The role of dreaming in emotional memory consolidation

Angela Bonheim and Cari Klipp

Department of Psychology, University of Cape Town

Supervisor: Dr. Gosia Lipinska

13 November 2020

Word count: 8000 words

PLAGIARISM DECLARATION

1. We know that plagiarism is wrong. Plagiarism is using another's work and to pretend that it is one's own.

2. We have used the <u>APA (6th edition)</u> convention for citation and referencing. Each significant contribution to, and quotation in, this essay/report/project from the work, or works of other people has been attributed and has been cited and referenced.

3. This essay/report/project is our own work.

4. We have not allowed, and will not allow, anyone to copy our work with the intention of passing it off as their own work.

5. We acknowledge that copying someone else's assignment or essay, or part of it, is wrong, and declare that this is our own work

SIGNATURES: <u>Angela Bonheim (BNHANG001), Cari Klipp (KLPCAR002)</u>

DATE: <u>13 November 2020</u>

Abstract

Objective: Dreams have been postulated to be the active ingredient in emotional memory consolidation during sleep. However, there is a dearth of research exploring this relationship. We aimed to determine whether dreaming is associated with improved emotional memory consolidation by investigating the relationship between emotionality in dreams originating from REM and NREM sleep and emotional recall accuracy.

Method: Data from two previous sleep studies (Diara, 2019; van Wyk, 2018) were used. Participants viewed a series of positive, negative, and neutral images. Following a night's sleep, recall accuracy was tested and dream reports were recorded. Composite scores of dream emotionality were developed from the Linguistic Inquiry and Word Count program and external ratings of dream reports. Emotional recall accuracy was measured against this composite score.

Results: Dream emotionality was not associated with emotional recall accuracy. Furthermore, positive, negative and neutral information were recalled equally for both high and low emotionality dreamers. Finally, the association between dreams of a particular emotional quality and recall accuracy of the same emotional quality was not significant. However, negative dream emotionality was associated with decreased negative and neutral recall accuracy. Furthermore, positive dream emotionality during REM was associated with improved emotional memory consolidation. Negative dream emotionality was negatively correlated with negative recall accuracy during REM sleep and with neutral information in NREM sleep.

Conclusion: During dreaming recall accuracy of negative information is modulated more than positive. Furthermore, dreaming during REM appears to play an important role in emotional memory consolidation depending on the dream valence, however NREM does not display the same associations. This suggests that there are both differences in neurophysiology of sleep stages as well as the function of dreams in these stages. Future studies should explore these relationships in more depth.

Literature Review

Evidence shows that emotional memory and sleep are intrinsically linked (Diekelmann & Born, 2010). Previous research suggests that Rapid Eye Movement (REM) sleep may consolidate emotional memories as a background process (Lipinska & Thomas, 2019). Furthermore, dreaming during REM sleep may play some role in the process of emotional memory consolidation. Consolidation during dreaming may help to balance positive and negative emotional memories. However, the involvement and mechanisms of dreaming in emotional memory consolidation are not fully understood.

Emotions play a vital role in the processing of memories (Walker, 2009). Emotional memory is a subcomponent of declarative memory; it serves to associate episodic events with their relevant emotions in long-term memory storage (LaBar & Cabeza, 2006). Thus, emotional arousal and the valence of events have a direct influence on memory (Kensinger, 2004). The memory modulation hypothesis states that the long-term memory of emotionally salient events is enhanced in comparison to less emotional experiences (Cahill & McGaugh, 1998). High attentional resources present during periods of emotional arousal help to consolidate memory; this enhanced consolidation subsequently allows for enhanced recall (LaBar & Cabeza, 2006).

It is established that sleep is vital for effective consolidation of emotional memories (Diekelmann & Born, 2010). Studies show that sleep is associated with improved emotional memory recall; participants displayed improved recall of high valence emotional materials in comparison to neutral materials (Hu, Stylos-Allan, & Walker, 2006; Wagner, Gais, & Born, 2001). Sleep serves to modulate and consolidate strong emotions by processing and reprocessing the emotional experiences of the day before (van der Helm & Walker, 2011). Research shows preferential recall for negative emotional material over neutral material (Payne, Chambers, & Kensinger, 2012; Wagner et al., 2001). However, positive emotional material is also preferentially recalled in comparison to neutral material (Atienza & Cantero, 2008; Chambers & Payne, 2013). Therefore, a possible outcome of emotional memory consolidation may be to have a fair distribution of negative and positive memories, thereby achieving an emotional balance.

Furthermore, REM sleep is an important component in emotional memory consolidation (Wagner et al., 2001). There is improved recall for emotional material after periods of REM-rich sleep. This improvement is significantly greater than comparative performance after non-rapid eye movement (NREM sleep), and after periods of wakefulness (Nishida, Pearsall, Buckner, &

Walker, 2009; Wagner et al., 2001). Unique states of the brain during REM sleep create suitable conditions for emotional memory consolidation (Hu et al., 2006; Scarpelli, Bartolacci, D'Atri, Gorgoni, & De Gennaro, 2019). During REM sleep the anterior cingulate cortex (ACC), amygdaloid complex, and hippocampus are highly active in the encoding and consolidation of emotional memories (Deliens, Gilson, & Peigneux, 2014). This has been thought to relate to the vivid nature of REM dreams (Schredl, Barrett, & McNamara, 2007). Furthermore, acetylcholine (ACh) in the forebrain and limbic system is particularly high during REM and is important for consolidating emotional memories into long term storage (McGaugh, 2004; Vazquez & Baghdoyan, 2001).

Dreams may be the active ingredient in emotional memory consolidation. Freud (1900) suggested that dreams are involved in the processing of emotional information as unconscious emotions and desires are reflected in the concealed, underlying content of dreams. Thus, dreaming may provide a mechanism for reprocessing of emotions and desires. This may assist in resolving emotional problems (Bion, 1962). Freud's theory may gain some credibility from Solms (2000), who found that during dreaming there is increased activation in the nucleus accumbens and ventral tegmental areas of the dopaminergic reward system. This dopaminergic system promotes fixation on reward-based, salient or emotional information and encourages motivation for action (Eichenlaub, Cash, & Blagrove, 2017; Perogamvros, Dang-Vu, Desseilles, & Schwartz, 2013). Dreams may be the body's spontaneous attempt to seek out salient emotional desires during sleep; individuals often dream of individual-specific and salient stimuli (Colace, 2004). The experience of fulfilling psychological desires within dreams is consistent with Freud's wish-fulfilling dream hypothesis (Solms & Turnbull, 2002). Therefore, dreaming may be involved in emotional reprocessing and the solving of emotional problems (Bion, 1962). If dreaming is successful individuals may have a balance of emotions. However, when this mechanism does not function properly it results in ineffective or maladaptive emotional memory consolidation; this may result in increased and inaccurate bias to either positive or negative stimuli (van der Helm & Walker, 2011).

Scarpelli and colleagues (2019) suggest that dreaming during REM sleep is a mechanism through which consolidation of emotional memories takes place. They point out that similar brain structures are implicated in emotional regulation and dreaming; in particular, the hippocampus, amygdala and medial prefrontal cortex. The amygdala is activated by stress

hormones during emotional events. It regulates the hippocampus, prefrontal and striatal areas. This regulation has been observed during encoding, retrieval and consolidation of emotional memories (Deliens et al., 2014). Additionally, theta oscillations are associated with dreaming, as well as the consolidation of emotional information. Together this evidence may indicate that REM dreaming plays a functional role in emotional memory consolidation (Scarpelli et al., 2019). However, as REM and dreaming are dissociable states (Solms, 2000), it is possible that NREM dreaming may also play a role in memory consolidation.

There has been a paucity of research examining the relationship between NREM dreaming and emotional memory consolidation. However, there is reason to believe that NREM dreaming may also be implicated in consolidating emotional memories. NREM and REM dreams differ with regards to vividness and emotional salience (Nielsen, 2000). Yet, due to the neurophysiological and functional differences in both these sleep states, NREM and REM dreams are thought to work in tandem to allow for effective memory consolidation (Stickgold, 2005). Furthermore, during NREM sleep emotional-regulatory areas of the brain are activated which assist in consolidating recent episodic events into long-term memory (Perogamvros et al., 2013; Preston & Eichenbaum, 2013). Thus, one can presuppose that dreaming serves a cognitive or emotional processing function independently of sleep state (Zhang & Guo, 2018). However, it is unknown to what extent these different dream states, specifically NREM dreaming, may influence emotional memory consolidation.

Rationale, Aims and Hypotheses

Research into sleep has only recently begun to factor the association between dreaming, emotional memory consolidation, and their neurophysiological links with sleep (Levin & Nielsen, 2007; Scarpelli et al., 2019). However, much of this research is in its early stages and only has preliminary data. Additionally, the current literature fails to answer what the role of NREM dreaming is in relation to emotional memory consolidation. As such, this study was one of the first to explore the relationship between dream emotionality and emotional memory recall accuracy in both REM and NREM sleep stages. Furthermore, this was the first study in this area of research to focus on a sample of individuals who did not have psychological or health disorders. Therefore, it provides novel insights into the purpose and function of dreaming in relation to emotional recall accuracy.

The current study contributes to, and adds to, existing literature and research on emotional memory consolidation, recall accuracy, and dreaming. Specifically, the relationship between emotionality in dream content and sleep-dependent emotional memory recall accuracy and consolidation. It was assumed that, 1) dreams involve the re-experiencing of elements of waking experiences (van der Helm & Walker, 2011) and, 2) that increased emotion in dreams indicates greater re-experiencing of emotional experiences. Thus, a link between increased dream emotionality and increased emotional memory recall accuracy would lead us to believe that dreams help consolidate emotional memories. Emotional memory consolidation is vital for processing experiences adaptively and healthily. As such, this study aimed to explicate why the emotional content of our dreams may matter. This study had the following hypotheses:

1. Dreaming during both REM sleep and NREM sleep helps to improve emotional memory recall accuracy: greater emotionality in dream reports is associated with greater emotional memory recall accuracy following sleep.

2. Those who have highly emotional dreams consolidate positive information and negative information equally and more efficiently than neutral information.

3. Dreams with a particular emotional quality help to consolidate information with the same emotional quality. Therefore, increases in the positive and negative emotion in dream reports are associated with greater memory consolidation of positive and negative material, respectively.

Methods

Design and Setting

This study integrated data collected from two previous studies conducted in the University of Cape Town's Sleep Sciences laboratory. The parent study used a quasi-experimental design to investigate the functional neurophysiological sequelae associated with high and low frequency dream recallers (van Wyk, 2018). Participants underwent polysomnographic recordings on two non-consecutive nights. They were given emotional declarative memory tasks and affective questionnaires which were completed before and after a night of sleep. The second study examined the emotionality in dreams recalled by high and low frequency dream recallers in van Wyk's study (Diara, 2019). The Diara (2019) study focused on dream recall frequency and sleep stage in relation to the emotionality present in dream recall reports.

This study focused on describing the relationship between emotional declarative memory recall accuracy and dream content. Thus, it utilized dream reports, emotional declarative memory measures, and sleep data from van Wyk (2018), as well as dream emotionality garnered from the dream reports using The Linguistic Inquiry and Word Count program (LIWC; Pennebaker, Booth, Boyd, Jordan, & Francis, 2015) as compiled in Diara's (2019) study.

The independent variable was dream emotionality reports (as measured by a composite score). The dependent variable was emotional declarative memory (EDM), as measured by recall accuracy.

This study took place at the University of Cape Town's Department of Psychology Sleep Sciences laboratory.

Participants

The sample consisted of healthy participants from a university population, aged 20-38 years. There were a total of 32 participants (female: $n = 17$). Their years of education range from 12 to 17.

Convenience sampling was used. Participants underwent a two-part screening process via an online questionnaire, and an in-person procedure at the UCT Sleep Science sleep laboratory. In total 2,041 people began the screening process, 1,453 of whom completed both screening procedures successfully. van Wyk (2018) excluded 1,417 potential participants during the screening phases based on the following strict eligibility criteria:

1. All participants were aged 20-40. This controlled for the effect of age on the characteristics of sleep (Blackman, 2000). Participants were excluded who were outside this age range (n=60).

2. Those with current or past alcohol or substance abuse were excluded due to research showing that those who consume alcohol excessively having altered sleep properties (Irwin, Miller, Gillin, Demodena, & Ehlers, 2000). Van Wyk (2018) excluded 33 participants.

3. Participants with current or pre-existing sleep disorders or psychiatric disorders, and those using medication for sleep or psychiatric disorders were excluded. These factors may alter sleep-cycle and dreaming properties. The parent study excluded 80 individuals with sleep disorders, 108 with psychiatric disorders and 51 using medication.

4.   The parent study excluded 34 participants with medical conditions that affected sleep properties, emotional or cognitive functioning, or dreaming were excluded.

5.   Only participants with either high or low frequency of dream recall were included in the study (that is, high frequency recallers (HFRs) versus low frequency recallers (LFRs). HFR individuals recalled more than 3 dreams per week and LFR individuals are those who recalled less than 2 dreams per month. 1,051 participants were excluded. Dream recall frequency was a critical element within the parent study. Research has shown that those with increased dream recall frequency have higher emotionality in their dreams (Wolcott & Strapp, 2002).

Dream reports from 4 participants were unsuitable for evaluation, they were therefore excluded. Two of these participants were excluded because they recalled no dreams, and 2 were excluded because they had no viable sleep stage data.

Lastly, with the available sample a power analysis was conducted to determine whether the study was adequately powered for the analyses required. Power of 0.92 was achieved for a one-sided correlation, where the significance level was 0.05, and the effect size was large (r=0.5) as reported in the parent study. Therefore, the sample size was acceptable.

Materials and Measures

Screening measures. The following screening measures were used in the parent studies and are relevant to the current study:

Dream Details: An online survey was sent out which contained four questions regarding dream frequency (see Appendix C).

The Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989): The PSQI is a self-rated questionnaire which evaluates sleep quality in the past month (see Appendix C). It has been previously used with success within the South African context and is both sound and valid (Rockwood, Mintzer, Truyen, Wessel, & Wilkinson, 2001). According to the standard clinical cut-off score on the PSQI, participants who scored > 5 on the PSQI were excluded from van Wyk's (2018) study.

The Beck Depression Inventory - Second Edition (BDI-II; Beck, Steer, & Brown, 1996): The BDI-II is a self-report questionnaire used to assess the severity of depressive symptoms in the last two weeks. Individuals who had a score of ≥14 (the minimum criteria for a depressive episode) were excluded from van Wyk's (2018) study. This questionnaire has demonstrated good

reliability and validity in both a clinical and research context in South Africa (Seedat, Nyamai, Njenga, Vythilingum, & Stein, 2004).

The Mini International Neuropsychiatric Interview (English version 5.0.0; MINI; Sheehan et al., 1998): The MINI is used to screen for major psychiatric disorders outlined in the Diagnostic & Statistical Manual of Mental Disorders, fourth edition (DSM-IV). It is a structured interview which has high reliability and validity when used in the South African population (Olley, Zeier, Seedat, & Stein, 2005). Potential participants who displayed any of the criteria for any disorders on the MINI were excluded from van Wyk's (2018) study.

The Michigan Alcoholism Screening Test (MAST; Selzer, 1971): The MAST is a structural interview which is used to determine alcohol use. It comprises 25 questions which aim to identify alcohol use behaviours, both past and present (see Appendix C). It has demonstrated good validity and consistency as a screening tool for the South African population (Bekker, & Van Velden, 2003). Individuals with a score of ≥ 5 on the MAST were excluded from van Wyk's (2018) study.

Experimental Measures. The following measures were used by the parent studies and are relevant to the current study (that is, experimental measures not relevant to this study were not presented here):

*Sleep laboratory equipment***:** Polysomnography (PSG) was used to record participants' objective sleep quality by measuring heart rate, eye movement, and muscle tone. It is used in sleep research to determine sleep stages; thus allowing van Wyk to determine which sleep stage the dream reports came from in her 2018 study.

The Most Recent Recall form (Domhoff & Shneider, 1998): This form is used to gather dream reports (see Appendix D). It was filled out by participants when they woke during both the experimental and adaptation nights.

*Emotional Declarative Memory (EDM) Task***:** van Wyk (2018) used a computerised EDM Task. This task assesses recall accuracy for emotional stimuli. The visual stimuli consist of pictures with normative ratings which were selected from the International Affective Picture System (IAPS). These pictures fall into three standardised categories which include 'neutral', 'negative', or 'positive'. This task was developed by a senior researcher in the UCT Sleep Sciences ACSENT laboratory using E-prime 2.0 software (Psychology Software Tools,

Pittsburgh, PA). It was successfully used prior to this study in the Sleep Sciences ACSENT laboratory (Lipinska & Thomas, 2019).

   The Linguistic Inquiry and Word Count Programme (LIWC; Pennebaker et al., 2015): The LIWC is used to analyse emotionality present in text; thus it was used by Diara (2019) to analyse the content and emotionality of dream reports. This programme categorises words which have a similar emotional valence by referencing words from the text to a dictionary file. Thus, words from the dream reports were matched to an emotional category. The program then calculates the percentage of words within each category.

   External Ratings of Dream Reports: Three external judges rated the dream reports according to overall emotional intensity, positive valence and negative valence. The dreams were rated on a scale of 1 to 5, where 1 represents the lowest possible emotional intensity/ valence score and 5 represents the highest possible emotional intensity/ valence score.

Procedure

   There were two phases of screening. Potential participants were recruited via an online survey using the university wide network, as well as the psychology department's research participation programme. The online survey required participants to complete the Beck Depression Inventory, The Pittsburgh Sleep Quality Index, The Michigan Alcoholism Screening Test, demographic information, medical details, and dream recall frequency information. Eligible participants were given the opportunity to partake in the second phase, an interview at the UCT Sleep Sciences laboratory. Participants were tested for psychiatric disorders using the MINI Neuropsychiatric interview.

   Eligible participants took part in an adaptation night up to 10 days after screening. The close proximity between screening and the adaptation night aimed to prevent participants from becoming ineligible over time. During the adaptation night, participants slept in the sleep laboratory, allowing them to adjust to the new environment and laboratory machines. This prevented results being confounded by the 'first-night-effect', which is the disruption of sleep resulting from sleeping in a new environment (Lorenzo & Barbanoj, 2002). Individuals arrived at the laboratory two hours prior to their usual bedtime. Participants were oriented to their environment and given an explanation of the procedures that would follow. They were then attached to the PSG and were left to sleep for 7-8 hours. Upon awakening, they filled in the Most Recent Dream Form.

2-10 nights after the adaptation night, participants attended a testing night. Testing was scheduled on a non-consecutive night based on the assumption that participants would experience disrupted sleep on the adaptation night, and therefore may experience catch-up sleep the following night with distorted sleep properties (Lorenzo & Barbanoj, 2002). Participants were given an explanation of how the study would proceed and were invited to ask questions. Following this, participants were seated in front of a 19-inch screen that showed the selected images at full-screen. They were instructed to remember each image. Images were presented so that no more than 3 pictures within each category (negative, neutral and positive) were presented in a row. Initially a fixation cross appeared for 2,000 milliseconds, followed by the image for 6,000 milliseconds, and finally a blank screen for 5,000 milliseconds. This method is commonly-used in similar experiments using the IAPS (Balconi, Brambilla, & Falbo, 2009). In order to prevent habituation to the continuous succession of images, a number appeared on the screen at certain intervals and participants were required to press the relevant key-board key. Participants began with a practice EDM task. Following this, 90 pictures were presented for the experimental task.

Thereafter, participants were attached to the EEG monitor and allowed to sleep for 7-8 hours. When they awoke, they were asked to fill in the Most Recent Dream Form. They completed the second stage of the EDM task, which proceeded similarly to stage one. A sequence of 135 images was presented, which included 90 previously-presented images and 45 new images. Thereafter, participants completed a recognition task. They were asked to indicate whether they had seen the presented images the previous night or whether they had not. After completion, participants were debriefed and were compensated with R300.

Ethics

Before sampling began ethical clearance was granted by the Faculty of Humanities for van Wyk's (2018) study. At the online-phase of screening information was provided about study aims and eligibility. Participants were informed that information was confidential and that they had the option of withdrawing at any stage with no consequences. Furthermore, they were informed that data could be used for more than one study, and shared with researchers outside the original team. They were able to access the survey only if they had provided consent. At the in-person screening stage, participants were provided with information about the procedures involved in the study as well as the potential risks and benefits of participation. Participants were

again made aware that information was confidential and that they had the option of withdrawing at any stage without consequences. They were invited to ask questions; thereafter written consent was obtained. If participants met the criteria for an untreated psychiatric disorder, substance-abuse problem, or medical condition they were put in contact with counsellor and/or general practitioners. Before partaking in the EDM task, participants were informed that some images may be considered offensive. They were reminded that they could stop the task at any point without consequence. Verbal consent was obtained.

Data analysis

R version 3.6.3 and Microsoft Excel was used to analyse the data. Following statistical convention, α was set at .05 to determine statistical significance (Wickham & Grolemund, 2017). We generated descriptive statistics to ensure that the assumptions of inferential statistical testing were upheld, as well as to provide information about the study sample. Following this, inferential and correlational analyses of the data were run.

Quantifying emotional memory. The outcomes for the EDM task were interpreted using the signal detection theory framework (SDT) (Macmillan, 2002). There were four possible outcomes to the EDM task: *hit*, the participant correctly stated that the image was presented on the previous night; *miss*, the participant incorrectly stated that the image was only presented in the morning; *correct rejection*, the participant correctly stated that the image was not presented on the previous night; *false alarm*, the participant incorrectly stated that the image was presented on the previous night. A participant's recognition accuracy was measured by finding the difference between the normalized probability of hit rates and false alarm rates.

$$d' = z(\text{hit rate}) - z(\text{false alarm rate})$$

Control variables. For each hypothesis, separate analyses were carried out in order to control for two factors: sleep stage and DRF. Research has shown that those with increased dream recall frequency have higher emotionality in their dreams (Wolcott & Strapp, 2002). Therefore, HFR and LFR were components that could confound our results, as such, dream recall frequency was be controlled for in our analyses. Furthermore, the sleep stage in which the dream took place may have impacted the emotionality of the dream. Dreams during REM sleep often contain more emotional and vivid imagery than dreams during NREM sleep (Nielsen, 2000). Therefore, sleep stage at the time of awakening was controlled for in our analysis.

Measures of dream emotionality. A composite score of dream emotionality was calculated by combining the z-scores of the valence-specific (positive, negative and neutral) 1) LIWC scores and, 2) External ratings of dream reports. This composite is a more accurate and generalisable way of measuring dream emotionality (Sikka, Feilhauer, Valli, & Revonsuo, 2017). Thus, the composite was used as the measure of dream emotionality throughout our study.

Hypothesis 1: Emotionality in dreams predicts emotional memory recall accuracy. A correlational analysis examined the relationship between dream emotionality and overall emotional recall accuracy. The measure for emotional recall accuracy in relation to neutral was calculated as follows:

$$d'(\text{emotional}) = d'(\text{positive} + \text{negative})/2 - d'(\text{neutral})$$

Hypothesis 2: Comparison of positive, negative and neutral memory recall accuracy in relation to high and low dream emotionality. A Mixed Linear Model (MLM) ANOVA was used to compare recall accuracy for emotional material (positive, negative, and neutral material) for different levels of dream emotionality (high and low). Dream emotionality was divided into levels of "high" and "low" where values were split around the median. A MLM was used in order to allow for multiple random and fixed effects to be analysed due to the hierarchical structure of the data.

Hypothesis 3: Valence-specific dream emotionality contributions to emotional memory recall accuracy. Separate correlational analyses were performed for the respective dependent variables: recall accuracy for positive material and recall accuracy for negative material, as well as recall accuracy for neutral material which acted as a control analysis. For all dependent variables, three separate analyses examined the independent variables: positive and negative dream emotionality. Following this, the analyses were re-run with the data split into 1) sleep stage (NREM and REM), and 2) DRF (HFR and LFR). Correlation analyses were chosen because our small sample size precluded the use of statistical techniques which required more power, such as multiple linear regressions.

Results

Testing Hypothesis 1: Emotionality in dreams predicts emotional memory recall accuracy. This one-tailed correlational analysis aimed to determine whether increased emotionality in dreams was positively associated with emotional recall accuracy. Results indicated that there were no significant correlations between composite dream emotionality and

emotional memory recall accuracy, r (30) = 0.20, p = 0.27. We, therefore, disconfirmed our hypothesis. To examine whether this result concealed any underlying effects of sleep stage and DFR, separate analyses correlating dream emotionality with recall accuracy for (a) participants recalling dreams from NREM versus REM sleep and (b) HFRs versus LFRs were performed. However, these analyses revealed no statistically significant correlations.

Testing Hypothesis 2: Comparison of positive, negative and neutral memory consolidation in relation to high and low dream emotionality. This ANOVA aimed to determine whether participants with high emotionality in their dreams recalled positive and negative emotional information with higher accuracy than neutral information. Thus valence (positive versus negative versus neutral) and dream emotionality (high versus low) were compared with regards to emotional memory recall accuracy.

For those with both high and low dream emotionality, positive recall accuracy was equal to negative recall accuracy. However, they were not significantly greater than neutral recall accuracy. The ANOVA was not significant regarding the main effect of valence (F(2, 31) =1.408, p= 0.253, effect size= 0.202), the main effect of dream emotionality (F(1, 31)= 0.954, p= 0.337, effect size= 0.088) or the interaction between valence and dream emotionality (F(2, 31)= 0.938, p= 0.397, effect size= 0.175). These results indicate that recall accuracy did not differ according to valence, dream emotionality or the valence category for those recalling high versus low emotionality in their dreams. Thus, this hypothesis was not confirmed. Furthermore, separate analyses were performed for (a) participants recalling dreams from NREM versus REM sleep and (b) HFRs versus LFRs were performed to examine whether these results concealed any underlying effects of sleep stage and DFR. However, these analyses revealed no statistically significant effects.

Plot 1. *Impact of image valence and dream emotionality on recall accuracy*
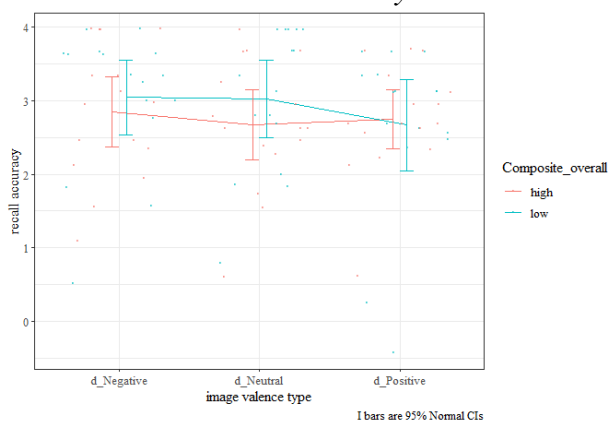
Testing Hypothesis 3: Valence-specific dream emotionality contributions to emotional memory recall accuracy. Correlational analyses were conducted to determine whether there were strong positive associations between valence-specific dream emotionality (positive and negative) and recall accuracy for specifically valenced material (positive and negative). Additional control analyses were performed for neutral recall accuracy.

The associations between positive dream emotionality and positive (r (30) =0.07, $p=$ 0.34), negative (r (30) =0.18, $p=$ 0.17), and neutral (r (30) =0.19, $p=$ 0.15) recall accuracy were not significant. The correlations between negative emotionality and negative (r (30) = -0.31, $p=$ 0.04) and neutral recall accuracy (r (30) = -0.38, $p=$ 0.02) were significant. This indicates that negative emotions in all dreamers inhibited recall accuracy of negative and neutral information. However, the correlation between negative emotionality and positive recall accuracy (r (30) = -0.16, $p=$ 0.19) was not significant.

Table 1

Descriptive Statistics and Correlations for Negative Dream Emotionality and Emotional Recall Accuracy (n=32)

Variable	*M*	*SD*	1	2	3	4
1. Negative emotionality	0.00	0.87				
2. Positive recall accuracy	2.71	0.97	-.16			
3. Negative recall accuracy	2.94	0.92	-.31*	.78**		
4. Neutral recall accuracy	2.85	0.94	-.38*	.74**	.74**	

Note. M and *SD* are used to represent mean and standard deviation, respectively. * indicates $p < .05$. ** indicates $p < .01$.

We anticipated that there would be different trends within each sleep stage and dream recall frequency group. Thus, further correlations were run which split the data into sleep stage (REM and NREM) and DRF (HFRs and LFRs). See appendix H for all correlation tables from hypothesis 3 testing.

NREM Sleep stage. This set of analyses examined dream emotionality and recall accuracy scores specifically in NREM sleep. There were no significant correlations between positive dream emotionality and positive recall accuracy (r (30) = -0.17, p = 0.23). The correlations between positive dream emotionality and negative (r (30) = -0.03, p = 0.44) and neutral (r (30) = 0.1, p = 0.32) recall accuracy were also insignificant. However, there was a significant negative correlation between negative NREM dream emotionality and recall of neutral information (r (30) = -0.45, p = 0.02). The significance of this correlation suggests that increased negativity in NREM dreams is associated with a reduction in the accurate recognition of neutral information. Statistical analysis did not yield significant associations between negative dream emotionality and positive (r (30) = -0.2, p = 0.18) and negative (r (30) = -0.3, p = 0.08) recall accuracy. Therefore, positive dream emotionality does not promote recall accuracy for positive information, and negative dream emotionality does not improve recall accuracy for negative information. The data does not support our hypothesis; valence-specific dream emotionality did not have significant contributions to recall accuracy.

Table 2

Descriptive Statistics and Correlations for Negative Dream Emotionality and Emotional Recall Accuracy in NREM dreamers (N= 23)

Variable	*M*	*SD*	1	2	3	4
1. Negative emotionality	0.16	0.84				
2. Positive recall accuracy	2.77	0.87	-.20			
3. Negative recall accuracy	3.00	0.92	-.30	.81**		
4. Neutral recall accuracy	2.80	0.98	-.45*	.77**	.74**	

Note. M and *SD* are used to represent mean and standard deviation. * indicates $p < .05$. ** indicates $p < .01$.

REM Sleep stage. Correlational analyses examining REM dream emotionality found that positive dream emotionality is not significantly associated with positive recall accuracy (r (30)

=0.47, p= 0.10). There was a significant positive relationship between positive dream emotionality and negative recall accuracy (r (30) =0.66, p= 0.03). This indicates that during REM dreaming, increased positive emotionality was associated with better recall of negative emotional information. The moderate size of the correlations between positive dream emotionality and positive and neutral recall accuracy tentatively suggests that there may be a trend in the data such that increased positivity in REM dreams is associated with an improvement in the accurate recognition of positive and neutral information.

Table 3

Descriptive Statistics and Correlations for Positive Dream Emotionality and Emotional Recall Accuracy in REM dreamers (N= 9)

Variable	*M*	*SD*	1	2	3	4
1.Positive emotionality	0.51	1.06				
2. Positive recall accuracy	2.54	1.22	.47			
3. Negative recall accuracy	2.80	0.97	.66*	.74*		
4. Neutral recall accuracy	2.97	0.85	.32	.78*	.82**	

Note. M and *SD* are used to represent mean and standard deviation, respectively. * indicates p < .05. ** indicates p < .01.

There was a trend-level moderate negative correlation between negative dream emotionality and negative recall accuracy (r (30) = -0.51, p= 0.08). The correlations for negative dream emotionality and positive (r (30) = -0.21, p= 0.29) and neutral (r (30) = -0.12, p= 0.38) recall accuracy were not significant. Whilst none of these were significant, the moderate correlation sizes suggest a consistent trend in the data such that negative dream emotionality is negatively correlated with emotional recall accuracy.

Table 4

Descriptive Statistics and Correlations for Negative Dream Emotionality Emotional Recall Accuracy in REM dreamers (N= 9)

Variable	M	SD	1	2	3	4
1. Negative emotionality	-0.41	0.87				
2. Positive recall accuracy	2.54	1.22	-.21			
3. Negative recall accuracy	2.80	0.97	-.51	.74*		
4. Neutral recall accuracy	2.97	0.85	-.12	.78*	.82**	

Note. M and *SD* are used to represent mean and standard deviation, respectively. * indicates *p* < .05. ** indicates *p* < .01.

These findings tentatively propose that increased negativity in REM dreams may be associated with poorer recall accuracy of emotional information, whilst positivity is associated with better emotional recall. As such, there may be differences in the relationship between dream emotionality and recall accuracy depending on sleep stage.

***High Recall Frequency dreamers*.** In HFR dreamers there was a significant positive relationship between positive dream emotionality and neutral emotional recall accuracy *(r* (30) = 0.47, *p* = 0.03). Thus, increased positive emotion in HRF dreamers' dreams was associated with increased neutral recall accuracy. Although insignificant, there was a trend-level positive relationship between positive dream emotionality and as positive recall accuracy (*r* (30) = 0.33, *p* = 0.10). The relationship between positive dream emotionality and negative recall accuracy was insignificant (*r* (30) = 0.17, *p* = 0.25).

Table 5

Descriptive Statistics and Correlations for Positive Dream Emotionality and Emotional Recall Accuracy in HFR dreamers (n=16).

Variable	M	SD	1	2	3	4
1.Positive emotionality	-0.14	0.59				

2. Positive recall accuracy	2.89	1.01	.33			
3. Negative recall accuracy	3.04	0.80	.18	.77**		
4. Neutral recall accuracy	3.15	0.81	.47*	.67**	.68**	

Note. *M* and *SD* are used to represent mean and standard deviation, respectively. * indicates $p < .05$. ** indicates $p < .01$.

Negative dream emotionality was not significantly correlated with positive ($r (30) = 0.02$, $p = 0.47$), or negative ($r (30) = -0.10$, $p = 0.35$) recall accuracy. There was a trend-level negative relationship between negative dream emotionality and neutral recall accuracy ($r (30) = -0.33$ $p = 0.10$). Thus, neither of the hypotheses were confirmed.

Low Frequency Recallers. For LFRs there were no significant correlations between positive dream emotionality and positive recall accuracy ($r (30) = -0.03$, $p = 0.54$). Nor between positive dream emotionality and negative recall accuracy ($r (30) = 0.21$, $p = 0.21$), as well as neutral recall accuracy ($r (30) = 0.16$, $p = 0.27$). However, there was a strong significant negative correlation between negative dream emotionality and negative recall accuracy ($r (30) = -0.49$, $p = 0.03$), as well as neutral recall accuracy ($r (30) = -0.42$, $p = 0.05$). Additionally, there were trend-level negative correlation between negative dream emotionality and positive recall accuracy ($r (30) = -0.38$, $p = 0.09$). This indicates that increased negatively in dreams was associated with worse recall accuracy, particularly worse negative recall accuracy. This does not support the original hypothesis.

Table 6

Descriptive Statistics and Correlations for Negative Dream Emotionality and Emotional Recall Accuracy in LFR dreamers (n=16).

Variable	*M*	*SD*	1	2	3	4
1. Negative emotionality	0.06	0.83				
2. Positive recall accuracy	2.52	0.91	-.36			

3. Negative recall accuracy	2.85	1.05	-.49*	.80**	
4. Neutral recall accuracy	2.55	0.98	-.42	.79**	.80**

Note. M and *SD* are used to represent mean and standard deviation, respectively. * indicates *p* < .05. ** indicates *p* < .01.

In HFR there was a significant positive relationship between positive dream emotionality and neutral recall accuracy. This indicates that increased positivity was associated with increased neutral recall accuracy. In LFR dreamers there was a significant negative relationship between negative dream emotionality and both negative and neutral recall accuracy. Therefore, increased negative emotion in dreams was associated with worse recall accuracy, particularly for negative information.

Discussion

The replay of emotional life events during dreams may aid in emotional memory consolidation (Perogamvros et al., 2013). However, only one empirical study, the parent study of this research (van Wyk, 2018), has examined this hypothesis. This study aimed to determine whether dreaming is associated with emotional consolidation by exploring the relationship between dream emotionality and emotional recall accuracy. This was one of the first studies to explore this relationship, and the first to examine the role of NREM sleep in dreaming and emotional memory consolidation. We found that there was no significant relationship between dream emotionality and emotional recall accuracy, as well as no difference between positive, negative and neutral recall accuracy in low and high emotional recallers. Positive dream emotionality was not associated with positive recall accuracy. However, negative dream emotionality was associated with poorer negative and neutral recall accuracy. Additionally, dreaming during REM may play an important role in emotional memory consolidation depending on the dream valence. Positivity in REM dreams was associated with enhanced recall of emotional information, especially negatively valenced information. Furthermore, the findings tentatively suggest that increased negativity in REM dreams was associated with poorer recall accuracy of emotional information, especially negative emotional information. NREM dreaming does not display the same associations. Findings are suggestive that negativity in NREM dreams was associated with significantly worse recall of neutral information. In addition, this pattern was present for HFR and LFR dreamers. Overall, this suggests that emotionality in dreams

function to help modulate recall and emotional memory consolidation, leading to an emotional homeostasis following sleep.

Hypothesis 1

A number of theoretical accounts suggest that dreams facilitate emotional memory consolidation during sleep (Payne, et al., 2012; Scarpelli et al., 2019). These accounts are supported by evidence that during dreaming motivational and emotional brain circuits are activated (Perogamvros et al., 2013; Scarpelli et al., 2019). In contrast, this study found no significant relationship to indicate that dreaming during both REM sleep and NREM sleep assists in the consolidation of emotional memories. The parent study of our research found that, in accordance with this study, more frequent dreaming was not associated with improved emotional memory (van Wyk, 2018).

Therefore, there may be a more complex relationship between sleep, dreaming and emotional memory consolidation than has been postulated. Looking at emotional memory recall accuracy broadly, irrespective of emotional memory valence or dream valence, may disregard relationships between specific valence categories present in dreams and specific emotional memory categories. Therefore, it may be too broad to look at overall emotionality and overall consolidation.

Hypothesis 2

Numerous studies have found that sleep preferentially consolidates negative information, in comparison with neutral information (Payne et al., 2012; Wagner et al., 2001). Furthermore, sleep preferentially consolidates positive information, in comparison with neutral information (Atienza & Cantero, 2008; Chambers & Payne, 2013). Therefore, sleep may aid in creating a balance of positive and negative memories. Dreams may be the method through which this takes balance place. Therefore, this study hypothesized that dreams with high emotionality consolidate positive and negative information equally and more efficiently than neutral information. However, we found that for both high and low emotionality dream groups, positive, negative and neutral information was consolidated equally.

Similarly, a number of studies have found that sleep does not consolidate negative and positive information more effectively than neutral information (Lipinska & Thomas, 2019; Ward, Peters, & Smith, 2013). However, it is well-established that during waking, emotional information is recalled preferentially to neutral information (Kensinger & Corkin, 2003;

Ochsner, 2000). Hence, we postulate that the function of sleep may be to reduce bias for memories of a particular valence. Thus, post-sleep there is balanced recall of positive, negative and neutral recall.

Hypothesis 3

Perogamvros and colleagues (2013) suggest that dreams replay previous emotional experiences, subsequently leading to their consolidation. (Perogamvros et al., 2013). Therefore, dreams with a particular emotional quality may help to consolidate information with the same emotional quality. In contrast, our study found that positive dream emotionality was not significantly associated with recall accuracy of positive information. Furthermore, negative dream emotionality was not significantly associated with high recall accuracy for negative information. However, negative dream emotionality was associated with poorer recall of negative and neutral information. Therefore, negative dreams may inhibit the consolidation of negative and neutral information. We speculate that this ensures there is not an over-consolidation of negative information following negative experiences; thereby allowing individuals to be more emotionally balanced following sleep.

An overall trend in the data tentatively suggests that positive dream emotionality was associated with improved recall accuracy, whereas negative dream emotionality was associated with poorer recall accuracy. Therefore, the incorporation of negative experiences into dream content may dampen memory consolidation. Thus, dreaming may act as a protective factor in the processing of negative experiences, preventing fixation. Dreaming may also enhance memory consolidation following positive events. Furthermore, following dreaming about both positive and negative events, positive, negative and neutral aspects are recalled equally. Therefore, rather than only recalling negative (positive) aspects of negative (positive) experiences, all information is recalled equally. Thus, when negative experiences are incorporated into dreams, all aspects of the experiences are recalled equally and less accurately. Whereas they are recalled equally and more accurately following positive experiences. The data was separated into sleep stage and DRF to investigate if these variables were masking potential relationships in the data.

In NREM dreams, negative emotionality was associated with poorer recall accuracy for neutral information. In REM dreams negative emotionality was strongly, although insignificantly, associated with poorer recall accuracy for negative information. However, positive emotionality in REM dreams was associated with enhanced

recall accuracy for negative information. Furthermore, although only at a trend-level, positive emotionality in REM dreams was strongly associated with improved recall accuracy for positive information. Negative recall accuracy seems to be modulated the most. We postulate that this valence of information needs the most modulation as having either too little or too much recall of negative information could be maladaptive. If there is too little recall of negative information one would not detect threats or aversive stimuli; however, too much recall of negative information may lead to conditions such as depression and anxiety.

REM dreams may inhibit memory consolidation for negative information and NREM dreams may inhibit consolidation for neutral content that is associated with negative experiences. We speculate that the differences in memory consolidation by sleep stage may arise due to physiological differences in brain activation during REM and NREM dreams (Chellappa, Frey, Knoblauch, & Cajochen, 2011). REM dreams are more vivid, bizarre and emotional, this is consistent with REM being implicated in emotional memory consolidation (Schäfer et al., 2020; Walker & van der Helm, 2009). In REM sleep both the hippocampus and amygdala are highly active – areas which are associated with memory and emotion. Whereas NREM dreams are more "thought-like", this aligns with NREM sleep playing a more important role in the consolidation of neutral information (McNamara et al., 2010). Furthermore, NREM sleep is associated with the consolidation of declarative memories mostly in the hippocampus (Payne et al., 2012). Thus, REM and NREM dreams may process information of different valences.

With regards to DRF, for HFR dreamers, positive dream emotionality was associated with improved recall accuracy for neutral material. However, for LFR dreamers negative dream emotionality was associated with poorer recall for negative material. Furthermore, negative dream emotionality was associated with poorer recall for neutral material. We surmise that these differences in emotional memory consolidation according to DRF may be due to the neurophysiological differences found in HFR and LFR (Eichenlaub, Bertrand, Morlet, & Ruby, 2014). We conjectured that these neurophysiological variances may alter sleep and dreaming, as well as leading individuals to encode, consolidate, and recall various emotional stimuli slightly differently. This would lead to variability in their recall accuracy following emotional dreams of different valence categories. However, further studies would be required to explore this.

Limitations and future directions

A number of limitations were present in this study. By relying on previously collected data we were unable to use a larger sample. Thus, the low level of power may have impacted our ability to detect statistically significant patterns in the data, particularly for the REM dreams group which only contained 9 participants. Furthermore, due to small sample size we were unable to conduct a multiple linear regression. Thus, we were only able to draw conclusions about correlational relationships between dream emotionality and emotional recall accuracy. Future studies should consider a larger sample size in order to examine the associations we found with greater statistical accuracy.

Furthermore, our study's reliance on the accurate external rating of dream reports in terms of emotionality raises potential limitations. Numerous studies have illustrated the fallibility of dream reports as individual ratings of the emotionality of dream reports frequently differ from external ratings of these dreams (Sikka et al., 2017). However, our use of a composite variable comprised of external ratings as well as LIWC score may mitigate this fallibility. Future studies should be cognizant of using a number of measures for the emotionality of dreams, as we did. Additionally, they should explore the relationship between dream emotionality and emotional memory consolidation with regards to differences between REM and NREM dreams, and DRF in more depth.

The preliminary findings of our study indicate that dreaming does play a role in emotional memory consolidation. However, our conclusions are highly speculative. Additional studies are required to establish a causal connection between dreaming and emotional memory consolidation. Furthermore, this study provides little information about the brain mechanisms implicated in valence-specific memory consolidation during dreaming. Additionally, further explorations into the role of bias and hit rate in relation to dreaming and emotional memory consolidation could yield interesting results.

Our findings could have implications for individuals with mental health disorders which have negative impacts on sleep, such as PTSD and depression, and should be replicated with these populations. Understanding the mechanisms of sleep and dreaming in emotional memory consolidation during REM and NREM sleep could lead to further insights into mental health disorders and their neuropsychological sequalae. These insights could be used to inform and

provide evidence for efficacious clinical interventions and management of mental health and sleep disorders.

Summary and Conclusion

This study was one of the first to empirically examine the role of dreaming in emotional memory consolidation. Our findings indicate that dreaming during NREM and REM together play a role in achieving a balance of emotional memories – with some emotional content being dampened and other content being enhanced. This selective decrease or increase in memory of certain valences of emotional information may be adaptive as it allows for individuals to avoid developing an emotional bias towards either negative or positive information. Thus, contrary to our hypothesis, increased emotions in dreams were not associated with increased recall accuracy of emotional information with the same valence. Our main finding suggests that negative recall accuracy is modulated more than positive recall accuracy. Furthermore, positive REM dreams were associated with increased recall accuracy for emotional information. Whereas, NREM dreams were associated with poorer recall accuracy for neutral material. This trend indicates that negative emotions in dreams are associated with less negative emotional memory accuracy. Whilst our findings are preliminary, they indicate that negative dream emotionality dampens memory of negative and neutral information. Furthermore, there is a definite difference in emotional memory consolidation following NREM compared to REM dreaming. We speculate there is an association between dreaming and emotional memory consolidation which aims to achieve an emotional balance following sleep. Our study is the first to consider the role of dreaming during NREM in emotional memory consolidation, and can guide future research into the function of dreaming during NREM sleep.

Acknowledgements

References

Atienza, M., & Cantero, J. (2008). Modulatory effects of emotion and sleep on recollection and familiarity. *Journal Of Sleep Research*, *17*(3), 285-294. doi: 10.1111/j.1365-2869.2008.00661.x

Balconi, M., Brambilla, E., & Falbo, L. (2009). Appetitive vs. defensive responses to emotional cues. Autonomic measures and brain oscillation modulation. *Brain Research, 1296*, 7284. doi:10.1016/j.brainres.2009.08.056

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Manual for the beck depression inventory II.* San Antonio: Psychological Corporation.

Bekker, D., & Van Velden, D. P. (2003). Alcohol misuse in patients attending a defence force general medical clinic. *South African Family Practice, 45*(2), 10-15. Retrieved from https://www.ajol.info/index.php/safp/article/view/13059/15666

Bion, W. R. (1962). *Learning from experience.* New York, NY: Basic Books

Blackman, M. R. (2000). Age-related alterations in sleep quality and neuroendocrine function: *Interrelationships and implications. Journal of the American Medical Association, 248*, 879-881. doi:10.1001/jama.284.7.879

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatric Research, 28*(2), 193-213. doi:10.1016/0165-1781(89)90047-4

Cahill, L., & McGaugh, J. L. (1998). Mechanisms of emotional arousal and lasting declarative memory. *Trends in Neurosciences, 21*, 294-299. doi:10.1016/s0166-2236(97)01214-9

Chambers, A., & Payne, J. (2013). Laugh yourself to sleep: memory consolidation for humorous information. *Experimental Brain Research*, *232*(5), 1415-1427. doi: 10.1007/s00221-013-3779-7

Chellappa, S., Frey, S., Knoblauch, V., & Cajochen, C. (2011). Cortical activation patterns herald successful dream recall after NREM and REM sleep. *Biological Psychology*, *87*(2), 251-256. doi: 10.1016/j.biopsycho.2011.03.004

Colace, C. (2004). Dreaming in addiction: A study on the motivational bases of dreaming processes. *Neuropsychoanalysis*, *6*(2), 165-179. doi:10.1080/15294145.2004.10773458

Cumming, G. (2013). The New Statistics. *Psychological Science, 25*(1), 7-29. doi: 10.1177/0956797613504966

Deliens, G., Gilson, M., & Peigneux, P. (2014). Sleep and the processing of emotions. *Experimental brain research*, *232*(5), 1403-1414. doi: 10.1007/s00221-014-3832-1

Diara, H. (2019). *Examining the relationship between emotion regulation and emotionality in recalled dreams of high frequency recallers and low frequency recallers* (Honours Research Project, University of Cape Town, South Africa). Retrieved from http://www.psychology.uct.ac.za/psy/graduateprogrammes/honours/projects

Diekelmann, S., & Born, J. (2010). The memory function of sleep. *Nature Reviews Neuroscience, 11*(2), 114-126. doi: 10.1038/nrn2762

Domhoff, G. W., & Shneider, A. (1998). New rationales and methods for quantitative dream research outside the laboratory. *Sleep, 21*(4), 398–404. doi:10.1093/sleep/21.4.398

Eichenlaub, J. B., Bertrand, O., Morlet, D., & Ruby, P. (2014). Brain reactivity differentiates subjects with high and low dream recall frequencies during both sleep and wakefulness. *Cerebral cortex (New York, N.Y. : 1991)*, *24*(5), 1206–1215. https://doi.org/10.1093/cercor/bhs388

Eichenlaub, J. B., Cash, S. S., & Blagrove, M. (2017). Daily life experiences in dreams and sleep-dependent memory consolidation. In N. Axmacher & B. Rasch (Eds.), Studies in neuroscience, psychology and behavioral economics. *Cognitive neuroscience of memory consolidation* (p. 161-172). Springer International Publishing. https://doi.org/10.1007/978-3-319-45066-7_10

Freud, S. (1900). *The interpretation of dreams* (J. Crick, Trans.). London: Oxford University Press.

Hu, P., Stylos-Allan, M., & Walker, M. P. (2006). Sleep facilitates consolidation of emotional declarative memory. *Psychological science, 17*(10), 891-898. doi: 10.1111/j.1467-9280.2006.01799.x

Irwin, M., Miller, C., Gillin, J. C., Demodena, A., & Ehlers, C. L. (2000). Polysomnographic and spectral sleep EEG in primary alcoholics: An interaction between alcohol dependence and african-american ethnicity. *Alcoholism: Clinical and Experimental Research, 24*, 1376-1384. https://doi-org.ezproxy.uct.ac.za/10.1111/j.1530-0277.2000.tb02106.x

Kensinger, E. A. (2004). Remembering emotional experiences: The contribution of valence and arousal. *Reviews in the Neurosciences, 15*(4), 241-252. doi: 10.1515/revneuro.2004.15.4.241

Kensinger, E. A., & Corkin, S. (2003). Effect of Negative Emotional Content on Working Memory and Long-Term Memory. *Emotion, 3*(4), 378-393. https://doi.org/10.1037/1528-3542.3.4.378

LaBar, K. S., & Cabeza, R. (2006). Cognitive neuroscience of emotional memory. *Nature, 7*, 54-64. doi: 10.1038/nrn1825

Levin, R., & Nielsen, T. A. (2007). Disturbed dreaming, posttraumatic stress disorder, and affect distress: A review and neurocognitive model. *Psychological Bulletin, 133*, 482-528. doi: 10.1037/0033-2909.133.3.482

Lipinska, G., & Thomas, K. (2019). The Interaction of REM Fragmentation and Night-Time Arousal Modulates Sleep-Dependent Emotional Memory Consolidation. *Frontiers In Psychology*, *10*. doi: 10.3389/fpsyg.2019.01766

Lorenzo, J. L., & Barbanoj, M. J. (2002). Variability of sleep parameters across multiple laboratory sessions in healthy young subjects: the "very first night effect". *Psychophysiology, 39*(4), 409-413. doi:10.1017.s0048577202394010

Macmillan, N. A. (2002). Signal Detection Theory. In H. Pashler (Ed.), *Steven's Handbook of Experimental Psychology: Third Edition* (Vol. Volume 4, pp. 55-102). New York: John Wiley & Sons, Inc.

McGaugh, J. L. (2004). The amygdala modulates the consolidation of memories of emotionally arousing experiences. *Annual Review of Neuroscience, 27*, 1–28. doi: 10.1146/annurev.neuro.27.070203.144157

McNamara, P., Johnson, P., McLaren, D., Harris, E., Beauharnais, C., & Auerbach, S. (2010). REM and NREM sleep mentation. *International review of neurobiology*, *92*, 69–86. https://doi.org/10.1016/S0074-7742(10)92004-7

Nielsen, T. A. (2000). A review of mentation in REM and NREM sleep: Human brain activity time-locked to rapid eye movements during REM sleep. *Behavioural and Brain Sciences, 23*, 851-866. doi: 10.1017/s0140525x0000399x

Nishida, M., Pearsall, J., Buckner, R. L., & Walker, M. P. (2009). REM sleep, prefrontal theta, and the consolidation of human emotional memory. *Cerebral cortex*, *19*(5), 1158-1166. doi: 10.1093/cercor/bhn155

Ochsner, K. (2000). Are affective events richly recollected or simply familiar? The experience and process of recognizing feelings past. *Journal of experimental psychology. General. 129*(2), 242-61. 10.1037//0096-3445.129.2.242.

Olley, B. O., Zeier, M. D., Seedat, S., & Stein, D. J. (2005). Post-traumatic stress disorder among recently diagnosed patients with HIV/AIDS in South Africa. *AIDS Care, 17*(5), 550-557. doi:10.1080/09540120412331319741

Payne, J., Chambers, A., & Kensinger, E. (2012). Sleep promotes lasting changes in selective memory for emotional scenes. *Frontiers in Integrative Neuroscience*, *6*, 108. doi: 10.3389/fnint.2012.00108

Pennebaker, J. W., Booth, R. J., Boyd, R. L., & Francis, M. E. (2015). *Linguistic Inquiry and Word Count: LIWC 2015*. Austin, TX: Pennebaker Conglomerates. Retrieved from http://www.LIWC.net.

Perogamvros, L., Dang-Vu, T. T., Desseilles, M., & Schwartz, S. (2013). Sleep and dreaming are for important matters. *Frontiers in psychology*, *4*, 474.

Preston, A. R., & Eichenbaum, H. (2013). Interplay of hippocampus and prefrontal cortex in memory. *Current Biology, 23*, R764-R773. doi: 10.1016/j.cub.2013.05.041

Rockwood, K., Mintzer, J., Truyen, L., Wessel, T., & Wilkinson, D. (2001). Effects of flexible galantamine dose in Alzheimer's disease: A randomised controlled trial. *Journal of Neurology, Neurosurgery & Psychiatry, 71*(5), 589-595. doi.10.1136/jnnp.71.5.589

Scarpelli, S., Bartolacci, C., D'Atri, A., Gorgoni, M., & De Gennaro, L. (2019). The functional role of dreaming in emotional processes. *Frontiers in psychology*, *10*. doi:10.3389/fpsyg.2019.00459

Schäfer, S.K., Wirth, B.E., Staginnus, M., Becker, N., Michael, T., Roxanne Sopp, M. (2020). Sleep's impact on emotional recognition memory: A meta-analysis of whole-night, nap, and REM sleep effects. *Sleep Medicine Reviews, 51*. https://doi.org/10.1016/j.smrv.2020.101280.

Schredl, M., Barrett, D., & McNamara, P. (2007). *The new science of dreaming: Vol. 2. Content, recall, and personality correlates.* Praeger Publishers/Greenwood Publishing Group.

Seedat, S., Nyamai, C., Njenga, F., Vythilingum, B., & Stein, D. J. (2004). Trauma exposure and post-traumatic stress symptoms in urban African schools. *The British Journal of Psychiatry, 184*(2), 169-175. doi:10.1192/bjp.184.2.169

Selzer, M. L. (1971). The Michigan Alcoholism Screening Test: The quest for a new diagnostic instrument. *American journal of Psychiatry, 127*(12), 1653-1658. doi:10.1176/ajp.127.12.1653

Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., ... & Dunbar, G. C. (1998). *The Mini-International Neuropsychiatric Interview (MINI): the development and validation of a structured diagnostic psychiatric interview for DSMIV and ICD-10.* The Journal of clinical psychiatry, 59, 22-33.

Sikka, P., Feilhauer, D., Valli, K., & Revonsuo, A. (2017). How You Measure Is What You Get: Differences in Self- and External Ratings of Emotional Experiences in Home Dreams. *The American Journal of Psychology, 130*(367-384). doi:10.5406/amerjpsyc.130.3.0367

Solms, M. (2000). Dreaming and REM sleep are controlled by different brain mechanisms. *Behavioral And Brain Sciences*, *23*(6), 843-850. doi: 10.1017/s0140525x00003988

Solms, M., & Turnbull, O. (2002). *Brain and the inner world: An introduction to the neuroscience of subjective experience*. Other Press, LLC.

Sterpenich, V., Perogamvros, L., Tononi, G., & Schwartz, S. (2019). Fear in dreams and in wakefulness: Evidence for day/night affective homeostasis. *Human Brain Mapping*, *41*(3), 840-850. doi: 10.1002/hbm.24843

Stickgold, R. (2005). Sleep-dependent memory consolidation. *Nature, 437*, 1272-1278. doi:10.1038/nature04286

van der Helm, E., & Walker, M. (2011). Sleep and Emotional Memory Processing. *Sleep Medicine Clinics*, *6*(1), 31-43. doi: 10.1016/j.jsmc.2010.12.010

van Wyk, M. (2018). *The Functional Neurophysiological Sequelae Associated with High Frequency Dream Recallers* (Doctoral Dissertation, University of Cape Town, South Africa). Retrieved from https://open.uct.ac.za/handle/11427/28149

Vazquez, J., & Baghdoyan, H. A. (2001). Basal forebrain acetylcholine release during REM sleep is significantly greater than during waking. *American Journal of Regulatory, Integrative and Comparative Physiology, 280,* R598–R601. doi: https://doi.org/10.1152/ajpregu.2001.280.2.R598

Wagner, U., Gais, S., & Born, J. (2001). Emotional memory formation is enhanced across sleep intervals with high amounts of rapid eye movement sleep. *Learning & Memory*, *8*(2), 112-119. doi:10.1101/lm.36801

Walker, M. P. (2009). The role of sleep in cognition and emotion. Annals of the New York *Academy of Sciences, 115*(6), 168-197. doi:10.1111/j.1749-6632.2009.04416.x

Ward, M., Peters, K., & Smith, C. (2013). Effect of emotional and neutral declarative memory consolidation on sleep architecture. *Experimental brain research, 232*(5). 10.1007/s00221-013-3781-0.

Wickham, H., & Grolemund, G. (2017). *R for data science*. Sebastapol: O'Reilly Media, Inc.

Wolcott, S., & Strapp, C. M. (2002). Dream recall frequency and dream detail as mediated by personality, behavior, and attitude. *Dreaming*, *12*(1), 27-44. DOI: 10.1023/A:1013842505744

Zhang, W., & Guo, B. (2018). Freud's Dream Interpretation: A Different Perspective Based on the Self-Organization Theory of Dreaming. *Frontiers In Psychology*, *9*. doi: 10.3389/fpsyg.2018.01553

APPENDICES

Appendix A

Participant Recruitment Email

Dear Students,

INFORMATION: UCT SLEEP STUDY All UCT students who want to participate in this PAID study, please read:

I am running a PhD study at the Department of Psychology at UCT. The study looks at memory and emotions in relation to sleep and dreaming. This study has been approved by the Humanities Faculty Research Ethics Committee.

The study will consist of three phases: the first phase entails filling out the online questionnaire, if you are deemed eligible, and willing to continue with the study, you will advance to the second phase. At the second phase you will briefly meet with the researcher to fill out additional questionnaires. Following this, and if you are still eligible and willing, you will be invited to participate in the sleep study. The sleep study will take place over two non-consecutive nights scheduled at your convenience. Before you go to bed you will complete some questionnaires, as well as three memory tasks. The memory tasks will be repeated the following morning. You will not be woken up during the night.

Who can participate?

I am looking for males and females between the ages of 20 and 40 years, who are not on any chronic medication like anti-depressants, anti-psychotics, sleeping pills or any other psychotropic medication.

What are the benefits?

1) You will learn more about your sleeping patterns.

 2) You will also receive **R300** payment upon completion of both sleep testing nights. Please follow the link below to fill out the consent form and advance to the first phase of the study:

https://www.surveymonkey.com/r/VXBPVGH

Please note that all personal information will be kept strictly confidential and it will not be used for purposes outside of this research study.

Please email sleep.dreamstudy@gmail.com if you have any questions.

Regards, Mariza (Head Researcher)

Appendix B

Online Survey Consent Form

Sleep Studies at UCT

Online consent form

This is a survey used for initial screening for sleep studies being carried out at the University of Cape Town (UCT). This online survey should take less than 15 minutes and will assess you on various aspects of your sleep routine and other qualities that affect sleep. Taking part in this survey is completely voluntary, and you may withdraw at any time without incurring any penalties. The information you provide will be kept strictly confidential. This means that your digital data will be kept in secure computer files, and will only be shared with the researchers of these studies. Any information that is released to the public will not include your name or any personal details that may be used to identify you. Please take this survey in a single session, and without consulting outside sources of information. This survey is intended to collect responses in a specific manner, and outside sources of information or activities between answering the questions may impact on the results. In order to control this to some degree, the survey must be completed in less than 20 minutes for the results to be considered.

If your responses indicate that you are eligible for the next phase, you may be contacted to meet with a researcher to participate in a second, short screening interview. This screening will determine if you are eligible for the sleep study, for which you will receive payment upon completion.

By continuing with this survey, you agree to supply personal information that is correct to the best of your knowledge.

If you do not agree, please close the page on your web-browser and do not continue.

If you have any questions, please contact sleep.dreamstudy@gmail.com

Appendix C

Online Survey

Demographic and Medical Information

1. **Full name**

2. **Student number**

3. **Course code (If applicable)**

4. **Please provide contact details: (We need to be able to contact you in order to organise sessions)**

5. **Highest level of education**

6. **Sex Male Female Other**

7. **Age (years)**

8. **What is your country of origin?**

9. **What is your primary language?**

10. **Are you currently on ANY medication? Please list ALL medications.**

11. **Have you ever had a head injury?**

12. **Did you lose consciousness?**

13. **Please list all past and current medical conditions**

14. **Have you ever been diagnosed with a psychiatric condition?**

15. **If yes, please list the condition(s)**

16. **Have you ever been diagnosed with a sleep disorder?**

17. **Which disorder, please explain**

18. **If there are any other details about your medical history, that you have not mentioned yet, please add them here:**

19. **Do you use any substances or drugs, for instance marijuana, cocaine, or MDMA?**

20. **If yes, please list the substance(s) and how frequently you use them per month**
    Dream Details

21. **If a dream is defined as a long and bizarre story, an image that vanishes rapidly, or a feeling of having dreamt, on average, how many mornings per week over the last couple of months did you wake up with a dream in mind?**

22. **In general, how interested are you in your dreams, e.g. thinking about them, trying to understand them, discuss them with other people, or write about them?**

23. **What is your definition of a dream?**

24. **If you have to give your best guess, how many times do you wake up during the night?**
    Alcohol Use Questionnaire
    The following questions relate to your alcohol use over the last 6 months. If you do not consume alcohol you still need to fill out the questionnaire.

25. **Do you feel you are a normal drinker? ("normal" – drink as much or less than most other people)?**

26. **Have you ever awakened the morning after some drinking the night before and found that you could not remember a part of the evening?**

27. **Does any near relative or close friend ever worry or complain about your drinking?**

28. **Can you stop drinking without difficulty after one or two drinks?**

29. **Do you ever feel guilty about your drinking?**

30. **Have you ever attended a meeting of Alcoholics Anonymous (AA)?**

31. **Have you ever gotten into physical fights when drinking?**

32. **Has drinking ever created problems between you and a near relative or close friend?**

33. **Has any family member or close friend gone to anyone for help about your drinking?**

34. **Have you ever lost friends because of your drinking?**

35. **Have you ever gotten into trouble at work because of drinking?**

36. **Have you ever lost a job because of drinking?**

37. **Have you ever neglected your obligations, your family, or your work for two or more days in a row because you were drinking?**

38. **Do you drink before noon fairly often?**

39. **Have you ever been told you have liver trouble such as cirrhosis?**

40. **After heavy drinking have you ever had delirium tremens (D.T.'s), severe shaking, visual or auditory (hearing) hallucinations?**

41. **Have you ever gone to anyone for help about your drinking?**

42. **Have you ever been hospitalized because of drinking?**

43. **Has your drinking ever resulted in your being hospitalized in a psychiatric ward?**

44. **Have you ever gone to any doctor, social worker, clergyman or mental health clinic for help with any emotional problem in which drinking was part of the problem?**

45. **Have you been arrested more than once for driving under the influence of alcohol?**

46. **Have you ever been arrested, even for a few hours, because of other behaviour while drinking?**

PSQI

INSTRUCTIONS The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

47. During the past month, what time have you usually gone to bed at night?

48. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

49. During the past month, what time have you usually gotten up in the morning?

50. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

For each of the remaining questions, check the one best response. Please answer ALL questions.

During the Past month, how often have you had trouble sleeping because you . . .

51. Cannot get to sleep within 30 minutes.

   Not during the past month

   Less than once a week

   Once or twice a week

   Three or more times a week

52. Wake up in the middle of the night or early morning

   Not during the past month

   Less than once a week

   Once or twice a week

   Three or more times a week

53. Have to get up to use the bathroom

   Not during the past month

   Less than once a week

   Once or twice a week

   Three or more times a week

54. Cannot breathe comfortably

   Not during the past month

   Less than once a week

Once or twice a week

Three or more times a week

55. Cough or snore loudly

Not during the past month

Less than once a week

 Once or twice a week

Three or more times a week

56. Feel too cold

Not during the past month

Less than once a week

Once or twice a week

Three or more times a week

57. Feel too hot

Not during the past month

Less than once a week

Once or twice a week

Three or more times a week

58. Had bad dreams

Not during the past month

Less than once a week

Once or twice a week

Three or more times a week

59. Have pain

Not during the past month

Less than once a week

Once or twice a week

Three or more times a week

60. Other reason(s), please describe

61. How often during the past month have you had trouble sleeping because of the possible reason(s) asked about in the preceding question?

Not during the past month

Less than once a week

Once or twice a week

Three or more times a week

62. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

Not during the past month

Less than once a week

Once or twice a week

Three or more times a week

63. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Not during the past month

Less than once a week

Once or twice a week

Three or more times a week

64. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

Not during the past month

Less than once a week

Once or twice a week

Three or more times a week

65. During the past month, how would you rate your sleep quality overall?

Very good

Fairly good

Fairly bad

Very bad

66. Do you have a bed partner or roommate?

    No bed partner or roommate

    Partner/roommate in other room

    Partner in same room, but not same bed

    Partner in same bed

BDI-II

Instructions: This questionnaire consists of 21 groups of statements. Please read each group of statements carefully, then pick out the one statement in each group that best describes the way you have been feeling during the past two weeks, including today. Select the statement you have picked. If several statements in the group seem to apply equally well, select the highest number for that group. Be sure that you do not choose more than one statement for any group, including Item 16 (Changes in Sleeping Pattern) or Item 18 (Changes in Appetite).

67. Sadness.

    0 I do not feel sad.

    1 I feel sad much of the time.

    2 I am sad all of the time.

    3 I am so sad or unhappy that I can't stand it.

68. Pessimism.

    0 I am not discouraged about my future.

    1 I feel more discouraged about my future than I used to be.

    2 I do not expect things to work out for me.

    3 I feel my future is hopeless and will only get worse.

69. Past Failure.

    0 I do not feel like a failure.

    1 I have failed more than I should have.

    2 As I look back, I see a lot of failures.

    3 I feel I am a total failure as a person.

70. Loss of Pleasure.

    0 I get as much pleasure as I ever did from the things I enjoy.

    1 I don't enjoy things as much as I used to.

    2 I get very little pleasure from the things I used to enjoy.

    3 I can't get any pleasure from the things I used to enjoy.

71. Guilty Feelings.

    0 I don't feel particularly guilty.

    1 I feel guilty over many things I have done or should have done.

    2 I feel quite guilty most of the time

    3 I feel guilty all of the time

72. Punishment feelings.

    0 I don't feel I am being punished.

    1 I feel I may be punished.

    2 I expect to be punished.

    3 I feel I am being punished.

73. Self-Dislike.

    0 I feel the same about myself as ever.

    1 I have lost confidence in myself.

    2 I am disappointed in myself.

    3 I dislike myself.

74. Self-Criticalness.

    0 I don't criticize or blame myself more than usual.

    1 I am more critical of myself than I used to be.

    2 I criticize myself for all of my faults.

    3 I blame myself for everything bad that happens.

75. Suicidal Thoughts or Wishes.

    0 I don't have any thoughts of killing myself.

    1 I have thoughts of killing myself, but would not carry them out.

2 I would like to kill myself.

3 I would kill myself if I had the chance.

76. Crying.

0 I don't cry any more than I used to.

1 I cry more than I used to.

2 I cry over every little thing.

77. Agitation

0 I am no more restless or wound up than usual.

1 I feel more restless or wound up than usual.

2 I am so restless or agitated that it's hard to stay still.

3 I am so restless or agitated that I have to keep moving or doing something.

78. Loss of Interest.

0 I have not lost interest in other people or activities.

1 I am less interested in other people or things than before.

2 I have lost most of my interest in other people or things.

3 It's hard to get interested in anything.

79. Indecisiveness.

0 I make decisions about as well as ever.

1 I find it more difficult to make decisions than usual.

2 I have much greater difficulty in making decisions than I used to.

3 I have trouble making any decisions.

80. Worthlessness.

0 I do not feel I am worthless.

1 I don't consider myself as worthwhile and useful as I used to.

2 I feel more worthless as compared to other people

3 I feel utterly worthless

81. Loss of Energy.

0 I have as much energy as ever.

1 I have less energy than I used to have.

2 I don't have enough energy to do very much.

3 I don't have enough energy to do anything.

82. Changes in Sleeping Pattern

0 I have not experienced any change in my sleeping pattern.

1a I sleep somewhat more than usual.

1b I sleep somewhat less than usual.

2a I sleep a lot more than usual.

2b I sleep a lot less than usual.

3a I sleep most of the day.

3b I wake up 1-2 hours early and can't get back to sleep.

83. Irritability

0 I am no more irritable than usual.

1 I am more irritable than usual.

2 I am much more irritable than usual.

3 I am irritable all the time.

84. Changes in Appetite

0 I have not experienced any change in my appetite.

1a My appetite is somewhat less than usual.

1b My appetite is somewhat greater than usual.

2a My appetite is much less than before.

2b My appetite is much greater than usual.

3a I have no appetite at all.

3b I crave food all the time.

85. Concentration Difficulty.

0 I can concentrate as well as ever.

1 I can't concentrate as well as usual.

2 It's hard to keep my mind on anything for very long.

3 I find I can't concentrate on anything.

86. Tiredness or Fatigue.

    0 I am no more tired or fatigued than usual.

    1 I get more tired or fatigued more easily than usual.

    2 I am too tired or fatigued to do a lot of the things I used to do.

    3 I am too tired or fatigued to do most of the things I used to do.

87. **Loss of Interest in Sex.**

    0 I have not noticed any recent change in my interest in sex.

    1 I am less interested in sex than I used to be.

    2 I am much less interested in sex now.

    3 I have lost interest in sex completely.

Appendix D

Most Recent Recall Form

Age _____

Gender _____   **MOST RECENT DREAM**

Date Today _____

We would like you to write down the last dream you remember having, whether it was last night, last month, or last year. But first please tell us the date this dream occurred: _____.
Then tell us what time of day you think you recalled it: _____. Then tell us where you were when you recalled it: _____.

Please describe the dream exactly and as fully as you remember it. Your report should contain, whenever possible: a description of the setting of the dream, whether it was familiar to you or not; a description of the people, their age, sex, and relationship to you; and any animals that appeared in the dream. If possible, describe your feelings during the dream and whether it was pleasant or unpleasant. Be sure to tell exactly what happened during the dream to you and the other characters. Continue your report on the other side and on additional sheets if necessary.

Appendix E

Information Sheet

PARTICIPATION IN UNIVERSITY OF CAPE TOWN RESEARCH STUDY

INFORMATION SHEET

Name of Participant: _____

Name of principal researcher: Mariza van Wyk

Department/research group address: Psychology Department, Faculty of Humanities,
University of Cape Town

Contact number: 0835658190 (Mariza van Wyk)

Email: mariza.v.w@gmail.com

Dear Participant

You are invited to take part in a research study conducted by the Psychology Department at the University of Cape Town. This study is interested in looking at the relationship between dreaming, memory and emotion regulation. Please note that you participation is completely voluntary and that you may withdraw from the study at any time without any negative consequences for yourself. Any information collected will only be used for research purposes.

What's involved?

Sleep study

For the sleep study, you will be asked to come to the UCT Sleep Sciences laboratory on two non-consecutive nights (this will be scheduled at your convenience). In preparation for this, you will be asked to not sleep at all during the day on the days that you will be coming to the sleep lab. You will also be asked to not drink any caffeine containing drinks (e.g. coffee) or alcohol on the days that you come to the sleep lab. Furthermore, we would like for you to avoid sugary foods and excessive exercise on the day. For the first night we will ask you to come to the sleep lab approximately an hour before your usual bedtime, and approximately 2 hours before your usual bedtime on the second night. Please eat at home before arriving as supper will not be provided for you. At the sleep lab, you will be given your own private room to sleep in. There

are bathroom facilities in the sleep laboratory and you will be given an opportunity to change into your sleeping clothes (please bring these with you). A researcher will then hook you up to a polysomnograph machine. This is a machine that records various aspects of sleep. It consists of a box (which will be placed on your bedside table) that has leads attached to it. Some of these leads are attached to an electrode that will be attached to you with a medically approved paste. The leads will be placed on your scalp, and on certain places on your face in order to measure brain and muscle activity, as well as eye movements. The electrodes will be removed the following morning by dissolving the paste in water for easy removal. The remaining leads will be attached to medically approved sticker electrodes. The sticker electrodes will be placed on certain places on your face and also on your chest area. These electrodes will measure muscle activity, eye movements and your heart rate. Once the leads have been attached, you will be asked to lie down in the bed. The technician will turn the machine on and test whether everything is working correctly. We will then turn off the lights and ask you to sleep as you would normally at home. You will be left alone in your own room, but the researcher will be just outside the room monitoring your brainwaves on a computer. While we will be able to hear you if you call out something, you will also be given access to an intercom if you need anything during the night. If you need to go to the bathroom during the night, we will simply unplug the machine and then plug in back in when you return.

Memory Testing

On the second night that you come to the sleep laboratory, we will ask you to complete three memory tasks. Two of the tasks are done verbally, and the third is a computer based task called an emotional memory task. In this task you will be shown a series of positive, neutral and negative images. Please note that some people might find some of the negative images offensive. If you think this might be a problem for you, please inform the researcher, you are under no obligation to participate in the study. Completing these tasks will take approximately 30 minutes. You will complete similar tasks the following morning.

What information will we be using?

All the information that we collect from you during the two screening phases, during memory testing, as well as the data from the sleep testing nights will only be used for research purposes. It will be used as part of the principal researcher's PhD thesis and will also be used in

future research publications. Complete confidentially will be maintained at all times, i.e. your information will be used, but your name will not appear on anything and all identifying information will be left out. Personal information will be kept completely private and stored on password-protected computers and locked filing cabinets.

Are there any risks?

There are no major risks associated with this study. However, through the years in very rare instances people have had a reversible skin reaction to some of the equipment. Please let us know in advance if you have sensitive skin or any medical condition that you think could be affected by the study procedure. The researcher will be there for every step of the study, and should you feel uncomfortable at any time you may ask the researcher any questions and you may withdraw from the study at any time without any negative consequences for yourself.

Are there any benefits?

There are no direct benefits for participating in this study as this study is for research purposes only. However, if any sleep disorder is detected in the sleep laboratory, this information will be given to your doctor.

Is there any payment?

As you will be giving up a lot of your time, you will be paid for the nights that you spend in the sleep laboratory. For each night in the sleep laboratory, you will receive R150. Thus, if you complete the full two nights in the sleep laboratory, you will be paid R300 upon completion of the second night.

Appendix F

PARTICIPATION IN UNIVERSITY OF CAPE TOWN RESEARCH STUDY

CONSENT FORM

Name of principal researcher: Mariza van Wyk

Department/research group address: Psychology Department, Faculty of

Humanities, University of Cape Town

Contact number: 0835658190 (Mariza van Wyk)

Email: mariza.v.w@gmail.com

I, _____, confirm that I have read and agree to all the

information in the information sheet provided for me and that I agree to take part in this

study. I hereby also confirm that I have supplied the researcher with all relevant medical

information, or any information that would be important for the purposes of this study.

I hereby give permission for the researcher to use the information collected in the

screening phases and the sleep study for research purposes. I acknowledge that all this

information will used for research purposes, will be kept for future research purposes, may be

used in future research publications, and will only be used if my name and all identifying

information is omitted.

I agree to a monetary compensation of R150 for every night that I spend in the sleep

laboratory that will be paid to me upon completion of the second night.

I am aware that my participation is completely voluntary and that I may withdraw

from this study at any stage without any negative consequences for myself.

Name of Participant: _____

Signature of Participant: _____

Date: _____

Name of Researcher: _____

Signature of Researcher: _____

Date: _____

Appendix G

Ethical Approval Documents

DEPARTMENT OF PSYCHOLOGY

REPORT OF THESIS COMMITTEE
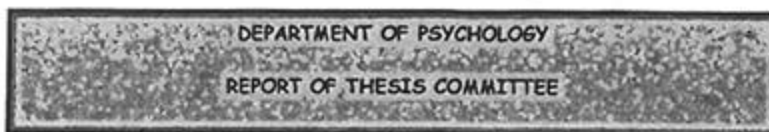
Student Name: Mariza van Wyk

Student #:

Degree: PhD

Title (as proposed) The role of dreaming in memory processes and emotion regulation during sleep

Supervisor: Prof Mark Solms

Co-supervisor:

Committee members: DR F. BOONZAIER

DR L SCHRIEFF

DR S. MALCOLM-SMITH

DR P. NJOMBORO

WE:

1. Approve the proposal, and recommend that the student continue with the research.

2. Approve the proposal, and recommend that the student may continue with the research. However, we recommend that change(s), as noted below, be incorporated in the research, to the satisfaction of the supervisor.

3. Approve the proposal in terms of its ethical implications. If necessary, explanatory notes appear below.

4. Find the proposal unsatisfactory, for the reason(s) listed below. The student is hereby requested to re-present the proposal to a departmental thesis committee by _____.

NOTES:

- Rethink framing of the study re: questions
- Make hypotheses more explicit
- State explicitly that a lack of proficiency in English would be an exclusion criterion
- Consent forms to be translated into home language of participants (state this in your proposal).

UNIVERSITY OF CAPE TOWN

FACULTY OF HUMANITIES

DC: HUM /

PROPOSAL APPROVAL FORM

DOCTORATE (A research proposal must accompany this form)	RESEARCH MASTERS (A research proposal must accompany this form)	C/W MASTERS

SECTION A: (To be completed by candidate)
Please complete this form and return it to the Faculty Office once you have obtained the signatures of the supervisor(s) and Head of Department.

Surname	van Wyk				First Name(s)	Mariza
Title	Mr.	Ms.	Mrs.	Miss	Student No	VWYMAR015
Address	6 Hillside road, Tamboerskloof, Cape Town					

Telephone(Home)			Work/Cell	083 5656 190

Note: Your UCT Email address is the default email address for all official communication – make sure that you access it regularly.

Department	Psychology

Title of Dissertation:
The Role of Dreaming in Memory Processes and Emotion Regulation during Sleep

Qualifications held			
Degree/Diploma	Major(s) &) Subjects	Month/Year awarded	University
BA Humanities Psychology Honours MA in Psychological Research	Psychology, Afrikaan Neuropsychology Neuropsychology	2009, December 2010, December 2013, June	Stellenbosch University UCT UCT

Signature of candidate: _____ Date: 24/04/14

SECTION B:

	Name	Signature	Date
Supervisor	Prof M. Solms		25/4/2014
Co-supervisor (if applicable)			
HOD	Prof. M. Solms		25/4/2014
Deputy-Dean: Research			
Ethics approval obtained where applicable	on behalf of Departmental Ethics Committee		24/4/2014

UNIVERSITY OF CAPE TOWN

Department of Psychology

University of Cape Town Rondebosch 7701 South Africa
Telephone (021) 650 3417
Fax No. (021) 650 4104

02 July 2020

Angela Bonheim and Cari Klipp
Department of Psychology
University of Cape Town
Rondebosch 7701

Dear Angela and Cari

I am pleased to inform you that ethical clearance has been given by an Ethics Review Committee of the Faculty of Humanities for your study, *The role of dreaming in emotional memory consolidation.* The reference number is PSY2020-026.

I wish you all the best for your study.

Yours sincerely

Catherine Ward
Professor
Chair: Ethics Review Committee

Appendix H

Hypothesis 3 descriptive statistics and correlations

Table 1

Descriptive Statistics and Correlations for Negative Dream Emotionality and Positive, Negative, Neutral and Emotional Recall Accuracy (n=32)

Variable	*M*	*SD*	1	2	3	4
1. Negative emotionality	0.00	0.87				
2. Positive recall accuracy	2.71	0.97	-.16			
			[-.48, .20]			
3. Negative recall accuracy	2.94	0.92	-.31*	.78**		
			[-.60, .04]	[.59, .89]		
4. Neutral recall accuracy	2.85	0.94	-.38*	.74**	.74**	
			[-.64, -.03]	[.52, .86]	[.53, .87]	

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence

interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2013). * indicates $p < .05$. ** indicates $p < .01$.

Table 2

Descriptive Statistics and Correlations for Negative Dream Emotionality and Positive, Negative, Neutral and Emotional Recall Accuracy in NREM dreamers (n=23).

Variable	*M*	*SD*	1	2	3	4
1. Negative dream emotionality	0.16	0.84				
2. Positive recall accuracy	2.77	0.87	-.20			
			[-.57, .23]			
3. Negative recall accuracy	3.00	0.92	-.30	.81**		
			[-.64, .13]	[.59, .92]		
4. Neutral recall accuracy	2.80	0.98	-.45*	.77**	.74**	
			[-.73, -.05]	[.53, .90]	[.47, .88]	

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2013). * indicates *p* < .05. ** indicates *p* < .01.

Table 3

Descriptive Statistics and Correlations for Positive Dream Emotionality and Positive, Negative, Neutral and Emotional Recall Accuracy in REM dreamers (N= 9)

Variable	*M*	*SD*	1	2	3	4
1. Positive dream emotionality	0.51	1.06				
2. Positive recall accuracy	2.54	1.22	.47			
			[-.29, .86]			
3. Negative recall accuracy	2.80	0.97	.66*	.74*		
			[-.01, .92]	[.14, .94]		
4. Neutral recall accuracy	2.97	0.85	.32	.78*	.82**	
			[-.44, .81]	[.24, .95]	[.33, .96]	

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). * indicates *p* < .05. ** indicates *p* < .01.

Table 4

Descriptive Statistics and Correlations for Negative Dream Emotionality and Positive, Negative, Neutral and Emotional Recall Accuracy in REM dreamers (N= 9)

Variable	*M*	*SD*	1	2	3	4

Variable	M	SD	1	2	3	4
1. Negative emotionality	-0.41	0.87				
2. Positive recall accuracy	2.54	1.22	-.21 [-.77, .53]			
3. Negative recall accuracy	2.80	0.97	-.51 [-.88, .24]	.74* [.14, .94]		
4. Neutral recall accuracy	2.97	0.85	-.12 [-.73, .59]	.78* [.24, .95]	.82** [.33, .96]	

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2013). * indicates $p < .05$. ** indicates $p < .01$.

Table 5

Descriptive Statistics and Correlations for Positive Dream Emotionality and Positive, Negative, Neutral and Emotional Recall Accuracy in HFR dreamers (n=16).

Variable	M	SD	1	2	3	4
1.Positive emotionality	-0.14	0.59				
2. Positive recall accuracy	2.89	1.01	.33			

| | | | [-.19, .71] | | | |
| | | | | | | |

Variable	M	SD	1	2	3	4
3. Negative recall accuracy	3.04	0.80	.18	.77**		
			[-.35, .62]	[.45, .92]		
4. Neutral recall accuracy	3.15	0.81	.47*	.67**	.68**	
			[-.03, .78]	[.27, .88]	[.28, .88]	

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2013). * indicates $p < .05$. ** indicates $p < .01$.

Table 6

Descriptive Statistics and Correlations for Negative Dream Emotionality and Positive, Negative, Neutral and Emotional Recall Accuracy in LFR dreamers (n=16).

Variable	M	SD	1	2	3	4
1. Negative dream emotionality	0.06	0.83				
2. Positive recall accuracy	2.52	0.91	-.36			
			[-.73, .17]			

3. Negative recall accuracy	2.85	1.05	-.49*	.80**		
			[-.80, .00]	[.51, .93]		
4. Neutral recall accuracy	2.55	0.98	-.42	.79**	.80**	
			[-.76, .10]	[.49, .92]	[.50, .93]	

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2013). * indicates $p < .05$. ** indicates $p < .01$.

Table 7

Descriptive Statistics and Correlations for Positive Dream Emotionality and Positive, Negative, Neutral and Emotional Recall Accuracy (n=32)

Variable	*M*	*SD*	1	2	3	4
1. Positive dream emotionality	0.00	0.81				
2. Positive recall accuracy	2.71	0.97	.07			
			[-.28, .41]			
3. Negative recall accuracy	2.94	0.92	.18	.78**		

			[-.18, .49]	[.59, .89]	
4. Neutral recall accuracy	2.85	0.94	.19	.74**	.74**
			[-.17, .50]	[.52, .86]	[.53, .87]

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2013). * indicates $p < .05$. ** indicates $p < .01$.

Table 8

Descriptive Statistics and Correlations for Positive Dream Emotionality and Positive, Negative, Neutral and Emotional Recall Accuracy in REM dreamers (N= 9)

Variable	*M*	*SD*	1	2	3	4
1. Positive dream emotionality	0.51	1.06				
2. Positive recall accuracy	2.54	1.22	.47			
			[-.29, .86]			
3. Negative recall accuracy	2.80	0.97	.66*	.74*		
			[-.01, .92]	[.14, .94]		
4. Neutral recall accuracy	2.97	0.85	.32	.78*	.82**	
			[-.44, .81]	[.24, .95]	[.33, .96]	

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence

interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). * indicates $p < .05$. ** indicates $p < .01$.

Table 9

Descriptive Statistics and Correlations for Negative Dream Emotionality and Positive, Negative, Neutral and Emotional Recall Accuracy in REM dreamers (N= 9)

Variable	M	SD	1	2	3	4
1. Negative emotionality	-0.41	0.87				
2. Positive recall accuracy	2.54	1.22	-.21			
			[-.77, .53]			
3. Negative recall accuracy	2.80	0.97	-.51	.74*		
			[-.88, .24]	[.14, .94]		
4. Neutral recall accuracy	2.97	0.85	-.12	.78*	.82**	
			[-.73, .59]	[.24, .95]	[.33, .96]	

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2013). * indicates $p < .05$. ** indicates $p < .01$.

Table 10

Descriptive Statistics and Correlations for Positive Dream Emotionality and Positive, Negative, Neutral and Emotional Recall Accuracy in HFR dreamers (n=16).

Variable	M	SD	1	2	3	4
1. Positive emotionality	-0.14	0.59				
2. Positive recall accuracy	2.89	1.01	.33			
			[-.19, .71]			
3. Negative recall accuracy	3.04	0.80	.18	.77**		
			[-.35, .62]	[.45, .92]		
4. Neutral recall accuracy	3.15	0.81	.47*	.67**	.68**	
			[-.03, .78]	[.27, .88]	[.28, .88]	

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2013). * indicates $p < .05$. ** indicates $p < .01$.

Table 11

Descriptive Statistics and Correlations for Negative Dream Emotionality and Positive, Negative, Neutral and Emotional Recall Accuracy in LFR dreamers (n=16).

Variable	M	SD	1	2	3	4

Variable						
1. Negative dream emotionality	0.06	0.83				
2. Positive recall accuracy	2.52	0.91	-.36			
			[-.73, .17]			
3. Negative recall accuracy	2.85	1.05	-.49*	.80**		
			[-.80, .00]	[.51, .93]		
4. Neutral recall accuracy	2.55	0.98	-.42	.79**	.80**	
			[-.76, .10]	[.49, .92]	[.50, .93]	

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2013). * indicates $p < .05$. ** indicates $p < .01$.

Table 12

Descriptive Statistics and Correlations for Positive Dream Emotionality and Positive, Negative, Neutral and Emotional Recall Accuracy in NREM dreamers (n=23)

Variable	*M*	*SD*	1	2	3	4
1. Positive dream emotionality	-0.20	0.61				

Variable	M	SD	1	2	3	4
2. Positive recall accuracy	2.77	0.87	-.17			
			[-.54, .27]			
3. Negative recall accuracy	3.00	0.92	-.03	.81**		
			[-.44, .39]	[.59, .92]		
4. Neutral recall accuracy	2.80	0.98	.10	.77**	.74**	
			[-.32, .49]	[.53, .90]	[.47, .88]	

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2013). * indicates *p* < .05. ** indicates *p* < .01.

Table 13

Descriptive Statistics and Correlations for Negative Dream Emotionality and Positive, Negative, Neutral and Emotional Recall Accuracy in HFR dreamers (n=16)

Variable	M	SD	1	2	3	4
1. Negative emotionality	-0.06	0.94				

Variable	M	SD	1	2	3	4
2. Positive recall accuracy	2.89	1.01	.02			
			[-.48, .51]			
3. Negative recall accuracy	3.04	0.80	-.10	.77**		
			[-.57, .41]	[.45, .92]		
4. Neutral recall accuracy	3.15	0.81	-.33	.67**	.68**	
			[-.71, .20]	[.27, .88]	[.28, .88]	

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2013). * indicates *p* < .05. ** indicates *p* < .01.

Table 14

Descriptive Statistics and Correlations for Positive Dream Emotionality and Positive, Negative, Neutral and Emotional Recall Accuracy in LFR dreamers (n=16).

Variable	M	SD	1	2	3	4
1. Positive dream emotionality	0.14	0.98				

	M	SD	1	2	3
2. Positive recall accuracy	2.52	0.91	-.03		
			[-.52, .47]		
3. Negative recall accuracy	2.85	1.05	.21	.80**	
			[-.32, .64]	[.51, .93]	
4. Neutral recall accuracy	2.55	0.98	.16	.79**	.80**
			[-.36, .61]	[.49, .92]	[.50, .93]

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2013). * indicates $p < .05$. ** indicates $p < .01$.