measures of dream recall that are sensitive enough to reveal statistically significant effects. Vitamin B6 supplementation did not have any detrimental effects on sleep quality compared to placebo. In contrast, the B complex preparation was found to cause a significant reduction in sleep quality and an increase in tiredness on waking compared to placebo, with no significant effects on dream recall.

The mechanism through which vitamin B6 enhances dream recall remains uncertain. There were no significant differences between the B6 and placebo groups in the self-reported number of awakenings throughout the night, amount of time spent awake during the night, total time spent asleep, or self-rated sleep quality. This discounts the theory that B6 caused disrupted sleep and more frequent awakenings that provided opportunities for dream content to be recalled and consolidated into long-term memory as per the arousal retrieval model of dream recall (Koulack & Goodenough, 1976; see also Goodenough, 1991; Schredl, 2009 for reviews). A more likely explanation is that vitamin B6 caused suppression of REM sleep during the first few hours of sleep via increased conversion of tryptophan into serotonin, leading to a REM rebound effect and increased dreaming activity later in the night.

11.3 Methodological limitations

Regarding the empirical investigation into measures of dream recall and the retrospective-logbook disparity presented in Chapter 7, an unfortunate error in the preparation of the Narrative logbooks meant that it was not possible to establish whether participants in the Narrative logbook group reported all or only some of the dreams they recalled (see Section 7.2.2.2). Thus, although there were no significant differences in general dream recall between the Checklist, Narrative and Quantity logbook groups, the possibility cannot be ruled out that Narrative logbooks caused a stronger logbook enhancement effect than the other logbooks, which was not observed due to a greater tendency for participants in the Narrative group to underreport their true dream recall in order to reduce the burden of providing dream narratives. Further research is needed to investigate whether keeping a Narrative logbook enhances dream recall more than Checklist and Quantity logbooks. This issue has implications for lucid dream induction, because although it is widely recommended that novice lucid dreamers should write out their dreams each morning in order to improve their dream recall (e.g. LaBerge & Rheingold, 1991; Love, 2013), this activity is very burdensome and its effectiveness is called into question by findings from the NALDIS.

Another limitation is that participants of the study of dream recall measures presented in Chapter 7 signed up for the NALDIS. Although they were told explicitly not to make any attempt to alter their dream recall during the Week 1 baseline period, these participants may have been motivated to pay more attention to their dreams in anticipation of learning to have lucid dreams in the Week 2 period of the NALDIS. Thus, findings may have limited generalisability to people who are less interested in dreams or less willing to comply with the demands of keeping a dream recall logbook.

As discussed in Section 8.4.1, it appears unlikely that reality testing contributed to the significantly increased lucid dreaming rate observed among participants who practised the MILD technique. However, the possibility that reality testing contributed to this effect cannot be ruled out. The smaller study into the SSILD technique suffers the same limitation, in that participants practised reality testing throughout the day in addition to practising the SSILD technique at night.

A limitation of the investigation into the SSILD technique is that the sample size was small – only 21 participants from the NALDIS (12.4%) went on to trial the SSILD technique. Furthermore, these participants differed significantly from the other participants of the NALDIS on several important variables, such as baseline general dream recall. This prohibits comparisons between the effectiveness of the MILD technique and the SSILD technique, and further research is needed to confirm that the SSILD technique is effective for inducing lucid dreams. A limitation shared by both the NALDIS and the investigation of the SSILD technique is that lucid dream induction techniques were only practised for seven days. It is often said that the effectiveness of lucid dream induction techniques increases with time (e.g. LaBerge & Rheingold, 1991; Love, 2013), but this has not yet been demonstrated.

A limitation of the study of B vitamins presented in Chapter 10 is that the B complex preparation included a range of different B vitamins, making it impossible to distinguish the effects that individual B vitamins other than B6 had on dreaming and sleep. Vitamin B6 on its own had a significant effect on dream recall, but the same dosage of vitamin B6 when taken with the other B vitamins in the B complex group did not have the same effect. It is possible that several of the B vitamins can enhance dream recall, possibly in synergistic ways, but that other B vitamins inhibit these effects. It remains unclear whether taking vitamin B6 at different times such as an hour before bed or during a brief awakening changes the effects it has on dream recall. It also remains unclear how long the effects of vitamin B6 supplementation on dream recall persist for. Daily supplementation before bed may become less effective over time, or may continue to be effective indefinitely. Vitamin B6 supplementation may also be more effective for some people, such as those who have insufficient dietary intake of the substance, than for others.

11.4 Directions for future research

Another large-scale study similar to the NALDIS is needed that compares the MILD technique combined with reality testing with the MILD technique on its own, in order to establish the effectiveness of the MILD technique when practised in isolation, and to investigate whether reality testing assists with lucid dream induction. A third experimental condition should include the SSILD technique (without reality testing), so that its effectiveness can be compared with the MILD technique. When participants of the NALDIS fell asleep within five minutes of completing the MILD technique, lucid dreaming frequency was 86.2% higher than on the other nights that they practised the technique. If this difference is extrapolated to the entire participant sample, the mean lucid dreaming rate would have been very high at 32.4% on nights when sleep was achieved within five minutes. Generalisability is limited because this was only achieved by 14 participants in the NALDIS, who had higher baseline Week 1 lucid dreaming rates than the other participants. Notwithstanding, falling asleep quickly after completing the MILD technique was clearly an important determinant of successful lucid dream induction. Participants of future studies should be given instructions to help them fall asleep quickly after completing the MILD technique, such as those suggested in Section 8.6. Participants should be asked to describe which approaches were most effective, so that instructions for practising the MILD technique can be further refined.

Converging evidence from the studies presented in Chapters 8 and 9 indicate that the physiological conditions that give rise to greater general dream recall are conducive to lucid dream induction. Findings from the study presented in Chapter 10 indicate that supplementation with vitamin B6 before bed can enhance dream recall. Thus, vitamin B6 supplementation could potentially improve the effectiveness of cognitive lucid dream induction techniques. Other substances may also be effective. The most widely used substance of this kind among lucid dreaming enthusiasts is the acetylcholine esterase inhibitor Galantamine, which influences the REM-on neurotransmitter acetylcholine. There is abundant anecdotal evidence on the extensive online lucid dream induction forums (e.g. “Dream Views”, “LD4all”, “World of Lucid Dreaming”) indicating that this substance promotes enhanced dream recall, and increases the effectiveness of cognitive lucid dream induction techniques. In support of this, participants of an unpublished study by LeMarca and LaBerge (2012, as cited in Sparrow, Hurd, & Carlson, 2016) who ingested Galantamine during a brief awakening purportedly experienced a five-fold increase in lucid dreaming compared to participants in a placebo condition. Furthermore, participants in a survey of 19 lucid dreaming enthusiasts who used Galantamine reported that their Galantamine-induced lucid dreams were significantly longer and more vivid than their other lucid dreams, and contained significantly less fear, threatening dream characters, violence and darkness (Sparrow, Hurd, & Carlson, 2016; see also Yuschak, 2006). Therefore, a placebo-controlled experiment similar to that presented in Chapter 10 could be conducted that compares the use of vitamin B6 and Galantamine (or some other potential dream-enhancing substance) for enhancing the effectiveness of the MILD technique. Ideally, such a study would be conducted after a study that further refines the effectiveness of the MILD technique, such as the one proposed above.

The two studies proposed above could potentially yield an effective approach to lucid dream induction. External stimulation techniques, and in particular light stimulation, may further enhance the effectiveness of this approach (see Section 8.6). Indeed, four studies have found that the use of light stimulation in combination with the MILD technique was significantly more effective than the MILD technique on its own (LaBerge, 1988; LaBerge & Levitan, 1995; LaBerge, Levitan, Rich, & Dement, 1988; Levitan & LaBerge, 1994). This was done using devices such as the *DreamLight*, *DreamLink,* and *NovaDreamer* developed by LaBerge's research group, and several generic versions are now available. These devices are designed for use in the home setting and involve an eye mask with sensors that detect REM sleep and then administer flashing LED light stimulation to the eyes, which can be incorporated into the dream experience and act as a cue that the person is dreaming. An experiment could be conducted that combines a refined version of the MILD technique, an effective dream-enhancing substance, and light stimulation. This tri-pronged approach to lucid dream induction could prove to be highly effective and reliable. If so, this would open the door to serious scientific exploration of the potential benefits and applications of lucid dreaming such as those discussed in Chapter 5.

Future studies of dream recall and lucid dream induction should follow the recommendations for the valid measurement of dream recall provided in the published paper presented in Chapter 7. In addition to any other operationalisations, lucid dreaming DRF (the percentage of days on which lucid dreaming occurs) should always be reported, so that findings from different lucid dream induction studies can be more easily compared. The effectiveness of lucid dream induction techniques cannot be established by comparing logbook lucid dreaming rates during an intervention period with retrospective measures of lucid dreaming rates, due to the non-equivalence of retrospective and logbook measures and the retrospective-logbook disparity discussed at length in Chapters 6 and 7. Therefore, lucid dream induction studies should always include a baseline logbook period and / or include a non-intervention comparison group. Researchers should seek to maximise sample sizes because small sample sizes are a major limitation of most lucid dream induction studies, and should also ensure that participants are not restricted to undergraduate students or highly proficient lucid dreamers. Lucid dreaming can generate substantial interest in the general public, and researchers who are willing to direct their energies to creative promotional strategies and media involvement will hopefully not find participant recruitment overly difficult (see Sections 8.2.1 and 10.2.1; see also Appendices B and O for promotional materials). Indeed, according to the University of Adelaide's External Relations Office, the total advertising space value of the media attention generated by the NALDIS and the study of B vitamins combined was AU$1,101,222, with an estimated potential audience reach of 99,728,288 people (personal communication, February 3, 2017). It is very important that future studies measure variables related to how lucid dream induction techniques are practised in order to establish the mechanisms through which they work, and to identify strategies for enhancing their effectiveness. In addition to the lucid dream induction techniques studied in the present thesis, there are many other lucid dream induction techniques that have never been investigated scientifically. Many of these are discussed at length on the extensive online lucid dream induction forums (e.g. “Dream Views”, “LD4all”, “World of Lucid Dreaming”). These forums are a rich source of additional avenues for future research.

11.5 Conclusion

The original research conducted for the present thesis addresses a range of psychometric issues related to the measurement of dream recall and contributes to the empirical literature on lucid dream induction. The NALDIS is the most methodologically sophisticated lucid dream induction field study ever conducted, and provides the strongest evidence to date that the MILD technique is effective for inducing lucid dreams. It is hoped that the research presented herein will stimulate further research on lucid dream induction, and promote greater methodological rigor in studies of dreaming. Although scientific interest in lucid dream induction has waned in recent decades, many promising avenues for research remain. A series of three studies were proposed in Section 11.4 that could potentially yield a highly effective and reliable approach to lucid dream induction. If this could be achieved, this would open up an entire field of research into the many potential benefits and applications of lucid dreaming in areas such as scientific dream research, the treatment of nightmares, improvement of skills through rehearsal in the lucid dream environment, recreation, and the use of lucid dreaming for problem solving and creative inspiration. The lack of effective and reliable lucid dream induction techniques is the only obstacle to this. Thus, the development of more effective lucid dream induction techniques should be considered a high priority among dream researchers.

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Appendix A: Ethics Approval for the NALDIS

THE UNIVERSITY of ADELAIDE

RESEARCH BRANCH
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY

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21 October 2013

Associate Professor P Delfabbro
School of Psychology

Dear Associate Professor Delfabbro

PROJECT NO: H-2013-083
An experiment for the development of effective lucid dream induction techniques

I write to advise you that the Human Research Ethics Committee has approved the above project. Please refer to the enclosed endorsement sheet for further details and conditions that may be applicable to this approval. Ethics approval is granted for a period of three years subject to satisfactory annual progress reporting. Ethics approval may be extended subject to submission of a satisfactory ethics renewal report prior to expiry.

The ethics expiry date for this project is: 31 October 2016

Where possible, participants taking part in the study should be given a copy of the Information Sheet and the signed Consent Form to retain.

Please note that any changes to the project which might affect its continued ethical acceptability will invalidate the project's approval. In such cases an amended protocol must be submitted to the Committee for further approval. It is a condition of approval that you immediately report anything which might warrant review of ethical approval including (a) serious or unexpected adverse effects on participants (b) proposed changes in the protocol; and (c) unforeseen events that might affect continued ethical acceptability of the project. It is also a condition of approval that you inform the Committee, giving reasons, if the project is discontinued before the expected date of completion.

A reporting form for the annual progress report, project completion and ethics renewal report is available from the website at http://www.adelaide.edu.au/ethics/human/guidelines/reporting/

Yours sincerely

per **Dr John Semmler**
Convenor
Human Research Ethics Committee

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OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY

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Applicant: Associate Professor P Delfabbro

School: School of Psychology

Project Title: ***An experiment for the development of effective lucid dream induction techniques***

THE UNIVERSITY OF ADELAIDE HUMAN RESEARCH ETHICS COMMITTEE

Project No: **H-2013-083** RM No: 0000017446

APPROVED for the period until: **31 October 2016**

It is noted that this project will be conducted by Denholm Aspy, PhD candidate.

Refer also to the accompanying letter setting out requirements applying to approval.

Dr John Semmler
Convenor
Human Research Ethics Committee

Date: 17 OCT 2013

Appendix B: Promotional Materials for the NALDIS

A5 size promotional flyer

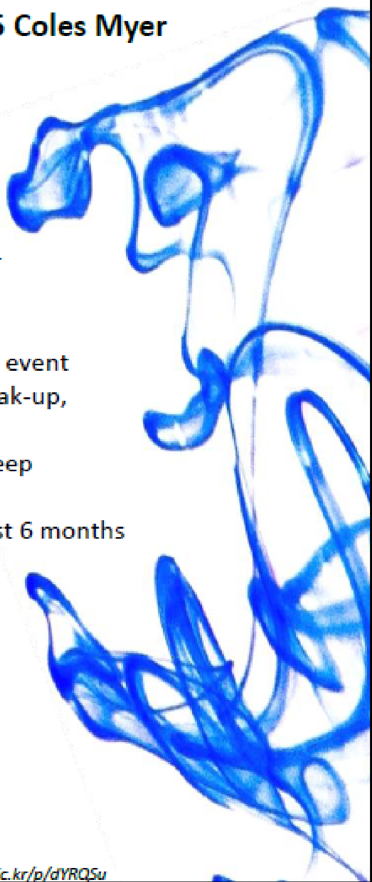
THE UNIVERSITY of ADELAIDE

Lucid Dreaming Study:

Participants Invited!

You are invited to participate in a study designed to teach you how to have *lucid dreams*. Lucid dreams are fascinating experiences where you realise that you are dreaming and can then control what happens in the dream. The study goes for two weeks and begins with a 10-15 minute online questionnaire. For the first week you will be asked to fill out a logbook each morning and in the second week you will be asked to practise a technique to help you have lucid dreams.

Participants will go into a raffle to win one of 15 Coles Myer vouchers (5 x $200 and 10 x $50)



Please do not participate if any of the following applies to you:

- You have been diagnosed with any kind of mental health disorder, sleep disorder or neurological disorder
- You suspect you *might* have one of the above disorders, but you are not sure
- You are experiencing a traumatic or highly stressful life event that is interfering with your sleep (e.g. relationship break-up, death of a loved one, etc)
- You suffer from persistent insomnia or are unable to keep a regular sleep schedule
- You have had sleep paralysis more than once in the past 6 months
- You find it unpleasant to think about your dreams
- You are under 18 years of age

If you would like to participate, please visit:
http://bit.ly/UAdreams

If you have any questions, email:
denholm.aspy@adelaide.edu.au

A4 size promotional poster

THE UNIVERSITY of ADELAIDE

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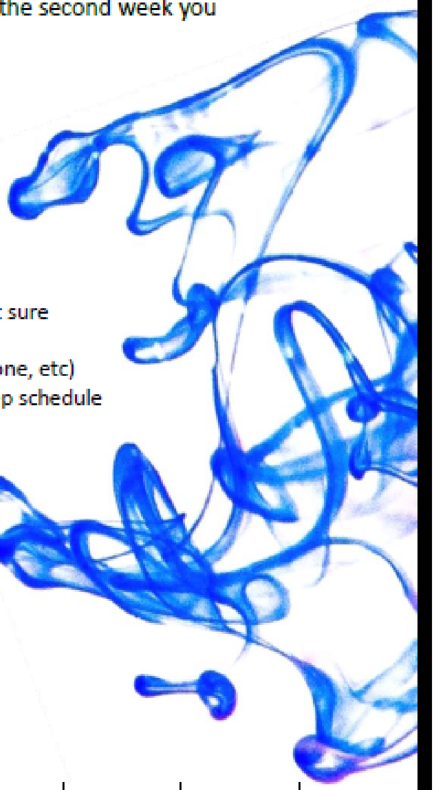

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Lucid dreaming study
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Appendix C: Participant Information Sheet for the NALDIS

THE UNIVERSITY of ADELAIDE

Information sheet: An experiment for the development of effective lucid dream induction techniques

My name is Denholm Aspy and I am a PhD student in the School of Psychology at the University of Adelaide. I would like to invite you to participate in a study designed to help you learn how to have *lucid dreams*. A lucid dream is a rare kind of dream where you know that you are asleep and dreaming while the dream is still happening. This makes it possible to then control what happens in the dream. Most people are amazed by how realistic lucid dreams are when they have them for the first time – in fact, it can be hard to tell the difference between a lucid dream and waking life.

Not only does lucid dreaming tend to be fun and exhilarating, it also has a wide range of potential scientific and therapeutic uses. For example, research suggests that people can improve waking life motor skills by practising them in lucid dreams, which could be very valuable for people such as stroke victims or people recovering from physical trauma. Lucid dreaming also has potential applications in psychotherapy, such as treatment for recurrent nightmares. Scientists have demonstrated that people can be taught how to have lucid dreams using various techniques. However, we still have a lot to learn about these techniques and more research is needed to refine them and make them as effective as possible. The purpose of my research is to compare and thoroughly investigate several widely-practised lucid dreaming techniques. By participating in this research you will not only make a valuable contribution to knowledge in this area, but may also learn how to have these experiences yourself. Furthermore, as a small token of our gratitude all participants who complete the study will go into a raffle to win one of 15 Coles Myer vouchers (5 x $200 and 10 x $50). We will also send you a summary of our findings when this research project is complete so that you can share in what we learn.

What does the study involve?

- The study goes for two weeks and is self-directed. (You will be given everything you need to complete the study on your own).
- Participants are divided into three groups that involve different lucid dreaming techniques.
- The study begins with an online questionnaire that will take 10-15 minutes to complete.
- Once you complete the questionnaire, you will be sent further instructions and materials via post.
- For the first week of the study you will be asked to fill out a logbook each morning. (For most people, this will take between 5 and 20 minutes each morning).
- For the second week of the study, you will continue to fill out a logbook each morning and will also be asked to practise techniques to help you have lucid dreams.
- Once you have practised the lucid dreaming techniques for exactly seven days, you will be asked to return your completed materials using a postage-paid envelope provided to you.
- Once data collection is complete, the raffle will be drawn and winners will be contacted.

The lucid dreaming techniques in the second week will require you to examine your surroundings several times per day and then do a simple test to confirm whether you are awake or in a dream.

(Developing this habit during the day makes it more likely you will do it when you are dreaming, helping you to have lucid dreams). You may also be required to wake up five hours after your initial bedtime using an alarm, practise a different lucid dreaming technique for about 10 minutes, then go back to sleep (for as long as you like). The seven days of practising a lucid dreaming technique in the second week do not have to be consecutive, so if you have a big Saturday night (for example) and are too tired to wake up in the middle of the night to practise your technique, that is OK. However, you will be urged to complete all seven days as quickly as possible. Practising the lucid dreaming techniques is the most important part of the study so please carefully consider whether you are willing to do this before signing up to participate!

Potential risks and ethical considerations

The risks associated with lucid dreaming are minimal and negative experiences are very rare. However, there is a chance that learning to have lucid dreams might have a negative effect on people who suffer from certain psychological disorders (e.g. schizophrenia), as well as certain sleeping disorders (e.g. narcolepsy). For these reasons, I urge you not to participate if any of the exclusion criteria (listed below) applies to you. If you find it unpleasant to think about your dreams you are advised not to participate because participation might make you more aware of them. Participation in this study may involve disruption to your sleep on seven nights, which could potentially result in sleep deprivation. For this reason, I recommend that you allow yourself 15-30 minutes of extra sleeping time in the morning to make up for any loss of sleep during the night. Finally, although it is very unlikely, participating in this study might slightly increase the chances of you experiencing something called *sleep paralysis*. Every night when we are dreaming, our bodies become temporarily paralyzed so that we don't act out our dreams in real life. However, it is possible to experience this paralysis while we are still conscious. Although this can sometimes be a frightening experience it is otherwise completely harmless and usually ends within a minute or two. If you choose to participate, you will be given detailed information about sleep paralysis, as well as advice on how to minimise the chances of it occurring and what to do if it does.

Subject to any legal requirements to disclose, all data collected from this research project will remain confidential and any information that you provide will be used solely for the purposes of this research. Your personal details (name, address, etc) will be kept in a secure location that is separate from your answers to the online questionnaire and your completed logbooks to ensure that your data is not personally identifiable. In addition, in accordance with University policy, all data collected will be securely stored on University grounds for up to five years. If you are a student at the University of Adelaide, please note that your participation in this study will not affect the services you receive from the University. Although your full participation is encouraged and appreciated, you are free to withdraw at any time you wish. It is hoped that you will experience lucid dreaming as a result of participation in this study. However, please note that this is not guaranteed, and that participation may not be of any personal benefit to you. You will be given the opportunity to receive a summary of the results after the study has been completed, as well as detailed descriptions of all three techniques used in the study.

Exclusion criteria

Please do not participate if any of the following applies to you:

- You have been diagnosed with any kind of mental health disorder, sleep disorder or neurological disorder.
- You suspect you *might* have one of the above disorders, but you are not sure.
- You are experiencing a traumatic or highly stressful life event that is interfering with your

sleep (e.g. relationship break-up, death of a loved one, etc).

- You suffer from persistent insomnia or are unable to keep a regular sleep schedule.
- You have experienced sleep paralysis more than once in the past 6 months.
- You find it unpleasant to think about your dreams.
- You are under 18 years of age.

You will be sent a copy of this information sheet in the post along with the other study materials if you choose to participate. However, if you would like to be sent a copy via email, or if you have any questions, please feel free to email me:

denholm.aspy@adelaide.edu.au

You may also contact any of the members of my supervisory panel who are also involved in this research project:

- Dr Paul Delfabbro (principal supervisor)
  Email: paul.delfabbro@adelaide.edu.au

- Dr Michael Proeve (co-supervisor)
  Email: michael.proeve@adelaide.edu.au

- Dr Philip Mohr (co-supervisor)
  Email: philip.mohr@adelaide.edu.au

The current research has been approved by the Human Research Ethics Committee (approval number: H-2013-083). For any ethical concerns regarding this study, please contact the Secretary of the University of Adelaide Human Research Ethics Committee:

) 8313 6028

Finally, in the unlikely event that you feel upset as a result of participating in this study you can obtain useful information about depression and anxiety by visiting www.beyondblue.com.au and http://www.anxietyattack.com.au. If necessary, you can access psychological services at an affordable rate at the University of Adelaide Counselling service, ph , or through your General Practitioner (GP).

Thank you for your assistance.
Yours sincerely

Denholm Aspy

Appendix D: General Instructions for Week 1 of the NALDIS

Overview and instructions:
Week 1

The first part of this study involved an online questionnaire, which you have already completed. This package contains the materials you will need to complete the rest of the study. You should have received the following:

- Introductory letter
- Overview and Instructions for Week 1 (this page)
- Information Sheet from the online questionnaire (for your records)
- Logbook for Week 1
- Sealed white envelope (this contains the materials for Week 2)
- Postage-paid yellow envelope (to return your materials when you finish the study)

The rest of the study is divided into two sections that each go for one week. The purpose of the first week is to gather baseline information about your normal sleeping patterns and your ability to recall dreams. The second week is where you practise a technique designed to help you have lucid dreams and is when you will hopefully get to experience lucid dreaming.

Week 1 instructions

- Fill out your Week 1 Logbook each morning for 7 days, starting from tomorrow. It is very important that you try to do this for 7 days *in a row* and do not skip any days (even if you have a lot to do in the morning or if you've had a bad sleep the night before). If you *do* miss a day, do an extra day at the end so that you end up filling out the logbook for exactly 7 days.
- Fill out your logbook *first thing* in the morning before you get out of bed. This is also very important. To make this easier, keep the logbook and a pen close to your bed, preferably on a bedside table.
- Please do *not* make any attempt to have lucid dreams or improve your dream recall during the first week. Also, please do not open the sealed white envelope included in this package until you have completed the first week of the study.

Once you have completed the first week of the study

Once you have completed all 7 entries in your logbook, please place it in the yellow reply-paid envelope provided (don't seal the envelope shut though, because you'll need to use it again at the end of Week 2). Then, open the white envelope that was included in this package, which contains the materials and instructions that you'll need to complete the second week of the study.

If you have any questions or difficulties, please feel free to contact me:
Email: denholm.aspy@adelaide.edu.au

Appendix E: General Instructions for Week 2 of the NALDIS

Overview and instructions:
Week 2

Welcome to the second and final week of the study! This is the most exciting part and is where you will practise a technique designed to help you have lucid dreams. This will require a significant amount of effort and commitment on your behalf and these will be the biggest factors that determine your likelihood of having lucid dreams. In this envelope, you should have received the following:

- Overview and Instructions for Week 2 (this page)
- Lucid Dreaming Technique sheets
- Logbook for Week 2
- Blank Pages (to write down lucid dreams or other interesting experiences)
- Transitional Experiences document (for your information)

This part of the study goes for seven days. Try to do all seven days *in a row*, although it's better to skip a day if you are feeling very sleep deprived. Even if you don't do them consecutively, **please try to do all seven days as quickly as possible.**

To maximise your chances of having lucid dreams, please follow the instructions on the other side of this page as closely as possible. However, you don't have to withdraw from the study if you don't follow the instructions perfectly, because any data you contribute – even if incomplete – will still be valuable. Furthermore, if you don't follow the instructions perfectly, it is vitally important that you tell us in your answers to the logbook questions. The validity of our results depends on you providing us with the most accurate data possible!

When you have practised the techniques on seven different days, place your logbook and any blank pages that you used into the yellow reply-paid envelope provided (along with your logbook from the first week of the study), seal it shut and then place it in any Australia Post post-box. You can keep the other sheets that came in the package such as the information sheet and the lucid dreaming technique sheets.

If you have any questions or difficulties, please feel free to contact me:
Email: denholm.aspy@adelaide.edu.au **Phone:**

Lucid dreaming instructions

During the day

- Perform a minimum of 10 reality tests each day using the instructions on the Daytime Lucid Dreaming Technique sheet. The more often you do reality tests the better.

Just before bed

- Just before you go to bed, read the Nighttime Lucid Dreaming Technique sheet and familiarise yourself with what you need to do later in the night.
- Set an alarm so that you will wake up 5 hours after you go to bed. Put the alarm somewhere where you have to get out of bed to turn it off, such as on a desk at the other end of the room. This is very important! If you put it on your bedside table you might end up reaching for the alarm, turning it off and then simply going back to sleep without doing the technique! Getting out of bed will help wake you up a little bit and prevent this problem from occurring.
- I also recommend that you either go to sleep 15-30 minutes early, or give yourself an extra 15-30 minutes to sleep in tomorrow morning. This will help ensure that you get as much sleep as you usually would.

When you wake up after 5 hours of sleep

- Do the nighttime technique using the instructions on the Nighttime Lucid Dreaming Technique sheet.

When you wake up in the morning

1. When you've finished sleeping for the night, stay in bed and spend at least 5-10 minutes trying to remember as many details from as many dreams as you can. This is important because the more familiar you are with your dreams the easier it will be for you to realise when you're dreaming and have lucid dreams. We usually forget dreams very quickly, so make sure this is the very first thing you do in the morning. The following tips will help:

    - Make sure you lie in the same position as when you first woke up when trying to remember your dreams. This tip alone will make it much easier to remember them.
    - Don't let your mind wander to other things (such as your plans for the rest of the day).
    - If you can only remember a small fragment of a dream, focus on it and try to recall what happened directly before it, and then before that, replaying the dream in reverse. Sometimes you can remember a long and detailed dream using this strategy.
    - If you can't remember anything, ask yourself: "what was I *just* doing?" If you keep trying, you will usually start to remember something. Be patient and don't give up too quick!

2. After you've remembered as many dreams as you can, fill out your logbook.
3. If you had a lucid dream, write it down using the blank pages provided.

Appendix F: Lucid Dream Induction Technique Sheets for the NALDIS

Daytime Lucid Dreaming Technique

One way to have a lucid dream is by noticing something unusual or bizarre that makes you realise you are dreaming. However, most of the time we simply ignore the many bizarre things that happen in our dreams or assume there must be some rational explanation. It's only after we wake up that we realise how obvious it was that we were dreaming. The following technique is called *reality testing* and it makes it more likely that you will notice when you are dreaming. It involves regularly questioning throughout the day whether or not you are dreaming. By making this a habit in your waking life, it becomes highly likely that you will do reality tests in your dreams as well. This is because the things that we think about and do during waking life are very often reflected in our dreams. If you are successful, there will be a time when you do a reality test, and to your surprise, you will find that you are dreaming! To do the technique, perform the following steps a minimum of 10 times each day:

Do this at least 10 times per day:

1) **Ask yourself, "Am I dreaming"?** Don't just automatically assume you are awake though, because then you will be training yourself to do the same thing in your dreams and the technique won't work! You need to always seriously consider the possibility that you might be in a dream when you do reality tests.
2) **Take a careful look around and see if you can notice anything strange or inconsistent**. One of the differences between waking life and dreams is that dreams tend to be unstable. Objects, people and even locations will often randomly transform or change.
3) **You then need to perform a reality test**. **To do this, close your lips together tightly and then try to breathe in through your mouth for two or three seconds.** Just try to breathe in naturally and expect that you *will* be able to. Alternatively, you can pinch your nose shut with your fingers and then try to inhale through your (tightly sealed) nose. Obviously, when you are awake you won't be able to inhale. However, when we are dreaming our ability to breathe is not affected by what our "dream lips" or "dream nose" are doing. So if you find that you *can* inhale, you are dreaming! This is the most important step of the technique, and a highly reliable way to tell whether or not you are dreaming. (Note: do not be tempted to use the classic "pinch test" instead to see if you're dreaming because it doesn't actually work – all it does is produce a realistic pinching sensation).
4) **Keep count of your reality tests every time you do them.** You will be asked to report how many reality tests you do in your logbook and it is important that you are as accurate as possible. If you have a smart phone, please download a free tally counter app such as "Count! The Tally Counter" (on Google Play for Android) or "Tally Counter" (on the iPhone App Store) and use it to keep count of how many reality tests you do each day. Alternatively, you could write down an "X" on a piece of paper that you carry with you or even the back of your hand every time you do a reality test.

The more frequently and carefully you practise reality testing, the more effective it will be. Aim to do a *minimum* of 10 reality tests throughout the day, although more will be even better. Reality testing is most effective when done at a range of different times and settings (e.g. after breakfast at home, at work, the supermarket, while spending time with friends, just before bed, etc). In particular, be sure to *always* do a reality test if you see something unusual or if something unexpected happens. Another useful strategy is to do a reality test every time you arrive or find yourself in a new location.

Nighttime Lucid Dreaming Technique

This technique involves focussing your mind on lucid dreaming at a time when lucid dreams are most likely to occur. As a consequence, you will be more likely to think about lucid dreaming in your dreams, which will help you to realise that you are dreaming. This technique also prepares you for what to do if you have a lucid dream.

How to do the technique

1) Set an alarm so that you will **wake up 5 hours after you go to bed**. (Do not practise the technique at the start of the night). Put the alarm in a place where you'll have to get out of bed to turn it off.
2) When the alarm goes off turn on the light, get out of bed and turn off the alarm. Go to the toilet if you need to. Then, jump back into bed and **read the information on the next page** (the page entitled "What to do if you have a lucid dream").
3) Turn off the lights, lie in a comfortable position and then **simply go to sleep as you normally would**.

What to do if you have a lucid dream

With any luck, you might have a lucid dream tonight! This can happen in several ways. For example you might be in a normal dream and then notice something bizarre or impossible, which makes you realise that you must be dreaming. It's also possible to enter a lucid dream *directly* without ever losing consciousness. Although this is very rare, it can sometimes happen when you keep your mind active while falling asleep. Often, lucid dreams happen for no apparent reason at all. Regardless of how it happens, **there are three things you should do if you have a lucid dream**:

1) ***Stay calm*** – getting too excited in a lucid dream can cause you to wake up! To avoid this problem, remember to stay calm. Then, to make sure you really *are* dreaming, you need to:
2) ***Do a reality test***. To do this, close your lips together tightly and then try to breathe in through your mouth. Just try to breathe in naturally and expect that you *will* be able to. If you find that you *can* inhale, you are dreaming! Remember, it's important to always do reality tests earnestly, and *always* assume that you might be dreaming (even if you're 100% sure you're awake!). This is because dreams can be extremely realistic. For the sake of practise, please do a reality test right now. Once you've confirmed that you're in a lucid dream, the last thing you need to do is:
3) ***Stabilise the dream***. To do this, rub the palms of your hands together vigorously and focus on the physical sensations in your hands. As you do this, repeat to yourself "this is a lucid dream". This technique is highly effective – focussing on physical sensation coming from your "dream body" prevents you from becoming aware of your "real" body. As a result, the technique "locks" you into the dream and prevents you from waking up. If you *do* start waking up, usually the first thing you'll notice is that everything starts to go dark. If this happens, do the stabilisation technique straight away! Even if everything is completely dark and you *think* you're awake, keep doing the technique for at least another 60 seconds – there's a very good chance that you're actually still dreaming!

Once you've **done a reality test** and **stabilised the dream**, you can do whatever you want! One idea is to just walk around and explore. Many people also love to fly in lucid dreams, which can certainly be an exhilarating experience! Whatever you do, try to keep the lucid dream going for as long as possible by doing the stabilisation technique whenever the dream starts to fade. Don't forget to regularly say to yourself "this is a lucid dream", because it's surprisingly easy to forget that you're dreaming!

A word about "false awakenings"...

A "false awakening" is when you have a dream about waking up somewhere (often in your own bed, but not always). Whenever you *think* you have woken up, you might *actually* still be dreaming! For this reason, every time you wake up you should take a careful look around to see if you can spot anything unusual. And if you ever suspect that you're dreaming, do a reality test! If you make a habit of doing these things, you might turn some of your false awakenings into lucid dreams!

What to do when you really *do* wake up

When you wake up, do a reality test straight away to make sure it isn't a false awakening! If it turns out you really *are* awake, and if you just had a lucid dream, please write it down using the blank pages provided. Even if you are tired and want to go back to sleep, please still write it down straight away. We usually forget dreams very quickly and if you don't write it down you might forget important details. Begin by describing what caused you to realise that you were dreaming and then describe the rest of the experience. Try to be as descriptive as possible, and don't forget to mention what happened if you did the stabilisation technique, if you did any reality tests in the dream or if you had any false awakenings.

Nighttime Lucid Dreaming Technique

This technique makes use of a specific kind of memory called "prospective memory", which is our ability to remember to do things in the future. A common example is when we make a mental note that we need to buy something when we go to the shops later on. When you set yourself the goal to remember to do something, you make the goal one of your current concerns and thereby activate a goal-seeking brain system that will stay activated in your unconscious mind until you achieve it. The more motivated you are, the more highly activated this system will be. It also works better if you make associations in your mind between the *goal* and the *circumstances* where you want to remember it. For example, if you want to remember to buy bread when you go to the shops later on, you should try to imagine yourself walking through the bakery section and putting a loaf of bread in your basket while forming this goal. This will make it much more likely that you'll remember to buy bread when you actually *are* walking through the bakery section. The lucid dreaming technique described below works in the same way, except instead of forming the goal to buy bread, you form the goal to *notice that you are dreaming* next time you're in a dream.

How to do the technique

4) Set an alarm so that you will **wake up 5 hours after you go to bed** (do not practise the technique at the start of the night). Put the alarm somewhere where you have to get out of bed to turn it off.

5) When the alarm goes off turn on the light, get out of bed and turn off the alarm. Then, jump back into bed (with the light still on), sit upright (don't lie down) and try to **remember a dream from just before you woke up**. Spend a minute or two on this, and try to recall as many details as possible. If you can't remember a dream, just recall any dream that you had recently.

6) If you need to go to the toilet, do so now.

7) Turn off the lights, lie in a comfortable position and concentrate single-mindedly on your intention to remember to recognise that you're dreaming. **Tell yourself: "Next time I'm dreaming, I will remember I'm dreaming,"** repeatedly, like a mantra. Don't just repeat it mindlessly though – you need to put real meaning into the words and focus on your intention to remember. If you find yourself thinking about anything else, let it go and bring your mind back to your intention. Try to stay still and avoid moving (but if you do need to move, that's OK).

8) While you're doing step 4, **also imagine that you are back in the dream you just recalled** (at step 2) and that you notice something bizarre or impossible that happened. See yourself realising that you're dreaming in response to this, and then doing a reality test (described on the Daytime Lucid Dreaming Technique sheet).

9) **Repeat steps 4 and 5 until you either fall asleep or are sure that your intention is set**. If you find yourself thinking of anything else, repeat the procedure so that the last thing in your mind before falling asleep is your intention to remember to recognise the next time you are dreaming.

As you practise, you might start to enter a pre-sleep state known as *hypnagogia* (this is described in the "Transitional Experiences" document you were given). If you do, you might see colours, patterns or images, hear things that aren't there or experience unusual physical sensations. You may also find that you start having random thoughts that don't follow any logical pattern. These are all good signs and mean that you are close to falling asleep. Simply relax and observe passively. If all goes well, you'll fall asleep while you're still doing the technique and then find yourself in a dream, at which point you'll remember to notice that you're dreaming. If it takes you a long time to fall asleep, don't worry – the longer you spend on doing the technique, the more likely you are to have a lucid dream when you eventually return to sleep!

Appendix G: Quantity Logbook Front Cover and Sample Page

Participant ID number__________________ **Admin code: 2MI**

Logbook – Week 2

Please keep this logbook and a pen beside your bed and be sure to fill it out first thing each morning (before you get out of bed or do anything else to start your day). If you are not sure of an exact answer, please provide your best estimate. Do not provide descriptions of amounts in your answers. For example, when reporting how much time you spent sleeping last night, provide an exact estimate such as “7 hours and 45 minutes”, not “nearly 8 hours” or “a bit less than usual”. Please try to answer all of the questions as completely as possible. However, if there are any questions that make you feel uncomfortable, you do not have to answer them.

Week 2 – Day 1

Date (this morning) ....

General dream details

- Did you spend any time thinking about or trying to recall your dreams before filling in this logbook?
  Yes ☐ **No** ☐ If "Yes", how much time?.............**minutes.**
- Can you recall anything *specific* about your dreams from last night? **Yes** ☐ **No** ☐
- If you answered "Yes", please provide a brief title for each dream you can remember. Then, rate the amount of content you can recall from each individual dream using the following categories. Please be as thorough as possible and rate *all* of the dreams that you can recall.

Fragmentary (F): You recall some content (such as a single scene or an isolated image), but not enough to provide any "flow" in the narrative. There are no transitions from one scene or event to the next.

Partial (P): You recall enough content for there to be some "flow" in the narrative from one scene or event to the next. However, you're pretty sure that *most of the dream has been forgotten*.

Majority (M): You recall a substantial amount and you're pretty sure you can recall *at least half* of the dream. However, there are frustrating gaps indicating that a significant amount is still missing.

Whole (W): Fairly complete recall of the dream without any frustrating gaps in your memory of what happened (although the beginning of the dream and some details might still be missing).

Dream #1 ____ Rating: ______________
Dream #2 ____ Rating: ______________
Dream #3 ____ Rating: ______________
Dream #4 ____ Rating: ______________
Dream #5 ____ Rating: ______________
Dream #6 ____ Rating: ______________
Dream #7 ____ Rating: ______________

- How long did it take for you to provide brief titles and ratings for your dreams?.............**minutes.**
- On a scale of **1** to **5**, how much do you recall of your dreams from last night?

1	**2**	**3**	**4**	**5**
nothing specific	*hardly anything*	*a small amount*	*a moderate amount*	*a large amount*

- On a scale of **1** to **5**, how difficult was it for you to remember your dreams from last night?

1	**2**	**3**	**4**	**5**
not at all difficult	*slightly difficult*	*somewhat difficult*	*quite difficult*	*very difficult*

- On a scale of **1** to **5**, how clear are your memories of your dreams from last night?

1	**2**	**3**	**4**	**5**
not at all clear	*slightly clear*	*somewhat clear*	*quite clear*	*very clear*

Please turn over for additional questions

Practice details

- What time did the alarm wake you up to do the lucid dreaming technique?..
- Were you in the middle of a dream when the alarm woke you up to do the technique?

  Yes ☐ **No** ☐ **Unsure** ☐

- On a scale of **1** to **5**, how motivated did you feel about doing the technique after the alarm went off? (please circle a number)

1	**2**	**3**	**4**	**5**
not at all motivated	*slightly motivated*	*somewhat motivated*	*quite motivated*	*very motivated*

- How long (approximately) did you spend on doing the technique?.................**minutes.**
- How many times (approx) did you repeat "next time I'm dreaming, I will remember I'm dreaming"?........
- On a scale of **1** to **5**, how difficult was it to focus on the technique? (please circle a number)

1	**2**	**3**	**4**	**5**
not at all difficult	*slightly difficult*	*somewhat difficult*	*quite difficult*	*very difficult*

- Did you fall asleep while you were still trying to do the technique? **Yes** ☐ **No** ☐
- If you answered "No" to the above question, how long (approximately) did it take for you to get to sleep after you stopped doing the technique?.................**minutes.**
- How many reality tests did you perform **yesterday**? (try to be as accurate as possible) ....

Other details

- How much time in total do you think you spent sleeping last night?............**hours,**............**minutes.**
- On a scale of **1** to **5**, what was the overall quality of your sleep last night? (please circle a number)

1	**2**	**3**	**4**	**5**
terrible	*poor*	*okay*	*good*	*excellent*

- On a scale of **1** to **5**, how tired do you feel this morning? (please circle a number)

1	**2**	**3**	**4**	**5**
not at all tired	*slightly tired*	*somewhat tired*	*quite tired*	*very tired*

- On a scale of **1** to **5**, how sleep deprived were you **yesterday**? (please circle a number)

1	**2**	**3**	**4**	**5**
not at all	*slightly*	*somewhat*	*quite*	*very*

- Did you do any meditation **yesterday**? **Yes** ☐ **No** ☐
- If "Yes" above, what type of meditation?.. For how long?...........**minutes.**
- Did you drink any alcohol **yesterday**? **Yes** ☐ **No** ☐ If "Yes", how many drinks?.........**drinks.**
- Did you consume any marijuana **yesterday**? **Yes** ☐ **No** ☐
- Did you have any lucid dreams last night? (lucid dreams are those in which a person becomes aware of the fact that he or she is dreaming <u>while the dream is still ongoing</u>) **Yes** ☐ **No** ☐
- Did your lucid dream happen *before* or *after* practising the technique? **Before** ☐ **After** ☐
- Approximately what time did the lucid dream happen? (if unsure, just leave blank)............................
- How long (approximately) do you think you were lucid dreaming?.................**minutes.**

If you had any lucid dreams (or any other interesting experiences), please write them down using the blank pages provided. Include the date at the top of the page and try to be as detailed and descriptive as possible.

Appendix H: Email Invitation for the SSILD Technique Trial

Dear Research Participant,

Thank you for completing our study on lucid dreaming! We are emailing you because we would like to invite you to trial a new lucid dreaming technique. Many people have reported success with this technique, but it has not yet been studied scientifically. The technique is similar to mindfulness meditation and involves focussing your awareness on vision (with eyes closed), hearing and bodily sensations for about 20 seconds each. This is done several times in a row and takes about 10 minutes to complete. The technique is practised in the early hours of the morning (after 5 hours of sleep) and conditions your mind and body into a subtle state that is optimized for lucid dreams to occur. You then return to sleep after doing the technique.

The procedure for trialling the new technique is basically the same as Week 2 of the main study you have already completed and goes for seven days. You will be sent all the materials you need in the mail. You will be asked to practise the technique and then fill out a logbook the following morning for seven nights. You will also be asked to practise reality testing (in the same way as in Week 2 of the main study). There is no online questionnaire and you will not be asked to complete a baseline period of logbook keeping.

Unfortunately, we cannot offer any financial incentive to trial the new technique. However, you will be sent a summary of the results so that you can share in what we learn. More importantly, you will be making a valuable contribution to knowledge in this area, which we hope will ultimately make lucid dreaming more accessible to everyone.

If you would like to trial the new technique, please reply to this email with your name and postal address and we will send you the materials in the mail. If you have any questions, feel free to ask me via email. Alternatively, you can call me on 0431 124 329.

Yours sincerely,
Denholm

Appendix I: General Instructions for the SSILD Technique Trial

Overview and instructions:
Additional technique

Thank you for your continued participation in these studies of lucid dreaming! The additional lucid dreaming technique you have been sent is a new technique that has not yet been studied scientifically. In the coming week, we ask that you also perform reality tests just like in Week 2 of the main study that you completed earlier. Full instructions on how to do reality tests and the new technique are enclosed. These instructions are similar to the instructions that you were given for the main study, but please be sure that you still read over them just as thoroughly as you did for the main study. You should have received the following:

- Overview and Instructions (this page)
- Lucid Dreaming Technique sheets
- Logbook
- Blank Pages (to write down lucid dreams or other interesting experiences)
- Transitional Experiences document (for your information)

Try to practise the technique for seven days *in a row*, although it's better to skip a day if you are feeling very sleep deprived. Even if you don't do them consecutively, **please try to do all seven days as quickly as possible.**

To maximise your chances of having lucid dreams, please follow the instructions on the other side of this page as closely as possible. However, you don't have to withdraw from the study if you don't follow the instructions perfectly, because any data you contribute – even if incomplete – will still be valuable. Furthermore, if you don't follow the instructions perfectly, it is vitally important that you tell us in your answers to the logbook questions. The validity of our results depends on you providing us with the most accurate data possible!

When you have practised the techniques on seven different days, place your logbook and any blank pages that you used into the yellow reply-paid envelope provided, seal it shut and then place it in any Australia Post post-box. You can keep the other sheets that came in the package such as the lucid dreaming technique sheets.

If you have any questions or difficulties, please feel free to contact me:
Email: denholm.aspy@adelaide.edu.au **Phone:**

Lucid dreaming instructions

During the day

- Perform a minimum of 10 reality tests each day using the instructions on the Daytime Lucid Dreaming Technique sheet. The more often you do reality tests the better.

Just before bed

- Just before you go to bed, read the Nighttime Lucid Dreaming Technique sheet and familiarise yourself with what you need to do later in the night.
- Set an alarm so that you will wake up 5 hours after you go to bed. Put the alarm somewhere where you have to get out of bed to turn it off, such as on a desk at the other end of the room. This is very important! If you put it on your bedside table you might end up reaching for the alarm, turning it off and then simply going back to sleep without doing the technique! Getting out of bed will help wake you up a little bit and prevent this problem from occurring.
- I also recommend that you either go to sleep 15-30 minutes early, or give yourself an extra 15-30 minutes to sleep in tomorrow morning. This will help ensure that you get as much sleep as you usually would.

When you wake up after 5 hours of sleep

- Do the nighttime technique using the instructions on the Nighttime Lucid Dreaming Technique sheet.

When you wake up in the morning

1. When you've finished sleeping for the night, stay in bed and spend at least 5-10 minutes trying to remember as many details from as many dreams as you can. This is important because the more familiar you are with your dreams the easier it will be for you to realise when you're dreaming and have lucid dreams. We usually forget dreams very quickly, so make sure this is the very first thing you do in the morning. The following tips will help:

    - Make sure you lie in the same position as when you first woke up when trying to remember your dreams. This tip alone will make it much easier to remember them.
    - Don't let your mind wander to other things (such as your plans for the rest of the day).
    - If you can only remember a small fragment of a dream, focus on it and try to recall what happened directly before it, and then before that, replaying the dream in reverse. Sometimes you can remember a long and detailed dream using this strategy.
    - If you can't remember anything, ask yourself: "what was I *just* doing?" If you keep trying, you will usually start to remember something. Be patient and don't give up too quick!

2. After you've remembered as many dreams as you can, fill out your logbook.
3. If you had a lucid dream, write it down using the blank pages provided.

Appendix J: SSILD Technique Instructions Sheet

Nighttime Lucid Dreaming Technique

This technique conditions your mind and body into a subtle state that is optimized for lucid dreams to occur. It involves performing a number of "cycles". **One** complete cycle involves **three** steps:

Step 1. Focus on Vision: Close your eyes and focus all your attention on the darkness behind your closed eyelids. Keep your eyes completely still and totally relaxed. You might see coloured dots, complex patterns, images, or maybe nothing at all. It doesn't matter what you can or cannot see – just pay attention in a passive and relaxed manner and don't "try" to see anything.

Step 2. Focus on Hearing: Shift all of your attention to your ears. You might be able to hear the faint sounds of traffic or the wind from outside. You might also be able to hear sounds from within you, such as your own heartbeat or a faint ringing in your ears. It doesn't matter what, if anything, you can hear – just focus all of your attention on your hearing.

Step 3. Focus on Bodily Sensations: Shift all of your attention to sensations from your body. Feel the weight of the blanket, your heartbeat, the temperature of the air, etc. You might also notice some unusual sensations such as tingling, heaviness, lightness, spinning sensations, and so on. If this happens simply relax, observe them passively and try not to get excited.

How to do the technique

1) Set an alarm so that you will **wake up 5 hours after you go to bed**. (Do not practise the technique at the start of the night). Put the alarm somewhere where you have to get out of bed to turn it off.
2) When the alarm goes off turn on the light, get out of bed and turn off the alarm. Go to the toilet if you need to. Then, jump back into bed and **read the information on the next page** (the page entitled "What to do if you have a lucid dream"). This step is important – not only will it remind you of what to do if you have a lucid dream; it will also wake you up a bit so that you don't fall asleep too soon.
3) Turn off the lights, lie in a comfortable position and **perform 4 fast cycles**. This is a warm-up exercise, and you should only spend **two or three seconds** on each sense (vision, hearing and bodily sensations). Try to stay still and avoid moving, but if you do need to move that's OK.
4) This step is the most important one. **Perform 4 to 6 slow cycles** and spend about **20 seconds** on each sense. Don't try to count the seconds as they pass – just move to the next sense when you think that *approximately* 20 seconds has passed.
5) It's good if you fall asleep while you're still doing the technique. However, **it's important that you complete at least 4 slow cycles**. If you complete all 6 slow cycles and are still awake, then simply go to sleep as you normally would.

If it takes more than a few minutes to fall asleep after doing all 6 slow cycles, try skipping the step where you read the information on the next page. If you find you are still too alert, try keeping the light off and putting the alarm by your bed so you don't have to get up. If you are falling asleep too *soon* (before completing at least 4 slow cycles), try staying awake (with the light on) for a little longer before doing the technique. You may need to experiment to find the right level of wakefulness. As you do the technique, you might see colours, patterns or images, hear things that aren't there or experience unusual physical sensations. You may also start having random thoughts that don't follow any logical pattern. These are all good signs and mean that you are close to falling asleep. Simply relax and observe passively. If you forget which step you are up to in the cycle, that’s OK – just start again from the beginning. Be sure to avoid the common mistake of "trying too hard" during the cycles. People often want to see things, hear things, and feel things. When nothing unusual happens they get discouraged and think the technique isn’t working. Try *not* to expect anything unusual – just follow the instructions above and let the results take care of themselves!

Appendix K: Information Provided to Participants About Sleep Paralysis

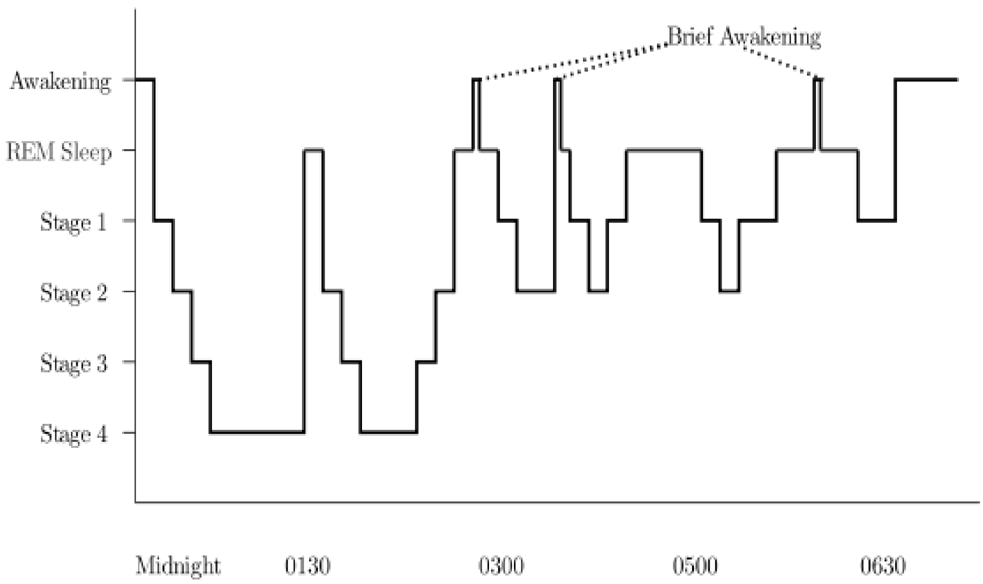
Transitional experiences:
Hypnagogia and sleep paralysis

Introduction

Hopefully, you will get to experience lucid dreaming by practising this technique. However, there are several other things that can happen as a result of practising a lucid dreaming technique and it's important that you are aware of them. This handout begins with some background information about sleep stages, and then describes a transitional state called *hypnagogia* that can occur while we are falling asleep. After that, a phenomenon called *sleep paralysis* is described. Because sleep paralysis can be a frightening experience, you will then be given strategies for avoiding it and what to do in the unlikely event that it happens to you.

Background information – sleep stages

Every night we go through several different types of sleep, or "sleep stages". For the study you are participating in, the most important of these stages is *Rapid Eye Movement* (REM) sleep. This is where most of our dreams occur and we have several periods of REM sleep every night. As you can see from the diagram below, it takes quite a while for us to enter our first REM period each night (usually about 1.5 hours) and it usually only lasts for a few minutes. However, later on in the night we have much *longer* REM periods. Furthermore, if we wake up in the middle of the night and then go back to sleep, we usually enter REM sleep much *faster* than we did at the start of the night. This means that we start dreaming more quickly and for longer periods of time later on in the night, which is why it's much better to practise lucid dreaming techniques after several hours of sleep.



Hypnagogia

When we are falling asleep we sometimes experience a state known as *hypnagogia*. This transitional state occurs when we are on the verge of falling asleep and is especially common after a brief awakening later on in the night (because at these times we enter REM sleep more quickly). Hypnagogia usually involves dream-like experiences such as seeing colourful patterns or images, hearing things that aren't there or feeling unusual physical sensations. If you're like most people, you've probably experienced hypnagogia before. It is completely natural, harmless, and very common. In fact, people who try to have lucid dreams generally *want* hypnagogia to occur while they practise lucid dreaming techniques because it means that dreaming is just around the corner. Hypnagogia isn't anything to worry about, so if you have experiences like those described above, simply relax and observe passively. You will probably fall asleep very soon and you might even have a lucid dream!

Sleep paralysis

During REM sleep most of our voluntary muscles become temporarily disabled so that we don't act out our dreams in waking life. This usually happens *after* we fall asleep, which means that we usually don't experience it consciously. However, on rare occasion it can happen while we are still awake. When this happens it is called *sleep paralysis*, and it involves being awake and aware of the room around you while being unable to move or speak. Vivid auditory and visual hallucinations can also occur, which are thought to result from the same processes that produce dreams during REM sleep. Indeed, sleep paralysis can be understood as a state of being both awake and dreaming at the same time. People often become quite frightened during sleep paralysis, especially if they don't know what's going on. Perhaps because they are frightened, people sometimes (but not always) have hallucinations that involve intruders such as people or animals in the room and sometimes even attacking them. Unusual physical sensations like tingling, floating and difficulty breathing are also sometimes reported.

Sometimes frightening, but otherwise harmless

Sleep paralysis is a common and naturally occurring phenomenon – it's estimated that between 20% and 60% of people will experience it at least once in their lives (you may have even experienced it already). Although it can be frightening, it's important to remember that it is otherwise completely harmless and poses no medical risk. It almost always only lasts for a minute or two at the most, and sometimes for only a matter of seconds. It can happen at two different times – while you're waking up, and also when you're falling asleep. The first kind (while waking up) is the most common and also the most frightening. Fortunately, participating in this study shouldn't make this kind of sleep paralysis any more likely. The other kind of sleep paralysis can sometimes happen if you keep your mind active while falling asleep, especially if you do this later on in the night when you enter REM sleep more quickly. By participating in this study, you might have a slightly increased chance of experiencing this kind of sleep paralysis. This is because study involves engaging your mind (doing a lucid dreaming technique) after several hours of sleep (when you're likely to enter REM sleep more quickly).

How big is the risk?

The risk of you experiencing sleep paralysis is expected to be very low. The study has been reviewed and approved by the University of Adelaide Human Research Ethics Committee (approval number H-2013-083). I have personally spent years attempting various lucid dreaming techniques and I have never experienced sleep paralysis as a result. Furthermore, there have been about 35 scientific studies over the last 30 years where participants were taught to have lucid dreams. Sleep paralysis was reported in only one of these studies. That study involved a very advanced kind of lucid dreaming technique where the participants tried to enter a lucid dream *directly* by keeping their mind active and remaining conscious until they were actually inside of a dream. This kind of technique basically involves *trying* to experience sleep paralysis. It is also extremely difficult – even when people try their very hardest to keep their minds active, they usually end up falling asleep just like normal. This is because it is actually *very difficult* to keep the mind active long enough to experience the process of falling asleep. My study doesn't involve this kind of advanced lucid dreaming technique. Although you will be asked to keep your mind active just *before* you fall asleep, you will probably either finish the technique and go to sleep like usual, or you will be so tired that you fall asleep before finishing it (and without experiencing sleep paralysis). But even though the risk is very low, please still read the following two sections.

Strategies for avoiding sleep paralysis

One of the best things you can do to minimise your chances of having sleep paralysis is to maintain a healthy sleeping pattern. Try to get at least 8 hours of sleep every night and avoid any unnecessary disruptions to your sleep. You should allow some extra time in the morning to catch up on any sleep you lose as a result of waking up to do the lucid dreaming technique. I also recommend that you avoid lying on your back while you're doing the lucid dreaming technique, because sleep paralysis usually occurs when people are lying on their back. If this is your preferred sleeping position, simply practise the technique on your side or your stomach, and then roll onto your back when you have finished the technique.

What to do if you *do* experience sleep paralysis

In the unlikely event that you do experience sleep paralysis, there are several things you can do to make the experience less frightening and to help it end quickly:

- The most important thing to do is to stay calm and don't panic. Make sure that you don't struggle to move your body as this can prolong the experience.
- Remember that sleep paralysis is totally harmless. Try repeating to yourself "this is harmless and will soon end" until it's over – it won't take long.
- Breathing in a controlled manner will help you stay calm. Try to make your breathing slow and deep – taking about 5 seconds to inhale and 5 seconds to exhale is ideal. The experience will end quicker if you can relax (but either way it won't go for very long).
- Try making small movements with your fingers or toes. These parts of the body usually aren't completely paralysed, and moving them can help to free up the rest of your body.
- If this doesn't work, try coughing. The muscles involved in breathing are never paralysed, and coughing can sometimes jolt you out of sleep paralysis.
- Sleep paralysis doesn't always involve unusual sensations or hallucinations, but sometimes it does. If you experience things like this, try to adopt an attitude of curiosity rather than fear – it might end up being a very interesting experience and not frightening at all!
- If you *do* have frightening sensations or hallucinations, remember that no matter how realistic they are, they're just harmless figments of your imagination (like dreams). Another thing that can help is to think about something that makes you feel happy and safe, such as someone who loves you or someone who you look up to.

Remember that although your participation is greatly appreciated, you are free to withdraw at any time and for any reason.

Appendix L: Safety Review of B Vitamins for the B Vitamin Study Ethics Application

Most of the B vitamins are very well tolerated and carry minimal risk of adverse effects. The dosages of B vitamins to be used in the present study are all within safe levels that can be found in various over the counter vitamin supplement preparations in Australia. Notwithstanding, information on the risks associated with each of the B vitamins to be administered in the proposed study is provided in this section. The section begins with a presentation of the dosages of the different B vitamins found in a range of vitamin B complex preparations that are available from Australian pharmacies. These are presented in Table 1 below, alongside the dosages of each B vitamin that will be used in the present study. Note the vitamin B2 (riboflavin) will not be administered in the present study. The reason for this is that riboflavin has the effect of imparting a bright yellow colour to urine, which would make it obvious to participants that they are not in the placebo or pyridoxine hydrochloride only condition. Information relevant to the risks associated with taking each of the B vitamins and related substances to be used in the present study is then presented. This information is copied from the Nutrient Reference Values for Australia and New Zealand (National Health and Medical Research Council, 2006) and from proffessional monographs prepared by Natural Medicines (formerly Natural Standard and Natural Medicines Comprehensive Database). Please see the referenced documents for full lists of references referred to in the excerpts provided below. Finally, a more in-depth review of ethical considerations related to vitamin B6 is presented. This is because the risks associated with taking vitamin B6 at the dosage proposed for the present study are greater than for any of the other B vitamins and related substances.

Table 1

Dosages of various B vitamins used in a selection of vitamin B complex preparations available in Australia, and comparison with the dosages to be used in the proposed study.

	Cenovis B Complex	Nature's Own Super B Complex	Golden Glow Super B + C	Blackmores Mega B Complex	Ethical Nutrients Super B Daily Stress +	Swisse Ultiboost Mega B +	Eagle TRESOS Activated B PluSe	Pure Innovation Activated B Complex	Dosages to be used in the proposed study
Thiamin hydrochloride (vitamin B1)	-	-	-	50mg	75mg	-	50mg	50mg	75mg
Thiamin nitrate (vitamin B1)	15mg	50mg	50mg	-	-	150mg	-	-	-
Riboflavine (vitamin B2)	15mg	25mg	25mg	30mg	50mg	20mg	20mg	20mg	-
Nicotinamide (vitamin B3)	30mg	50mg	50mg	100mg	100mg	200mg	220mg	80mg	200mg
Nicotinic acid (vitamin B3)	-	-	-	-	-	-	5mg	20mg	-
Calcium pantothenate (vitamin B5)	8mg	50mg	50mg	50mg	100mg	150mg	100mg	164mg	150mg
Pyridoxine hydrochloride (vitamin B6)	5mg	50mg	50mg	50mg	50mg	50mg	50mg	20mg	240mg
Pyridoxal 5-phosphate (vitamin B6)	-	-	-	-	-	-	-	10mg	-
Biotin (vitamin B7)	-	50µg	50µg	50µg	-	40µg	150µg	500µg	40µg
Folic acid (vitamin B9)	150µg	200µg	200µg	300µg	200µg	400µg	400µg	-	400µg
Calcium folinate (vitamin B9)	-	-	-	-	-	-	-	500µg	-
Cyanocobalamin (vitamin B12)	10µg	50µg	50µg	50µg	200µg	60µg	100µg	500µg	500µg
Inositol	-	50µg	50µg	50mg	-	25mg	25mg	100mg	25mg
Choline Bitartrate	-	50µg	50µg	50mg	-	25mg	40mg	100mg	100mg

Note. Eagle TRESOS Activated B PluSe and Pure Innovation Activated B Complex are practitioner only formulations. All other formulations are available over the counter from Australian pharmacies. Some of the above formulations contain additional ingredients such as vitamin C.

As can be seen in Table 1, with only one exception the dosages of each substance to be administered in the present study do not exceed those that can be found in various other vitamin B complex preparations. The exception to this is Vitamin B6 (pyridoxine hydrochloride). The dosage of 240mg pyridoxine hydrochloride is used because the previous study on the effects of pyridoxine hydrochloride on dreaming used a high dosage of 250mg and the present study seeks to replicate this study. A slightly lower dose of 240mg will be used in the present study because 240mg pyridoxine hydrochloride is equivalent to 197mg of pyridoxine and is thus below the No Observed Adverse Effects Level (NOAEL) of 200mg pyridoxine established in the Nutrient Reference Values for Australia and New Zealand (National Health and Medical Research Council, 2006). Preparations of vitamin B6 containing up to 240mg of pyridoxine hydrochloride and approved by the Therapeutic Goods Administration are available over the counter in Australian pharmacies, such as Blackmores Vitamin B6 (240mg pyridoxine hydrochloride). Note also that the dosage of vitamin B12 to be used in the present study is relatively high and is only found in one of the vitamin B complex preparations presented in Table 1, which is a practitioner only preparation. However, over the counter preparations that contain only vitamin B12 frequently contain much more than this, such as Swisse Ultiboost High Strength Vitamin B12 (1000µg cyanocobalamin), Nature's Own Vitamin B12 (1000µg cyanocobalamin) and Thompson's Ultra B12 (1000µg cyanocobalamin). The dosage of vitamin B12 to be used in the present study is 500µg cyanocobalamin, which is half of that found in these three preparations. Note that Inositol and Choline are no longer considered vitamins. However, Inositol was once described as vitamin B4 and choline was once described as vitamin B8. Both of these substances are closely related to the other B vitamins, work synergistically with them, and are typical ingredients in vitamin B complex preparations.

Vitamin B1: Thiamin

Excerpt from the Nutrient Reference Values for Australia and New Zealand:

> The upper level of intake of thiamin cannot be estimated. There are no reports of adverse effects from consumption of excess thiamin by ingestion of food but there were reports from the 1940s of sensitivity to continuous high doses of oral thiamin in fortified foods or supplements (Laws 1941, Leitner 1943, Stein & Morgenstern 1944, Stiles 1941). There have also been reports of anaphylaxis and death after inappropriate parenteral administration (Reingold & Webb 1946, Schiff 1941, Stephen et al 1992) and of allergic sensitivity and pruritis with intramuscular administration (Royer-Morrot et al 1992, Wrenn et al 1989). However, there are insufficient data to estimate a UL. Existing evidence available from clinical studies as well as the long history of therapeutic use indicate that current levels of intake from thiamine from all sources do not represent a health risk for the general population. (National Health and Medical Research Council, 2006)

Thiamine is classified as "LIKELY SAFE ...when used orally and appropriately" in the Natural Medicines professional monograph on thiamine. Thiamine is also described as "generally considered nontoxic, although, rare hypersensitivity reactions have occurred". Adverse effects of taking thiamine are described as "rare and minor".

Vitamin B3: Niacin (as Nicotinamide)

Excerpt from the Nutrient Reference Values for Australia and New Zealand:

Nicotinamide is not a vasodilator (so does not cause the flushing that occurs with nicotinic acid) and has potential therapeutic value (Knopp 2000). For nicotinamide taken in supplemental form, a UL of 900 mg/day for men and non-pregnant, adult women is suggested. This is in line with recommendations from the European Commission (2002). Large doses of nicotinamide (up to 3,000 mg/day for periods of up to 3 years) appear to be well tolerated, as reported in trials on the possible benefits of nicotinamide in patients with, or at risk of developing, diabetes. The NOAEL from these studies is approximately 1,800 mg/day. This value represents the lowest reported dose in a number of high quality trials of (Lampeter et al 1998, Pozilli et al 1995). Many of these used sensitive biomarkers of hepatic function and glucose homeostasis, and included a range of age groups, with some subjects treated with up to 3,600 mg/day. A UF of 2 was used to allow for the fact that adults may eliminate nicotinamide more slowly than the study groups, many of which were children, and that data for children would not refl ect the full extent of intersubject variability that could occur in an older population. There is a lack of data on the safety of nicotinamide in pregnancy and lactation, and no relevant animal data. This level does not therefore apply to pregnant and lactating women. (National Health and Medical Research Council, 2006)

Nicotinamide is classified as “LIKELY SAFE ...when used orally and appropriately” in the Natural Medicines professional monograph on Niacin. Nicontinamide found in dietary supplements is described as “well-tolerated” and is not associated with the flushing reactions that can occur when niacin is taken in the form of nicotinic acid. For this reason, the form of niacin to be used in the proposed study will be nicotinamide. According to the Natural Medicines monograph, nicontinamide “can interfere with blood glucose control requiring dosing adjustment of antidiabetic agents. Niacin and niacinamide can cause hyperglycemia, abnormal glucose tolerance, and glycosuria” and “might exacerbate gallbladder disease.” Furthermore, “niacin and niacinamide have been associated with liver damage. Avoid large amounts in patients with a history of liver disease” and “large amounts of niacin or niacinamide might activate peptic ulcer disease”. This is unlikely to be problematic for the proposed study due to the low dosages of nicotinamide that will be used. Notwithstanding, participants will be excluded if they have diabetes or disease of the gallbladder, kidney or liver.

Vitamin B5: Pantothenic Acid

Excerpt from the Nutrient Reference Values for Australia and New Zealand:

> A UL cannot be determined at this stage. There are no reports of adverse effects of oral pantothenic acid in either humans or animals on which to base a quantitative estimate. Thus a UL cannot be determined at this stage, but current intakes are unlikely to be associated with adverse health effects. (National Health and Medical Research Council, 2006)

Pantothenic acid is classified as "LIKELY SAFE ...when used orally and appropriately" in the Natural Medicines professional monograph on pantothenic acid. Furthermore, "Amounts up to 10 grams have been ingested without significant adverse effects" and **"**Moderate doses have been ingested without reports of significant adverse effects. According to secondary sources, large amounts of pantothenic acid taken by mouth may cause diarrhoea. In theory, nausea and heartburn may occur."

Vitamin B7: Biotin

Excerpt from the Nutrient Reference Values for Australia and New Zealand:

> There is insufficient evidence of adverse effects in humans or animals to set a UL for any age. Two rat studies showed effects on inhibition of fetal and placental growth and resorption of foetuses (Paul & Duttagupta 1975, 1976) but both used very high doses of injected biotin without a control group. The data were therefore not useful for setting human ULs. In *ex vivo* experiments, 600 µg biotin produced a significant reduction of 33% or greater in mitogen-induced proliferation and cytokineresponse of lymphocytes (Zempleni et al 2001). These biomarkers are indicative of a weakened immune response but are not sufficient to allow the setting of a UL. It is unlikely that current levels of intake would be associated with adverse health effects. (National Health and Medical Research Council, 2006)

Biotin is classified as "LIKELY SAFE...when used orally and appropriately" in the Natural Medicines professional monograph on biotin. Furthermore, **"**it is safe at levels typically found in food. Ingestion of pharmacologic doses is considered safe; adverse effects are lacking with single oral (2.1, 8.2, or 81.9mcM) or intravenously administered (18.4mcM) doses that are 600 times the normal dietary intake or with lifelong doses that are 300 times the normal dietary intake". Finally, "Based on a review, supplementation with pharmacological doses of biotin has been associated only with minor side effects, primarily gastrointestinal upset."

Vitamin B9: Folate

Excerpt from the Nutrient Reference Values for Australia and New Zealand:

> No adverse effects have been associated with consumption of the amounts of dietary folate equivalents normally found in foods or fortified foods (Butterworth & Tamura 1989). High supplemental intakes of folic acid have been shown to be related to adverse neurological effects in people with B12 deficiency as they can precipitate or exacerbate the B12 deficiency (Israels & Wilkinson 1949, Schwartz et al 1950, Spies et al 1948, Will et al 1959). General toxicity (Hunter et al 1970), increased carcinogenesis (Selby et al 1989) and adverse reproductive and developmental effects have also been reported (Czeizel & Dudas 1992, Czeizel et al 1994, Holmes-Siedle et al 1992, Kirke et al 1992, Lawrence et al 1981, Mukerjee et al 1984, Smithells et al 1981, Vergel et al 1990, Wald et al 1991). In line with the FNB:IOM (1998) findings, setting of the LOAEL was based on the neurological effects seen with B12 deficiency, as this is a fairly common deficiency in the population and as these data have some dose-response characteristics. A LOAEL of 5 mg/day was set on the basis of the studies described above, as there were 100 cases of neurological damage above this level but only 8 below. A UF of 5 was used as the dose-response data were not well controlled, the adverse effects are severe and a LOAEL only, rather than a NOAEL, was available. The UL was therefore estimated to be 1 mg folic acid (1,000 μg)/day for adults. There are no data to suggest increased susceptibility in pregnancy or lactation, so the adult UL was applied to these groups as well. There is little direct evidence for other ages, so the UL was set on a relative body weight basis for children and adolescents. It was not possible to set a UL for infants. (National Health and Medical Research Council, 2006)

Folic acid is classified as "LIKELY SAFE ...when used orally or parenterally and appropriately" in the Natural Medicines professional monograph on folic acid. Furthermore, "folic acid is safe when used in doses less than 1000 mcg per day" and "folic acid is well-tolerated in amounts found in fortified foods and supplements."

Vitamin B12: Cyanocobalamin

Excerpt from the Nutrient Reference Values for Australia and New Zealand:

> There are insufficient data to allow setting of a UL. There is no evidence that the current levels of intake from foods and supplements represent a health risk. No adverse effects have been associated with excess vitamin B12 intake from food or supplements in healthy individuals. There is weak evidence from animal studies that vitamin B12 may potentiate the effects of carcinogenic chemicals (Day et al 1950, Georgadze 1960, Kalnev et al 1977, Ostryanina 1971) but other studies contradict this (Rogers 1975). The apparent lack of toxicity could relate to the body's ability to decrease absorption in response to high intakes. As there are no dose-response data, no UL can be set. (National Health and Medical Research Council, 2006)

Vitamin B12 is classified as "LIKELY SAFE ...when used orally, topically, intravenously, or intranasally and appropriately" in the Natural Medicines professional monograph on vitamin B12. Furthermore, "vitamin B12 is generally considered safe, even in large doses."

Inositol

The Nutrient Reference Values for Australia and New Zealand (National Health and Medical Research Council, 2006) does not provide any information on inositol becasue inositol is no longer considered an essential nutrient. This is due to the fact that the body is able to produce sufficient amounts endogenously. Inositol is classified as "POSSIBLY SAFE ...when used orally and appropriately" in the Natural Medicines professional monograph on inositol. Furthermore, "inositol has been used in amounts up to 12 grams per day for up to 4 weeks, and 6 grams daily for 10 weeks with no significant adverse effects." Also, "orally, inositol is generally well tolerated. It can cause nausea, tiredness, headache, and dizziness."

Choline

Excerpt from the Nutrient Reference Values for Australia and New Zealand:

> The data used to set the UL included a single case report of hypotension and several studies involving cholinergic effects and body odour effects after large choline doses. There are no data to establish a NOAEL. A LOAEL of 7.5 g/day was derived from the study of Boyd et al (1977) of seven dementia patients receiving choline therapy and reports of hypotension, cholinergic responses and fishy body odour in other patients undergoing treatment (Gelenberg et al 1979, Growdon et al 1977a,b, Lawrence et al 1980). In these studies, intakes of 4 g/day showed no effect in terms of hypotension, nausea, diarrhoea or other cholinergic effects but at 7.5 g/day or over, these effects were reported in some patients. A UF of 2 was selected because of limited data, giving a UL of 3.5 g/day (3,500 mg/day) after rounding down. There are no data to suggest that during pregnancy or lactation, there is increased susceptibility, so the same UL was set. For infants, there were no data on which to set a UL. The only source should be breast milk, formula and food. For older children and adolescents, the UL was set on a body weight basis from the adult value, and rounded down. (National Health and Medical Research Council, 2006)

Choline is classified as “LIKELY SAFE ...when used orally and appropriately” in the Natural Medicines professional monograph on choline. It is further classified as “POSSIBLY UNSAFE ...when used orally in excessive doses. High doses can increase the risk of adverse effects. Tell patients not to exceed 3.5 grams per day for adults over age 18.” Also, “Choline is generally regarded as safe and appears to be well tolerated.”

Vitamin B6

Vitamin B6 refers to a group of six water-soluble compounds that are essential for human life. The six different forms (vitamers) of vitamin B6 are pyridoxine, pyridoxine 5'-phosphate, pyridoxal, pyridoxal 5'-phosphate pyridoxamine and pyridoxamine 5'-phosphate (Institute of Medicine Food and Nutrition Board, 1998; McCormick, 2006). Vitamin B6 is involved in more than 100 enzyme reactions, with most of these involving the metabolism of amino acids, carbohydrates and lipids. Thus, Vitamin B6 plays an important role in energy production in humans (Institute of Medicine Food and Nutrition Board, 1998; Mackey, Davis, & Gregory, 2005). Vitamin B6 also plays an important role in the biosynthesis of neurotransmitters including serotonin, dopamine, epinephrine, norepinephrine and gamma-aminobutyric acid (Combs, 2008; Institute of Medicine Food and Nutrition Board, 1998; Mackey et al., 2005; Pfeiffer, 1975; Wyatt et al., 1970). According to the Nutrient Reference Values for Australia and New Zealand (National Health and Medical Research

Council, 2006), the Recommended Dietary Intake (RDI) of vitamin B6 in adults is between 1.3 and 1.7mg per day depending on age and gender. Vitamin B6 is abundant in most diets and occurs in particularly high concentrations in meat, eggs, milk, whole-grain cereals, nuts, vegetables such as chickpeas and potatoes and some fruits including bananas and avocados (Institute of Medicine Food and Nutrition Board, 1998; Mackey et al., 2005). Many foods are also fortified with vitamin B6 such as breakfast cereals that are low in whole grains. For these reasons, vitamin B6 deficiency is uncommon in Australia (National Health and Medical Research Council, 2006). However, some populations are at increased risk of deficiency, including pregnant women and people that are alcohol dependent or obese (Institute of Medicine Food and Nutrition Board, 1998; Lumeng & Li, 1974). Vitamin B6 deficiency is also more common among people with impaired renal function, rheumatoid arthritis, malabsorptive autoimmune disorders such as inflammatory bowel disease, celiac disease, Chron’s disease and ulcerative colitis (Mackey et al., 2005) and certain genetic diseases such as homocystinuria (McCormick, 2006). Some medications can lead to deficiency over time, such as the antiepileptic drugs valproic acid, phenytoin and carbamazepine (Apeland, Froyland, Kristensen, Strandjord, & Mansoor, 2008; Clayton, 2006) and the drug theophylline, which is used in the treatment of asthma and other respiratory diseases (Bender, 1999; Natural Medicines, 2014). For people taking these medications, supplemental vitamin B6 may be indicated.

Adverse effects have not been reported for high intakes of vitamin B6 through dietary sources alone (Institute of Medicine Food and Nutrition Board, 1998). However, adverse effects associated with taking vitamin B6 supplements (typically in the form of pyridoxine hydrochloride) are well documented. The primary concern is sensory neuropathy leading to pain and ataxia (loss of control of bodily movements), although other adverse effects including photosensitivity, headache, sleepiness and gastrointestinal problems such as heartburn, loss of appetite, nausea and vomiting can also occur. These effects are typically only observed with very high intakes of supplemental pyridoxine of at least 500mg per day and more typically between 1000-6000mg per day taken for periods of at least 12 months. Symptom severity appears to be dose dependent and symptoms are typically reversible upon cessation of pyridoxine supplementation (Bender, 1999; Bendich & Cohen, 1990; Gdynia et al., 2008; Institute of Medicine Food and Nutrition Board, 1998; Perry, Weerasuriya, Mouton, Holloway, & Greig, 2004; Simpson, Bailey, Pietrzik, Shane, & Holzgreve, 2010).

Schaumburg et al. (1983) observed severe sensory neuropathy in seven adults after taking doses of pyridoxine that started at 50-100mg per day and were then increased to 2000-6000mg per day over 2 to 40 months. However, sensory neuropathy did not occur at doses of less than 2000mg per day. In a study by Bernstein & Lobitz (1988), 70 participants were given doses of 100-150mg per day for up to five years and no adverse neurological effects were observed despite rigorous neurological testing. Similar results were reported in a study by Del Tredici, Bernstein and Chin (1985), in which 24 participants were given between 100mg and 300mg per day for four months. In a survey conducted by Dalton and Dalton (1987) it was found that participants who reported adverse effects from pyridoxine had been taking supplements for an average of 2.9 years and those who experienced no adverse effects had been taking them for an average of 1.9 years. Symptoms disappeared completely for all participants once they had stopped taking supplements for six months. In a systematic review of randomised placebo-controlled trials investigating the therapeutic effects of pyridoxine for morning sickness in pregnant women by Wyatt, Dimmock, Jones and O'Brien (1999), no conclusive evidence of vitamin B6 toxicity was found. The dosages used in the nine studies included in the review ranged from 50mg to 600mg per day for up to four months and only one participant out of 934 included in the analysis reported neurological symptoms that could potentially be attributed to pyridoxine. This participant reported tingling in their fingers after taking 600mg per day for approximately three months (London, Bradley, & Chiamori, 1991). In another review by Kasdan and Janes (1987), the authors report that there were no adverse effects among 494 patients who were treated for carpel tunnel syndrome with doses of 200mg of pyridoxine (100mg twice daily) for up to three months or more.

In contrast to the above studies, some reports suggest that sensory neuropathy can occur at lower doses of 500mg per day or less. Parry and Bredeson (1985) observed sensory neuropathy in two individuals who took 500mg per day for 8 and 36 months and in one individual who took between 100mg and 200mg per day for 36 months. However, it is unclear whether the observation for the person taking 100-200mg was confirmed by a neurologist. In a letter to the editor by Dalton (1985), sensory neuropathy was reported for 23 out of 58 women treated with 50-300mg pyridoxine per day for premenstrual syndrome. Similarly, in the aforementioned survey by Dalton and Dalton (1987), 103 out of 172 patients attending a private clinic for premenstrual syndrome experienced neurological symptoms while taking between 50mg and 500mg of pyridoxine for 6 months or more. However, both of these sources have been criticised for not including sufficient information about the duration of supplementation, the exact amounts taken, whether other medications or herbal supplements were also used and the methods used to determine adverse neurological effects (Institute of Medicine Food and Nutrition Board, 1998).

Based on the literature reviewed above, it is accepted in the Nutrient Reference Values for Australia and New Zealand (National Health and Medical Research Council, 2006) and also by the Food and Nutrition Board of the American Institute of Medicine (Institute of Medicine Food and Nutrition Board, 1998) that the No-Observed-Adverse-Effect Level (NOAEL) for pyridoxine is 200mg per day in adults. Due to limitations in the literature regarding the long-term effects of taking dosages of pyridoxine below 500mg per day and the longer-term effects of taking pyridoxine for several years or more, an uncertainty factor (UF) of 4 was used in the Nutrient Reference Values for Australia and New Zealand (National Health and Medical Research Council, 2006) to derive an upper level of intake (UL) for pyridoxine of 50 mg per day. Despite this recommendation, supplements approved by the Australian Therapeutic Goods Administration containing up to 240mg of pyridoxine hydrochloride are widely available in pharmacies, supermarkets and various other outlets in Australia without a prescription. For this reason, we anticipate that the risks to participants associated with taking 240mg of pyridoxine hydrochloride in the present study are minimal.

In addition to the concerns regarding high dosages of pyridoxine taken for long periods of time, pyridoxine supplements should be taken with caution by people taking certain medications due to the potential for adverse drug interactions. In particular, pyridoxine supplementation in excess of 200mg per day may increase the rate at which some drugs are metabolised, thus decreasing their effectiveness. Examples include the antiepileptic drugs phenytoin and phenobarbital (Bender, 1999; Hansson & Sillanpaa, 1976) and the antiparkinsonian medication levodopa except when taken with carbidopa, which prevents the interaction from occurring (Natural Medicines, 2014). Some studies (Hatzitolios, Iliadis, Katsiki, & Baltatzi, 2008; Lal, Dakshinamurti, & Thliveris, 1996; Vasdev, Ford, Parai, Longerich, & Gadag, 1999) indicate that pyridoxine may also have the effect of lowering blood pressure and should thus be taken with caution when antihypertensive drugs and other supplements including herbs also taken due to the risk of blood pressure becoming too low (Arena, Murri, Piccini, & Muratorio, 1984). Some of these drugs, supplements and herbs include andrographis, casein peptides, cat's claw, coenzyme Q-10, L-arginine, lycium, stinging nettle and theanine (Natural Medicines, 2014). In addition, pyridoxine might enhance the photosensitivity that can be caused by taking amiodarone (an antiarrhythmic heart medication) thus increasing the risk of sunburn and dermatitis on exposed areas of skin (Natural Medicines, 2014).

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Appendix M: Adverse Events Procedure for the B Vitamin Study

Adverse events procedure

If a participant contacts the researchers regarding any adverse effects, the following steps will be taken:

1. Obtain the participant's ID number and name in order to establish the contents of the capsules given to the participant.
2. Notify the participant of the contents of their capsules, advise them not to take any more of the capsules, ask them for a description of the adverse effects they are experiencing and advise them to seek advice from a medical doctor or from a registered nurse by calling Healthdirect on 1800 022 222.
3. Ask the participant to call back as soon as possible after they have received medical advice and / or if they experience any changes in the adverse effects they are experiencing.
4. Notify the HREC secretariat of the incident immediately after communicating with the participant.
5. When the participant provides an update, ask them if they were advised to seek medical assistance and make a record of the medical advice they have been given. Ask them whether there has been any change in the adverse effects they are experiencing.
6. Immediately notify the HREC secretariat of any updates on the incident.
7. If the participant does not call back within 24 hours, the researchers will attempt to contact them by phone and also by email.
8. The researchers will attempt to maintain regular contact at least once per day with the participant until cessation of all adverse effects is reported.

Appendix N: Ethics Approval for the B Vitamin Study

THE UNIVERSITY *of* ADELAIDE

RESEARCH BRANCH
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY

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18 June 2015

Professor P Delfabbro
Psychology

Dear Professor Delfabbro

PROJECT NO: H-2015-077
An investigation into the effects of vitamin B6 and other B vitamins on dreaming

I write to advise you that the Human Research Ethics Committee has approved the above project. Please refer to the enclosed endorsement sheet for further details and conditions that may be applicable to this approval. Ethics approval is granted for a period of three years subject to satisfactory annual progress reporting. Ethics approval may be extended subject to submission of a satisfactory ethics renewal report prior to expiry.

The ethics expiry date for this project is: 30 June 2018

Where possible, participants taking part in the study should be given a copy of the Information Sheet and the signed Consent Form to retain.

Please note that any changes to the project which might affect its continued ethical acceptability will invalidate the project's approval. In such cases an amended protocol must be submitted to the Committee for further approval. It is a condition of approval that you immediately report anything which might warrant review of ethical approval including (a) serious or unexpected adverse effects on participants (b) proposed changes in the protocol; and (c) unforeseen events that might affect continued ethical acceptability of the project. It is also a condition of approval that you inform the Committee, giving reasons, if the project is discontinued before the expected date of completion.

A reporting form for the annual progress report, project completion and ethics renewal report is available from the website at http://www.adelaide.edu.au/ethics/human/guidelines/reporting/

Yours sincerely

per **Dr L Denson**
Human Research Ethics Committee

THE UNIVERSITY of ADELAIDE

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Applicant: Professor P Delfabbro

School: Psychology

Project Title: ***An investigation into the effects of vitamin B6 and other B vitamins on dreaming***

THE UNIVERSITY OF ADELAIDE HUMAN RESEARCH ETHICS COMMITTEE

Project No: **H-2015-077** RM No: 0000020444

APPROVED for the period until: **30 June 2018**

Thank you for the detailed response dated 9.6.15 to the matters raised by the Committee. It is noted that this study will be conducted by Denholm Aspy, PhD student.

Refer also to the accompanying letter setting out requirements applying to approval.

per **Dr L Denson**
Human Research Ethics Committee

Date: 18 June 2015

Appendix O: Promotional Materials for the B Vitamin Study

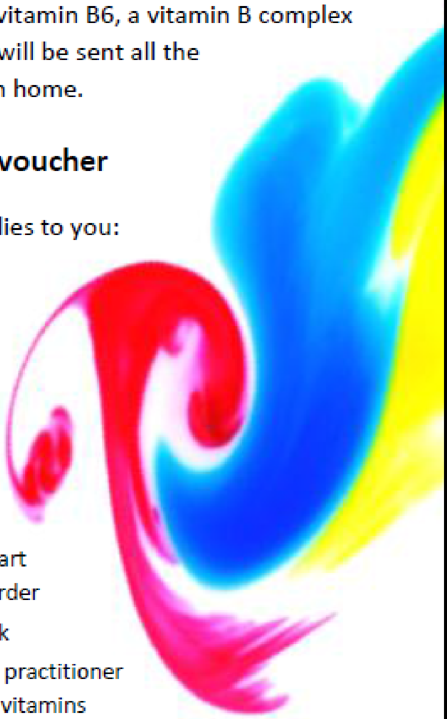
A5 size promotional flyer

THE UNIVERSITY *of* ADELAIDE

Dream Enhancement Study

Participants Invited!

You are invited to participate in a study investigating whether B vitamins can enhance dreaming. Research suggests that vitamin B6 can make dreams more vivid and colourful. B vitamins may also help people to remember their dreams and have more lucid dreams. The study begins with a brief online questionnaire. You will then be asked to fill out a logbook each morning for five days and take either vitamin B6, a vitamin B complex preparation or a placebo for another five days. You will be sent all the materials needed to complete the study in your own home.



Participants will receive a $50 Coles Myer voucher

Please do not participate if any of the following applies to you:

- You are under 18 years of age or over the age of 40
- You find it unpleasant to think about your dreams
- You are currently pregnant or breast-feeding
- You nap during the day, have insomnia or are unable to keep a regular sleep schedule
- You are not proficient in English
- You have any significant medical problems, including diabetes, epilepsy, low blood pressure, heart disease, liver disease, kidney disease or a sleep disorder
- You drink more than seven alcoholic drinks per week
- You have been told by a doctor or other health care practitioner to take a supplement or medication that contains B vitamins

If you are interested in participating, visit: **bit.ly/vitamindreams**

If you have any questions, email: **denholm.aspy@adelaide.edu.au**

Image: "yellow blue pink on white" by Robert Parviainen, available under CC BY-NC 2.0 license at https://flic.kr/p/8MBiH

A4 size promotional poster

THE UNIVERSITY of ADELAIDE

Dream Enhancement Study

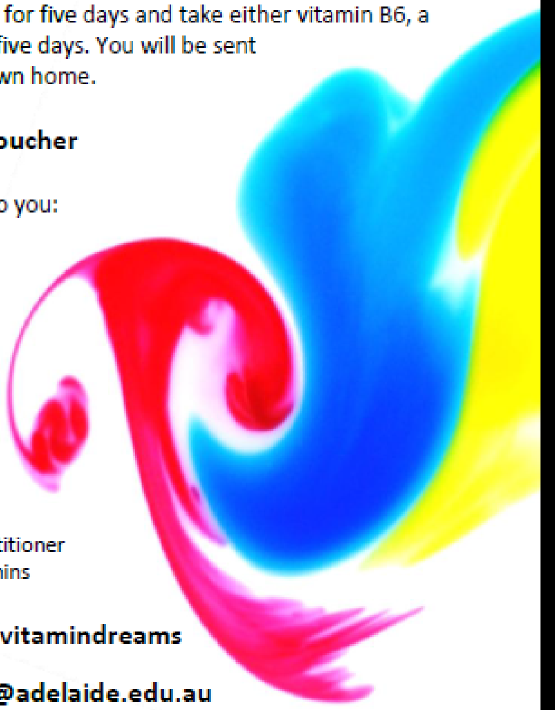
Participants Invited!

You are invited to participate in a study investigating whether B vitamins can enhance dreaming. Research suggests that vitamin B6 can make dreams more vivid and colourful. B vitamins may also help people to remember their dreams and have more lucid dreams. The study begins with a brief online questionnaire. You will then be asked to fill out a logbook each morning for five days and take either vitamin B6, a vitamin B complex preparation or a placebo for another five days. You will be sent all the materials needed to complete the study in your own home.

Participants will receive a $50 Coles Myer gift voucher

Please do not participate if any of the following applies to you:

- You are under 18 years of age or over the age of 40
- You find it unpleasant to think about your dreams
- You are currently pregnant or breast-feeding
- You nap during the day, have insomnia or are unable to keep a regular sleep schedule
- You are not proficient in English
- You have any significant medical problems, including diabetes, epilepsy, low blood pressure, heart disease, liver disease, kidney disease or a sleep disorder
- You drink more than seven alcoholic drinks per week
- You have been told by a doctor or other health care practitioner to take a supplement or medication that contains B vitamins



If you are interested in participating, visit: **bit.ly/vitamindreams**

If you have any questions, email: **denholm.aspy@adelaide.edu.au**

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Dream enhancement study
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Appendix P: Information Sheet for the B Vitamin Study

THE UNIVERSITY of ADELAIDE

Information sheet: An investigation into the effects of vitamin B6 and other B vitamins on dreaming

My name is Denholm Aspy and I am a PhD student in the School of Psychology at the University of Adelaide. I would like to invite you to participate in a study investigating whether B vitamins can enhance dreaming. Research suggests that vitamin B6 can make dreams more vivid, colourful, emotional and bizarre. Vitamin B6 and other B vitamins may also help people to remember their dreams and have more *lucid dreams*, which are dreams where the dreamer knows they are dreaming and can then control what happens in the dream. By participating in this research you will not only make a valuable contribution to knowledge in this area, but may also get to experience dreams that are easier to remember and more vivid, colourful, emotional and bizarre. As a small token of our gratitude, participants who complete the study will be sent a $50 Coles Myer gift voucher. We will also send you a summary of our findings when the study is complete so that you can share in what we learn.

What does the study involve?

- The study is self-directed, which means that you will be sent everything you need to complete the study in your own home.
- The study begins with an online questionnaire that takes 15-20 minutes to complete.
- You will then be sent further instructions and materials via post.
- The main part of the study goes for 10 days and involves filling out a logbook each morning. This will take most people about 10 minutes each morning.
- The study also involves taking two capsules before going to bed for the last five days of the 10-day study period. The capsules contain vitamin B6, a vitamin B complex preparation or an inactive placebo. You will not know which type of capsules you have been given.
- Once you have completed the study, you will be asked to return your completed materials using a postage-paid envelope provided to you.
- Participants who complete the study will be sent a $50 Coles Myer voucher via post.

During the entire 10-day study period, it is important that you do not consume any yeast extract spreads (e.g. Vegemite, Promite, Marmite), energy drinks (e.g. Red Bull, Mother, V), energy-enhancing products (e.g. Berocca) or supplements that contain added B vitamins (e.g. multivitamin pills). Furthermore, please do not consume any of the following if they contain added B-vitamins: weight-loss shakes, protein shakes, body-building supplements or liquid breakfast / meal replacement products (e.g. UP&GO, Sustagen, LCMs bars). In most cases, similar products are available that do not contain added B vitamins. If you are thinking of consuming any of these products, please check the back label to make sure that none of the B vitamins listed below are on the ingredients list:

- Vitamin B1 (aka Thiamin, Thiamine)
- Vitamin B2 (aka Riboflavin, Riboflavine)
- Vitamin B3 (aka Niacin, Nicotinamide, Nicotinic acid)

- Vitamin B5 (aka Pantothenic acid, Pantothenate, Calcium pantothenate)
- Vitamin B6 (aka Pyridoxine)
- Vitamin B7 (aka Biotin)
- Vitamin B9 (aka Folate, Folic acid, Folinic acid, Calcium folinate)
- Vitamin B12 (aka Cyanocobalamin)
- Choline (aka Choline bitartrate, Choline Citrate, Alpha GCP)

Baked products, breakfast cereals and vegetarian / vegan meat-substitute products typically contain small amounts of added B vitamins. You can eat as much of these products as you want during the study.

Please note that if your doctor or other health care practitioner has told you to take a supplement that contains B vitamins, it is important that you do not stop taking it without consulting your doctor or health care practitioner first.

Exclusion criteria

Please do not participate if any of the following applies to you:

- You are under 18 years of age or over the age of 40.
- You find it unpleasant to think about your dreams.
- You are currently pregnant or breast-feeding.
- You nap during the day, have insomnia or are unable to keep a regular sleep schedule.
- You are not proficient in English.
- You have any significant medical problems, including diabetes, epilepsy, low blood pressure, heart disease, liver disease, kidney disease or a sleep disorder.
- You drink more than seven alcoholic drinks per week.
- You have been told by a doctor or other health care practitioner to take a supplement or medication that contains B vitamins.

Please note that taking B vitamins can increase the rate at which some drugs are metabolised, which can decrease their effectiveness. Taking B vitamins may reduce the effectiveness of the antiepileptic drugs phenytoin and phenobarbital, and the Parkinson's disease medication levodopa (except when taken with carbidopa, which prevents the interaction from occurring). B vitamins might also have the effect of lowering blood pressure and should be taken with caution by people who are taking drugs, supplements or herbs that lower blood pressure. Some of these drugs, supplements and herbs include andrographis, casein peptides, cat's claw, coenzyme Q-10, L-arginine, lycium, stinging nettle and theanine. Vitamin B6 supplements might cause photosensitivity in people taking amiodarone (an antiarrhythmic heart medication), which may increase the risk of sunburn and dermatitis on exposed areas of skin. If you are taking any of the drugs, supplements or herbs listed above, please do not participate in this study.

Potential risks and ethical considerations

Vitamin B supplements are widely available without a prescription, are generally considered safe and have a low risk of adverse effects. The dosages used in this study are all within safe limits. If you experience mild nausea or stomach discomfort, try taking the capsules with a full glass of water or a light snack. If you continue to experience mild nausea or mild stomach discomfort, or if you experience any of the following, stop taking the capsules: moderate to severe nausea or stomach discomfort, rash, swelling, weakness, shortness of breath or tingling in the hands, feet or other parts of the body. If you experience these or any other adverse effects, please seek advice from a medical doctor. You can also seek medical advice from a registered nurse 24 hours a day by calling Healthdirect on 1800 022 222. To find out what your capsules contain, call 0431 124 329 and quote the code written on the bag that contains the capsules (this code also appears on the top right of your logbook). However, please note that you will not be able to continue with the study if you are told what your capsules contain. It is very important that you report any adverse effects to us as soon as possible using the contact details below.

The capsules are made from gelatin. They do not contain any lactose or gluten. Each vitamin B6 capsule contains pyridoxine hydrochloride (vitamin B6) 120mg. Because the study involves taking two capsules at a time, the dosage of pyridxoxine used in the study is 240mg. Each vitamin B complex capsule contains: thiamine hydrochloride (vitamin B1) 37.5mg, nicotinamide (vitamin B3) 100mg, calcium pantothenate (vitamin B5) 75mg, pyridoxine hydrochloride (vitamin B6) 120mg, biotin (vitamin B7) 20µg, folic acid (vitamin B9) 200µg, cyanocobalamin (vitamin B12) 250µg, inositol 12.5mg and choline bitartrate 50mg. Because the study involves taking two capsules at a time, the dosages for participants who are given the B complex capsules are: thiamine hydrochloride (vitamin B1) 75mg, nicotinamide (vitamin B3) 200mg, calcium pantothenate (vitamin B5) 150mg, pyridoxine hydrochloride (vitamin B6) 240mg, biotin (vitamin B7) 40µg, folic acid (vitamin B9) 400µg, cyanocobalamin (vitamin B12) 500µg, inositol 25mg and choline bitartrate 100mg.

Note that none of the capsules contain vitamin B2 (riboflavin). Vitamin B2 can cause urine to become brightly coloured and is the reason why urine usually becomes bright yellow after taking multivitamin pills, B complex supplements and other products that contain added vitamin B2. Vitamin B2 has been excluded so that participants cannot tell which type of capsule they are given.

Subject to any legal requirements to disclose (including, for example, criminal and/or civil proceedings from which the project data are not protected), all data collected from this research project will remain confidential and any information that you provide will be used solely for the purposes of this research. Your personal details (name, address, etc) will be kept in a secure location that is separate from your answers to the online questionnaire and your completed logbooks to ensure that your data is not personally identifiable. However, such secure and separate storage of project data will not prevent disclosure in criminal and/or civil proceedings. In accordance with University policy, all data collected will be securely stored on University grounds for up to five years. If you are a student at the University of Adelaide, please note that your participation in this study will not affect the services you receive from the University. Although your full participation is encouraged and appreciated, you are free to withdraw at any time you wish. It is hoped that you will experience dreams that are easier to remember and more vivid, colourful, emotional and bizarre as a result of participating in this study. However, please note that this is not guaranteed, and that participation may not be of any personal benefit to you. You will be given the opportunity to receive a summary of the results after the study has been completed.

You will be sent a copy of this information sheet in the post along with the other study materials if you choose to participate. However, if you would like to be sent a copy via email, or if you have any questions, please feel free to email me:

denholm.aspy@adelaide.edu.au

You may also contact my principal supervisor, who is also involved in this research project:

- Professor Paul Delfabbro (principal supervisor)
  Email: paul.delfabbro@adelaide.edu.au Phone: (08) 8313 4936

The current research has been approved by the Human Research Ethics Committee (approval number: H-2015-077). For any ethical concerns regarding this study, please contact the Secretary of the University of Adelaide Human Research Ethics Committee:

Email: hrec@adelaide.edu.au

Finally, in the unlikely event that you feel upset as a result of participating in this study you can obtain useful information about depression and anxiety by visiting www.beyondblue.com.au and http://www.anxietyattack.com.au. If necessary, you can access psychological services at an affordable rate at the University of Adelaide Counselling service, ph or through your General Practitioner (GP).

Thank you for your assistance.
Yours sincerely

Denholm Aspy

Appendix Q: Instructions Sheet for the B Vitamin Study

Overview

Thank you for your continued participation in this study! The study began with an online questionnaire, which you have already completed. The package you have now received contains the materials you will need to complete the rest of the study, which is divided into two sections that each go for five days. The purpose of the first five-day section is to gather baseline information about your dreams and your typical sleeping patterns. The second five-day section is when you take the capsules sent to you. These contain vitamin B6, a vitamin B complex preparation or an inactive placebo. You should have received the following materials:

- Overview and Instructions (this sheet)
- Information Sheet from the online questionnaire (for your records)
- Logbook (to be filled in first thing each morning during the study)
- Sealed bag containing ten capsules
- Reply-paid envelope (to return your completed logbook when you finish the study)

Please store the capsules in a cool, dry location where children and pets cannot access them. During the entire 10-day study period, it is important that you do not consume any yeast extract spreads (e.g. Vegemite, Promite, Marmite), energy drinks (e.g. Red Bull, Mother, V), energy-enhancing products (e.g. Berocca) or supplements that contain added B vitamins (e.g. multivitamin pills). Furthermore, please do not consume any of the following if they contain added B-vitamins: weight-loss shakes, protein shakes, body-building supplements or liquid breakfast / meal replacement products (e.g. UP&GO, Sustagen, LCMs bars). In most cases, similar products are available that do not contain added B vitamins. If you are thinking of consuming any of these products, please check the back label to make sure that none of the B vitamins listed below are on the ingredients list:

- Vitamin B1 (aka Thiamin, Thiamine)
- Vitamin B2 (aka Riboflavin, Riboflavine)
- Vitamin B3 (aka Niacin, Nicotinamide, Nicotinic acid)
- Vitamin B5 (aka Pantothenic acid, Pantothenate, Calcium pantothenate)
- Vitamin B6 (aka Pyridoxine)
- Vitamin B7 (aka Biotin)
- Vitamin B9 (aka Folate, Folic acid, Folinic acid, Calcium folinate)
- Vitamin B12 (aka Cyanocobalamin)
- Choline (aka Choline bitartrate, Choline Citrate, Alpha GCP)

Baked products, breakfast cereals and vegetarian / vegan meat-substitute products typically contain small amounts of added B vitamins. You can eat as much of these products as you want during the study.

Adverse effects

Vitamin B supplements are widely available without a prescription, are generally considered safe and have a low risk of adverse effects. The dosages used in this study are all within safe limits. If you experience mild nausea or stomach discomfort, try taking the capsules with a full glass of water or a light snack. If you continue to experience mild nausea or mild stomach discomfort, or if you experience any of the following, stop taking the capsules: moderate to severe nausea or stomach discomfort, rash, swelling, weakness, shortness of breath or tingling in the hands, feet or other parts of the body. If you experience these or any other adverse effects, please seek advice from a medical doctor. You can also seek medical advice from a registered nurse 24 hours a day by calling Healthdirect on 1800 022 222. To find out what your capsules contain, call 0431 124 329 and quote the code written on the bag that contains the capsules (this code is also on the front of your logbook). However, please note that you will not be able to continue with the study if you are told what your capsules contain. It is very important that you report any adverse effects to us as soon as possible using the contact details below.

Instructions

Instructions for the 1st five-day section

- Keep the logbook and a pen close to your bed, preferably on a bedside table.
- Fill out your Logbook each morning for five consecutive days, starting on the coming Monday.
- It is very important that you always fill out your logbook *first thing* in the morning before you get out of bed. This is why you should keep the logbook beside your bed.
- It is also important that you fill in your logbook for five consecutive *weekdays* (Monday to Friday) and not on weekends. This makes it easier for us to compare the first five days with the second five days.
- If you *do* miss a day, please do an extra day at the end (on the weekend) to make up for it so that you fill out your logbook for exactly 5 days in the first five-day section of the study.
- Do not take any of the capsules during the first five-day section of the study.

Once you have completed the 1st five days of the study

You should have made the 5th entry in your logbook on a Friday morning. You do not need to make any logbook entries over the weekend (unless you need to make up for a skipped day). The 2nd five-day section of the study begins on Sunday night.

Instructions for the 2nd five-day section

- Take two capsules directly before going to bed for five consecutive days, starting on Sunday. This means you should take the capsules on Sunday, Monday, Tuesday, Wednesday and Thursday night.
- It is best to take the capsules as close as possible to the time when you go to sleep, so make sure this is the last thing you do before going to bed. However, don't worry if it takes you a while to fall asleep after taking the capsules.
- Taking B vitamins on an empty stomach can cause mild nausea and stomach discomfort in some people. You can reduce the likelihood of this happening by taking the capsules with a full glass of water or a light snack. This is recommended if it has been several hours since you last ate.
- Fill out your logbook first thing in the morning after each night that you take the capsules. This means you should fill out your logbook on Monday, Tuesday, Wednesday, Thursday and Friday morning.

When you have completed the study

When you have completed the study, please place your logbook into the reply-paid envelope, seal it shut and then place it in any Australia Post post-box. If you were only able to complete part of the study, please place all remaining capsules in the envelope and return these as well. Please note that you should not take high doses of vitamin B6 after completing the study on a long-term basis without the guidance of a medical doctor. This is because taking high doses of vitamin B6 for prolonged periods (several months or years) can cause harmful (but usually reversible) effects such as sensory neuropathy. All participants who complete the study will be sent a $50 Coles Myer gift voucher in the mail as a token of appreciation.

If you have any questions or difficulties, please feel free to contact me:
Email: denholm.aspy@adelaide.edu.au

Appendix R: Published Version of Manuscript Presented in Chapter 6

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Review

Is dream recall underestimated by retrospective measures and enhanced by keeping a logbook? A review

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ABSTRACT

There are two methods commonly used to measure dream recall in the home setting. The retrospective method involves asking participants to estimate their dream recall in response to a single question and the logbook method involves keeping a daily record of one's dream recall. Until recently, the implicit assumption has been that these measures are largely equivalent. However, this is challenged by the tendency for retrospective measures to yield significantly lower dream recall rates than logbooks. A common explanation for this is that retrospective measures underestimate dream recall. Another is that keeping a logbook enhances it. If retrospective measures underestimate dream recall and if logbooks enhance it they are both unlikely to reflect typical dream recall rates and may be confounded with variables associated with the underestimation and enhancement effects. To date, this issue has received insufficient attention. The present review addresses this gap in the literature.

Contents

1. Introduction

There are two widely used methods for measuring dream recall in the home setting. The logbook method requires research participants to record their dream recall each morning using a logbook (AKA diary or journal), typically for a period

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1053-8100/

of several weeks. Using this method, dream recall is most commonly operationalised as *Dream Recall Frequency* (DRF), which refers to the number of mornings in a given time period on which some amount of dream content is recalled. Participants are sometimes asked to record the number of separate dreams recalled each morning, which permits an alternative operationalisation referred to as *Dream Count* (DC) in the present review. Logbooks may also require participants to provide written narratives of their dreams, allowing additional operationalisations of dream recall such as the number of words per dream narrative. These logbooks are referred to as *narrative logbooks* in the present review as opposed to *checklist logbooks*, which do not require participants to write out their dreams. The primary alternative to the logbook method is the retrospective method, which involves asking participants to report their dream recall in response to a single question. These questions take a variety of forms but are typically either open-ended (e.g. "How many dreams do you recall per week?") or involve reporting one's DC or DRF by selecting one of several fixed response options (e.g. "almost every morning", "several times a week", "about once a week", etc.). Until recently, the implicit assumption has been that the choice between using retrospective or logbook measures is of little consequence and that the two are essentially equivalent (Beaulieu-Prévost & Zadra, 2007). However, this assumption is challenged by numerous studies that have used both measures in the same sample and found that retrospective measures yield significantly lower dream recall rates than logbook measures.

This retrospective-logbook disparity has two principal explanations. One of these is that retrospective dream recall measures have a tendency to underestimate true dream recall rates (Beaulieu-Prévost & Zadra, 2007; Schredl, 2002; Zadra & Robert, 2012). The other is that keeping a logbook tends to enhance dream recall (Beaulieu-Prévost & Zadra, 2007; Cohen, 1969; Cory, Ormiston, Simmel, & Dainoff, 1975; Goodenough, 1991; Schredl, 2002). If retrospective measures underestimate dream recall, they may provide a poor reflection of true dream recall rates and could be confounded with other variables related to underestimation (for example, participants with poorer long-term memory function may be more prone to underestimation). Similarly, if logbooks have a tendency to enhance dream recall, they may also fail to provide an accurate reflection of typical (unaltered) dream recall rates and may be confounded with variables related to the enhancement effect (for example, highly motivated participants may spend more time trying to recall dreams prior to making logbook entries and experience greater enhancements in dream recall as a consequence). It may even be the case that the retrospective-logbook disparity is due to a combination of both retrospective underestimation *and* logbook enhancement. If this is correct, *both* measures may be of limited validity. This might even explain why most studies on correlates of home dream recall have found only weak relationships and inconsistent or even contradictory findings (for reviews, see Beaulieu-Prévost & Zadra, 2007; Blagrove & Pace-Schott, 2010; Goodenough, 1991; Schredl & Montasser, 1996/1997a, 1996/1997b; Schredl, Wittmann, Ciric, & Götz, 2003; Zadra & Robert, 2012). Clearly then, the retrospective-logbook disparity is an important issue that has potentially far-reaching implications for research on home dream recall. However, as several authors have noted this issue has received insufficient attention and the cause of the disparity remains uncertain (Beaulieu-Prévost & Zadra, 2007; Schredl, 2002; Schredl & Fulda, 2005; Zadra & Robert, 2012). The purpose of the present review is to address this gap in the literature and raise awareness of psychometric issues related to the measurement of dream recall in the home setting.

2. Literature search

An extensive literature search was conducted to identify studies in which a retrospective-logbook disparity for general dream recall was reported or could be calculated. The primary search strategy was to identify studies in which logbooks were used and examine them to see if retrospective measures were also used. A secondary strategy was to identify and check the measures used in studies that were specifically about dream recall. Titles and abstracts were searched in the electronic databases Embase, MEDLINE, PsycINFO, and Scopus using the following search terms: *dream* AND (recall OR dream journal* OR diar* OR log*)*. Studies were excluded if they were not published in English, if they were not published in a peer-reviewed journal, if logbook dream recall was measured in a laboratory or non-home setting, if they were case studies or if they were non-controlled studies that involved an intervention during the logbook period likely to affect dream recall. The literature search was conducted in August–September 2014 and initially yielded 211 results from Embase, 418 from Medline, 1058 from PsycINFO and 246 from Scopus. Based on a preliminary reading of titles and abstracts, 235 studies that did not meet any of the exclusion criteria were identified as potentially relevant. Full texts of these studies were examined and a total of 24 studies were found in which a retrospective-logbook disparity was reported. Two studies (Antrobus, Dement, & Fisher, 1964; Cory et al., 1975) were excluded because there was insufficient data to calculate the size of the disparity and one study (Paulson & Parker, 2006) was excluded because it involved a lucid dreaming training program that may have affected logbook dream recall rates. Four studies (Schredl, 2004a, 2008, 2009b, 2010) were discarded because they were based on the same dataset as an earlier study that also reported a disparity (Schredl et al., 2003). Details of the remaining 17 studies are presented in Table 1. In all cases, disparities are expressed as percentages of the retrospective dream recall rates (i.e. logbook rate minus retrospective rate divided by retrospective rate).

The majority of studies (77%) included in Table 1 observed a retrospective-logbook disparity of between 10% and 610% and the mean (unweighted) disparity for all 17 studies was 115%. In several studies dream recall was operationalised as DC but mistakenly referred to as DRF and in all such cases this has been corrected. With only one exception, the operationalisation of dream recall was consistent for both retrospective and logbook measures. However, the disparity reported by Redfering and Keller (1974) may have been inflated due to retrospective-DRF being compared to logbook-DC.

Table 1
Studies in which a retrospective-logbook disparity was reported or can be calculated.

Reference	Disparity	Type of retrospective measure (and response options/estimation period)	Type of logbook
Schredl (2002)	−12%	Fixed response options, DRF (never, less than once a month, about once a month, twice or three times a month, about once a week, several times a week, almost every morning)	Narrative, DRF
Schredl et al. (2003)[a]	−12%[†]	Three separate DRF measures were administered at pre-test. One was the same as Schredl (2002) above but was administered once in a questionnaire about dreams ("DQ") and again in a questionnaire about sleep ("LISST"). The final measure was open-ended and based on the previous 28 days ("OE"). The disparity presented for this study is based on the mean of all three measures because they all yielded very similar DRF rates (DQ = −15%, LISST = −8% and OE = −14%)	Narrative, DRF
Schredl (2001)[b]	2%[†]	Fixed response options, DRF (never, less than once a month, about once a month, two or three times a month, about once a week, several times a week, almost every morning)	Narrative, DRF
Schredl and Engelhardt (2001)[c]	5%[†] (control group)	Fixed response options, DRF (never, less than once a month, about once a month, two or three times a month, about once a week, several times a week, almost every morning)	Narrative, DRF
Zadra and Robert (2012)	10% (narrative group)	Open-ended, DC (number of dreams typically remembered per week)	Narrative, DC
	61%[*] (checklist group)	Open-ended, DC (number of dreams typically remembered per week)	Checklist, DC
Beaulieu-Prévost and Zadra (2005)	13%[*]	Open-ended, DC (number of dreams typically remembered per week)	Narrative, DC
Schredl, Götz, and Ehrhardt-Knutsen (2010)[d]	14%[†]	Fixed response options, DRF (never, less than once a month, about once a month, twice or three times a month, about once a week, several times a week, almost every morning)	Narrative, DRF
Schredl et al. (2013)	15%[†]	Fixed response options, DRF (never, less than once a month, about once a month, twice or three times a month, about once a week, several times a week, almost every morning)	Narrative, DRF
Zadra and Donderi (2000)	15%[†]	Open-ended, DC (number of dreams typically remembered per week)	Checklist, DC
Beaulieu-Prevost, Charneau, and Zadra (2009)[e]	19%[†]	Open ended, DC (number of dreams typically remembered per week)	Narrative, DC
Schredl et al. (1996)	52%[†]	Fixed, DRF (less than once per month, once or twice per month, once or twice per week, several times per week)	Checklist, DRF
Baekeland (1970)	72%[*]	Open-ended, DRF (average frequency of recall every two weeks)	Checklist, DRF
Blagrove, Morgan, Curran, Bromley, and Brandner (2009)[f]	82%[†] (control group)	Fixed response options, DRF (never, about once per year or less, less than once per month, one to three times per month, one to three times per week, four to seven times per week)	Checklist, DC
Cohen (1969)	200%[†]	Fixed response options, DRF (hardly ever, couple of times a month, about once a week or twice a week, just about every day or every other day)	Checklist, DRF
Levin and Fireman (2002)	247%[†]	Not specified	Checklist, DRF
Redfering and Keller (1974)[g]	605%[*] (Group 3)	Fixed response options, DC (no dreams, a couple per year, one or two per month, one per week, three per week, one per night)	Checklist, DRF
Yu (2014)[h]	610%[†]	Fixed response options, DRF (never, less than once a month, about once a month, two to three times a month, about once a week, several times a week, almost every morning)	Narrative, DRF

In four cases (Schredl et al., 1996, 2010, 2013; Yu, 2014), responses to retrospective measures had to be converted to DRF rates in order to calculate a retrospective-logbook disparity. This was done by using or adapting Schredl's (2004c) approach (i.e. never = 0.0 mornings per week, less than once a month = 0.13, about once a month = 0.25, two or three times a month = 0.63, about once a week = 1.0, several times a week = 3.5, almost every morning = 6.5).

[a] It was established through personal communication with the author (June 16, 2014) that logbooks were narrative type.

[b] Data was originally reported separately for singles and non-singles. Disparity calculated for all participants combined.

[c] Data was provided for several other groups of participants but these are not reported here because of high attrition rates that may have biased the disparities. There was no attrition in the control group ($N = 152$ for both measures).

[d] It was established through personal communication with the author (September 16, 2014) that logbooks were narrative type.

[e] Data was originally reported separately for participants with different "dreamer profiles". Disparity calculated for all participants combined.

[f] This study investigated the effects of Ketamine on dream recall. Disparity calculated for the control group only.

[g] This study included four different groups involving different amounts of contact with the experimenters and encouragement to enhance dream recall. Only group 3 is included because it is the only group that involved keeping a daily logbook but did not involve encouragement to enhance dream recall.

[h] Logbook DRF ($M = 1.42$ per week) was obtained through personal communication with the author (August 16, 2014).

[*] $p = <.05$.

[†] P value not reported.

Indeed, such an effect is likely because although DRF cannot exceed the number of days in a given measurement period, the DC operationalisation has no upper limit (i.e. people can report substantially more dreams than there are days in a given measurement period). To illustrate, in a study by Schredl (2004b) it was found that participants recalled multiple dreams on more than 20% of mornings, with a maximum of 12 dreams recalled by one participant on a single morning. If the study by Redfering and Keller (1974) is excluded, the mean disparity for the remaining 16 studies is reduced to 85%.

Another factor that appears to have affected the size of the disparity is the use of narrative versus checklist logbooks. For the most part the studies that reported the greatest disparities used checklist logbooks whereas those in which the disparity was smallest used narrative logbooks. As has been argued previously (e.g. Robert & Zadra, 2008), participants are likely to underreport their true dream recall while keeping narrative logbooks in order to reduce the amount of time (often over half an hour) required to write out their dreams. This argument is supported by findings from Zadra and Robert (2012), who assigned participants to conditions involving either narrative or checklist logbooks. The authors found a significant disparity only in the latter group (see Table 1). Furthermore, logbook-DC was significantly higher in the checklist condition compared to the narrative condition (by 56%) and the checklist participants maintained their logbooks for significantly longer (31.6 vs. 24.7 days), which suggests that the narrative logbooks were more burdensome. These results replicate findings from an earlier study (Robert & Zadra, 2008), in which participants given checklist logbooks maintained them for significantly longer (30.1 vs. 23.2 days) and had significantly higher logbook-DC (by 42%).

In two of the studies included in Table 1 (Schredl, 2002; Schredl et al., 2003), the disparity was in the opposite direction and logbook dream recall rates were slightly *lower* than retrospective dream recall rates (−12% in both cases). However, when the participants in one of these studies (Schredl, 2002), were divided into groups according to their retrospective dream recall rates, "low recallers" (retrospective-DRF of 0–1 per fortnight) and to a lesser extent "medium recallers" (retrospective-DRF of 2–4 per fortnight) showed substantial and statistically significant disparities (421% and 81% respectively). The disparity was in the opposite direction and also smallest (−36%) for "high recallers" (retrospective-DRF of 5–14 per fortnight), which accounts for the lack of significant disparity for all participants combined. Based on additional data obtained through personal communication with the author (February 2, 2015), it was established that the same pattern was observed in the study by Schredl et al. (2003).[1] The disparity was 531% for low recallers, 89% for medium recallers and −31% for high recallers. A similar pattern of results was found by Zadra and Robert (2012) for participants in the narrative group (results were presented graphically and exact disparities could not be calculated), but not in the checklist group (for which the disparity appears to have been about the same for low, medium and high recallers). It is likely that several other studies included in Table 1 would have reported similar results if analyses had been conducted separately for low, medium and high recallers. Indeed, in a study by Antrobus et al. (1964), logbook-DRF was approximately 1000% higher than retrospective-DRF in "non recallers" (retrospective-DRF < once per month), but appears not to have differed among "recallers" (retrospective-DRF of 3+ nights per week). Similarly, Cory et al. (1975) found a retrospective-logbook disparity among low recallers but not high recallers. Unfortunately though, the size of these disparities could not be calculated (and for this reason they are not included in Table 1).

None of the studies presented in Table 1 provided sufficient data to explore gender differences in the retrospective-logbook disparity. However, additional data bearing on this issue was obtained for two studies through personal communication (February 2, 2015). In the study by Schredl (2002), the disparity was slightly larger for females (−15%; $N = 212$) than for males (−1%; $N = 73$).[2] The gender difference was reversed in the study by Schredl et al. (2003), with the disparity being slightly smaller for females (−13%; $N = 373$) than for males (−21%; $N = 66$).[3] Based on these results and in light of two recent meta-analyses (Schredl & Reinhard, 2008, 2011) showing that the choice between retrospective and logbook measures does not affect gender differences in dream recall, it seems reasonable to conclude that gender is not likely to be an important factor for understanding the retrospective-logbook disparity. The above findings confirm that the retrospective-logbook disparity is a common occurrence and that it is often very substantial in size, especially among low recallers and when checklist logbooks are used. In the following sections, the retrospective underestimation and the logbook enhancement effects are given in-depth consideration as explanations for the retrospective-logbook disparity.

3. The retrospective underestimation hypothesis

Theoretical support for the retrospective underestimation hypothesis can be derived from research on frequency estimation. According to Tversky and Kahneman's (1973) ***availability heuristic***, people estimate the frequency of events based on the *availability of exemplars*, i.e. the ease with which instances of an event can be brought to mind. If availability is high, people tend to estimate the frequency of an event to be greater than if availability is low. Numerous studies have shown that the availability heuristic is used in a wide range of situations (see Schwarz, 1998 for a review). In one of the most classic demonstrations, Schwarz et al. (1991) found that participants rated themselves as significantly more assertive after being asked to recall only six occasions on which they behaved assertively (a relatively easy task) compared to participants who were asked to recall twelve occasions (a more difficult task). This suggests that the ease with which exemplars were recalled (and not the *number* of exemplars) determined assertiveness ratings. Furthermore, the self-rated difficulty of recalling instances of behav-

[1] These disparities were calculated based on fortnightly "DQ" retrospective-DRF (see Table 1) and logbook-DRF rates provided by the author. For low recallers ($N = 30$), retrospective-DRF $M = 0.38$ ($SD = 0.16$) and logbook-DRF $M = 2.40$ ($SD = 1.92$). For medium recallers ($N = 164$), retrospective-DRF $M = 1.77$ ($SD = 0.35$) and logbook-DRF $M = 3.34$ ($SD = 1.91$). For high recallers ($N = 245$), retrospective-DRF $M = 8.74$ ($SD = 2.73$) and logbook-DRF $M = 6.01$ ($SD = 3.44$).

[2] Retrospective dream recall data for each gender was provided in the original paper but had not been converted to fortnightly DRF rates and thus did not permit calculation of gender differences for the disparity. Mean fortnightly retrospective-DRF was $M = 4.92$ ($SD = 4.06$) for females and $M = 3.77$ ($SD = 3.76$) for males.

[3] The disparities for females and males were based on the "DQ" retrospective-DRF measure (see Table 1). Retrospective fortnightly "DQ" DRF was $M = 5.73$ ($SD = 4.17$) for females and $M = 4.61$ ($SD = 3.78$) for males.

ing assertively was negatively correlated with self-rated assertiveness. These results were replicated by Aarts and Dijksterhuis (1999) in a study that used the frequency of a previously performed behaviour as the dependent variable rather than personality self-assessment. It was found that participants estimated their bicycle use to be 31% less frequent after being asked to recall eight different locations they had ridden to rather than three locations and this frequency rate was negatively correlated with the self-rated difficulty of recalling the locations (i.e. estimated frequency was greater when participants found the recall task less difficult). These authors argued that the availability heuristic is likely to influence frequency judgments for almost all behaviours that have been performed more than a few times. In light of this it seems highly likely that people will also use the availability heuristic when estimating the frequency with which they recall dreams.

When the availability of exemplars is closely related to the overall frequency of the event in question, the availability heuristic will tend to produce reasonably accurate frequency estimates. However, overestimation or underestimation may occur if the availability of exemplars does *not* reflect overall frequency. This is known as the *ease of recall bias* (see Buontempo & Brockner, 2008) and provides a plausible explanation for why retrospective measures might underestimate true dream recall rates. Individuals who are interested in their dreams and who tend to spend time thinking about them, writing them down, discussing them with other people or otherwise devoting attention to them are likely to have greater availability of dream recall instances and should thus be able to provide fairly accurate responses to retrospective dream recall measures. However, individuals who have little interest in their dreams are likely to spend less time recalling and encoding memories of dreams, resulting in lower availability of instances of dream recall and thus greater susceptibility to underestimation. This theory is consistent with studies that have shown "inner focus" variables to be more strongly correlated with retrospective dream recall measures than logbook measures. For example, in a meta-analysis by Beaulieu-Prévost and Zadra (2007) it was found that the estimated mean correlation between attitudes toward dreams (one of the most widely researched predictors of dream recall) and dream recall was significantly stronger when dream recall was measured retrospectively ($r = .357$) than with logbook measures ($r = .252$). Two other dream recall predictors were included in this meta-analysis – *absorption* and *psychological boundaries*. Both of these variables operationalise (among other things) the extent to which people are aware of internal experiences and they were both found to have statistically significant estimated correlations with retrospective measures (absorption, $r = .246$; psychological boundaries, $r = .290$) but not logbook measures (absorption, $r = .086$; psychological boundaries, $r = .098$). Other studies have shown that introversion (Early, 1977, as cited in Schredl, 2002), imaginative involvement and fantasy proneness (Levin, Fireman, & Rackley, 2003) are also correlated with retrospective but not logbook measures.

If the above theory is correct, the underestimation effect should tend to be stronger for retrospective measures based on longer time periods (e.g. the previous 12 months) compared to those based on shorter time periods (e.g. the previous month). This is because measures based on longer periods should require participants to consider the availability of a greater number of exemplars, and frequency estimations tend to be lower when this is the case as discussed above (Aarts & Dijksterhuis, 1999; Schwarz et al., 1991). Furthermore, instances of dream recall should *on average* have lower availability during longer time periods due to the well-documented tendency for memories to become increasingly difficult to recall with the passage of time (Roediger, Weinstein, & Agarwal, 2010). Therefore, to the extent that the retrospective-logbook disparity is due to retrospective underestimation it should tend to be larger in studies that have used retrospective measures based on longer time periods. Indeed, among the studies presented in Table 1 that used checklist logbooks, the largest disparities were observed when participants were asked to consider their dream recall over longer time periods (the last few months) in response to questions involving fixed response options. The disparities were smallest when estimates were based on open-ended measures enquiring about the previous one or two weeks (the only exception to this is Schredl, Kleinferchner, & Gell, 1996). This pattern of findings constitutes tentative empirical support for the theory of retrospective underestimation outlined above. In contrast, the studies in which *narrative* logbooks were used mostly reported small disparities, possibly due to participants underreporting their logbook dream recall in order to reduce the burden of participation as argued earlier.

The most compelling empirical support for the retrospective underestimation hypothesis comes from studies that have measured dream recall using retrospective measures based on different time periods within the same sample. Zadra and Donderi (2000) measured the recall frequency (DC) of lucid dreams, dreams about flying, bad dreams (defined as very disturbing dreams) and nightmares (very disturbing dreams that cause an awakening) during a 4-week logbook period and also using retrospective measures based on both the previous month and the previous 12 months. In every case the prorated retrospective-logbook disparity was greater when based on the 12-month retrospective measure than the 1-month measure (lucid dreams, 35% vs. 2%; flying dreams, 29% vs. 23%; bad dreams, 69% vs. 53%; nightmares, 162% vs. 92%). Similar results were reported in studies by Wood and Bootzin (1990), Pietrowsky and Köthe (2003) and Robert and Zadra (2008) that all compared 1-month and 12-month retrospective measures of various kinds of distressing dreams, although unfortunately no studies to date have attempted to replicate these findings using measures of *general* dream recall.[4] Nonetheless, it is difficult to explain why in every case the 12-month retrospective measures yielded lower recall rates than the 1-month measures if not because of a retrospective underestimation effect that varies as a function of the size of the estimation period. Retrospec-

[4] In all but one of these studies, logbooks yielded the highest dream recall rates, followed by the 1-month retrospective measure and then the 12-month retrospective measure. However, Pietrowsky and Köthe (2003) found that the 1-month retrospective measure yielded the highest nightmare recall frequency, followed by the logbook measure and then the 12-month retrospective measure. This may be due to participants underreporting their true nightmare frequency during the logbook period in order to reduce the burden of having to complete a 43-item questionnaire for each day on which nightmares occurred.

tive underestimation may also account for the retrospective-logbook disparities based on the 1-month retrospective measures, although a logbook enhancement effect cannot be ruled out.

The above findings also discount an otherwise plausible alternative explanation for the retrospective-logbook disparity. Given that logbooks cause people to pay greater attention to their dreams, people might be more likely to notice and then include "borderline" instances of dream recall when making logbook entries that tend not to be captured by retrospective measures (e.g. single images or lingering emotions from otherwise forgotten dreams). If this is correct it could explain the retrospective-logbook disparity without needing to appeal to any retrospective underestimation or logbook enhancement effects. However, in the above studies substantial retrospective-logbook disparities were found even though the definitions for dreams were precise and consistent for both the logbook and the retrospective measures. This makes it very unlikely that the disparities were due to differences in what participants counted as instances of dream recall. There is no obvious reason to think that the cause of these disparities is different from the cause of the disparities observed in studies of general dream recall. Thus, it seems unlikely that disparities between retrospective and logbook measures of general dream recall can be accounted for by a wider range of instances of dream recall being captured by logbooks.

To the extent that retrospective measures are prone to an underestimation effect their validity is likely to be compromised by a wide range of confounding variables. For example, people who score more highly on "inner focus" variables such as those described above or who have better long-term memory function may have less difficulty recalling instances of dream recall and thus be less prone to underestimation. People may also be relatively immune to retrospective underestimation if they estimate their dream recall using a more elaborative cognitive process rather than a heuristic one. For example, participants could estimate their dream recall frequency over the previous 12 months by counting the number of times they recalled dreams during the previous month and then multiplying this number by 12. This would result in a dream recall rate that does not differ from the prorated 1-month estimate. The tendency to use this kind of elaborative processing is related to a range of variables (e.g. need for cognition, Suedfeld & Tetlock, 2001) that may constitute additional confounds for retrospective dream recall measures. Clearly, if retrospective measures underestimate dream recall they are likely to provide a poor reflection of true dream recall rates. Retrospective measures based on longer time periods are likely to be the least valid and are probably not suitable for studies investigating predictors of dream recall, whereas those based on shorter periods (e.g. the previous week or month) should be less problematic. However, it remains unclear whether the underestimation effect is likely to be related to the different forms that retrospective measures can take. For example, open-ended measures that require participants to estimate their dream recall over the past 12 months may not underestimate dream recall to the same extent as measures that include "once per year" as one of several fixed response options. The wording of retrospective measures and their response options may also influence the dream recall rates they yield irrespective of the time periods involved.

4. The logbook enhancement hypothesis

A highly plausible theory of why keeping a logbook might enhance dream recall can be obtained from one of the most prominent models of dream recall, the arousal retrieval model (Koulack & Goodenough, 1976; see also Goodenough, 1991; Schredl, 2009a for reviews). According to this model, dream recall is most likely when a period of arousal (wakefulness) interrupts or occurs shortly after dreaming, or else dream content is likely to be lost from short-term memory. Dream content must then be retrieved from short-term memory and consolidated into long-term memory if it is to be retained, and recall will be superior if retrieval occurs immediately upon awakening and in the absence of other distracting mental activity. It follows that logbooks should enhance dream recall because they require participants to spend time on the retrieval process each morning either immediately or shortly after awakening – participants must consider whether or not they can recall dream content in order to make a logbook entry. If this is correct, the size of the logbook enhancement effect should be proportional to the amount of time spent on retrieval. Consequently, the logbook enhancement effect should also vary as a function of one's pre-existing tendency to spend time trying to recall dreams. Individuals with a relatively weak tendency are more likely to be low recallers as a result and should then experience a relatively strong logbook enhancement effect, because keeping a logbook will cause them to spend substantially more time on the retrieval process than they otherwise would. In contrast, individuals with a strong pre-existing tendency to spend time recalling dreams are more likely to consequently be high recallers and should experience a relatively weak or non-existent logbook enhancement effect because keeping a logbook will have less (or no) impact on the amount of time they spend trying to recall dreams. This would explain why the retrospective-logbook disparity tends to be strongest in individuals with relatively low retrospectively measured dream recall rates.

In exploring the logbook enhancement hypothesis it is important to consider whether there are any alternative aspects of dream recall studies that might result in heightened logbook dream recall rates. For example, if participants are encouraged to enhance their dream recall while keeping a logbook or are asked to practise techniques designed to achieve this, it could lead to enhancements in dream recall that are *not* due to keeping a logbook. Alternatively, the demand characteristics of studies aiming to enhance dream recall may lead participants to exaggerate their dream recall. However, both of these factors are unlikely to explain the retrospective-logbook disparity because none of the studies included in Table 1 involved any encouragement or instruction to enhance dream recall. Of course, there may still be more subtle demand characteristics associated with simply participating in a study about dreams. However, it seems very implausible that this could result in participants exaggerating their dream recall to such an extent that it would account for the size of the retrospective-logbook disparities that many studies have observed (see Table 1). It is hard to imagine how dream recall would have otherwise been enhanced in these studies if not because of a logbook enhancement effect.

Despite it being theoretically plausible and widely believed among dream researchers that logbooks enhance dream recall (e.g. Beaulieu-Prévost & Zadra, 2005; Goodenough, 1991; LaBerge & Rheingold, 1991; Parker, Bauermann, & Smith, 2000; Schredl & Montasser, 1996/1997a; Wittmann, Schredl, & Kramer, 2006) there is a lack of empirical evidence that unambiguously demonstrates this. Of course, the existence of the retrospective-logbook disparity does not do so because the phenomenon can just as easily be explained by the retrospective underestimation hypothesis. However, the logbook enhancement hypothesis is tentatively supported by a study by Cohen and Wolfe (1973, study 4) that examined the effects of post-sleep distraction on dream recall. Immediately upon awakening, participants in an experimental group were required to phone a weather information service and write the forecasted temperature for the day on the top of a logbook sheet. After completing this task, which took approximately 1.5 min, participants were required to provide written narratives of their dreams. Participants in a control group were asked to simply lie still for 1.5 min before writing out their dreams. It was found that significantly fewer participants in the distraction group were able to recall dream content on the day of the experiment (33% versus 63%). There were no differences between the two groups on a retrospective dream recall measure administered at pre-test, nor were there any group differences in logbook dream recall rates for a subsequent 7-day period. These results were replicated in a second study reported in the same paper (study 5) and show that dream recall is superior when people focus on their dreams without distraction. This is precisely the kind of effect that keeping a logbook should have, especially for people who ordinarily tend not to pay attention to their dreams.

In lieu of more compelling empirical support, the logbook enhancement hypothesis can be assessed indirectly by examining predictions related to the mechanisms likely to underlie the enhancement effect. If the effect is proportional to the amount of time spent trying to recall dreams it should be influenced by motivation. Indeed, motivation is widely considered to be a key determinant of dream recall (e.g. Belicki, 1987; Goodenough, 1991; Reed, 1973; Schredl, Funkhouser, Cornu, Hirsbrunner, & Bahro, 2001). It can thus be predicted that the logbook enhancement effect should tend to gradually decline over time in tandem with motivation as the initial novelty of participation wears off and participants spend less time trying to recall their dreams each morning (as long as they are not given ongoing encouragement or techniques for enhancing dream recall). Indeed, several studies have produced results consistent with this. Schredl (2001, as cited in Schredl & Fulda, 2005) found that narrative logbook-DC was 28% lower in the second week of keeping a logbook compared to the first and Bernstein and Belicki (1995/1996) found that when narrative logbooks (eliciting written descriptions of only one dream per night) were maintained for two 14-day periods separated by several months, logbook-DC was significantly lower by 18% in the second period. Similar results were found by Schredl et al. (2001) using a sample of older adults that were asked to report their dream recall each week over the telephone for 26 weeks instead of keeping a logbook. The number of dreams reported in the second 4-week period was 22% lower compared to the first 4-week period and 39% lower in the final 4-week period (although only the latter comparison was statistically significant). Schredl, Brennecke, and Reinhard (2013) observed a 17% decline in narrative logbook-DRF over two time periods of approximately one week each (although the difference was not statistically significant) and Busby and De Koninck (1980) reported a mean reduction in narrative logbook-DC of 21% in the fifth compared to the first week of keeping a logbook for two groups of participants across four different conditions that involved practising meditation, relaxation and two non-intervention periods. In the aforementioned study by Zadra and Robert (2012) the mean number of words per dream in the narrative group was 11% lower in the second 5-day period and 20% lower in the third 5-day periods compared to the first 5-day period (although only the latter was significant). There was also a significant reduction in logbook-DC in the second 5-day time period compared to the first that appears to have been between about 15% and 20% for both the narrative and the checklist groups (results were presented graphically and exact figures not provided). Similar results were reported in an earlier study by Robert and Zadra (2008).

In contrast to the above, the present author is aware of four studies that failed to observe significant reductions in logbook dream recall rates over time. Watson (2003) found no significant difference in logbook-DRF between the first three weeks and the last three weeks of a 14-week checklist logbook period and participants in a study by Schredl and Fulda (2005) who kept a checklist logbook for four weeks did not show any significant difference in logbook-DRF between the first and second 2-week periods. Dream recall rates based on a checklist logbook that involved rating the extent to which each dream was recalled remained stable over three consecutive 2-week periods in a study by Rochlen, Ligiero, Hill, and Heaton (1999) and narrative logbook-DRF remained stable across two consecutive 20-day periods in a study by Segall (1980) for participants in a control group (the other group involved assertiveness training, which was expected to affect dream recall and is thus not described here). It is noteworthy that most of these studies used checklist logbooks whereas all the studies in which dream recall declined over time used narrative logbooks (except for the study by Schredl et al., 2001, in which dream recall was assessed using weekly telephone interviews). However, Segall (1980) is an exception to this pattern and in studies by Zadra and Robert (2012) and Robert and Zadra (2008) participants showed similar declines in dream recall regardless of whether checklist or narrative logbooks were used. In light of this it seems unlikely that the four studies in which dream recall remained stable can be explained by the type of logbook used. An alternative explanation is that participants in these studies may have experienced little if any logbook enhancement effect to begin with. This could conceivably occur when participants have low motivation and consequently spend little or no time recalling dreams prior to making a logbook entry each morning for the entire logbook period. Indeed, participants in the study by Rochlen et al. (1999) were recruited on the basis of having below-average interest in dreams and participants of all four studies involved undergraduates who were given course credit in exchange for participation. Thus, these studies, like those in which logbook dream recall rates declined over time, are consistent with the logbook enhancement hypothesis. However, none of these findings provide compelling empirical support for the hypothesis because reductions in logbook dream recall rates may simply reflect failures on behalf of participants to record their dream recall that increase in frequency over time due to waning motivation levels. This tendency to underreport might remain stable in studies involving participants with consistently low motivation, explaining the studies in which no reductions in logbook dream recall rates were observed.

It remains unclear whether narrative or checklist type logbooks are more likely to enhance dream recall. Studies that have compared the two have found that checklist logbooks yield significantly higher dream recall rates than narrative logbooks (Robert & Zadra, 2008; Zadra & Robert, 2012). This may be due to checklist logbooks having a stronger tendency to enhance dream recall, perhaps because people are willing to spend more time recalling their dreams prior to making a logbook entry if they are not required to provide written narratives for them. However, an alternative explanation is that both types of logbook have a similar effect on dream recall but participants are more likely to underreport their dream recall with narrative logbooks in order to reduce the burden of writing out their dreams. Narrative logbooks may even cause a *stronger* enhancement in dream recall than checklist logbooks, which could occur if writing out one's dreams facilitates dream recall. However, this would not be reflected by narrative logbook dream recall rates if the underreporting effect is stronger than the enhancement effect. Regardless of whether checklist or narrative logbooks are more likely to enhance dream recall, narrative logbooks will be more vulnerable to confounding variables associated with underreporting. For example, people who are less conscientious, who have poor sleep hygiene or who simply have less available time in the morning (e.g. due to 9-to-5 employment) may be less willing or able to report the full extent of their dream recall using narrative logbooks. Thus, checklist logbooks are likely to provide a more valid measure of dream recall than narrative logbooks.

5. Discussion

Several possible explanations for the retrospective-logbook disparity were explored in the present review. The disparity is unlikely to be due to participants exaggerating their dream recall or making deliberate attempts to enhance it while keeping a logbook because the demand characteristics of studies in which it has been observed were minimal and none of them involved any encouragement or instruction to enhance dream recall. The disparity is also not likely due to participants including a wider range of instances of dream recall in logbook measures compared to retrospective measures because several studies have observed substantial disparities for specific kinds of dreams that were defined precisely and consistently for both retrospective and logbook measures. The two most plausible remaining explanations are that retrospective measures tend to underestimate dream recall and that keeping a logbook tends to enhance it. These two explanations were referred to as the retrospective underestimation hypothesis and the logbook enhancement hypothesis respectively and were both explored in relation to theoretical considerations and available empirical evidence.

The retrospective underestimation hypothesis is supported theoretically by Tversky and Kahneman's (1973) availability heuristic, according to which people estimate the frequency of events based on the ease with which exemplars can be brought to mind. People who spend less time recalling and encoding memories of dreams should find it more difficult to recall instances of dream recall and thus be more prone to underestimation. The retrospective underestimation effect should also be stronger for retrospective measures based on longer periods of time (e.g. the previous 12 months) than those based on shorter periods (e.g. the previous month). This is because frequency judgments have been shown to be lower when people are required to consider the availability of a larger number of exemplars (e.g. Aarts & Dijksterhuis, 1999; Schwarz et al., 1991) and also because forgetting becomes increasingly likely over time (Roediger et al., 2010). Indeed, the retrospective-logbook disparity is for the most part greatest in studies that have used retrospective measures based on longer time periods. Furthermore, studies that have used multiple retrospective measures based on different time periods in the same sample have shown that retrospective dream recall rates are significantly lower when based on longer time periods, at least for specific types of dreams including lucid dreams, flying dreams, bad dreams and nightmares (Pietrowsky & Köthe, 2003; Robert & Zadra, 2008; Wood & Bootzin, 1990; Zadra & Donderi, 2000). Taken together these findings constitute compelling empirical support that retrospective measures underestimate dream recall, at least when they are based on relatively long time periods. Retrospective measures are likely to be confounded with a wide range of variables related to this underestimation effect, such as "inner focus" variables (e.g. introversion, fantasy proneness, absorption, etc.) and memory function. Consequently, retrospective measures are likely to be most valid when they are based on shorter time periods (e.g. the previous two weeks).

The logbook enhancement hypothesis is supported theoretically by the arousal retrieval model of dream recall, according to which dream recall is proportional to the amount of time spent trying to retrieve memories of dreams (Koulack & Goodenough, 1976). Participants must consider whether they can recall dreams prior to making logbook entries and for this reason logbooks should enhance dream recall, especially for participants who ordinarily do not pay much attention to their dreams. However, although this theory is highly plausible and theoretically supported, there is a lack of empirical evidence bearing upon it directly and more empirical research is needed to confirm that logbooks enhance dream recall. It also remains unclear whether narrative or checklist type logbooks would be more likely to enhance dream recall, although participants will be more likely to underreport the number of dreams they recall while keeping narrative logbooks in order to reduce the substantial burden of writing out their dreams and may choose to only include the most salient or memorable dreams. In contrast, participants are more likely to report all of the dreams they recall with checklist logbooks because checklist logbooks can be completed quickly and easily regardless of the number of dreams recalled. Thus, checklist logbooks are likely to be the most valid and are the most suitable for studies investigating predictors of dream recall. However, it may be the case that narrative and checklist logbooks are similarly valid in certain populations, such as lucid dreaming enthusiasts or people who are otherwise willing to spend as much time as necessary providing comprehensive narrative logbook entries every morning. If narrative logbooks are used it is likely that word counts will be the least valid operationalisation because they will be the most vulnerable to the underreporting effect and other possible confounds such as verbal intelligence or writing style. In contrast, DC and DRF are likely to be less affected by underreporting and thus more valid, although further research is needed before firm conclusions can be made about this. But even when validity is maximised and underreporting is minimised, checklist and narrative logbooks are both likely to enhance dream recall, meaning that even if they provide a valid measure of *enhanced* dream recall they may still fail to provide an accurate reflection of *typical* (unaltered) dream recall.

6. Recommendations for future research

The theory of retrospective underestimation outlined above would be strengthened if it could be shown that people estimate their dream recall using the availability heuristic. This could be done by replicating the study conducted by Aarts and Dijksterhuis (1999) using frequency of dream recall as the dependent variable rather than frequency of bicycling. The relationship between the retrospective underestimation effect and the size of the estimation period could be further explored by administering multiple retrospective measures based on various different time periods (e.g. the previous week, month and 12 months) in the same sample and this should be done using measures of general dream recall. If measures based on longer time periods yield lower dream recall rates this would suggest an underestimation effect that increases with the size of the estimation period. It would also be informative to explore whether different types of retrospective measures that include the same time period yield different dream recall rates, such as open ended measures based on the previous 12 months and measures that include "once per year" as one of their fixed response options. Future studies should measure variables likely to be associated with retrospective underestimation such as need for cognition and participants' self-rated certainty that their responses to retrospective measures are correct. If greater need for cognition and certainty is associated with a smaller retrospective-logbook disparity it would suggest the presence of a retrospective underestimation effect related to heuristic processing. The lack of empirical research bearing directly on the logbook enhancement hypothesis could be addressed by logbook studies that ask people to record the amount of time they spend thinking about their dreams prior to making logbook entries each morning and to also rate the extent to which they think their dream recall improved (if at all) at post-test. If these variables were significantly correlated with a retrospective-logbook disparity it would suggest that keeping a logbook enhanced dream recall by causing participants to spend more time on the retrieval process. This could be complemented by a qualitative approach whereby participants are asked at post-test if they think their dream recall improved during the logbook period, and if so, why.

Future studies should also calculate and explore the retrospective-logbook disparity separately for low, medium and high recallers because the disparity has been shown to vary as a function of retrospective recall rates (Antrobus et al., 1964; Cory et al., 1975; Schredl, 2002; Schredl et al., 2003; Zadra & Robert, 2012). Demand characteristics should be minimised because they could potentially bias both retrospective and logbook dream recall rates. For example, participants might exaggerate their dream recall if they think that high recall rates are desired. What counts as an instance of dream recall should be made clear to participants and this should be consistent for retrospective and logbook measures to ensure that both measures operationalise dream recall comparably. Otherwise, there is a risk of participants including a wider range of dream recall instances (especially borderline cases) in their logbook entries than in their retrospective estimates. It is also important that retrospective-logbook disparities are not derived by comparing DRF measures with DC measures because although DRF rates cannot exceed the number of days in a measurement period, DC has no upper limit. For this reason DC may be better able to capture logbook enhancement effects than DRF and may thus be more appropriate for exploring the retrospective-logbook disparity, especially among high recallers. Indeed, logbook DRF will not capture enhancement effects at all among participants for whom baseline DRF is already close to 100%.

7. Conclusions

The retrospective-logbook disparity is likely to be due to a combination of both retrospective underestimation and logbook enhancement. Retrospective and logbook measure are both likely to be confounded with a wide range of variables that may have little or no relationship to true dream recall rates. This calls into question much of the existing empirical literature on predictors of home dream recall, especially studies in which narrative logbooks (as opposed to checklist logbooks) or retrospective measures based on relatively long time periods have been used. In light of this, further research exploring the extent to which retrospective measures underestimate dream recall and logbooks enhance it should be considered a high priority among dream researchers.

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Appendix S: Published Version of Manuscript Presented in Chapter 7

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Is dream recall underestimated by retrospective measures and enhanced by keeping a logbook? An empirical investigation

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ABSTRACT

In a recent review, Aspy, Delfabbro, and Proeve (2015) highlighted the tendency for retrospective measures of dream recall to yield substantially lower recall rates than logbook measures, a phenomenon they termed the *retrospective-logbook disparity*. One explanation for this phenomenon is that retrospective measures underestimate true dream recall. Another explanation is that keeping a logbook tends to enhance dream recall. The present study provides a thorough empirical investigation into the retrospective-logbook disparity using a range of retrospective and logbook measures and three different types of logbook. Retrospective-logbook disparities were correlated with a range of variables theoretically related to the retrospective underestimation effect, and retrospective-logbook disparities were greater among participants that reported improved dream recall during the logbook period. These findings indicate that dream recall is underestimated by retrospective measures and enhanced by keeping a logbook. Recommendations for the use of retrospective and logbook measures of dream recall are provided.

1. Introduction

Dream recall in the home setting is assessed using two widely used types of measures. Logbook measures involve keeping a daily record of one's dream recall, which is usually operationalised as either the number of mornings on which dream content is recalled (regardless of how much is recalled) or the number of separate dreams recalled each morning. These two operationalisations are referred to as *Dream Recall Frequency* (DRF) and *Dream Count* (DC) respectively (Aspy, Delfabbro, and Proeve (2015)). Some logbooks elicit written narratives of each dream recalled and are referred to as *Narrative logbooks*, whereas logbooks that do not elicit dream narratives are referred to as *Checklist logbooks*. In contrast to logbook measures, retrospective measures of dream recall involve estimating one's DRF or DC for a recent specified time period (e.g. the past week) or by selecting one of several response options (e.g. "almost every morning", "several times a week", "about once a week", etc.). Until recently, there has been an implicit assumption that retrospective and logbook measures are essentially equivalent and that the choice between them is of little consequence in empirical research (Beaulieu-Prévost & Zadra, 2007a, 2007b). However, in a recent review, Aspy et al. (2015) drew attention to the tendency for logbook measures to yield substantially higher dream recall rates than retrospective measures. Aspy et al. (2015) termed this the *retrospective-logbook disparity*, a phenomenon that previous authors have also drawn attention to (Beaulieu-Prévost & Zadra, 2007a, 2007b; Schredl, 2002; Schredl & Fulda, 2005; Zadra & Robert, 2012). Aspy et al. (2015) found that out of 17 studies in which a disparity was

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reported or could be calculated, the majority (77%) found that logbook dream recall rates were between 10% and 610% higher than retrospective rates with an unweighted mean disparity of 115%.

There are two principal explanations for the retrospective-logbook disparity. According to the *retrospective underestimation hypothesis* (Aspy et al., 2015; see also Beaulieu-Prévost & Zadra, 2007a, 2007b; Schredl, 2002; Zadra & Robert, 2012), retrospective measures tend to underestimate true dream recall rates. According to the *logbook enhancement hypothesis* (Aspy et al., 2015; see also Beaulieu-Prévost & Zadra, 2007a, 2007b; Cohen, 1969; Cory, Ormiston, Simmel, & Dainoff, 1975; Goodenough, 1991; Schredl, 2002), keeping a logbook enhances dream recall due to greater attention being paid to dreams each morning. Both of these explanations have important implications for the measurement of dream recall. If the retrospective underestimation hypothesis is correct, retrospective measures may be confounded with a range of variables related to the tendency to underestimate dream recall but that are unrelated to true dream recall rates. Similarly, if the logbook enhancement hypothesis is correct, logbook measures may fail to accurately reflect ordinary dream recall rates and may be confounded with variables related to the enhancement effect. Indeed, although there have been well over 100 empirical studies on correlates of home dream recall using a variety of retrospective and logbook measures, most of these have found only weak relationships and findings are often inconsistent or even contradictory (for reviews, see Beaulieu-Prévost & Zadra, 2007a, 2007b; Belicki, 1987; Blagrove & Pace-Schott, 2010; Goodenough, 1991; Schredl & Montasser, 1996–1997a, 1996–1997b; Schredl, Wittmann, Ciric, & Götz, 2003; Zadra & Robert, 2012). Aspy et al. (2015) gave in-depth consideration to the retrospective-logbook disparity and concluded that it is likely to be the result of both retrospective underestimation and logbook enhancement effects. This calls into question much of the existing empirical literature on home dream recall, and Aspy et al. (2015) concluded that further research into this issue should be considered a high priority among dream recall researchers.

1.1. The retrospective underestimation hypothesis

According to Tversky and Kahneman's (1973) availability heuristic, people estimate the frequency of events based on how easily specific instances of the event in question can be recalled. This heuristic has been shown to apply in a wide range of situations (see Schwarz, 1998 for a review) and provides theoretical support to the retrospective underestimation hypothesis. Retrospective measures should be fairly accurate when the number of instances of dream recall brought to mind reflects the true frequency of dream recall. However, when this is not the case underestimation is likely to occur, an example of what is referred to as the *ease of recall bias* (see Buontempo & Brockner, 2008). Underestimation should thus be more likely to occur among people who have little interest in dreams or that spend relatively less time thinking about them, discussing them with other people, or attending to them generally. This is because such people should find it harder to recall occasions on which they recalled their dreams. Tentative support for this theory comes from studies that have found "inner focus" variables (variables that operationalise awareness of inner mental experiences) to be more strongly correlated with retrospective measures of dream recall than logbook measures, such as absorption and psychological boundaries (Beaulieu-Prévost & Zadra, 2007a, 2007b), introversion (Early, 1977, as cited in Schredl, 2002), imaginative involvement and fantasy proneness (Levin, Fireman, & Rackley, 2003). Attitude toward dreams has also been shown to be more strongly correlated with retrospective measures than logbook measures (Beaulieu-Prévost & Zadra, 2007a, 2007b). Aspy et al. (2015) theorised that retrospective underestimation should be less likely to occur if people estimate their dream recall using an elaborative cognitive process rather than a heuristic one, e.g., by estimating their dream recall over the past month and multiplying this by 12 to estimate their dream recall over the past year. Elaborative processing is operationalised by variables such as *need for cognition* (Suedfeld & Tetlock, 2001), which may thus be related to retrospective underestimation (Aspy et al., 2015). However, to date there have been no investigations into correlations between the aforementioned variables and disparities between retrospective and logbook measures of dream recall.

The theory of retrospective underestimation predicts that measures based on longer time periods will be more prone to underestimation. This is because such measures should require participants to recall more instances of dream recall. Indeed, several studies have shown that frequency estimates tend to be lower when people are asked to recall a greater number of instances (e.g. Aarts & Dijksterhuis, 1999; Schwarz et al., 1991) and it is well documented that the tendency to forget becomes increasingly likely over time (Roediger, Weinstein, & Agarwal, 2010). Unsurprisingly, of the studies reviewed by Aspy et al. (2015), the largest retrospective-logbook disparities were mostly found when retrospective measures based on relatively long time periods were used (e.g. the past year vs. the past month). However, the strongest empirical support for the retrospective underestimation hypothesis comes from several studies that used logbook measures and multiple retrospective measures of specific types of dream recall in the same sample. Zadra and Donderi (2000) found that retrospective-logbook disparities for nightmares, bad dreams, lucid dreams and dreams about flying were greater when retrospective measures based on the past month were used than when retrospective measures based on the past year were used. Similar findings were reported by Wood and Bootzin (1990), Pietrowsky and Köthe (2003) and Robert and Zadra (2008), who measured various types of distressing dreams using logbook measures and retrospective measures based on the past month and the past year. It is important to note that in all of these studies, what counted as an instance of dream recall was clearly defined and consistent across retrospective and logbook measures. This rules out the otherwise plausible theory that the disparities were simply due to participants noticing and then including more borderline instances of dream recall (e.g. single images or other remnants from dreams that were mostly forgotten) when making logbook entries than in their responses to retrospective measures. Aspy et al. (2015) argued that there is no clear reason to think that the cause of these disparities is different from the cause of the disparities observed between measures of general dream recall, and concluded that these findings provide strong support for the retrospective underestimation hypothesis. However, more research is needed to replicate these findings and investigate differences between different retrospective measures of general dream recall.

1.2. The logbook enhancement hypothesis

The logbook enhancement hypothesis is theoretically supported by the arousal retrieval model of dream recall (Koulack & Goodenough, 1976; see also Goodenough, 1991; Schredl, 2009 for reviews). According to this model, dream recall will be greatest if a period of arousal (wakefulness) occurs during or shortly after dreaming. Otherwise, it is likely that dream content will be lost from short-term memory. Dream content must then be retrieved in order for it to be consolidated into long-term memory and retained. Dream recall will be greatest when retrieval occurs shortly after arousal and without distraction. It follows that logbooks will tend to enhance dream recall because participants need to spend at least some time on the retrieval process in order to make a valid logbook entry and this is typically done immediately or shortly after waking. The logbook enhancement effect should thus be related to the amount of time spent on recalling dreams prior to making each logbook entry. The logbook enhancement effect should also be related to one's pre-existing tendency to spend time recalling dreams. People who typically spend little time recalling dreams should experience a relatively strong enhancement effect because keeping a logbook will result in them spending more time than usual on the retrieval process. In contrast, people who have a stronger pre-existing tendency to spend time recalling their dreams should experience less of an effect because keeping a logbook will have relatively little (if any) effect on the amount of time they spend recalling dreams. This may explain why several studies have found the retrospective-logbook disparity to be greatest among "low recallers" (people with low retrospective recall rates) and smallest among "high recallers" (Antrobus, Dement, & Fisher, 1964; Cory et al., 1975; Purcell, 1987; Schredl, 2002; Zadra & Robert, 2012). However, it is important to note that the tendency for the retrospective-logbook disparity to be greatest among low recallers does not unambiguously support the logbook enhancement hypothesis. An alternative explanation is that low recallers are simply more prone to retrospective underestimation.

Although it is both widely believed (e.g. Beaulieu-Prévost & Zadra, 2005; Goodenough, 1991; LaBerge & Rheingold, 1991; Parker, Bauermann, & Smith, 2000; Schredl & Montasser, 1996–1997a; Wittmann, Schredl, & Kramer, 2006) and theoretically likely that logbooks tend to enhance dream recall, there is a lack of unambiguous empirical evidence in support of this. Aspy et al. (2015) suggested that future studies could address this gap in the literature by asking research participants to record the amount of time spent trying to recall dreams prior to making each logbook entry and to rate how much they think their dream recall improved at the end of the logbook period. If these variables were found to be correlated with the differences between retrospective and logbook measures of dream recall for each participant, this would support the logbook enhancement hypothesis. Aspy et al. (2015) also suggested that future studies should further investigate whether Checklist or Narrative type logbooks are more likely to enhance dream recall. The retrospective-logbook disparities in the studies reviewed by Aspy et al. (2015) tended to be larger when Checklist logbooks were used. Furthermore, studies that have compared Checklist and Narrative logbooks have found that Checklist logbooks yield significantly higher dream recall rates than Narrative logbooks (Robert & Zadra, 2008; Zadra & Robert, 2012). However, the explanation for these findings is unclear. It may be the case that participants are willing to spend more time recalling dreams when given Checklist logbooks because the amount of content recalled has minimal effect on the overall burden of making Checklist logbook entries. An alternative explanation is that participants are more likely to underreport their true dream recall while keeping Narrative logbooks in order to reduce the substantial burden of having to provide written narratives for each dream. Further research investigating whether Checklist or Narrative logbooks are more likely to reflect true (unaltered) dream recall rates is warranted.

1.3. Aims and hypotheses

The present study follows suggestions for further research by Aspy et al. (2015) and provides a thorough empirical investigation into the retrospective underestimation hypothesis and the logbook enhancement hypothesis as explanations for the retrospective-logbook disparity. Several retrospective and logbook measures based on different time periods were used to assess general dream recall as well as recall of nightmares, bad dreams, lucid dreams and flying dreams. Three different types of logbooks were used: a Checklist logbook, a Narrative logbook and a "Quantity logbook" that quantifies the overall amount of dream content recalled by asking participants to specify how completely each individual dream is recalled. This operationalisation of dream recall will henceforth be referred to as *Dream Quantity* (DQ). Based on the preceding review, it was hypothesised that logbook measures of dream recall would yield significantly higher dream recall rates than comparable retrospective measures of dream recall.[1] Furthermore, it was hypothesised that retrospective-logbook disparities would be greatest for low recallers and smallest for high recallers. The following additional experimental hypotheses related specifically to the retrospective underestimation hypothesis and the logbook enhancement hypothesis were investigated.

[1] It is very important that retrospective-logbook disparities not be based on comparisons between measures that use different operationalisations of dream recall. Although DRF cannot exceed the number of days in a given measurement period, DC has no upper limit.

1.3.1. The retrospective underestimation hypothesis

- It was hypothesised that retrospective measures of dream recall based on longer time periods would yield significantly lower dream recall rates than comparable retrospective measures based on shorter time periods.
- It was hypothesised that there would be significant negative correlations between retrospective-logbook disparities and the following pre-test variables: self-rated confidence that responses to retrospective measures were correct, the frequency of thinking about dreams, the frequency of discussing dreams, the amount of attention paid to dreams, attitude toward dreams, interest in dreams and need for cognition.

1.3.2. The logbook enhancement hypothesis

- It was hypothesised that retrospective-logbook disparities would be significantly greater for participants that recorded all of their dreams while keeping a logbook compared to participants that recorded only some of their dreams.
- It was hypothesised that retrospective-logbook disparities would be significantly greater for participants that attempted to improve their dream recall while keeping a logbook compared to participants that did not attempt to improve their dream recall.
- It was hypothesised that retrospective-logbook disparities would be significantly greater for participants that reported improvement in dream recall while keeping a logbook compared to participants that did not report improvement.
- It was hypothesised that there would be significant positive correlations between retrospective-logbook disparities and the amount of time spent trying to recall dreams while keeping a logbook.
- It was hypothesised that there would be significant positive correlations between retrospective-logbook disparities and participants' self-rated improvement in dream recall while keeping a logbook.

2. Method

2.1. Participants

The present study is based on data from a pre-test questionnaire and a baseline period logbook used in a larger study comparing the effectiveness of different lucid dream induction techniques. A total of 420 participants who did not meet the exclusion criteria signed up for the study and completed the pre-test questionnaire. The sample consisted of 221 (53%) females, 197 (47%) males and 2 participants who identified their gender as "other" (0.5%). The mean age was 34.4 (SD = 14.2) and ranged from 18 to 82. Most of the participants were employed non-students (n = 271, 65%), with 112 (27%) participants being students and 37 (9%) being unemployed or retired. A total of 187 participants went on to complete and return their Week 1 logbooks. The ratio of males to females did not differ between participants who did and did not complete the logbook: $\chi^2(1, N = 418) = 1.49$, $p = .222$. Participants who completed the logbook were significantly older than those who did not (see Table 1). The proportions of participants who were employed non-students, students, and unemployed or retired did not differ among participants who did and did not complete the logbook: $\chi^2(2, N = 420) = 5.02$, $p = .081$. Participants heard about the study from a range of recruitment sources: 138 (33%) from physical posters or flyers distributed in public locations across the Australian states of South Australia, Victoria and New South Wales; 89 (21%) from word of mouth; 59 (14%) from nationally televised news interviews with the author; 43 (10%) from newspaper articles; 38 (9%) from social media; 27 (6%) from other internet sources; and 26 (6%) from radio interviews. Participants were excluded from the study if they had been diagnosed with any kind of mental health disorder, sleep disorder or neurological disorder; suspected they *might* have one of these disorders; were experiencing a traumatic or highly stressful life event that was interfering with their sleep; suffered from persistent insomnia or were unable to keep a regular sleep schedule; had experienced sleep paralysis more than once in the past 6 months; found it unpleasant to think about their dreams; or were under 18 years of age. All participants who completed the study went into a raffle to win one of five $200 gift vouchers or one of ten $50 gift vouchers.

2.2. Materials

Materials included an online pre-test questionnaire and physical packages that contained an instructions sheet for the first week of the study (see Section 2.3), three different types of Week 1 logbook and a sealed white envelope containing materials for the second week of the study. This envelope had the words "Week 2 materials – do not open until Week 1 is complete" printed on the front to discourage participants from attempting the lucid dreaming techniques prematurely, because this might have influenced responses during the Week 1 baseline period. All participants reported that they did not open the Week 2 envelope before completing their Week 1 logbooks. In the present paper, pre-test variables begin with a capital "P" to distinguish them from logbook variables, which begin with a capital "L."

2.2.1. Pre-test questionnaire

2.2.1.1. Demographic questions. Participants were asked to indicate their age, gender, occupation and how they heard about the study.

Table 1
Descriptive statistics for pre-test and logbook variables with Wilcoxon signed-ranks tests for pre-test differences between participants who did and did not complete the logbook.

Pre-test variable	*M (SD)*			Wilcoxon test		Logbook variable	*M (SD)*	*N*
	All participants (N = 420)	Logbook completers (n = 184)	Non-completers (n = 233)	Z	p			
Age	34.4 (14.2)	38.6 (14.9)	31.1 (12.6)	−5.29	<.001	L Mins recalling dreams	6.5 (8.2)	184
P DRF Schredl	2.8 (2.3)	3.1 (2.4)	2.6 (2.2)	−1.92	.055	L DRF	5.4 (1.5)	184
P DRF last week	2.9 (2.0)	3.1 (2.1)	2.8 (1.9)	−1.07	.287	L DC	12.0 (7.4)	184
P DC weekly	4.1 (4.5)	4.5 (4.3)	3.8 (4.6)	−1.73	.083	L DQ	6.1 (7.0)	53
P DC nightmares (month)	1.0 (2.3)	0.8 (1.8)	1.2 (2.7)	−0.66	.510	L Recall rating	2.8 (0.8)	184
P DC bad dreams (month)	2.1 (3.6)	1.8 (2.9)	2.3 (4.1)	−0.48	.632	L DC nightmares	1.1 (2.5)	184
P DC flying (month)	0.8 (2.5)	0.9 (2.9)	0.7 (2.1)	−0.76	.449	L DC bad dreams	2.9 (5.2)	184
P DC lucid (month)	1.4 (3.8)	1.4 (3.9)	1.4 (3.8)	−0.14	.890	L DC flying	0.9 (2.9)	184
P DC nightmares (year)	0.6 (1.9)	0.4 (1.4)	0.7 (2.3)	−1.22	.224	L DC lucid	3.0 (7.5)	184
P DC bad dreams (year)	1.1 (2.5)	1.2 (2.9)	1.0 (2.1)	−0.22	.823	L Mins to record dreams	3.9 (4.6)	184
P DC flying (year)	0.4 (1.3)	0.5 (1.6)	0.3 (1.0)	−1.80	.072	L Recall clarity	2.6 (0.9)	184
P DC lucid (year)	0.8 (2.7)	0.8 (3.0)	0.7 (2.4)	−0.56	.575	L Recall difficulty	3.1 (0.9)	184
P DRF confidence	4.1 (0.9)	4.2 (0.8)	4.0 (0.9)	−1.37	.170	L Recall improvement	2.4 (1.1)	173
P Dream think freq	4.2 (5.3)	4.2 (5.1)	4.2 (5.4)	−0.72	.475	L Mins per log entry	7.4 (5.8)	173
P Dream discuss freq	3.0 (1.0)	3.1 (1.0)	3.0 (1.0)	−0.67	.506	L Days to complete log	7.4 (3.1)	173
P Dream attention	3.4 (1.1)	3.4 (1.1)	3.4 (1.2)	−0.05	.958	L Total log entries	7.0 (0.2)	184
P ATD	4.4 (0.5)	4.4 (0.5)	4.3 (0.5)	−0.59	.554	L Percent recorded	95.5% (11.2%)	116
P Interest in dreams	4.6 (0.7)	4.5 (0.8)	4.6 (0.6)	−0.64	.522			
P Need for cognition	28.3 (18.3)	25.9 (18.2)	30.1 (18.2)	−2.08	.037			

Note: Dream recall rates for nightmares, bad dreams, flying dreams and lucid dreams were prorated to monthly rates in all cases.

2.2.1.2. General dream recall. Several retrospective measures of general dream recall were used. The first of these (*P DRF Schredl*) was Schredl's (2004) widely used DRF measure that asks participants "How often have you recalled your dreams recently (in the past several months)?" Participants respond using a Likert-type scale ranging from 0 to 6 (0 = "never", 1 = "less than once a month", 2 = "about once a month", 3 = "two or three times a month", 4 = "about once a week", 5 = "several times a week" and 6 = "almost every morning"). Responses are converted to the approximate number of mornings per week with dream recall using the following class means: 0 = 0, 1 = 0.125, 2 = 0.25, 3 = 0.625, 4 = 1.0, 5 = 3.5, 6 = 6.5. Participants were then asked "How confident are you that your answer to the last question (about your dream recall) is accurate?" (*P DRF confidence*) and responded using a Likert-type scale ranging from 1 ("not at all") to 5 ("very"). This question appeared on a new page to ensure that participants could not modify their answer to the previous question (participants were not able to navigate back to previous pages of the pre-test questionnaire). Two more general dream recall measures were then presented. The first assessed DRF over the last week (*P DRF last week*) by asking "How many days during the last week did you remember your dreams from the previous night?" Participants selected one of eight options from a drop-down menu ranging from "0 days" to "7 days." Following, the number of separate dreams recalled over the past week (*P DC weekly*) was assessed by asking "On average, how many separate dreams do you usually remember per week?" Participants could select any whole number between 0 and 50 or "more than 50" from a drop-down menu.

2.2.1.3. Dream-related behaviours. Three questions assessed dream-related behaviours. The first of these (*P Dream think freq*) asked "How often do you spend time thinking about your dreams?" The same response options and recoding as Schredl's (2004) dream recall measure (see above) were used except that an additional response option (7 = "several times a day", recoded as 21.0 times per week) was offered. The other two questions were adapted from Brown and Donderi's (1986) 72-item *Sleep and Dream Questionnaire* (SDQ) and were both answered using Likert-type scales ranging from 1 to 5: "How often do you discuss your dreams with family or friends?" (*P Dream discuss freq*; 1 = "never", 5 = "very often"); "How much attention do you usually pay towards your dreams?" (*P Dream attention*; 1 = "very little", 5 = "very much").

2.2.1.4. Recall of specific types of dreams. Four questions adapted from Brown and Donderi's (1986) *Sleep and Dream Questionnaire* (SDQ) were included to assess retrospective dream recall for nightmares (*P DC nightmares month*), bad dreams (*P DC bad dreams month*), lucid dreams (*P DC lucid month*) and flying dreams (*P DC flying month*) over the past month. *Nightmares:*

"Nightmares are very disturbing and often elaborate dreams in which the unpleasant visual imagery and/or emotions *wake you up* (i.e., the dream's unpleasant content woke you up while the dream was still ongoing). Please estimate the number of nightmares you have had in the past month." *Bad dreams*: "Bad dreams are very disturbing dreams which, though being unpleasant, do not cause you to awaken (e.g., you feel that the dream occurred earlier in the night prior to your awakening or you remembered it only after being awakened by external factors such as your alarm clock). Please estimate the number of bad dreams you have had in the past month." *Lucid dreams*: "Lucid dreams are those in which a person becomes aware of the fact that he or she is dreaming while the dream is still ongoing. For example: 'I was in England talking to my grandfather when I remembered that (in real life) he had died several years ago and that I had never been to England. I concluded that I was dreaming and decided to fly to get a bird's eye view of the countryside...' Please estimate the number of lucid dreams you have had in the past month." *Flying dreams*: "Please estimate the number of flying dreams (dreams in which you were able to fly) you have had in the past month." A second version of the above four questions (with the word "month" changed to "year") was used to assess recall over the past year. Both times, the four questions appeared together on a single page and the order of the two pages was randomised. The first page appeared directly after the questions about dream-related behaviours and the second page appeared after the *Need for Cognition Scale – short form*. For the past month questions, participants answered by selecting any whole number from 0 to 30 or "more than 30" from a drop-down menu. For the past year questions, participants chose from 0 to 365 or "more than 365." Responses to the past year questions were prorated to monthly rates (by dividing by 12) to permit direct comparison with past month versions of the questions.

2.2.1.5. Attitude toward dreams. Attitude toward dreams (*P ATD*) was assessed using Schredl, Brenner, and Faul's (2002) *Attitude Toward Dreams scale*. This measure includes 10 statements such as "If I am very moved by a dream, I try to make sense of it." Participants indicate their level of agreement using a Likert-type scale ranging from 1 ("not at all") to 5 ("total agreement"). Eight of the items are reverse scored and all items are then summed and averaged, resulting in a score ranging from 1 to 5 (higher scores indicate more positive attitude toward dreams). This scale was chosen because it avoids a problem that is common in other measures of attitude toward dreams whereby items with direct reference to dream recall are included, which results in attitude toward dreams being confounded with dream recall (Schredl, 2010; Schredl et al., 2002). Schredl et al. (2002) found high test-retest reliability for this scale when it was re-administered after four weeks ($r = .73$) and good internal consistency at both testing times ($\alpha = .91$ and $\alpha = .89$). In the present study, an internal consistency of $\alpha = .74$ was observed.

2.2.1.6. Interest in dreams. A single item measure was used to assess interest in dreams (*P interest in dreams*). Participants indicated their level of agreement with the statement "I am interested in my dreams" using a Likert-type scale ranging from 1 ("not at all") to 5 ("total agreement").

2.2.1.7. Need for cognition. Need for cognition (*P Need for cognition*) was assessed using the *Need for Cognition Scale – short form* developed by Cacioppo, Petty, and Kao (1984). This measure includes 18 statements such as "I would prefer complex to simple problems." It is based on the original 34 item *Need for Cognition Scale* developed by Cacioppo and Petty (1982). Participants indicate their level of agreement with each statement using a 9-point Likert-type scale that ranges from −4 ("very strong disagreement") to +4 ("very strong agreement"). Responses are summed after reverse scoring nine of the items, resulting in scores that range from −72 to 72 (higher scores indicate greater need for cognition). Cacioppo et al. (1984) found that the short form was strongly correlated with the full version of the scale ($r = .95$) and had good internal consistency ($\alpha = .90$; see also Cacioppo, Petty, Feinstein, & Jarvis, 1996 for a review). In the present study, an internal consistency of $\alpha = .87$ was observed.

2.2.2. Week 1 logbooks

Three different Week 1 logbooks were used. Each logbook used a different primary measure of general dream recall but were otherwise identical. The following instructions appeared on the first page of all three logbooks: "If you are not sure of an exact answer, please provide your best estimate. Do not provide descriptions of amounts in your answers. For example, when reporting how much time you spent sleeping last night, provide an exact estimate such as '7 hours and 45 minutes', not 'nearly 8 hours' or 'a bit less than usual'." Questions were answered each morning for seven days and appeared in the same order as below. Chronbach's alpha reliability coefficients for the measures of general dream recall are provided in Table 5. Participants first indicated the date of each entry so that the number of days taken to complete all seven entries could be assessed (*L Days to complete log*). The total number of logbook entries made by each participant (*L Total log entries*) was also counted. The amount of time spent trying to recall dreams prior to making a logbook entry (*L Mins recalling dreams*) was assessed in all three logbooks using the following questions: "Did you spend any time thinking about or trying to recall your dreams before filling in this logbook?" ("yes" or "no") and then "If 'yes', how much time?...minutes." All three logbooks then included the question "Can you recall anything *specific* about your dreams from last night?" ("yes" or "no"). This, along with answers to the primary measures of general dream recall, were used to determine the number of days with dream recall (*L DRF*) and the number of separate dreams recorded (*L DC*).

2.2.2.1. Primary measures of general dream recall. For the Checklist logbook, participants were instructed: "Please provide a brief title for each dream you can remember." Participants were then provided with seven blank lines preceded by "Dream

#1", "Dream #2", etc. to provide brief titles. For the Narrative logbook, participants were instructed: "Please provide detailed descriptions for each dream you can remember. Please be as thorough as possible and write out everything you can remember about your dreams. Please also draw a horizontal line between each dream so that we can tell how many separate dreams you had." Participants were provided with approximately two blank horizontally ruled pages to provide dream narratives. They were also instructed to use additional blank pages provided to them if they ran out of space. The Quantity logbook was the same as the Checklist logbook but included an additional measure that quantifies the overall amount of dream content recalled by asking participants to rate how completely each individual dream is recalled. This operationalisation of dream recall is referred to as *Dream Quantity* (DQ) in the present paper. Participants were instructed: "Please provide a brief title for each dream you can remember. Then, rate the amount of content you can recall from each individual dream using the following categories. Please be as thorough as possible and rate *all* of the dreams that you can recall." The four categories were presented as follows:

Fragmentary (F): You recall some content (such as a single scene or an isolated image), but not enough to provide any "flow" in the narrative. There are no transitions from one scene or event to the next.
Partial (P): You recall enough content for there to be some "flow" in the narrative from one scene or event to the next. However, you're pretty sure that *most of the dream has been forgotten.*
Majority (M): You recall a substantial amount and you're pretty sure you can recall *at least half* of the dream. However, there are frustrating gaps indicating that a significant amount is still missing.
Whole (W): Fairly complete recall of the dream without any frustrating gaps in your memory of what happened (although the beginning of the dream and some details might still be missing).

Participants were provided with seven blank lines as per the Checklist logbook to provide brief titles and ratings. This measure was adapted from an earlier measure developed by Reed (1973, see also Reed 1976). The number of categories was reduced and the definitions were made more concise to render the measure quicker and easier for participants to complete. Responses were converted to numerical values as per the procedure originally devised by Reed (1973): "*F*" = 1, "*P*" = 2, "*M*" = 4, "*W*" = 8. Reed (1973) found that this geometrical series closely approximated the proportional number of elements reported in the dreams of successive categories. A total of 729 dreams were rated as follows: *F*, 195 (27%); *P*, 211 (29%); *M*, 195 (27%); *W*, 128 (18%). Numerical values were summed for each logbook entry, resulting in total dream recall scores (higher scores indicate greater recall of dream content). This variable is referred to as *L DQ* in the present paper. In all three logbooks, the following question appeared directly after the primary dream recall measure: "How long did it take for you to provide [brief titles/brief titles and ratings/written descriptions] for all of your dreams?. . .minutes" (*L Mins to record dreams*).

2.2.2.2. Secondary measures of general dream recall. Three additional questions were used in all three logbooks to assess overall self-rated dream recall (*L Recall rating*), difficulty (*L Recall difficulty*) and clarity (*L Recall clarity*) using Likert-type scales ranging from 1 to 5: *L Recall rating*, "On a scale of 1 to 5, how much do you recall of your dreams from last night?" (1 = "nothing specific", 2 = "hardly anything", 3 = "a small amount", 4 = "a moderate amount", 5 = "a large amount"); *L Recall difficulty*, "On a scale of 1 to 5, how difficult was it for you to remember your dreams from last night?" (1 = "not at all difficult", 2 = "slightly difficult", 3 = "somewhat difficult", 4 = "quite difficult", 5 = "very difficult"); and *L Recall clarity*, "On a scale of 1 to 5, how clear are your memories of your dreams from last night?" (1 = "not at all clear", 2 = "slightly clear", 3 = "somewhat clear", 4 = "quite clear", 5 = "very clear").

2.2.2.3. Recall of specific types of dreams. Four questions were included to assess the number of nightmares (*L DC nightmares*), bad dreams (*L DC bad dreams*), lucid dreams (*L DC lucid*) and flying dreams (*L DC flying*). Definitions were the same as in the pre-test questionnaire (see Section 2.2.1) and were provided in parentheses. The questions took the following form: "Did you have any flying dreams [definition included in parentheses] last night?" Participants ticked a box to indicate either "yes" or "no." Participants were then asked "If 'yes', how many?" and given a blank space to provide an answer. Dream recall rates were prorated to monthly rates (by multiplying by four) to permit direct comparison with retrospective DC measures of these specific types of dreams.

2.2.2.4. Summary questions. The following questions were presented only once and appeared directly after the questions for Day 7 in each logbook. Participants were asked, "Over the last seven days, did you typically provide brief titles for *all* of the dreams you remembered each morning before filling in your logbook or only for *some* of your dreams? (don't include dreams you recalled later in the day after you made a logbook entry)" ("all" or "some"), and were then asked to rate the extent to which they reported their dreams with the following question: "If you answered "some" above, how many of the dreams that you remembered in the morning did you typically provide brief titles for each morning?" Response options were "0–20%", "20–40%", "40–60%", "60–80%" and "80–100." These were converted to the following values for analysis: 0.1, 0.3, 0.5, 0.7 and 0.9 (*L Percent recorded*). Unfortunately, there were some errors in the wording of the above two questions in the Narrative logbook and thus the Narrative logbook group had to be excluded from analysis of these variables. Participants were then asked "Did you make any deliberate attempt to improve your dream recall while keeping this logbook?" ("yes" or "no"). Two questions were used to assess self-reported improvement in dream recall: "Was your dream recall better than usual while keeping this logbook over the last seven days?" ("yes" or "no"). Following, "On a scale of 1 to 5, how much did your dream recall improve while keeping this logbook?" (*L Recall improvement*; 1 = "not at all", 2 = "slightly", 3 = "somewhat", 4 = "quite a lot", 5 = "very much"). Participants were then asked "Did you open the white envelope for Week 2 before completing this logbook?" ("yes" or "no"). Finally, participants were asked "On average, how long did it take you to fill out this logbook each morning?. . .minutes." (*L Mins per log entry*).

2.3. Procedure

Participants accessed the online pre-test questionnaire and an information sheet outlining the study using a web URL that was included in all promotional materials and media items. The questionnaire was hosted by the popular survey management website *Survey Monkey* and was configured so that participants could not navigate backwards to change their answers. At the end of the questionnaire, participants provided postal details so that they could be sent the materials needed to complete the study via post. Participants thus completed the study in their own homes, which allowed participants from anywhere in Australia to take part. Participants were randomly allocated to the three different logbook groups. The Week 1 instructions sheet explained that the purpose of the first week was to gather baseline information about normal sleeping patterns and dream recall ability. Participants were urged to complete all seven logbook days consecutively and to do extra days at the end if necessary to make up for any skipped days. They were instructed to keep the logbook and a pen beside their bed and to make each entry first thing upon waking. They were asked not to make any attempt to have lucid dreams or to improve their dream recall during the first week and to only open the Week 2 envelope when all seven Week 1 logbook entries were complete. Participants were instructed to return their completed logbooks once they had completed their Week 2 logbooks using pre-paid envelopes provided to them. Several attempts were made to contact participants via email if they had not returned their completed materials within approximately six weeks of completing the pre-test questionnaire. Several participants returned their completed Week 1 logbooks after opting to withdraw from the lucid dream induction component of the study.

3. Results

3.1. Data preparation and overview of analysis

Logbook data from three participants was excluded from analysis because most questions were not answered and in some cases multiple answers were provided for the same question. Most variables were not normally distributed and non-parametric tests were used in most cases. Outliers were removed for correlations and multiple regression analysis using the outlier labelling rule (Hoaglin, Iglewicz, & Tukey, 1986; Tukey, 1977). A multiplier value of 2.2 was used as per the recommendations of Hoaglin and Iglewicz (1987). Retrospective-logbook disparities were calculated as follows: (mean logbook rate – mean retrospective rate)/mean retrospective rate. For disparities between two retrospective measures based on different time periods, the following method was used: (shorter retrospective measure – longer retrospective rate)/longer retrospective measure. The low, medium and high recaller groups were defined according to the following recoded responses to Schredl's (2004) DRF measure: low recallers = 0.0, 0.125 and 0.25 per week; medium recallers = 0.625 and 1.0 per week; high recallers = 3.5 and 6.5 per week.

3.2. Descriptive statistics and preliminary analyses

Descriptive statistics with Wilcoxon signed-ranks tests for differences in pre-test variables between participants who did and did not complete the Week 1 logbook are presented in Table 1. The slightly higher rates of pre-test general dream recall variables among logbook completers suggests that logbook completers may have had slightly higher general dream recall. Logbook completers also had significantly lower need for cognition and were significantly older than non-completers, but were almost identical on all other measures. Thus, it appears that logbook completers were representative of non-completers in most ways. Because the mean age difference was substantial (7.5 years), correlations between age and all other variables were examined. It was found that age was only significantly correlated with four of the variables in Table 1: *L Mins recalling dreams*, ($r = .21$, $p = .005$); *L DQ*, ($r = .28$, $p = .044$); *L Recall rating* ($r = .16$, $p = .034$); and *L Recall difficulty* ($r = -.16$, $p = .035$). Since age was related to measures of dream recall that involved subjective self-ratings but not *L DRF* or *L DC*, it may be the case that older participants differed in their subjective judgments of their dream recall but did not differ in the true extent to which they recalled their dreams.

Correlations between retrospective and logbook measures of general dream recall are presented in Table 2. All three retrospective measures were strongly correlated with each other, with shared variance ranging from 48% to 70%. Correlations among logbook measures were mostly of a similar magnitude with shared variance ranging from 33% to 66%. However, correlations between retrospective measures and logbook measures were in most cases substantially smaller, ranging from 19% to 42% in shared variance. These findings demonstrate that retrospective and logbook measures of dream recall are not equivalent.

Kruskal–Wallis tests were conducted to investigate whether logbook measures were influenced by the type of logbook used. These analyses are presented in Table 3. Five of the group differences were statistically significant at the .05 alpha level.

Table 2
Pearson correlations between retrospective and logbook measures of general dream recall.

	P DRF Schredl	P DRF last week	P DC weekly	L DRF	L DC	L DQ
P DRF last week	.84**	–	–	–	–	–
P DC weekly	.69**	.77**	–	–	–	–
L DRF	.49**	.51**	.44**	–	–	–
L DC	.43**	.45**	.52**	.71**	–	–
L DQ	.50**	.55**	.65**	.57**	.81**	–
L Recall rating	.51**	.53**	.47**	.73**	.62**	.81**

* p = <.05.
** p = <.01.

Table 3
Kruskal–Wallis tests for differences between the Checklist, Quantity and Narrative logbook groups on logbook measures of dream recall.

	Logbook type	*M* (*SD*)	Kruskal–Wallis test	
			χ^2	p
L Mins recalling dreams	Checklist	5.9 (6.0)	6.48	.039
	Quantity	4.8 (4.9)		
	Narrative	8.7 (11.5)		
L DRF	Checklist	5.4 (1.4)	1.53	.466
	Quantity	5.4 (1.6)		
	Narrative	5.3 (1.5)		
L DC	Checklist	12.9 (7.9)	2.54	.280
	Quantity	12.8 (8.6)		
	Narrative	10.5 (5.5)		
L Recall rating	Checklist	2.8 (0.7)	1.55	.462
	Quantity	3.0 (0.9)		
	Narrative	2.8 (0.8)		
L DC nightmares	Checklist	0.8 (2.0)	0.84	.657
	Quantity	1.5 (3.4)		
	Narrative	1.0 (2.2)		
L DC bad dreams	Checklist	4.0 (6.4)	6.53	.038
	Quantity	2.4 (3.7)		
	Narrative	2.3 (4.8)		
L DC flying	Checklist	0.4 (1.2)	5.99	.050
	Quantity	1.2 (2.2)		
	Narrative	1.2 (4.4)		
L DC lucid	Checklist	4.0 (9.4)	0.84	.657
	Quantity	2.7 (6.1)		
	Narrative	2.3 (6.3)		
L Mins to record dreams	Checklist	1.8 (1.3)	74.82	<.001
	Quantity	2.0 (1.7)		
	Narrative	8.0 (5.9)		
L Recall clarity	Checklist	2.5 (0.8)	1.32	.516
	Quantity	2.7 (0.9)		
	Narrative	2.5 (0.8)		
L Recall difficulty	Checklist	3.1 (0.8)	4.24	.120
	Quantity	2.9 (0.9)		
	Narrative	3.3 (0.8)		
L Recall improvement	Checklist	2.4 (1.1)	1.42	.491
	Quantity	2.3 (1.2)		
	Narrative	2.5 (1.0)		
L Mins per log entry	Checklist	6.0 (3.8)	29.52	<.001
	Quantity	5.0 (3.4)		
	Narrative	10.9 (7.3)		
L Days to complete log	Checklist	7.9 (5.1)	5.30	.071
	Quantity	7.1 (0.5)		
	Narrative	7.1 (0.3)		
L Total log entries	Checklist	7.0 (0.2)	2.17	.337
	Quantity	7.0 (0.2)		
	Narrative	7.0 (0.00)		

Note: Dream recall rates for nightmares, bad dreams, flying dreams and lucid dreams were prorated to monthly rates in all cases.

Pairwise comparisons were conducted with adjusted significance values calculated by multiplying the unadjusted significance values for each pairwise comparison by the number of comparisons for each variable. It was found that participants in the Checklist group had significantly less flying dreams than those in the Quantity group ($\chi^2 = -14.84$, $p = .043$). However, the differences between the Checklist and Narrative groups ($\chi^2 = 5.90$, $p = .931$) and the Narrative and the Quantity groups ($\chi^2 = 8.94$, $p = .451$) were not significant. Participants in the Checklist group reported significantly more bad dreams than those in the Narrative group ($\chi^2 = 20.88$, $p = .033$), but there were no significant differences between the Narrative and Quantity groups ($\chi^2 = 9.30$, $p = .866$) or between the Quantity and Checklist groups ($\chi^2 = 11.58$, $p = .529$). Based on the p values in Table 3, it seems most likely that these findings are spurious. *L Mins to record dreams* was significantly higher in the Narrative group compared to both the Quantity ($\chi^2 = -72.21$, $p = <.001$) and Checklist ($\chi^2 = 71.53$, $p = <.001$) groups, with the difference between the Quantity and Checklist groups being non-significant ($\chi^2 = 0.68$, $p = .100$). Similarly, *L Mins per log entry*, was significantly higher in the Narrative group compared to both the Quantity ($\chi^2 = -48.99$, $p = <.001$) and Checklist ($\chi^2 = -36.55$, $p = <.001$) groups, with the difference between Quantity and Checklist groups being non-significant ($\chi^2 = 12.45$, $p = .543$). Finally, *L Mins recalling dreams* was significantly higher in the Narrative group compared to the Quantity group ($\chi^2 = -25.09$, $p = .035$). However, the differences between the Narrative and the Checklist groups ($\chi^2 = -14.62$, $p = .350$) and the Quantity and Checklist ($\chi^2 = 10.46$, $p = .846$) groups were non-significant. Despite participants in the Narrative group spending substantially more time recalling and recording their dreams than participants in the other two groups, this does not seem to have resulted in higher dream recall rates. Indeed, dream recall was slightly (but not significantly) lower in the Narrative group compared to the other two groups for measures of general dream recall (*L DRF*, *L DC* and *L Recall rating*).

Pearson correlations were calculated to investigate whether logbook measures of dream recall changed over the course of keeping a logbook. Ascending consecutive numbers were assigned to each logbook day (from first to last) for each participant and this variable was then correlated with daily responses to logbook measures of dream recall. As can be seen in Table 4, for all participants combined, *L DRF*, *L DC*, *L Recall rating* and *L Recall clarity* decreased over time and *L Recall difficulty* increased. When changes over time were examined for participants in each logbook group separately, it was observed that these changes were strongest for participants in the Narrative group. One possible explanation for this is that the burden of having to provide written dream narratives caused participants in the Narrative group to lose motivation more quickly than participants in the other groups. No significant changes over time were observed for participants in the Quantity group. Changes in logbook dream recall measures are also graphically represented in Fig. 1 for all participants combined and in Figs. 2–4 for participants in the Checklist, Narrative and Quantity groups respectively. In almost every case, dream recall was poorest on Day 5. The explanation for this is not clear.

To further investigate effects of different types of logbooks on measures of general dream recall, Chronbach's alpha reliability coefficients were calculated for all participants combined and for each logbook group separately. As can be seen in Table 5, reliability was highest in every case for measures presented in the Quantity logbook. *L DRF* and *L DC* showed the lowest reliability when presented in the Narrative logbook, while *L Recall rating* and *L Recall clarity* showed the lowest reliability in the Checklist logbook.

3.3. The retrospective-logbook disparity

It was hypothesised that logbook measures of dream recall would yield significantly higher dream recall rates than comparable retrospective measures of dream recall. It was also hypothesised that retrospective-logbook disparities would be greatest for low recallers and smallest for high recallers. Wilcoxon matched-pair signed-ranks tests were conducted to investigate differences between comparable retrospective and logbook measures of dream recall for all participants combined and also for low, medium and high recallers. As can be seen in Table 6, all three retrospective-logbook disparities based on measures of general dream recall were statistically significant for all participants combined and also for low, medium and high recallers. Furthermore, these disparities were highest for low recallers and lowest for high recallers. These findings support both hypotheses. However, results for retrospective-logbook disparities based on measures of specific types of dreams only partially supported the hypotheses. Disparities were statistically significant for all participants combined for bad dreams and lucid dreams but not for nightmares or flying dreams. Despite being substantial in size in most cases, disparities were mostly non-significant for low, medium and high recaller groups. This is likely due to reduced statistical power for the three recaller groups compared to all participants combined. This issue is compounded by the fact that many participants had both retrospective and logbook DC of "0" for measures of specific types of dreams.

To further investigate the hypothesis that retrospective-logbook disparities would be greatest for low recallers and smallest for high recallers, retrospective-logbook disparities for measures of general dream recall were calculated for each individual participant and then group differences between low, medium and high recallers were examined using Kruskal–Wallis tests. These general retrospective-logbook disparities were named after the dream recall operationalisation and the retrospective measure used as follows: *DISP DRF (Schredl)*, *DISP DRF (last week)* and *DISP DC (weekly)*. All three variables were non-normally distributed. For these variables there were 2, 19 and 10 cases respectively where a retrospective recall rate of "0" was converted to the low recaller mean value for that measure to permit calculating disparities. When the analyses were re-run with these cases excluded, the statistical significance (at the .05 alpha level) of all findings remained the same. As can be seen in Table 7, findings mostly supported the hypothesis. Note that retrospective-logbook disparities could not be

Table 4
Pearson correlations between day of logbook entry and logbook measures of general dream recall for all participants combined and for participants in each logbook group.

	Logbook day			
	All participants	Logbook group		
		Checklist	Narrative	Quantity
L DRF	−.11**	−.11*	−.12**	−.10
L DC	−.12**	−.14**	−.13**	−.09
L DQ	–	–	–	−.03
L Recall rating	−.10**	−.08	−.15**	−.06
L Recall clarity	−.09**	−.06	−.16**	−.04
L Recall difficulty	.09**	.06	.13**	.06

* p = <.05.
** p = <.01.

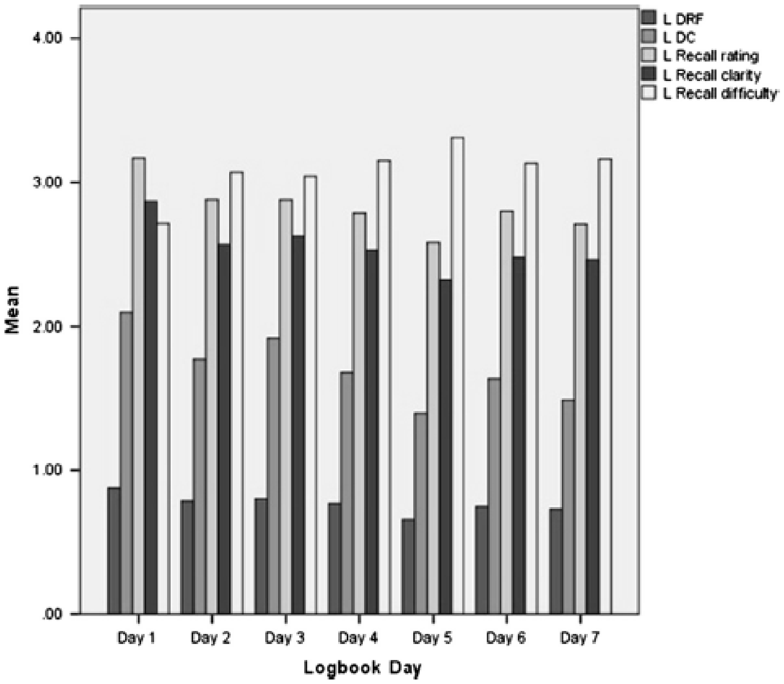

Fig. 1. Changes in logbook measures of general dream recall for all participants combined.

calculated individually for each participant for nightmares, bad dreams, lucid dreams or flying dreams because in most cases participants responded "0" to the retrospective measures.

3.4. The retrospective underestimation hypothesis

It was hypothesised that retrospective measures of dream recall based on longer time periods would yield significantly lower dream recall rates than comparable retrospective measures based on shorter time periods. The findings presented in Table 6 provide some support for this hypothesis. With only one exception (flying dreams for low recallers), retrospective-logbook disparities were greater when retrospective measures of specific types of dream recall based on the past year were used than when measures based on the past month were used. To further investigate this hypothesis, differences between retrospective measures of both general and specific types of dream recall based on different time periods were investigated using Wilcoxon matched-pair signed-ranks tests. As can be seen in Table 8, the hypothesis was partially supported. Dream recall rates for nightmares, bad dreams, flying dreams and lucid dreams were significantly lower for the past year compared

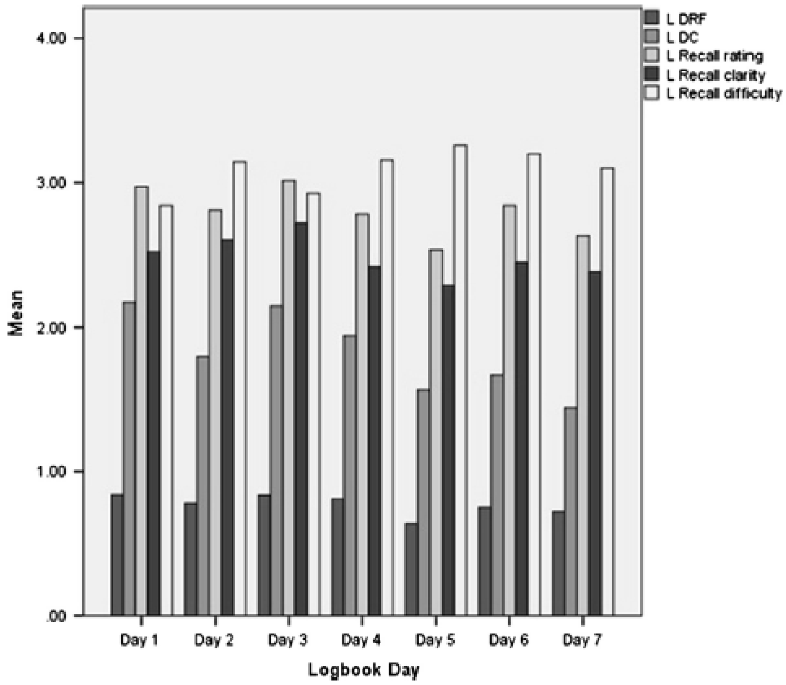

Fig. 2. Changes in logbook measures of general dream recall for participants in the Checklist group.

to the past month. However, the difference between the two measures of general dream recall was minimal and not statistically significant. This indicates that *P DRF Schredl* and *P DRF last week* are similar in the way that they measure dream recall. Indeed, the correlation between these two variables ($r = .84$) was higher than any of the other correlations between retrospective and logbook measures of dream recall reported in Table 2.

It was hypothesised that there would be significant negative correlations between retrospective-logbook disparities and the following pre-test variables: self-rated confidence that responses to retrospective measures were correct, the frequency of thinking about dreams, the frequency of discussing dreams, the amount of attention paid to dreams, attitude toward dreams, interest in dreams and need for cognition. To test this hypothesis, general retrospective-logbook disparities were calculated for each participant as described in Section 3.3 and correlated with the hypothesised predictor variables. Pearson correlations between predictor variables and both retrospective and logbook measures of general dream recall were also calculated and are presented in Table 9. Results partially supported the hypothesis. *P DRF Confidence*, *P Dream think freq*, *P Dream discuss freq* and *P Dream attention* were all significantly correlated with all three general retrospective-logbook disparities. These findings support the retrospective underestimation hypothesis whereby participants who pay less attention to their dreams and are thus less aware of their dreaming patterns are more likely to underestimate their dream recall. An alternative explanation is that perhaps participants who spent less time thinking about, discussing and attending to their dreams had lower dream recall as a consequence and then experienced a relatively strong logbook enhancement effect because keeping a logbook caused them to spend more time attending to their dreams than usual. However, the pattern of correlations presented in Table 9 indicates that this does not explain the findings, at least not fully. This is because in every case, *P DRF Confidence*, *P Dream think freq*, *P Dream discuss freq* and *P Dream attention* were more strongly correlated with retrospective measures of dream recall than with logbook measures. If the correlations between these predictor variables and the general retrospective-logbook disparities were simply due to a logbook enhancement effect, one would expect them to be correlated at least as strongly with the logbook measures as with the retrospective measures. Furthermore, it was found that *P DRF Confidence* was significantly correlated with *P Dream think freq* ($r = .35$, $p = <.001$), *P Dream discuss freq* ($r = .27$, $p = <.001$) and *P Dream attention* ($r = .25$, $p = <.001$). Thus, these findings support the retrospective underestimation hypothesis. The remaining predictor variables (*P ATD*, *P Interest in dreams* and *P Need for cognition*) were not significantly correlated with general retrospective-logbook disparities. Excluding cases where retrospective dream recall values of "0" were converted to the low recaller mean value to permit calculation of disparities did not change the statistical significance of any of the findings.

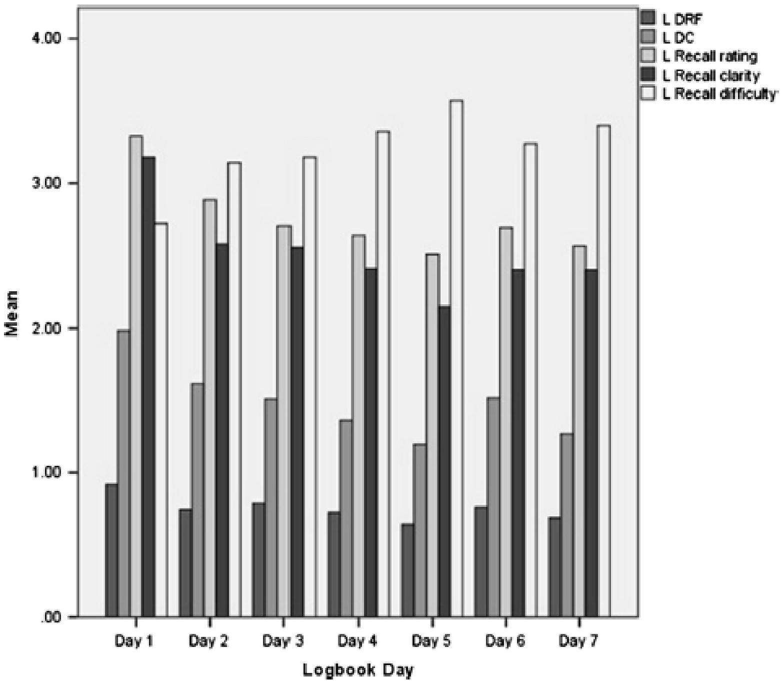

Fig. 3. Changes in logbook measures of general dream recall for participants in the Narrative group.

3.5. The logbook enhancement hypothesis

It was hypothesised that retrospective-logbook disparities would be significantly greater for participants that recorded all of their dreams while keeping a logbook compared to participants that recorded only some of their dreams. As can be seen in Table 10, findings from Wilcoxon matched-pair signed-ranks tests did not support this hypothesis, suggesting that the general retrospective-logbook disparities were not related to whether participants reported all or only some of their dreams (note however that Narrative participants were excluded from this analysis). It was hypothesised that retrospective-logbook disparities would be significantly greater for participants that attempted to improve their dream recall while keeping a logbook compared to participants that did not attempt to improve their dream recall. As shown in Table 10, Wilcoxon matched-pair signed-ranks tests indicated that participants who attempted to improve their recall while keeping a logbook had significantly greater general retrospective-logbook disparities. These findings support the logbook enhancement hypothesis. It was hypothesised that retrospective-logbook disparities would be significantly greater for participants that reported improvement in dream recall while keeping a logbook compared to participants that did not report improvement. As can be seen in Table 10, Wilcoxon matched-pair signed-ranks tests indicated that participants that reported improvement in dream recall had significantly greater general retrospective-logbook disparities. Indeed, in every case the disparity was more than twice as large among participants that reported improvement in dream recall. These findings provide further support for the logbook enhancement hypothesis.

It was hypothesised that there would be significant positive correlations between retrospective-logbook disparities and the amount of time spent trying to recall dreams while keeping a logbook. As shown in Table 11, this hypothesis was not supported. *L Mins recalling dreams* was only weakly correlated with one of the logbook dream recall variables (*L Recall rating*) and was not correlated with any of the general disparities (or pre-test dream recall variables). It may be the case that the amount of time participants spent recalling dreams was moderated by how much content was initially recalled. Participants may have tended to spend more time trying to recall dreams on mornings when recall was initially poor, which would have brought their recall rates closer to those that occurred on mornings when they were more easily able to recall dreams and likely to spend less time recalling dreams as a consequence. This would explain the lack of significant correlations between *L Mins recalling dreams* and logbook dream recall rates. This theory is supported by the significant correlation observed between *L Mins recalling dreams* and *L Recall difficulty* ($r = .13$, $p = <.001$). It was hypothesised that there would be significant positive correlations between retrospective-logbook disparities and participants' self-rated improvement in dream recall

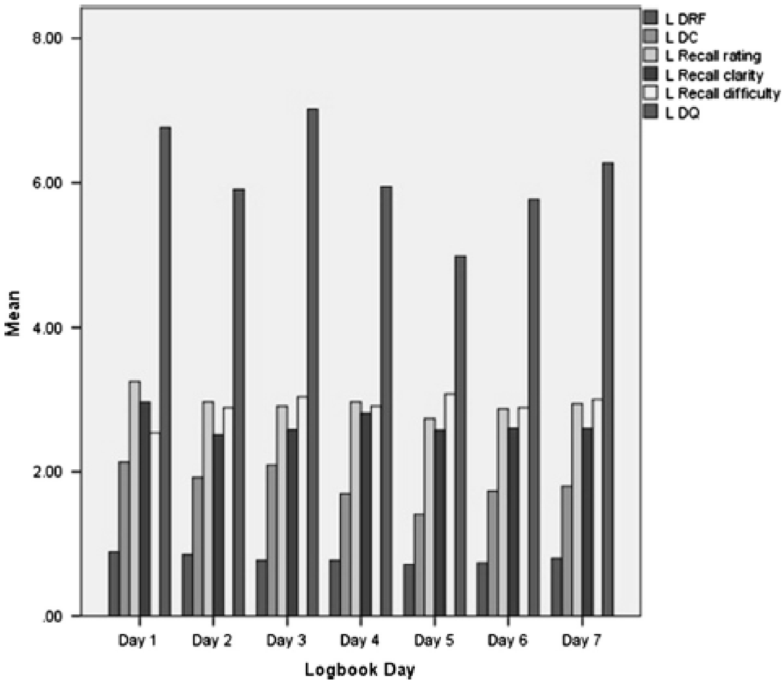

Fig. 4. Changes in logbook measures of general dream recall for participants in the Quantity group.

Table 5
Chronbach's alpha reliability coefficients for measures of general dream recall for all participants combined and for participants in each logbook group.

	All participants	Logbook group		
		Checklist	Narrative	Quantity
L DRF	.54	.52	.48	.61
L DC	.83	.84	.72	.86
L DQ	–	–	–	.92
L Recall rating	.69	.62	.68	.75
L Recall clarity	.73	.69	.71	.79
L Recall difficulty	.68	.65	.65	.73

while keeping a logbook. As can be seen in Table 11, this hypothesis was supported. *L Recall improvement* was correlated with all three general retrospective-logbook disparities and was also correlated with retrospective measures of general dream recall. However, no significant correlations were observed between *L Recall improvement* and logbook measures of dream recall. These findings are best explained as being due to a logbook enhancement effect that was greatest for low recallers and smallest for high recallers. Unsurprisingly, *L Mins to record dreams* and to a lesser extent *L Mins per log entry* were positively correlated with both pre-test and logbook dream recall variables, suggesting that people with greater dream recall required more time to record their dreams and complete their logbooks. Removing cases where disparities were calculated by converting "0" to the low recaller mean value did not change the statistical significance of any of the findings.

3.6. Multiple regression analysis

Multiple regression analysis was conducted to investigate the amount of variance that could be explained in retrospective-logbook disparities between measures of general dream recall, using variables theorised to be related to the retrospective underestimation and logbook enhancement effects. The following statistically significant correlates of general retrospective-logbook disparities (see Tables 9 and 11) were entered as predictors in forward linear multiple regression analyses: *P DRF confidence*, *P Dream think freq*, *P Dream discuss freq*, *P Dream attention* and *L Recall improvement*. Whether or not participants made a deliberate attempt to improve their dream recall during the logbook period was also included as a

Table 6
Wilcoxon matched-pair signed-ranks tests for retrospective-logbook disparities.

Retrospective measure	Logbook measure	Recaller group	M (SD)		Disparity (%)	Wilcoxon test	
			Retrospective measure	Logbook measure		Z	p
P DRF Schredl	L DRF	All	3.05 (2.38)	5.39 (1.51)	76	−10.30	<.001
		Low	0.18 (0.08)	3.88 (1.53)	2055	−4.20	<.001
		Medium	0.83 (0.19)	4.75 (1.49)	472	−6.41	<.001
		High	4.83 (1.50)	6.05 (1.10)	25	−6.13	<.001
P DRF last week	L DRF	All	3.01(2.12)	5.39 (1.51)	79	−10.49	<.001
		Low	0.52 (0.59)	3.88 (1.53)	646	−4.21	<.001
		Medium	1.47 (0.79)	4.75 (1.49)	222	−6.42	<.001
		High	4.34 (1.75)	6.05 (1.10)	39	−6.97	<.001
P DC weekly	L DC	All	4.43 (4.35)	12.01 (7.44)	171	−11.20	<.001
		Low	0.65 (0.65)	6.88 (3.83)	957	−4.11	<.001
		Medium	1.91 (1.24)	9.55 (5.79)	400	−6.28	<.001
		High	6.56 (4.58)	14.40 (7.84)	120	−8.35	<.001
P DC nightmares (month)	L DC nightmares	All	0.73 (1.64)	1.07 (2.52)	47	−1.88	.061
		Low	0.22 (0.52)	0.87 (2.40)	296	−1.22	.223
		Medium	0.51 (0.86)	0.58 (1.62)	14	−0.12	.908
		High	0.96 (2.02)	1.37 (2.88)	43	−1.80	.071
P DC nightmares (year)	L DC nightmares	All	0.44 (1.43)	1.07 (2.52)	143	−1.17	.240
		Low	0.14 (0.19)	0.87 (2.40)	521	−0.85	.393
		Medium	0.26 (0.38)	0.58 (1.62)	123	−2.04	.042
		High	0.60 (1.85)	1.37 (2.88)	128	−0.07	.941
P DC bad dreams (month)	L DC bad dreams	All	1.81 (2.95)	2.95 (5.21)	63	−2.83	.005
		Low	0.83 (1.19)	1.59 (2.37)	93	−1.34	.180
		Medium	0.93 (1.18)	2.04 (3.60)	120	−2.07	.038
		High	2.48 (3.62)	3.72 (6.17)	50	−1.64	.101
P DC bad dreams (year)	L DC bad dreams	All	1.15 (2.80)	2.95 (5.20)	157	−2.83	.005
		Low	0.48 (0.69)	1.59 (2.37)	233	−0.85	.394
		Medium	0.55 (0.64)	2.04 (3.60)	271	−0.74	.460
		High	1.61 (3.59)	3.72 (6.17)	130	−2.63	.009
P DC flying (month)	L DC flying	All	0.75 (2.31)	0.85 (2.88)	13	−0.65	.518
		Low	0.04 (0.21)	0.17 (0.83)	325	−0.45	.655
		Medium	0.35 (0.78)	0.58 (1.62)	69	−1.04	.297
		High	1.11 (2.94)	1.14 (3.57)	3	−0.05	.959
P DC flying (year)	L DC flying	All	0.38 (1.12)	0.85 (2.88)	124	−1.37	.172
		Low	0.06 (0.12)	0.17 (0.83)	183	−1.19	.233
		Medium	0.18 (0.44)	0.58 (1.62)	222	−0.77	.441
		High	0.56 (1.42)	1.14 (3.57)	104	−0.91	.365
P DC lucid (month)	L DC lucid	All	1.45 (3.88)	2.99 (7.50)	106	−3.20	.001
		Low	0.09 (0.29)	0.35 (1.52)	289	−1.10	.285
		Medium	0.62 (1.05)	3.20 (7.71)	416	−3.03	.002
		High	2.17 (4.94)	3.45 (8.09)	59	−1.65	.099
P DC lucid (year)	L DC lucid	All	0.81 (3.00)	2.99 (7.50)	269	−2.21	.027
		Low	0.07 (0.12)	0.35 (1.52)	400	−0.42	.674
		Medium	0.24 (0.39)	3.20 (7.71)	1233	−1.94	.053
		High	1.26 (3.89)	3.45 (8.09)	174	−1.48	.140

Note: Dream recall rates for nightmares, bad dreams, flying dreams and lucid dreams were prorated to monthly rates in all cases. In all cases, group sizes were as follows: All participants, $N = 183$; low recallers, $n = 22$; medium recallers, $n = 54$; high recallers, $n = 105$. Descriptive statistics are provided to two decimal places due to the very low recall rates for some variables in some recaller groups.

dichotomous predictor variable (see Table 10). Retrospective dream recall rates were not entered into regression analyses because this would not clarify whether disparities were due to underestimation or enhancement effects specifically. The reason for this is that although low recallers had the greatest disparities, this could be due to them underestimating their true dream recall the most, experiencing the greatest logbook enhancement effect, or both. As can be seen in Table 12, for all three general disparities *L Recall improvement* was a significant predictor, indicating that the disparities were partly due to a logbook enhancement effect. However, for all three disparities most of the variance was explained by *P DRF Confidence* and *P Dream think freq*, with *P Dream discuss freq* also being a significant predictor in one case. Thus, it appears that the retrospective-logbook disparities were mostly explained by retrospective underestimation. However, it is not possible to make firm conclusions about the relative strength of the retrospective underestimation effect and the logbook enhancement effect based on these findings. Furthermore, most of the variance in the retrospective-logbook disparities remained unexplained. Indeed, R^2 ranged from .32 to .20 in the final models for each disparity, with a mean of .26.

Table 7
Kruskal–Wallis tests for differences in general retrospective-logbook disparities between low, medium and high recaller groups.

Disparity	Kruskal–Wallis test		Post hoc pairwise comparison		
	χ^2	p	Recaller groups	χ^2	p
DISP DRF (Schredl)	133.60	<.001	Low-Med	34.94	.024
			Low-High	113.69	<.001
			Med-High	78.75	<.001
DISP DRF (last week)	82.42	<.001	Low-Med	22.24	.275
			Low-High	86.35	<.001
			Med-High	64.11	<.001
DISP DC (weekly)	43.60	<.001	Low-Med	14.01	.867
			Low-High	61.63	<.001
			Med-High	47.62	<.001

Note: Disparities are named after the retrospective measure they are based on: *DISP DRF (Schredl)* is the disparity between *P DRF Schredl* and *L DRF*; *DISP DRF (last week)* is the disparity between *P DRF last week* and *L DRF*; and *DISP DC (weekly)* is the disparity between *P DC weekly* and *L DC*. For post hoc pairwise comparisons, *p* values were adjusted by multiplying the unadjusted values for each comparison by the number of comparisons for each variable.

Table 8
Wilcoxon matched-pair signed-ranks tests for disparities between retrospective measures of dream recall based on different time periods.

Retrospective measure 1	Retrospective measure 2	Recaller group	*M (SD)* Retrospectivemeasure 1	*M (SD)* Retrospective measure 2	Disparity (%)	Wilcoxon test *Z*	*P*
P DRF Schredl	P DRF last week	All	2.82 (2.31)	2.91 (2.01)	3	−1.79	.073
		Low	0.18 (0.07)	0.72 (0.86)	300	−3.56	<.001
		Medium	0.83 (0.19)	1.54 (0.95)	86	−7.72	<.001
		High	4.72 (1.48)	4.30 (1.60)	−9	−4.54	<.001
P DC nightmares (year)	P DC nightmares (month)	All	0.58 (1.93)	1.03 (2.32)	78	−6.24	<.001
		Low	0.13 (0.18)	0.21 (0.50)	62	−0.10	.921
		Medium	0.26 (0.33)	0.55 (0.95)	112	−3.60	<.001
		High	0.89 (2.59)	1.52 (2.99)	71	−5.32	<.001
P DC bad dreams (year)	P DC bad dreams (month)	All	1.12 (2.49)	2.05 (3.61)	83	−10.52	<.001
		Low	0.39 (0.52)	0.62 (0.93)	59	−2.09	.037
		Medium	0.57 (0.77)	1.22 (2.42)	114	−5.60	<.001
		High	1.64 (3.26)	2.92 (4.34)	78	−8.52	<.001
P DC flying (year)	P DC flying (month)	All	0.37 (1.30)	0.78 (2.48)	111	−4.43	<.001
		Low	0.05 (0.11)	0.08 (0.27)	60	−0.04	.972
		Medium	0.15 (0.34)	0.35 (0.78)	133	−2.38	.018
		High	0.59 (1.73)	1.21 (3.27)	105	−3.82	<.001
P DC lucid (year)	P DC lucid (month)	All	0.76 (2.65)	1.42 (3.81)	87	−7.61	<.001
		Low	0.17 (0.41)	0.36 (1.33)	112	−1.16	.247
		Medium	0.22 (0.34)	0.59 (1.07)	168	−4.82	<.001
		High	1.25 (3.55)	2.20 (4.98)	76	−5.82	<.001

Note: Dream recall rates for nightmares, bad dreams, flying dreams and lucid dreams were prorated to monthly rates in all cases. In all cases, group sizes were as follows: All participants, $N = 420$; low recallers, $n = 53$; medium recallers, $n = 143$; high recallers, $n = 224$. Descriptive statistics are provided to two decimal places due to the very low recall rates for some variables in some recaller groups.

4. Discussion

The purpose of the present study was to investigate the retrospective underestimation hypothesis and the logbook enhancement hypothesis as explanations for the retrospective-logbook disparity. Differences between a variety of retrospective and logbook dream recall measures and three different types of logbook were explored. As predicted, large and statistically significant disparities were observed between retrospective and logbook measures of general dream recall. Disparities were also observed for nightmares, bad dreams, flying dreams and lucid dreams, although these were not statistically significant in all cases (most likely due to low statistical power). In support of the retrospective underestimation hypothesis, retrospective measures based on longer time periods (the past year) yielded significantly lower dream recall rates than comparable retrospective measures based on shorter time periods (the past month). Furthermore, significant correlations were observed between general retrospective-logbook disparities and a range of variables theoretically related to the retrospective underestimation effect. In support of the logbook enhancement hypothesis, it was found that general retrospective-logbook disparities were significantly greater among participants that made a deliberate attempt to improve their dream recall and among participants that reported improved dream recall during the logbook period. These findings have important implications for the measurement of dream recall.

Table 9
Pearson correlations between measures of general dream recall and selected pre-test variables.

Pre-test variable	Dream recall measure									
	DISP DRF (Schredl)	DISP DRF (last week)	DISP DC (weekly)	P DRF Schredl	P DRF last week	P DC weekly	L DRF	L DC	L DQ	L Recall rating
P DRF confidence	−.50**	−.41**	−.31**	.54**	.55**	.46**	.38**	.30**	.33*	.42**
P Dream think freq	−.35**	−.37**	−.31**	.52**	.56**	.44**	.28**	.25**	.23	.27**
P Dream discuss freq	−.23**	−.22**	−.26**	.29**	.30**	.25**	.18*	.07	.23	.25**
P Dream attention	−.22*	−.27**	−.24**	.37**	.37**	.33**	.25**	.23**	.30*	.28**
P ATD	−.05	−.12	−.07	.13	.17*	.14	.03	.09	.29*	.18*
P Interest in dreams	−.06	−.02	−.07	.21**	.18*	.21**	.11	.18	.18	.12
P Need for cognition	.05	.05	.12	−.07	−.07	−.07	.04	−.02	−.07	.05

Note: Disparities are named after the retrospective measure they are based on: *DISP DRF (Schredl)* is the disparity between *P DRF Schredl* and *L DRF*; *DISP DRF (last week)* is the disparity between *P DRF last week* and *L DRF*; and *DISP DC (weekly)* is the disparity between *P DC weekly* and *L DC*. All correlations are based on data from participants who completed the logbook only.
* $p = <.05$.
** $p = <.01$.

Table 10
Wilcoxon matched-pair signed-ranks tests for differences in general retrospective-logbook disparities between participants who reported all or only some of their dreams, who did or did not attempt to improve their dream recall, and who reported that their dream recall either was or was not better while keeping a logbook.

Retrospective measure	Logbook measure	Comparison variable	Comparison group	*n*	*M (SD)*		Disparity (%)	Wilcoxon tests for each disparity		Wilcoxon tests for differences between disparities	
					Retrospective measure measure	Logbook measure		*Z*	*p*	*Z*	*p*
P DRF Schredl	L DRF	Percentage of dreams reported	All	22	3.3 (2.5)	5.5 (1.4)	67	−2.71	.007	−0.36	.721
			Some	94	3.0 (2.3)	5.4 (1.6)	81	−7.93	<.001		
P DRF last week	L DRF		All	22	3.2 (2.2)	5.5 (1.4)	73	−3.05	.002	−0.39	.700
			Some	94	2.9 (2.2)	5.4 (1.6)	84	−7.81	<.001		
P DC weekly	L DC		All	22	4.3 (3.7)	12.1 (5.6)	179	−3.64	<.001	−0.58	.561
			Some	94	4.7 (4.7)	12.6 (8.6)	171	−8.08	<.001		
P DRF Schredl	L DRF	Did the participant attempt to improve their dream recall?	Yes	70	2.4 (2.2)	5.3 (1.3)	117	−6.83	<.001	−2.92	.003
			No	104	3.5 (2.5)	5.4 (1.6)	55	−7.22	<.001		
P DRF last week	L DRF		Yes	70	2.6 (2.0)	5.3 (1.3)	101	−6.82	<.001	−1.99	.046
			No	104	3.3 (2.2)	5.4 (1.6)	64	−7.50	<.001		
P DC weekly	L DC		Yes	70	3.6 (3.2)	11.5 (6.4)	219	−7.11	<.001	−2.14	.033
			No	104	5.0 (5.0)	11.9 (8.0)	136	−8.19	<.001		
P DRF Schredl	L DRF	Was dream recall better during the logbook period?	Yes	106	3.9 (2.5)	5.2 (1.8)	32	−4.73	<.001	−4.69	<.001
			No	69	2.5 (2.2)	5.5 (1.3)	118	−8.60	<.001		
P DRF last week	L DRF		Yes	106	3.7 (2.3)	5.2 (1.8)	42	−5.46	<.001	−4.21	<.001
			No	69	2.6 (2.0)	5.5 (1.3)	108	−8.44	<.001		
P DC weekly	L DC		Yes	106	5.8 (5.0)	11.1 (7.9)	93	−6.19	<.001	−5.19	<.001
			No	69	3.6 (3.8)	12.3 (7.2)	239	−8.88	<.001		

Note: Narrative logbook participants were excluded from the comparison of participants who reported all or only some of their dreams because responses to this question from the Narrative logbook participants were not valid (see Section 2.2.2).

Table 11
Pearson correlations between selected dream recall variables.

	L Mins recalling dreams	L Mins to record dreams	L Mins per log entry	L Recall improvement	L Percent recorded
L Mins to record dreams	.35**	–	–	–	–
L Mins per log entry	.38**	.80**	–	–	–
L Recall improvement	.08	.13	.16*	–	–
L Percent recorded	−.27**	−.00	−.27*	−.14	–
L DRF	−.05[a]	.32**[a]	.14	.11	−.02
L DC	−.03[a]	.33**[a]	.21**	.12	.04
L DQ	−.01[a]	.38**[a]	.45**	−.19	−.02
L Recall rating	−.06*[a]	.37**[a]	.23**	.08	−.08
DISP DRF (Schredl)	−.02	−.11	−.07	.31**	−.00
DISP DRF (last week)	−.07	−.13	−.13	.22**	−.02
DISP DC (weekly)	−.05	.05	.02	.27**	−.13
P DRF Schredl	.02	.20**	.10	−.30**	−.04
P DRF last week	.11	.25**	.17*	−.19*	−.04
P DC weekly	.02	.20**	.18*	−.22**	.07

Note: Disparities are named after the retrospective measure they are based on: *DISP DRF (Schredl)* is the disparity between *P DRF Schredl* and *L DRF*; *DISP DRF (last week)* is the disparity between *P DRF last week* and *L DRF*; and *DISP DC (weekly)* is the disparity between *P DC weekly* and *L DC*. All correlations with *L Percent recorded* are with Narrative participants excluded because responses to this question from the Narrative logbook participants were not valid (see Section 2.2.2). All correlations with *L DQ* are for people in the Quantity logbook group only.

[a] These correlations were performed using observations from each individual logbook day for both variables. All other correlations were performed using weekly means for each participant or summary questions from the final page of the logbook.

* $p = <.05$.

** $p = <.01$.

Table 12
Forward linear multiple regression analyses predicting general retrospective-logbook disparities from *P DRF confidence*, *P Dream think freq*, *P Dream discuss freq*, *P Dream attention*, *L Recall improvement* and whether or not participants made a deliberate attempt to improve their dream recall while keeping a logbook. Only statistically significant predictors are shown.

Outcome variable	Model	R^2	*F* (df)	*p*	Predictors	β	*P*
DISP DRF (Schredl)	1	.245	50.87	<.001	P DRF confidence	−.50	<.001
	2	.305	35.63	<.001	P DRF confidence	−.47	<.001
					L Recall improvement	.26	<.001
	3	.323	26.09	<.001	P DRF confidence	−.41	<.001
					L Recall improvement	.25	<.001
					P Dream think freq	−.16	.025
DISP DRF (last week)	1	.176	36.41	<.001	P DRF confidence	−.42	<.001
	2	.225	24.70	<.001	P DRF confidence	−.33	<.001
					P Dream think freq	−.24	.001
	3	.249	18.72	<.001	P DRF confidence	−.32	<.001
					P Dream think freq	−.23	.002
					L Recall improvement	.16	.020
DISP DC (weekly)	1	.090	17.00	<.001	P Dream think freq	−.30	<.001
	2	.145	14.36	<.001	P Dream think freq	−.27	<.001
					L Recall improvement	.23	.001
	3	.180	12.33	<.001	P Dream think freq	−.20	.011
					L Recall improvement	.22	.002
					P DRF confidence	−.20	.008
	4	.201	10.60	<.001	P Dream think freq	−.16	.044
					L Recall improvement	.23	.001
					P DRF confidence	−.19	.012
					P Dream discuss freq	−.15	.034

Note: Disparities are named after the retrospective measure they are based on: *DISP DRF (Schredl)* is the disparity between *P DRF Schredl* and *L DRF*; *DISP DRF (last week)* is the disparity between *P DRF last week* and *L DRF*; and *DISP DC (weekly)* is the disparity between *P DC weekly* and *L DC*.

4.1. The retrospective underestimation hypothesis

Retrospective measures of nightmares, bad dreams, flying dreams and lucid dreams based on the past year yielded significantly lower recall rates than comparable measures based on the past month. It is important to note that the wording for the two versions of these measures was identical (except for the time period) and the order in which they were presented was randomised, controlling for order effects. Although these disparities were not statistically significant in all cases, their magnitude provides strong evidence that retrospective measures based on relatively long time periods underestimate dream recall. It is reasonable to assume that, to a lesser extent, measures based on shorter time periods will also tend to underestimate dream recall. These findings replicate those of previous studies by Zadra and Donderi (2000), Wood and Bootzin (1990), Pietrowsky and Köthe (2003) and Robert and Zadra (2008), which also investigated differences between retrospective measures of specific types of dream recall based on the past month and past year. The present study also investigated differences between two measures of general dream recall. Results showed that DRF for the previous week was only 3% higher than DRF measured using Schredl's (2004) measure that includes multiple response options ranging from "never" and "less than once a month" to "almost every morning." These two measures were selected because Schredl's measure has been used widely in dream research and it is thus useful to compare it to another retrospective measure that should be minimally affected by retrospective underestimation. Findings indicate that the two measures are similarly robust to retrospective underestimation. A likely explanation for this is that the fixed response options of Schredl's measure allow most participants to respond without considering their DRF beyond the past week. Indeed, most participants (72%) responded that their DRF was once per week or higher. However, it is possible that participants were motivated to ensure their answers to the two questions were consistent. Indeed, these two questions were separated by only one other question, which asked participants to rate how confident they were that their answers to Schredl's measure were correct.

In addition to investigating mean disparities between different types of retrospective measures, the present study employed a novel approach to investigating the retrospective-logbook disparity that involved calculating disparities for each participant separately, and then examining correlations between this and other variables theoretically linked to the retrospective underestimation and logbook enhancement effects. Aspy et al. (2015) theorised that people who spend less time thinking about their dreams, discussing them with other people and paying attention to them are likely to have a poorer understanding of their dream recall patterns, and will be more prone to retrospective underestimation as a consequence. This is based on research into the availability heuristic (Tversky & Kahneman, 1973) that has shown frequency estimates to be lower when people have more difficulty recalling specific instances of an event (Buontempo & Brockner, 2008). Findings from the present study support this theory. It was found that less time spent thinking about, discussing and attending to dreams were all correlated with greater general retrospective-logbook disparities. Furthermore, participants that were less confident in their answers to Schredl's (2004) retrospective dream recall measure had greater general retrospective-logbook disparities. These correlations were found to be statistically significant in every case and for all three general retrospective-logbook disparities. Two of these disparities operationalised dream recall as DRF, and one as DC, indicating that the findings are robust and likely to be generalisable to other types of dream recall measures. It was also found that greater self-rated confidence in the answers to Schredl's measure was significantly correlated with greater time spent thinking about, discussing and attending to dreams. Taken together, these findings indicate that participants who were less aware of their dream recall were more prone to retrospective underestimation.

Contrary to predictions, attitude toward dreams and interest in dreams were not related to general retrospective-logbook disparities. A likely explanation is that more positive attitude toward and greater interest in dreams only result in greater awareness of one's own dreaming (and thus less retrospective underestimation) if they lead to increased frequency of dream-related behaviours such as thinking about, discussing and attending to dreams. It is also possible that there was restriction of range in both attitude toward dreams and interest in dreams in the present study (participants signed up based on their interest in learning to have lucid dreams). Aspy et al. (2015) suggested that retrospective underestimation may also be related to whether participants take a heuristic rather than an elaborative approach to estimating their dream recall. However, the results did not support this prediction as there was no significant correlation between need for cognition and the general retrospective-logbook disparities. A possible explanation for this is that few if any participants in the present study took an elaborative approach to estimating their dream recall. Indeed, as discussed above it is likely that most participants answered Schredl's (2004) DRF measure without any need to consider their dream recall beyond the past week and the other two retrospective measures of general dream recall were both open-ended and based on the past week.

4.2. The logbook enhancement hypothesis

Participants who reported improvement in their dream recall during the logbook period had significantly greater general retrospective-logbook disparities. For all three disparities, these were more than twice as large as those observed for participants who did not report improvement in their dream recall. Furthermore, the self-rated extent to which participants' dream recall improved during the logbook period was significantly correlated with all three general disparities. Of course, these findings may be partly due to participants underestimating their true dream recall prior to the logbook period and then incorrectly believing that their recall had improved when in fact it had not. However, because participants who simply *attempted* to improve their dream recall also had significantly higher disparities, it is very likely that the disparities were at least partly due to logbook enhancement effects. The present study thus provides the strongest evidence to date in support of the widely held belief that keeping a logbook tends to enhance dream recall. It is interesting to note that participants were explicitly instructed *not* to make any attempt to improve their dream recall during the first week. This indicates that participants of dream recall studies may attempt to improve their dream recall regardless of whether they are told to do so, and even if they are explicitly told *not* to.

As per the arousal retrieval model of dream recall (Koulack & Goodenough, 1976), it was expected that the logbook enhancement effect would be related to the amount of time spent on the retrieval process prior to making each logbook entry. However, the number of minutes spent recalling dreams prior to making logbook entries was not correlated with general retrospective-logbook disparities. Furthermore, the number of minutes spent recalling dreams was not correlated with any of the logbook measures of general dream recall. The most likely explanation for this is that although spending more time trying to recall dreams will almost certainly improve dream recall, the amount of time spent on this may largely be determined by the overall difficulty of recalling dreams. If a person is easily able to recall a large amount of dream content upon waking (perhaps due to waking directly from REM sleep), they may feel little need to spend much time trying to recall dreams. However, if a person recalls relatively little dream content upon waking (perhaps due to waking from non-REM sleep), they may be inclined to spend more time trying to retrieve dream content. Indeed, in the present study it was found that participants spent significantly more time trying to recall dreams when self-rated difficulty of recalling dreams was higher.

4.3. Comparisons between different types of logbooks

Participants in the Narrative logbook group took significantly longer to record their dreams and fill out their logbooks each morning than participants in the Checklist and Quantity groups. Furthermore, Narrative participants spent the most time each morning recalling dreams prior to making logbook entries. However, DRF was virtually identical in all three logbook groups and the number of dreams recalled each morning (DC) was only slightly (but not significantly) lower in the Narrative group than in the other two groups. This is at odds with studies in which Narrative logbooks yielded significantly lower dream recall rates than Checklist logbooks (Robert & Zadra, 2008; Zadra & Robert, 2012) and is also at odds with the observation by Aspy et al. (2015) that retrospective-logbook disparities tend to be smaller when Narrative logbooks are used. There are two likely explanations for these findings. One explanation is that Narrative logbooks caused a stronger logbook enhancement effect due to the greater amount of time participants had to spend thinking about their dreams while providing written narratives, but due to the burden of having to write out each dream recalled, participants in the Narrative group were more likely to underreport their true dream recall. An alternative explanation is that there was little if any difference between Narrative, Checklist and Quantity logbooks in their effects on overall weekly dream recall rates, perhaps because participants in the present study were participating in a larger study on lucid dream induction and were more likely to comply with the study requirements in the hopes that this would help them have lucid dreams. Unfortunately, due to an error in the preparation of the Narrative logbooks, the wording of the post-test question asking whether participants recorded all or only some of the dreams they recalled during the logbook period was not valid and so it was not possible to investigate underreporting in the Narrative group directly. It is thus unclear which of the two explanations account for the findings.

Although the three logbooks yielded similar weekly dream recall rates it was found that over the seven days of keeping a logbook, DRF, DC, self-rated recall and self-rated clarity declined the most, and self-rated recall difficulty increased the most, in the Narrative group. These changes were all smaller in the Checklist group and were the smallest and (in every case) non-significant in the Quantity group. It was also found that reliability coefficients for measures of general dream recall were all higher when presented in the Quantity logbook than in the Checklist and Narrative logbooks. These findings can be most easily explained by considering the major pros and cons of Checklist, Narrative and Quantity logbooks. Checklist logbooks can be completed quickly and easily, thereby minimising participant burden and the likelihood of underreporting. However, as a consequence some participants may fill in Checklist logbooks hastily and without taking the time to carefully think about how much dream content they can recall. Narrative logbooks address this issue by prompting participants to think carefully about the specific details of their dreams in order to provide written narratives, but this requires a large amount of time and participants may underreport their dream recall in order to minimise this burden. This could occur due to waning motivation (which might explain why dream recall rates declined most strongly in the Narrative group in the present study), or may occur when participants simply don't have the time required to make a complete Narrative logbook entry due to other time pressures such as having to get ready for work. Quantity logbooks combine the best attributes of Checklist and Narrative logbooks while avoiding those that are most problematic. Participants must think about the extent of their dream recall in order to provide DQ ratings, but this only takes slightly longer than making a Checklist logbook entry (12 s on average in the present study, see Table 3).

5. Strengths, limitations and future directions

A major strength of the present study is that it was based on a diverse sample of participants recruited from across the country using a wide variety of recruitment strategies, with only 27% being students. Furthermore, although only 44% of participants went on to complete the Week 1 logbook, results indicated that logbook completers were comparable to non-completers in most ways except for having lower need for cognition, being older (by 7.5 years on average) and possibly having slightly higher dream recall. However, it should be noted that participants signed up for the study out of interest in learning to have lucid dreams and future studies should attempt to replicate the present findings using participants with lower interest in dreaming. It is likely that such participants would be less motivated and less willing to fulfil the requirements of keeping a logbook. This may help clarify whether Narrative logbooks are more prone to underreporting than Checklist or Quantity logbooks, an issue that remains unclear at present. In future studies, participants should be asked to indicate if they reported all or only some of the dreams they recalled at post-test as per the approach outlined in Section 2.2.2 above. Future studies should investigate differences between retrospective measures of general dream recall using measures based on different time periods. This could be done using questions that use the same wording but offer different sets of fixed response options or using open-ended questions involving different time periods (e.g. the past week vs. the past month). The order in which different retrospective measures of general dream recall are presented should be randomised and they should be separated by other questions that are unrelated.

In a recent publication, Zunker et al. (2015) outlined a promising approach for investigating the retrospective underestimation hypothesis. These authors suggested that after completing a dream recall logbook, research participants could be asked to complete a retrospective measure that enquires about dream recall during the logbook period specifically. Post-test retrospective dream recall rates could then be compared to logbook dream recall rates, which would reveal the extent to which the retrospective measure underestimated dream recall during the logbook period. This approach was employed by Zadra and Beaulieu-Prévost (2006), who found that post-test retrospective measures underestimated logbook recall rates by 9% for bad dreams and 21% for nightmares. However, this approach has not yet been used for measures of general dream recall. It would be important in such a study to ensure that participants do not have access to their logbooks when answering the post-test retrospective measure. A potential problem is that some participants may chose to keep their own dream journal in addition to completing logbooks provided by researchers (several participants of the present study reported doing this). It would be interesting to compare DRF and DC post-test retrospective measures and to ask some participants to answer them after a waiting period (e.g. one week) while asking others to answer them the day after completing their final logbook entry. As mentioned earlier, there are many inconsistencies and contradictory findings in the empirical literature on correlates of home dream recall and it would be of great value to the field if this literature were re-evaluated in light of the recommendations for the measurement of dream recall provided below. Specifically, previous studies could be sorted according to how valid the dream recall measures used are likely to have been. This might resolve some of the inconsistencies and contradictions in the literature.

6. Recommendations for the measurement of dream recall

In the present study, different retrospective measures of general dream recall were strongly correlated with each other and the same was true of different types of logbook measures. However, correlations between retrospective and logbook measures were much smaller, with shared variance ranging from only 19% to 42%. This demonstrates that retrospective and logbook measures are not equivalent and should not be used interchangeably. The choice between using retrospective and logbook measures involves a trade-off between ecological validity and internal validity, and will depend on the aims of the research being conducted.

6.1. Retrospective measures

Retrospective measures of general dream recall are likely to provide superior ecological validity compared to logbook measures because they assess typical (unaltered) dream recall rates. However, they are likely to provide poorer internal validity due to their tendency to underestimate dream recall and will tend to be confounded with variables related to this effect such as the frequency with which participants think about, discuss and attend to their dreams. These problems can be minimised by using retrospective measures based on relatively short time periods such as the past week. Retrospective measures offering fixed response options focussing on the recent past appear to be similarly valid, such as Schredl's (2004) measure. Retrospective measures of general dream recall based on longer time periods should be avoided. However, for retrospective measures of specific types of dreams that tend to occur infrequently (e.g. nightmares or lucid dreams), it will not be appropriate to limit the time period to the past week because this will only capture dream recall variation in the most frequent recallers. At this point, it seems the ideal approach is to either base such measures on the past month or to use fixed response options such as those provided by Schredl (2004). Another important consideration is the way in which retrospective measures operationalise dream recall, and it is important to not treat different operationalisations as interchangeable. For retrospective measures of general dream recall, DRF should be preferred over DC because participants that have a poor understanding of their dream recall are less likely to be able to provide an accurate estimation of their DC than their DRF. This is because DC measures require participants to recall many more instances of dream recall than DRF measures (i.e. the number of separate dreams recalled vs. the number of days when any amount of content was recalled). If retrospective DC measures of general dream recall are used, they should be limited to the past week at most. For retrospective measures of specific types of dreams that occur relatively infrequently, DC measures are likely to be less problematic.

6.2. Logbook measures

Logbook measures of dream recall are likely to provide superior internal validity compared to retrospective measures because dream recall is recorded immediately upon waking each morning. However, logbooks are likely to provide poorer ecological validity due to their tendency to enhance dream recall. This enhancement effect appears to be partly mediated by whether participants attempt to enhance their dream recall and it is important to note that participants may do this even if they are explicitly told not to. Narrative logbooks will tend to be more affected by time constraints and fluctuations in motivation that may lead participants to underreport their dream recall in order to reduce the substantial burden of providing written dream narratives. Narrative logbooks should thus be avoided except where dream content is of particular interest. Dream recall operationalised as DC, DQ and self-rated dream recall will be more sensitive to daily fluctuations in dream recall than DRF and are thus more appropriate for investigating correlates of dream recall on a day-to-day basis. Indeed, DRF will capture little or no variation in dream recall among high recallers who recall dream content on most or all mornings. In the present study, DQ and self-rated dream recall, but not DRF or DC, were significantly correlated with both age and attitude toward dreams, suggesting that DC is less likely to be confounded with other variables that may influence subjective judgments about dream recall. However, DC does not entirely avoid this problem – the tendency to count multiple scenes or dream fragments as one long dream or several shorter dreams may differ among participants, possibly in systematic ways. For example, people with a very strong interest in dreaming such as dedicated lucid dreaming practitioners might be more meticulous about counting multiple dream fragments as being part of the same dream. Notwithstanding, as long as this tendency remains fairly stable over time within individuals, DC is preferable to DRF for investigating daily correlates of dream recall. In contrast, DRF will be more robust to subjective bias and underreporting, and may be more appropriate for investigating absolute differences in dream recall between individuals and between different populations that might differ in their judgments about their DC dream recall. Regardless of how dream recall is operationalised, it seems that dream recall measures are most valid and reliable when Quantity logbooks are used. This type of logbook can be constructed using the information provided in Section 2.2.2.

7. Conclusions

The present study provides the strongest evidence to date that dream recall is underestimated by retrospective measures and enhanced by logbooks. Many questions remain unanswered and it is still unclear whether retrospective underestimation effects are stronger than logbook enhancement effects or vice versa. Nonetheless, results from the present study permit a range of recommendations for the use of retrospective and logbook measures of dream recall. These recommendations can be used to guide future research on dream recall in the home setting and could also be used as a basis for re-evaluating the empirical literature on correlates of home dream recall.

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