

The Role of Napping in the Consolidation of Clinically-Relevant Information in Non-Depressed
and Depressed Participants

By

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Abstract

The hypothesis that sleep may have beneficial effects on memory consolidation has been widely reported for many years (Jenkins & Dallenbach, 1924; Van Ormer, 1933; Fowler, Sullivan, & Ekstrand, 1973). Since then, these findings regarding improved memory retention have also been extended to shorter napping periods (Tucker et al., 2006). Given the memory impairments commonly displayed in individuals with depression (Bearden et al., 2006), this study aimed to explore the impacts of napping on memory consolidation in depressed individuals. Specifically, this study attempted to mimic the educational aspect of cognitive remediation therapy to explore whether napping can be beneficial to memory retention of clinically-relevant information in depressed individuals. To simulate the didactic portion of cognitive remediation, we developed a clinically-relevant memory test using a psychoeducational video that introduces the effects of depression on cognition. Subsequently, we determined whether a napping period can benefit the consolidation of this clinically-relevant material in depressed and non-depressed individuals. We found no differences in memory performance over time between individuals who napped and individuals who stayed awake. However, we did observe associations between several sleep parameters and the degree of memory decay. The findings of this study contribute to the understanding of the relationship between napping and memory consolidation in individuals with depression and may provide a more ecologically valid style of memory testing for future studies.

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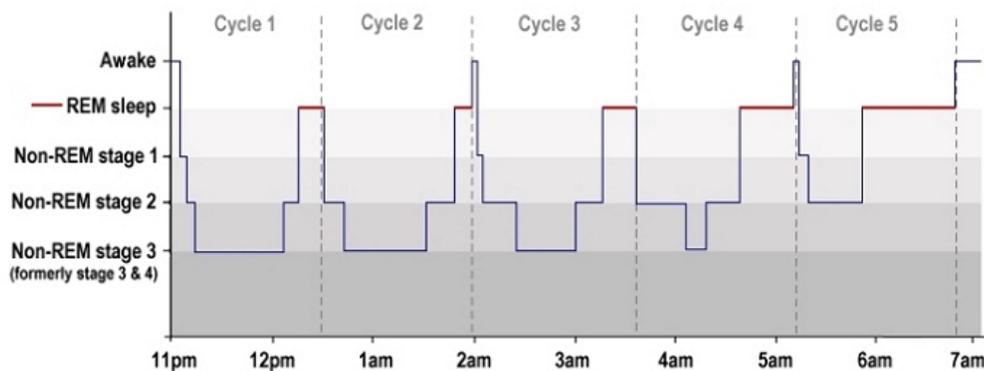
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Chapter 1 Introduction: The Role of Napping in the Consolidation of Clinically-Relevant Information in Non-Depressed and Depressed Participants

Forgetting is a function of time. This was the suggestion that seemingly kindled the idea that sleep could be beneficial to information retention (Ebbinghaus, 1885; Van Ormer, 1933). Since these early suggestions, the link between sleep and memory has been firmly established and a myriad of findings supporting the sleep-memory hypothesis have been published in the past several decades (Fowler, Sullivan, & Ekstrand, 1973; Karni et al., 1994; Stickgold, 2005; Rasch & Born, 2013).

Sleep Stages

Historically, sleep was viewed as a periodic temporary suspension of wakefulness, which is the state we commonly associate with life. Because wakefulness generally takes up a larger portion of the 24-hour day-night cycle and is the period in which we perform overt activities, it was considered to be more important than sleep. However, research has shown that sleep serves numerous biological, psychological, and behavioural functions (Walker, 2008). Sleep is divided into two distinct modes, non-rapid eye movement (NREM) sleep and rapid eye movement (REM) sleep. Within NREM sleep, there are further divisions into stage 1, stage 2, and slow wave sleep (SWS). One complete sleep cycle, which includes both NREM and REM sleep, typically lasts about 90 minutes (Figure 1).



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Figure 1. A typical night of sleep with breakdown of sleep stages and cycles. Reprinted from *Sleep*, by Luke Mastin, 2019, Retrieved from http://www.lukemastin.com/sleep/types_cycles.html. Copyright (2019) by Luke Mastin. Reprinted with permission.

States of wakefulness and different stages of NREM and REM sleep can be distinguished by differences in the pattern of electroencephalographic (EEG) activity (Loomis, Harvey, & Hobart, 1935). Relaxed wakefulness with the eyes closed is commonly characterized by rhythmic alpha activity (8 to 13 Hz) (Carskadon & Rechtschaffen, 2011). Stage 1 sleep is characterized by lower voltage activity, the cessation of alpha activity, and the presence of theta waves (3 to 7 Hz) (Carskadon & Rechtschaffen, 2011). Stage 2 sleep is distinguished from stage 1 sleep through two unique EEG characteristics, the sleep spindle and the K-complex. Sleep spindles occur in the range of 12 to 14 Hz for about 0.5 to 1.5 seconds (Carskadon & Rechtschaffen, 2011). Typically, sleep spindles occur at a frequency of about three to eight spindles per minute (Carskadon & Rechtschaffen, 2011). The K-complex is characterized by a negative sharp wave immediately followed by a positive component and usually occurs over a duration of 0.5 seconds or more (Carskadon & Rechtschaffen, 2011). SWS is characterized by high-voltage delta waves of 2 Hz or slower with amplitudes greater than 75 μ V. In order for sleep to be characterized as SWS, delta waves should take up at least 30% of a 30 second epoch (Carskadon & Rechtschaffen, 2011).

Sleep & Memory

As research on the relationship between sleep and memory has matured, an increasing number of studies have indicated the functional significance of sleep for the consolidation and retention of information. In general, research has assessed the potential effects of sleep on memory by comparing memory retention after overnight sleep and an equivalent period of wakefulness. The large majority of these studies have found superior memory recall after time

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intervals containing sleep, thus providing strong support for the sleep-memory hypothesis (Maquet, 2001; Gais & Born, 2004; Walker & Stickgold, 2006). For example, performance on a visual discrimination task was found to be significantly better after a period of practice followed by a full night of sleep, compared to an equal period of practice along with wakefulness or shorter periods of early or late sleep (Gais, Plihal, Wagner, & Born, 2000). A functional magnetic resonance imaging (fMRI) study using a pursuit task, in which participants were trained to manipulate a cursor using a joystick to maintain the cursor position as close as possible to a moving target, found that participants who were sleep deprived immediately after learning performed worse at testing compared to participants who underwent a full night of sleep after learning. This suggested that a lack of sleep may inhibit the consolidation of recent memory traces and lead to poorer performance compared to sleeping after learning. The fMRI data, collected in participants who slept during the first post-training night, also indicated increased functional connectivity between the superior temporal sulcus and dentate nucleus, both of which are areas that have been implicated in the processing of biological motion and the initiation and control of voluntary movements, respectively (Maquet, Schwartz, Passingham, & Frith, 2003).

In another example, Fischer, Hallschmid, Elsner, & Born (2002) found that performance improvements in a finger motor task were significantly greater after periods of sleep compared to wakefulness. Participants who had a night of sleep following task learning showed improved performance, measured by the time taken to complete the task, and lower error rates, as compared to participants who had an equal period of wakefulness after learning (Fischer et al., 2002). Using an image recognition task, researchers also found that participants assigned to a sleep deprivation condition after learning perform significantly worse at testing compared to participants assigned to a sleep condition, even when participants in the sleep deprivation group

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were given two nights of recovery sleep (Yoo, Hu, Gujar, Jolesz, & Walker, 2007). Taken together, these and numerous other studies (Karni, Tanne, Rubenstein, Askenasy, & Sagi, 1994; Stickgold, James, & Hobson, 2000; Stickgold, Whidbee, Schirmer, Patel, & Hobson, 2006) provide strong support for the role of sleep in memory retention and consolidation. However, it should also be noted that differences in performance between experimental sleep and wake conditions may also be due to additional factors, such as circadian influences or differences in levels of acute arousal, attention, and fatigue, all of which could exert significant effects on performance at the time of recall testing (Vertes, 2004).

Sleep Characteristics & Memory

Although much research has shown that sleep plays an important role in memory consolidation, the non-uniform distribution of different sleep stages over time makes it difficult to pinpoint exactly which stages of sleep and the associated features, as well as the interaction between sleep stages or with non-sleep factors, contribute to the memory facilitation effect. Potentially due to the complexity of sleep, as well as the multiple types of interacting memory systems, experimental findings in the field of sleep and memory research have not always been consistent. Correlational analyses have suggested a link between sleep spindle activity, an EEG characteristic of stage 2 sleep in which the thalamic reticular nucleus (TRN) and other thalamocortical networks generate bursts of oscillatory activity at a frequency of approximately 10-12 Hz, and better performance in declarative memory tasks (Clemens, Fabó, & Halász, 2005). It was demonstrated that participants who exhibited higher levels of stage 2 spindle activity during post-learning overnight sleep showed enhanced memory performance at testing on the following morning (Schabus et al., 2004). This observation suggested that successful storage of new information, as reflected in increased recall performance, was associated with an increase in

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spindle activity. In addition to the hypothesis that sleep spindles in stage 2 sleep may promote memory consolidation, SWS has also been suggested to act as an important contributor to memory consolidation during sleep (Gais & Born, 2004). It has been shown that the slow potential oscillations within SWS can enhance the consolidation of declarative memory (Marshall, Helgadottir, Mölle, & Born, 2006) by generating spindles and ripples that are thought to underlie hippocampal memory reactivation (Möller, Yeshenko, Marshall, Sara, & Born, 2006). The importance of SWS for memory consolidation has also been supported by neurophysiological evidence. Hippocampal sharp waves have been observed in EEG recordings of rats during SWS (Buzsaki, Leung, & Vanderwolf, 1983) and retention of a task was suggested to be enhanced if training was followed by sleep, due to the abundance of these sharp waves during SWS (Buzsaki, 1989). Also, high levels of the neuromodulator acetylcholine are present in the hippocampus and neocortex during wakefulness (Hasselmo, 1999). This cholinergic activity leads to a partial suppression of excitatory feedback, which then inhibits consolidation of previously stored information. However, decreased levels of acetylcholine during SWS may release this suppression and allow increased activity within the hippocampus itself and the entorhinal cortex-hippocampal system, which is particularly important for the consolidation of memory traces (Hasselmo, 1999). Although the details and underlying mechanisms remain unclear, these findings highlight the generally beneficial effects of sleep on memory consolidation.

NREM Sleep & Memory

The evidence for a role of sleep in memory consolidation is particularly abundant with regard to the involvement of NREM sleep in the processing of declarative memories. Tamminen, Payne, Stickgold, Wamsley, & Gaskell (2010) conducted a study in which participants learned a

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list of novel (nonsense) words and then were tested for the integration of those words into their existing body of lexical knowledge. The idea of this lexical competition effect is that when a newly learned word is added to the mental lexicon, it should compete with similar familiar words during recognition tasks and increase the response time required to recognize the already familiar word. The delay in recognition of the familiar word due to competition from the novel word acts as a marker of the integration of the novel word into the recognition system. They found that the magnitude of this lexical competition effect was positively predicted by the number of sleep spindles (Tamminen et al., 2010). In a study comparing the effects of different phases of sleep on memory, Plihal and Born (1997) found superior recall of paired-associates lists following early nocturnal sleep, a period of the night in which SWS is dominant, compared to late nocturnal sleep, in which REM sleep is more abundant. This suggests that sleep stages that are prevalent earlier in the night may have more direct effect on memory, providing further support of the importance of NREM sleep for memory consolidation. In addition, there is evidence for the positive effects of NREM sleep on memory that extend beyond declarative memory. A positron emission tomography (PET) study examining spatial memory found that the hippocampal areas that were activated during learning were also activated during subsequent slow wave sleep (Peigneux et al., 2004). In addition, Peigneux and colleagues (2004) found that the amount of hippocampal activity that was expressed during SWS was positively correlated with improvements in retrieval performance the following day. Their findings suggest that the learning-dependent hippocampal activity that occurs during NREM sleep may be indicative of the processing of recent memory traces, which is associated with subsequent performance improvements.

Napping & Memory

Given the general robustness of the effect of nocturnal sleep on memory, it has been speculated that sleep-related memory enhancements may also be induced by shorter episodes of napping, which consist mostly of NREM sleep and relatively low amounts of REM sleep compared to overnight sleep (Lahl, Wispel, Willigens & Pietrowsky, 2008). In a study that isolated the effects of NREM sleep by allowing participants to obtain only NREM sleep during a 60-minute nap, Tucker et al. (2006) observed that participants in the napping condition showed greater improvement on a paired associates declarative memory task than participants who stayed awake for the same duration. Further supporting the possible beneficial effects of napping on memory, Lahl et al. (2008) found that even a nap as short as six minutes was sufficient to significantly improve declarative memory performance when compared to waking controls. These findings lend further support to the evidence regarding the effects of sleep on memory consolidation and also bear important implications regarding the generalizability of the sleep-memory hypothesis by suggesting that the beneficial effects of sleep on memory may also generalize to shorter napping episodes.

Sleep, Depression, & Memory

Cognitive impairments, such as memory and attentional deficits, have been widely reported in patients with depression (Bearden et al., 2006; Golinkoff & Sweeney, 1989; Watts, Dalgleish, Bourke & Healy, 1990). Impaired cognition has been estimated to occur in approximately two-thirds of patients with depression (Abas, Sahakian & Levy, 1990; Afridi, Hina, Qureshi & Hussain, 2011). Past research has also shown that patients with depression are prone to cognitive deficits (Marazziti, Consoli, Picchetti, Carlini, & Faravelli, 2010), as they appear to use weak or incomplete encoding strategies to organize and manipulate information

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(Weingartner, Cohen, Murphy, Martello, & Gerdt, 1981). A meta-analysis by Burt, Zembar, and Niederehe (1995) revealed that there was, indeed, a stable, significant association between depressive symptoms and memory impairments. It is noteworthy that, in the past, the cognitive deficits associated with depression were often viewed as an epiphenomenon of the disorder (Austin, Mitchell, & Goodwin, 2001). However, Neu et al. (2005) reported persistence in cognitive deficits in depressed patients after treatment, even after being remitted for six months, suggesting that impaired cognition may not be a secondary effect of depression (Reppermund, Ising, Lucae, & Zihl, 2008). In addition, cognitive decline observed in depression has been associated with permanent structural changes in the brain (Bhalla et al., 2006), further suggesting that cognitive deficits are not a simple epiphenomenon of depression. More recently, it has been recognized that the remediation of cognitive impairment could play an important role in improving outcomes for patients with depression, and that cognitive impairments may represent a core feature of depression and, therefore, should be considered as an important target for treatment (Rock, Roiser, Riedel, & Blackwell, 2014). Depressed individuals also tend to display increased and reduced attention towards negative and positive information, respectively. This selective bias of information processing is believed to play an important role in the maintenance and perpetuation of depressive episodes (Baert, De Raedt, Schacht, & Koster, 2010). Consequently, it has been suggested that modification of these attentional biases could help manage depressive symptoms and reduce the risk of relapse (Browning, Holmes, Charles, Cowen, & Harmer, 2012). As a result, a range of treatments have been, and are being developed to improve the cognitive outcomes for patients with depression.

One of the increasingly common treatments for depression is cognitive remediation therapy. Cognitive remediation refers to a range of treatments used to enhance neurocognitive

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abilities in clinical populations, with a focus on the six major domains of cognitive functions as classified by the Diagnostic and Statistical Manual of Mental Disorders (5th edition): complex attention, executive function, learning and memory, language, perceptual-motor, and social cognition (American Psychiatric Association, 2013). These approaches are typically based on some combination of training, strategy monitoring, and generalization. Using these principles, patients undergo repetitive practice on cognitive training exercises, develop problem-solving and compensatory strategies, and attend group discussions to reduce the effects of persistent cognitive impairments (McGurk, Twamley, Sitzer, McHugo, & Mueser, 2007). A study showed that, after 10 weeks of cognitive remediation therapy, patients with depression exhibited improved performance on a range of tests measuring attention, verbal learning, and memory (Elgamal, McKinnon, Ramakrishnan, Joffe, & MacQueen, 2007). A recent review of cognitive remediation therapy concluded that, when cognitive remediation was delivered as a psychotherapy in which a therapist guided patients' development of novel problem-solving strategies, patients demonstrated improved performance on neuropsychological tests (Bowie et al., 2013). The study of cognitive remediation therapy on cognition in depressed individuals remains a relatively new field, but these results suggest that repetitive targeted practice of cognitive exercises may offer a feasible strategy to improve cognitive functioning in patients with depression.

Sleep, depression, and cognitive functioning have also all been found to be closely linked with each other (Jagannath, Peirson, & Foster, 2013). Disruptions in sleep are common in depression (Murphy & Peterson, 2015) but improved stabilization and management of sleep has been suggested to reduce multiple symptoms of depression, including cognitive deficits (Wulff, Gatti, Wettstein, & Foster), suggesting that sleep can benefit both depression and memory.

Napping to Reduce Cognitive Impairments in Depression

Given the benefits of sleep and napping on memory, there has been growing interest in whether these positive effects can also be applied to individuals with depression who display memory impairments. In a study exploring the effects of daytime naps on both declarative and procedural memory in patients with mental illness, it was found that both patients with depression and non-depressed participants showed improvements in performance in both memory domains after napping compared to the wake condition (Seeck-Hirschner et al., 2010). Thus, this study suggested that the positive effects of napping on memory consolidation may also apply to patients with depression. However, at present, it is unknown whether napping can impact memory consolidation of clinically-relevant and psychoeducational information in depressed individuals. It is also noteworthy that SWS and REM sleep may have different effects on the consolidation of emotional and neutral memories in participants who display depressive symptoms. Individuals reporting higher levels of depressive symptoms have been found to consolidate more neutral memories during SWS and marginally more negative memories during REM sleep (Harrington, Johnson, Croom, Pennington, & Durrant, 2018). Due to the shorter duration of typical naps compared to overnight sleep, there is less time to enter REM sleep, which suggests that the consolidation of negative emotional memories during a nap may be reduced relative to longer sleep intervals.

Objectives & Hypotheses

The primary purpose of the present study was to examine whether napping can improve memory consolidation of clinically relevant information in non-depressed and depressed individuals. The initial objective was to develop a more ecologically valid measure to assess memory consolidation of clinically-relevant psychoeducational information. Psychoeducational

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interventions emphasize the development of skills to cope with depression and have been found to be effective in reducing depressive symptoms (Cuijpers, Munoz, Clarke, & Lewinsohn, 2009; Donker, Griffiths, Cuijpers, & Christensen, 2009). The majority of declarative tasks currently used to assess memory consolidation rely on neutral and nonsense (e.g., random word pair associations) information. This new measure was an attempt to examine the effects of napping on memory for clinical/depression-related material. A short video was created to introduce how depression can affect cognitive functioning. After the video presentation, participants were assessed on their retention of the material through a test of thematic gist, free recall of presented material, and paired-associate learning of some of the cognitive deficits displayed in depression and the corresponding strategies to deal with these deficits. It was hypothesized that non-depressed individuals would display significantly better memory retention after a short nap compared to an equal time interval of wakefulness.

Subsequently, this psychoeducational video was presented to individuals with depression to determine whether the hypothesized beneficial effects of napping also apply to memory retention of clinically relevant material in depressed individuals. This study did not intend to replace any form of therapy, but rather aimed to mimic the targeted educational aspect of cognitive rehabilitation in order to determine whether napping can be used to supplement and enhance the effectiveness of cognitive remediation therapy. Given that cognitive impairments are experienced by many individuals with depression, it is important to gain a better understanding of the role of sleep in memory retention and consolidation in depressed individuals, as well as determine whether the benefits of napping on memory can be applied to enhance depressed patients' learning and memory of psychoeducational information. It was hypothesized that,

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similar to non-depressed individuals, a period of napping will lead to better memory retention in individuals with depression when compared to an equal amount of time spent in wakefulness.

Research has also shown that the severity of depressive symptoms may be associated with cognitive abilities. Mohn and Rund (2016) found significant correlations between depressive symptom severity and performance on neurocognitive tests, suggesting that individuals with more severe depressive symptoms may have poorer cognitive functioning. However, this association has not always been consistent, with Rund et al. (2006) finding no significant relationship between clinical symptom load and neurocognitive performance. We were also interested in assessing whether a possible relationship between cognitive performance and severity of depression was present in the current study using our newly developed memory tests.

The association between time spent in each sleep stage and declarative memory performance has also been inconsistent, with support for stage 2 sleep (Clemens et al., 2005; Schabus et al., 2004) and SWS (Gais & Born, 2004; Marshall et al., 2006) being reported. Therefore, we also explored the association between the duration of sleep stages during the 60-minute nap and performance in the new memory tests used in this study.

Chapter 2: Methods

Participants

62 participants, between the ages of 18 and 27, were recruited for the current study. Participants were recruited through the Queen's University psychology subject pool and Facebook advertisements in the "Queen's Paid Research" group, as well as from the community to take part in the study. All participants received or were receiving a post-secondary education. Participants were required to either have a previous diagnosis of depression or to have no history of psychological disorders. Several participants were referred to our study from a clinical lab at Queen's University and therefore had their diagnoses confirmed but otherwise, participant membership to the "depression" group was determined via self-reports of diagnosis of depression and/or BDI scores ≥ 21 . Participants in the "depression" group were not required to be in a depressive episode at the time of the experiment as we did not attempt to establish their current status. Participants were also required to be regular nappers, defined as, on average, napping at least once a week for the past two months. The napping criterion was used to ensure that, if assigned to the napping condition, participants would be able to fall asleep during the experiment. Other important exclusion criteria included that participants could not take any type of medication that could affect their sleep (such as sleep aids) or suffer from a diagnosed sleep disorder.

Materials

Demographics A brief interview was conducted during the first appointment of the experiment to gather basic demographic information from each participant. Questions included participants' age, gender, current and/or history of psychological diagnoses, medications that may interfere with sleep, as well as napping and overnight sleeping habits. (Appendix A)

Wide Range Achievement Test 4 (WRAT-4): Word Reading Subtest (Wilkinson & Robertson, 2006). The WRAT-4 measures basic academic skills such as reading, spelling, and math. The word reading subtest was used to screen for general cognitive functioning to ensure that there were no significant differences at baseline between participants in each condition. Participants were required to read a list of words out loud and were scored on their pronunciation of each word, based on the guidelines provided by the WRAT.

Hopkins Verbal Learning Test-Revised (HVLTR) (Shapiro, Benedict, Schretlen, & Brandt, 1999). The HVLTR assesses verbal learning and memory. Participants were read a list of 12 nouns, with four words drawn from three different categories, and asked to repeat as many nouns as possible over three trials. Form #1 was used in this study.

Beck Depression Inventory-II (BDI) (Beck, Steer, & Brown, 1996). The BDI is a 21-item self-report inventory that measures the severity of depression. Each item on the BDI has answers with values ranging from 0 to 3. A total score from 0 – 13 indicates minimal depression, 14 – 19, indicates mild depression, 20 – 28 indicates moderate depression, and 29 – 63 indicates severe depression. The BDI was administered during the first appointment of the study. If the period between the first and second appointment of the study was greater than 14 days, the BDI was administered again during the second appointment. For the purposes of the current study, the “Non-depressed comparison” group consisted of participants with no history of depression and had a BDI score of 13 or less. The “Depression” group consisted of participants who either had a previous diagnosis of depression and/or had a BDI score of 21 or higher.

Epworth Sleepiness Scale (ESS) (Johns, 1991). The ESS was used to measure participants’ level of sleepiness before initiation of the experimental condition (video or nap). It includes eight questions regarding a participant’s likelihood to fall asleep if they were placed in a

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variety of situations, answered on a 0 to 3 point scale (0 = would never dose; 1 = slight chance of dosing; 2 = moderate chance of dosing; 3 = high chance of dozing). The instructions to complete the ESS were modified to ask participants to report on their *current* state of sleepiness, rather than the more general, trait-like state of alertness that is typically assessed with the ESS.

Psychoeducational video and free recall memory test A new memory test was developed in order to assess participants' memory of clinically-relevant information. A video consisting of two parts, didactic information and personal experience, was presented to each participant. The didactic portion was an introduction to common cognitive difficulties that may be experienced during depression, presented by a registered clinical psychologist with a specialization in cognition in mental illnesses. The psychologist spoke directly into the camera in order to mimic a real-life one-on-one therapy session. The personal experience portion consisted of an actress speaking about her experiences with depression, how it had affected her life, and the steps she had taken to combat the disorder. The personal experience portion was designed to mimic the Story Learning task from the Neuropsychological Assessment Battery (Appendix C). The free-recall memory test format was used to best simulate the experiences of daily life. After the presentation of the video, participants were asked to repeat the personal experience portion of the video exactly as it was told, using the same words. Following the hour-long experimental condition, participants were asked to repeat the personal experience portion of the video again, without seeing the video. Participants' responses, both before and after their experimental condition, were voice recorded and independently scored by two separate researchers out of a total of 42 possible points. A scoring rubric was developed for the free recall memory test (Appendix C). Consistent with the Story Learning Task from the Neuropsychological

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Assessment Battery, points were given for accurately repeating the personal experience portion, as well as recalling the gist of the story.

Paired associates task A new paired-associates task was developed to enhance the clinical relevance of the tested material (Appendix C). Each word pair (10 word pairs in total) consisted of one cognitive deficit common in depression and one strategy to help with the deficit. Each word pair was presented on a separate PowerPoint slide and a voiceover simultaneously read the word pairs aloud. After being presented with all ten word pairs, participants were shown the deficit half of the pairs and asked to recall the corresponding coping strategy. Participants had 10 seconds to recall each item before the PowerPoint automatically moved to the next word pair. The paired associates task was administered after the free recall memory test. Responses were also voice recorded and independently scored by two separate researchers out of a total of 10 points. Points were only given if participants' response matched the correct answer.

Video Distraction *Planet Earth* is a British nature documentary television series produced by the BBC in 2006. The video was selected as the stimulus for participants assigned to the waking condition. The purpose of this video was to provide a relatively emotionally neutral stimulus that would prevent participants from falling asleep and from actively rehearsing the information from the memory tests.

Polysomnographic equipment Participants' cortical activity was recorded during the 60-minute experimental condition. Four EEG electrodes were placed on the scalp according to the International 10-20 system (Fp1 referenced against O1, C4 referenced against O2) (Fig. 1). Further, a ground electrode was placed on the left and right sides of the head on the mastoid process. Two EOG electrodes were placed near the eyes to monitor eye movement, one electrode lateral and above one eye and another electrode lateral and below the other eye. The ground

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electrode for the EOG channel was placed on the nasal bone. One EMG electrode was placed on the masseter to monitor movement in the jaw and chin. The electrodes used were Genuine Grass Gold Disc Electrodes (Natus Neurology, Ireland). All signals were amplified (Grass P511 amplifiers, half-amplitude filters set at 0.3 Hz and 10 kHz), digitized (200Hz; PowerLab /30 system running LabChart software, v. 8. 1. 11, ADInstruments, Toronto, Ont.), and stored for subsequent offline analysis (using Labchart software).

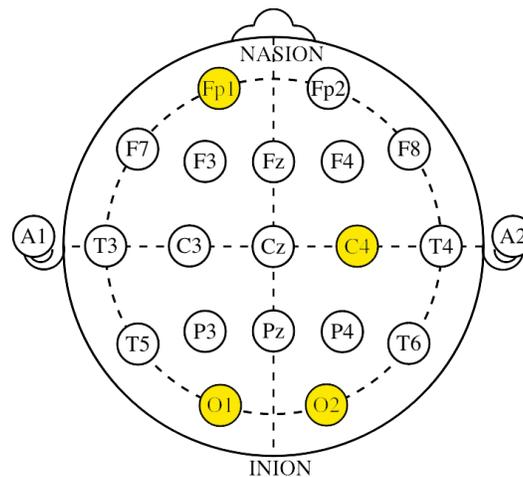


Figure 2. EEG electrode placements. Locations used in the present study are represented in yellow on the 10-20 system. (“10-20 system (EEG)”, n.d.)

Scoring of Polysomnographic Recordings

All polysomnographic recordings were scored according to the American Academy of Sleep Medicine criteria. Polysomnographic recordings for participants assigned to the wake (control) condition were checked to ensure the participant did not fall asleep during their condition. If a wake participant’s polysomnographic recording revealed that they did fall asleep, their data was excluded from the analyses. Polysomnographic recordings for participants assigned to the nap condition were checked to confirm sleep onset and quantify various sleep characteristics. Parameters included time in bed, sleep onset latency, number of awakenings,

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total sleep time, minutes spent in each sleep stage, and percent of total sleep time spent in each sleep stage (Berry, 2018).

Procedure

Appointment 1. Participants were given an introduction to the study and experimental procedures and asked for their written informed consent (Appendix A). The researcher then conducted a demographic interview to ensure the participant met the inclusion criteria to take part in the study. Participants then completed the WRAT-4 and form 1 of the HVLTR. Afterwards, participants were required to complete the BDI. Item 9 on the BDI was checked by the researcher to ensure that the participant was in a state safe to proceed with the experiment. The BDI item 9 addresses suicidal thoughts or wishes. In the case that the participant scored a 2 or higher on that item, indicating serious thoughts of suicide, the researcher contacted a registered clinical psychologist to immediately come and conduct a suicidal risk assessment. Following the BDI, the researcher applied a small amount of Nuprep gel and Ten20 conductive paste to the participant's forearm to check for allergic reactions. If the participant experienced any discomfort, alternate hypoallergenic gels and pastes were tested. Participants then received a tour of the sleep room so they would feel more comfortable with their surroundings if asked to nap during their second appointment. This was an attempt to minimize the "first night effect" (Agnew Jr., Webb, & Williams, 1966), which involves sleep alterations and/or disturbances when sleeping in a novel environment. Participants were also invited to bring their own pillow and blanket, as well as a comfortable change of clothes. After the end of the first appointment, each participant was randomly assigned to either the napping or waking condition using a random number generator in Microsoft Excel. The duration of the first appointment was

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approximately 30 minutes and participants from the Queen's University psychology subject pool were compensated with 0.5 course credits.

Appointment 2. The second appointment was scheduled around the participant's typical nap time, which they indicated in the demographics interview during their first appointment. The participant returned to the Neuroplasticity Lab and watched the psychoeducational and personal experience video, followed by the completion of the story memory test and the paired-associates task. All responses were recorded with an audio recorder for subsequent scoring purposes.

After completing the pre-condition tests, the participant was prepared for the EEG, EOG, and EMG setup. After the setup, the participant was asked to complete the Epworth Sleepiness Scale (ESS) and were also informed of their experimental condition (nap or wake). The participant was then led from the main lab area into the sleep room to undergo a calibration process for the polysomnogram. Calibration consisted of the participant being given specific instructions (e.g. open and close eyes, blink, and move eyes left and right) while the researcher monitored the responses on the EEG, EOG, and EMG channels to ensure the polysomnographic recording matched the expected responses. Finally, the participant was left alone in the sleep room to undergo their 60-minute experimental condition. Participants assigned to the waking condition watched an episode of *Planet Earth Season 1* and participants assigned to the napping condition were encouraged to fall asleep. The real-time polysomnographic recording was monitored by the researcher in an adjacent room during the 60-minutes. The participant was not allowed to access their phone or any materials or devices during their condition.

Upon completion of the 60-minute condition, the researcher knocked on the door of the sleep room to inform the participant that the condition was completed. The participant then returned to the main lab area to have the attached electrodes removed. Afterwards, the participant

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was given the same set of instructions as in the pre-condition test and asked to complete the story memory test once again, this time without seeing the video followed by completion of the paired associates task test. Again, all responses were audio recorded for subsequent scoring.

The participant was then given a debriefing on the purpose of the study and provided the opportunity to ask questions. Lastly, the participant was compensated for their time with either \$10 and an additional 1.5 bonus credits for participants recruited from the Queen's University Psychology Subject Pool, or \$30 for all other participants.

Chapter 3: Results

For the current study, the criteria for participants to be included in the “non-depressed comparison group” was to obtain a BDI score of ≤ 13 . For participants to be included in the “depression” group, it was required that they either had a formal diagnosis of depression or obtained a BDI score of ≥ 21 . Data were collected from 62 participants, but four participants with no previous diagnosis of depression had BDI scores between 14 and 21 and so were excluded from the analyses. Of the 34 participants in the “depression” group, 16 participants had a previous diagnosis of depression.

Data from 58 participants were analyzed (10 males). The average age of participants was 20.43 years ($SD = 2.21$). Overall, participants in the Depression group napped more often, napped for longer durations, and had poorer sleep quality compared to participants in the Non-depression group (Table 1). Participants’ performance, broken down into the different experimental groups and conditions, on the general cognitive assessments and the depressive symptom severity measure based on group and condition are shown in Table 2.

Table 1

Mean and standard deviation values of participant demographic information

Non-Depression					
	Age	Gender	Naps/Week	Typical Nap Length (minutes)	Sleep Quality
	20.63 (2.16)	17F/7M	2.46 (1.22)	70.33 (33.37)	2.21 (0.72)
Depression					
	20.29 (2.26)	32F/2M	3.68 (1.92)	100.85 (50.09)	2.85 (0.89)
Statistics	$p = .579$		$p = .008$	$p = .012$	$p = .005$

Note. Age is represented in years; Typical nap length is represented in minutes; Sleep quality was measured using a 5-choice format (A-E; Appendix A) where A = 1, B = 2... E = 5. Higher values represent poorer sleep quality.

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Table 2

Mean and standard deviation values of general cognitive assessments and the depressive symptom severity measure

Measure	Group		Condition	
	Non-Depression	Depression	Nap	Wake
WRAT (Total)	49.83 (3.34)	51.26 (2.48)	51.46 (2.85)	50.03 (2.88)
HVLT (Total)	28.42 (4.34)	29.53 (3.10)	28.73 (4.58)	29.34 (2.77)
BDI	7.92 (3.96)	23.35 (12.22)	18.08 (13.87)	16.06 (11.04)
BDI Range	1-13	0-56	2-56	0-39

Note. WRAT = Wide Range Achievement Test; HVLT = Hopkins Verbal Learning Test; BDI = Beck Depression Inventory. Maximum scores for the WRAT, HVLT, and BDI are 57, 36, and 63, respectively.

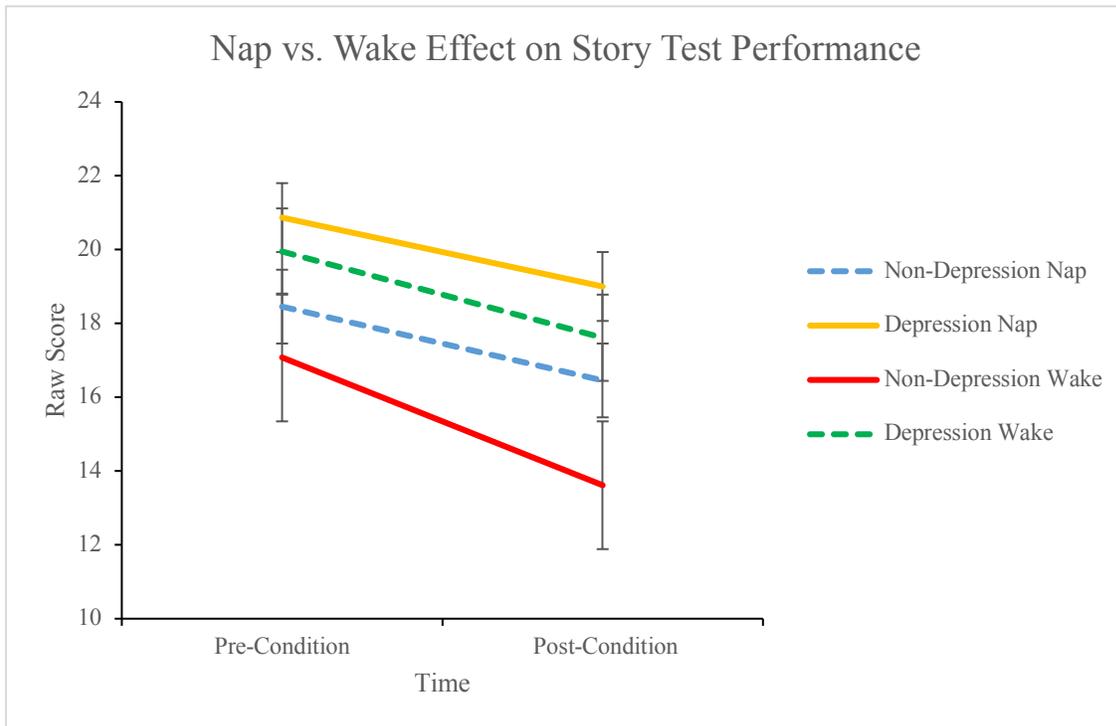
Scores on the WRAT and HVLT were similar between groups and conditions, which suggests that potential performance differences found between groups or conditions on the clinical memory tests were unlikely to be due to general differences in cognitive ability. On the WRAT, scored out of 67 possible points, participants in the Non-depression and Depression groups did not score significantly differently from each other, ($p = .066$). On the HVLT, scored out of 36 possible points, participants in the Non-depression and Depression groups again did not score significantly differently from each other ($p = .259$). Participants assigned to the Nap condition scored marginally higher than participants in the Wake condition on the WRAT, but this difference was not significant ($p = .064$). Participants assigned to the Nap and Wake conditions did not score significantly differently from each other, on the HVLT ($p = .532$). Due to our selection/exclusion criteria, the only measure in which scores were significantly different between groups was the BDI ($p < .001$), in which participants in the non-depression group had a mean score of 7.92, which corresponds to a minimal level of depression, and participants in the Depression group had a mean score of 23.35, which corresponds to a moderate level of depression (Beck, Steer, & Brown, 1996).

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Memory consolidation was measured using the newly developed story free-recall test and paired associates task. Participants' mean performance on the two memory tasks over time (Pre-condition test vs. Post-condition test) was calculated and is shown in Table 3 (Appendix C).

Story Free-Recall Test

A repeated measures analysis of variance (ANOVA) was conducted to compare participants' performance on the story free-recall test over time, across groups, and across



conditions At the pre-condition test, the average score of participants in the non-depression and depression groups was 17.71 and 20.35, respectively, out of 42 possible points. At the post-condition test, the average score of participants in the non-depression and depression groups was 14.92 and 18.26 points, respectively. No significant interaction was found between time, group, and condition, $F(1, 54) = 0.41, p = .527$ (Figure 3). There were also no significant interactions between time and group ($p = .430$), time and condition ($p = .272$), or group and condition ($p = .727$).

Figure 3. Average performance of participants on the story free-recall test according to condition (nap vs. wake) in each group (Non-depression vs. Depression) before and after the 60-minute condition (Time \times Group \times Condition interaction, $p = .527$). Error bars represent standard error of the mean.

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When collapsing across groups and experimental conditions, our results showed a significant decay in recall over time from the pre-condition test to the post-condition test, as indicated by the main effect of time, $F(1, 57) = 35.41, p < .001$ (Figure 4).

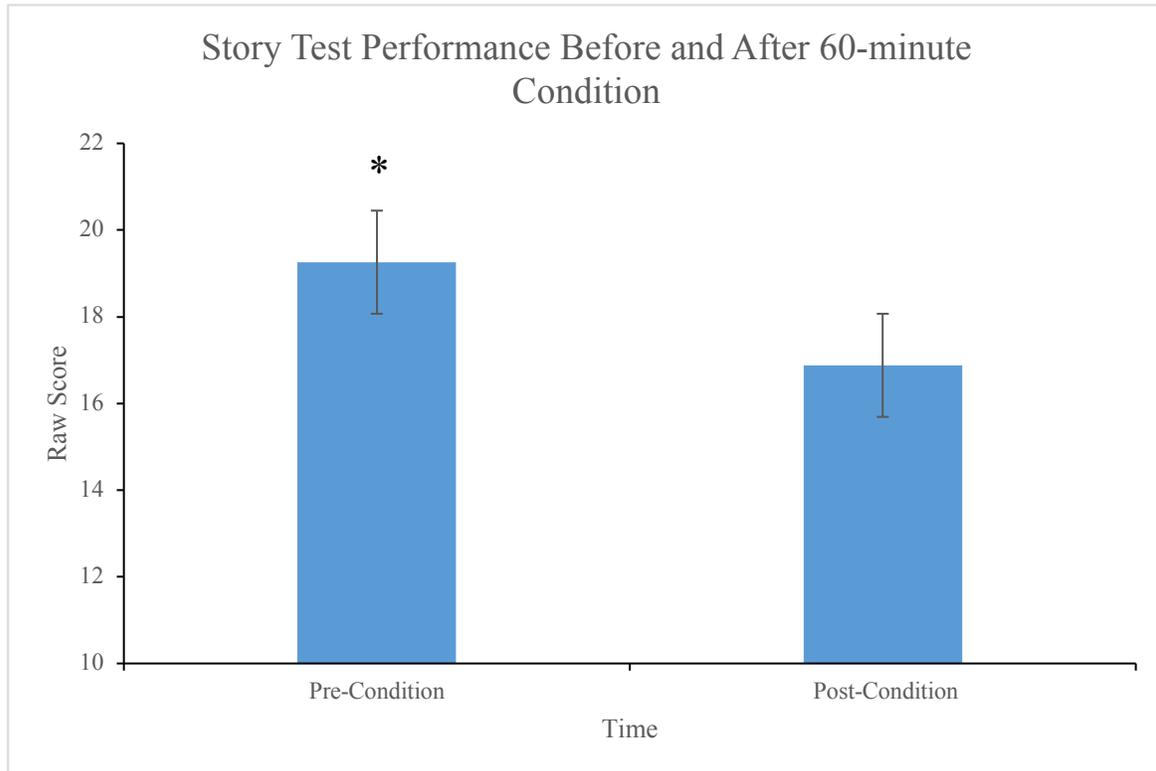


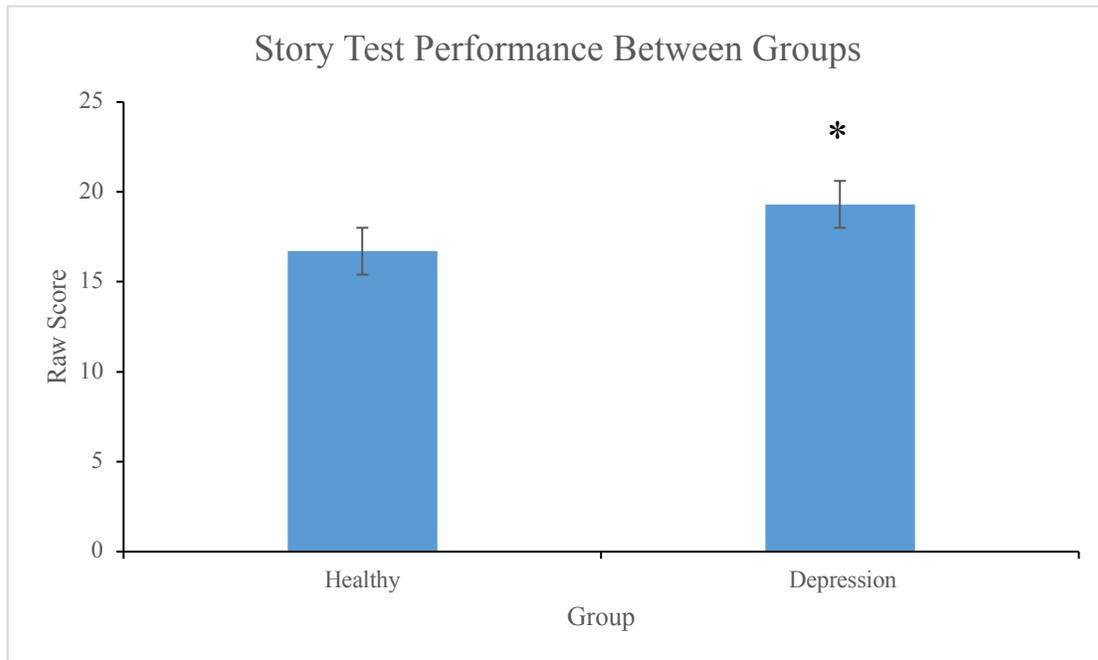
Figure 4. Average performance on the story free-recall test, across groups and conditions, before and after the 60-minute condition ($p < .001$). Error bars represent standard error of the mean.

Contrary to the widely reported protective effects of napping on memory, we observed no significant main effect of condition. Participants assigned to the nap condition did not exhibit significantly better retention of the material learned for the story memory test compared to participants assigned to an equal period of wakefulness, $F(1, 54) = 1.30, p = .259$.

Interestingly, we found a significant main effect of group. Despite the cognitive deficits commonly associated with depression, participants in the Depression group consistently performed significantly better on the story free-recall test compared to participants in the Non-depression group, $F(1, 54) = 4.43, p = .040$ (Figure 5A & 5B).

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A)



B)

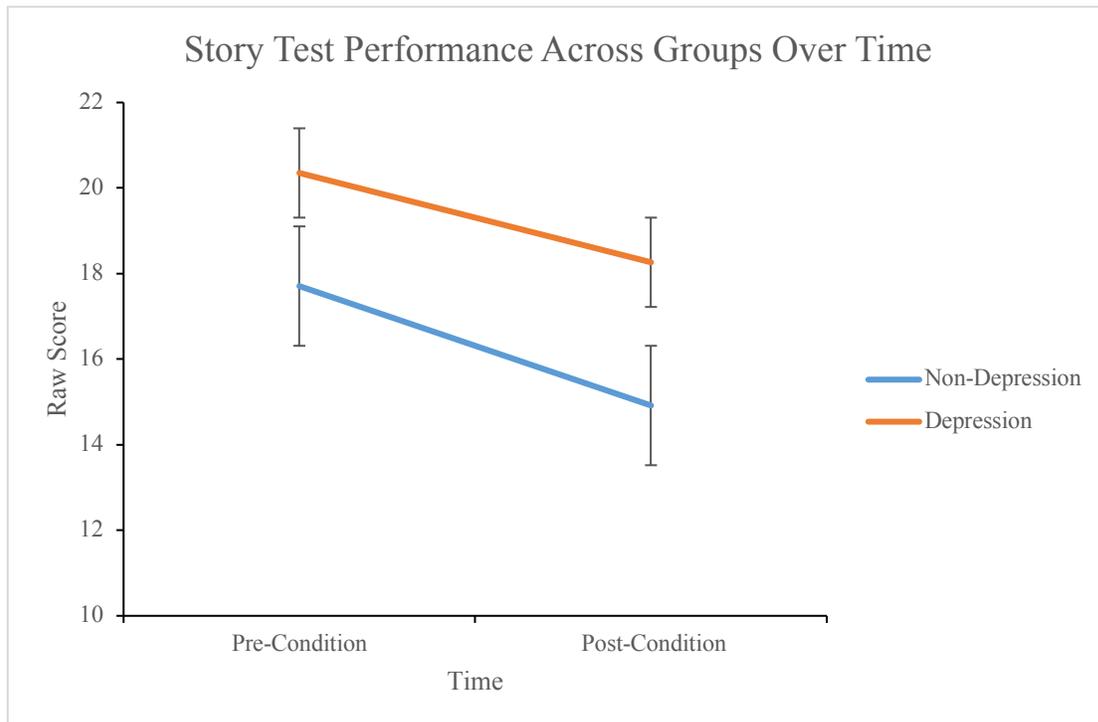


Figure 5. (A) Average performance on the story free-recall test between the Non-depression and Depression groups, regardless of time ($p = .04$). (B) Average performance on the story free-recall test for the Non-depression and Depression group before and after the 60-minute condition. Error bars represent standard error of the mean.

Paired Associates Task

A repeated measures ANOVA was conducted to compare participants’ performance on the paired associates task over time, across groups, and across conditions (Figure 6). At the pre-condition test, the average score of participants in the Non-depression and Depression groups was 6.08 and 6.44, respectively, out of 10 possible points. At the post-condition test, the average score of participants in the Non-depression and Depression groups was 5.67 and 6.06, respectively. No significant interaction was found between time, group, and condition, $F(1, 54) = .127, p = .723$. We also found no significant interaction effects between time and group ($p = .845$), time and condition ($p = .164$), or group and condition ($p = .590$).

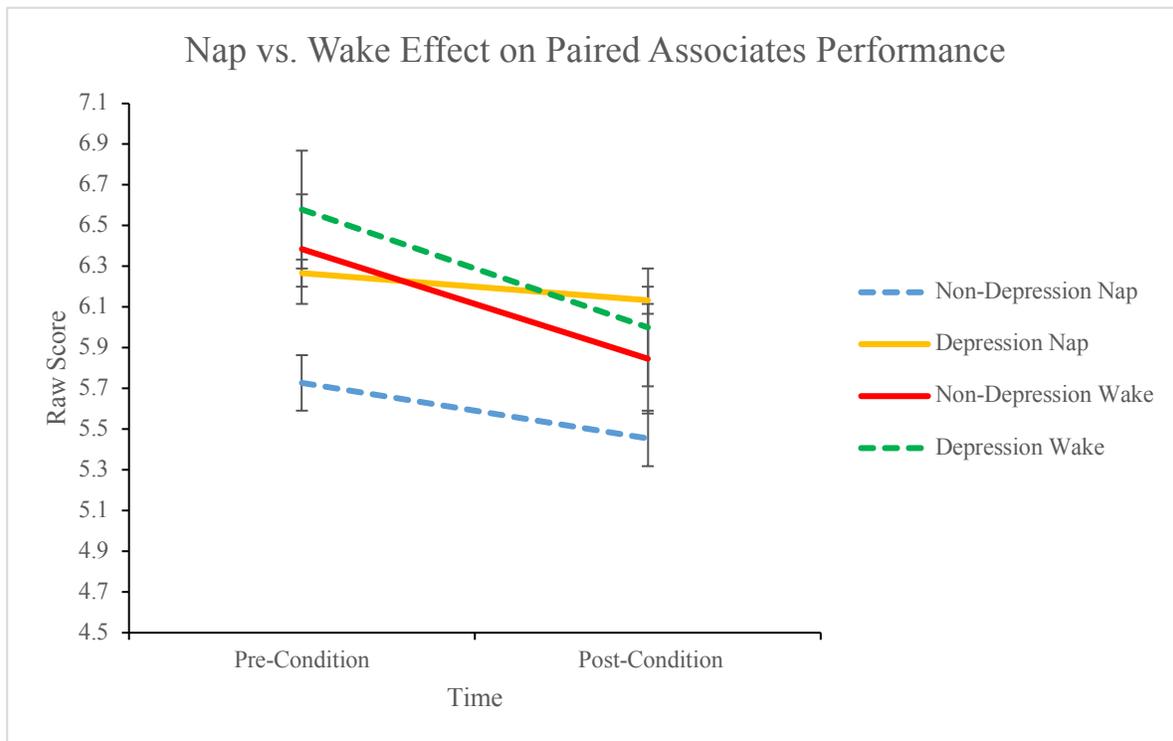


Figure 6. Average performance on the paired associates task according to condition (nap vs. wake) in each group (Non-depression vs. Depression) before and after the 60-minute condition (Time × Group × Condition interaction, $p = .723$). Error bars represent standard error of the mean.

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Consistent with the story free-recall test results, there was a significant main effect of time, as shown by the decay in performance over time, regardless of group or condition, $F(1, 54) = 9.14, p = .004$ (Figure 7). Contrary to the results from the story memory test, there was no main effect of group as there were no significant differences in recall between the Non-depression and Depression groups on the paired associates task ($p = .422$).

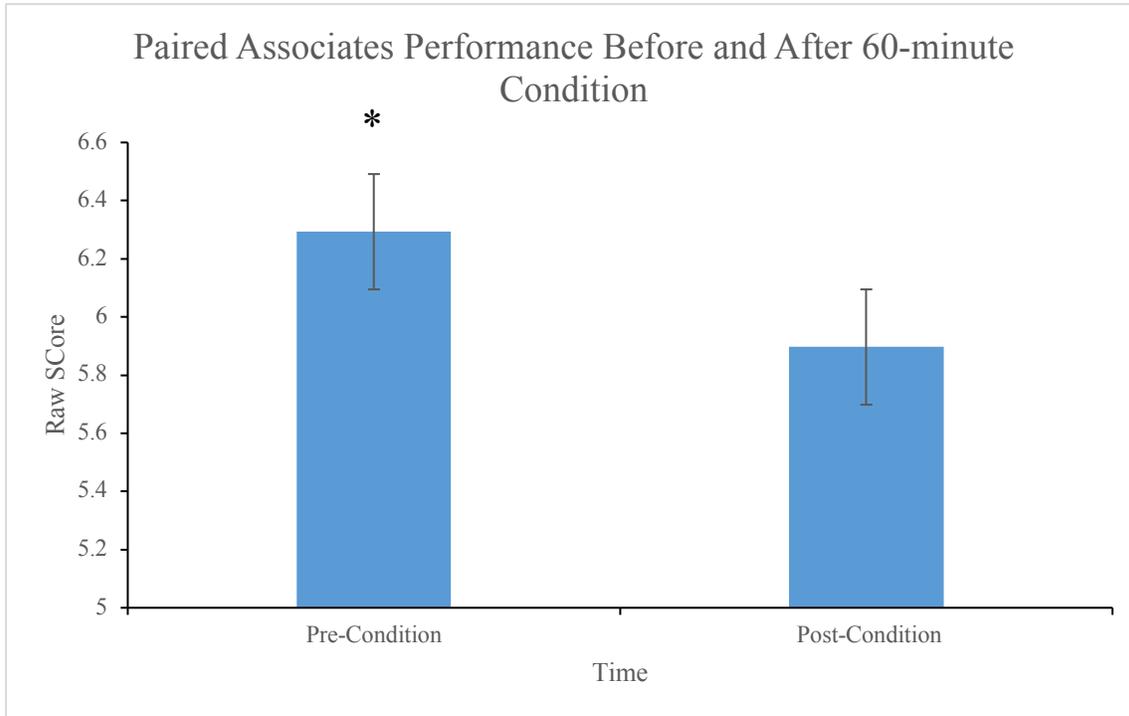


Figure 7. Average performance on the paired associates task, across groups and conditions, before and after the 60-minute condition ($p = .004$). Error bars represent standard error of the mean.

Nap

Sleep parameters of participants in the Nap condition were measured and results are displayed in Table 3.

Table 3

Mean values of sleep parameters for participants in the Nap condition

Parameter	Group	Mean (standard deviation)
Sleep Latency (min)	Non-depression	10.08 (4.49)

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	Depression	14.66 (5.40)
	All	12.72 (5.45)
Stage 1 (min)	Non-depression	8.18 (5.73)
	Depression	8.84 (5.07)
	All	8.56 (5.26)
Stage 2 (min)	Non-depression	19.90 (9.12)
	Depression	21.36 (11.35)
	All	20.74 (10.30)
SWS (min)	Non-depression	13.53 (11.65)
	Depression	12.86 (12.30)
	All	13.15 (11.80)
Stage 1 (%)	Non-depression	20.79 (15.96)
	Depression	21.51 (13.13)
	All	21.15 (14.55)
Stage 2 (%)	Non-depression	45.42 (17.35)
	Depression	49.74 (22.40)
	All	47.58 (19.88)
SWS (%)	Non-depression	28.83 (22.17)
	Depression	28.75 (26.36)
	All	28.79 (24.27)
Total Sleep Time (min)	Non-depression	43.86 (9.62)
	Depression	43.06 (7.94)
	All	43.46 (8.78)

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Number of Arousals	Non-depression	3.27 (3.38)
	Depression	3.60 (3.38)
	All	3.44 (3.38)

Note. Sleep latency and total sleep time are represented in minutes; Stages of sleep are represented in both minutes and as a percentage of total sleep time.

The average total time asleep of all napping participants was approximately 44 minutes. On average, participants took about 13 minutes to fall asleep and obtained about 21% stage 1 sleep, 48% stage 2 sleep, and 29% SWS. Of the 26 participants in the Nap condition, 19 entered SWS during the 60-minute sleep opportunity. Participants had an average of approximately 3.5 arousals throughout their naps.

Participants in the Depression group took significantly longer to fall asleep compared to participants in the Non-depression group, $t(24) = -2.29, p = .031$. Otherwise, there were no significant differences between groups on time spent in stage 1 sleep ($p = .757$), stage 2 sleep ($p = .730$), SWS ($p = .889$), or total sleep time ($p = .819$). There was also no difference between groups on the number of arousals during the nap ($p = .809$).

Correlational Analyses

Pearson correlations were performed to explore the relationships between participants' recall performance on the memory tests, sleep parameters, and baseline cognitive functioning. Difference scores between pre-condition test scores and post-condition test scores were calculated to represent the change in performance before and after the 60-minute condition (Pre – Post; higher positive values indicate greater memory decay whereas negative values indicate improved memory recall from the pre- to the post-condition test).

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We found a small negative correlation between total sleep time (TST) and difference scores on the story free-recall test, suggesting that with more sleep obtained in the 60-minute sleep opportunity, memory decay for the story material decreased; however, this effect was not significant, $r = -.205$, $p = .314$ (Figure 8). A similar negative, but nonsignificant relationship between TST and memory decay on the story free-recall test was observed in nappers in the Non-depression group, $r = -.184$, $p = .588$, and in nappers in the Depression group, $r = -.240$, $p = .389$ (Figure 9A & 9B).

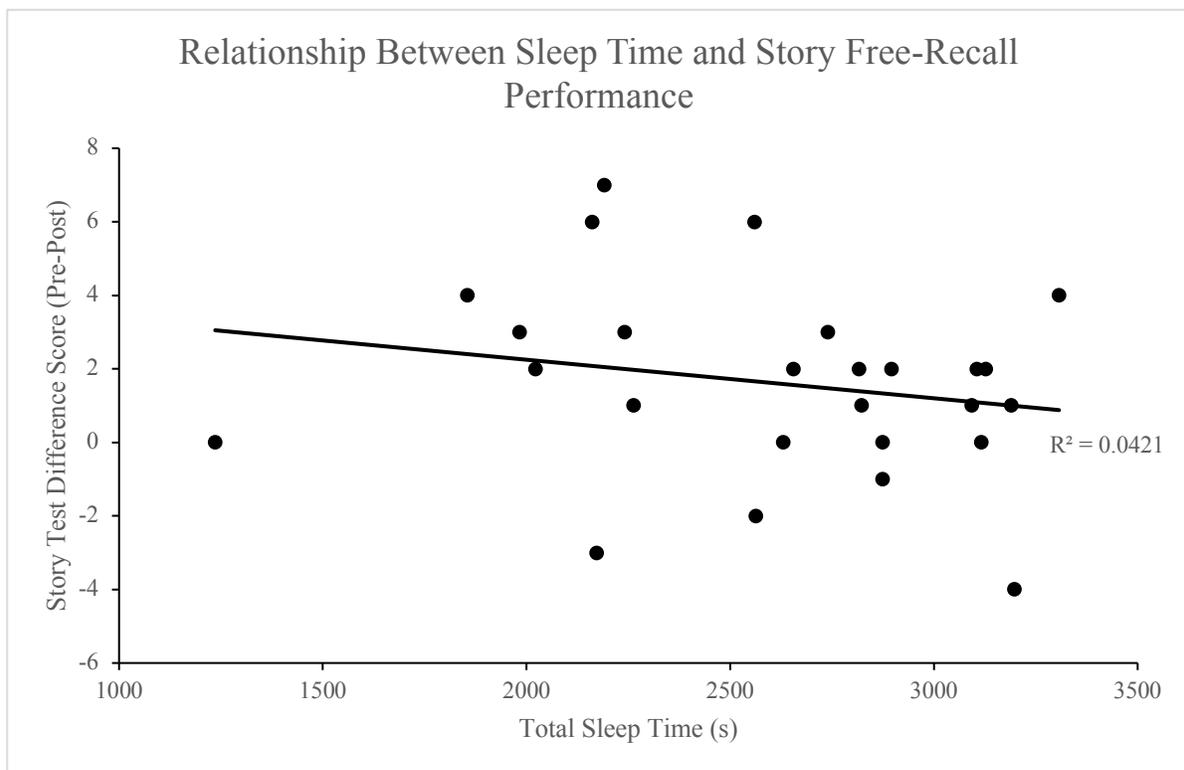
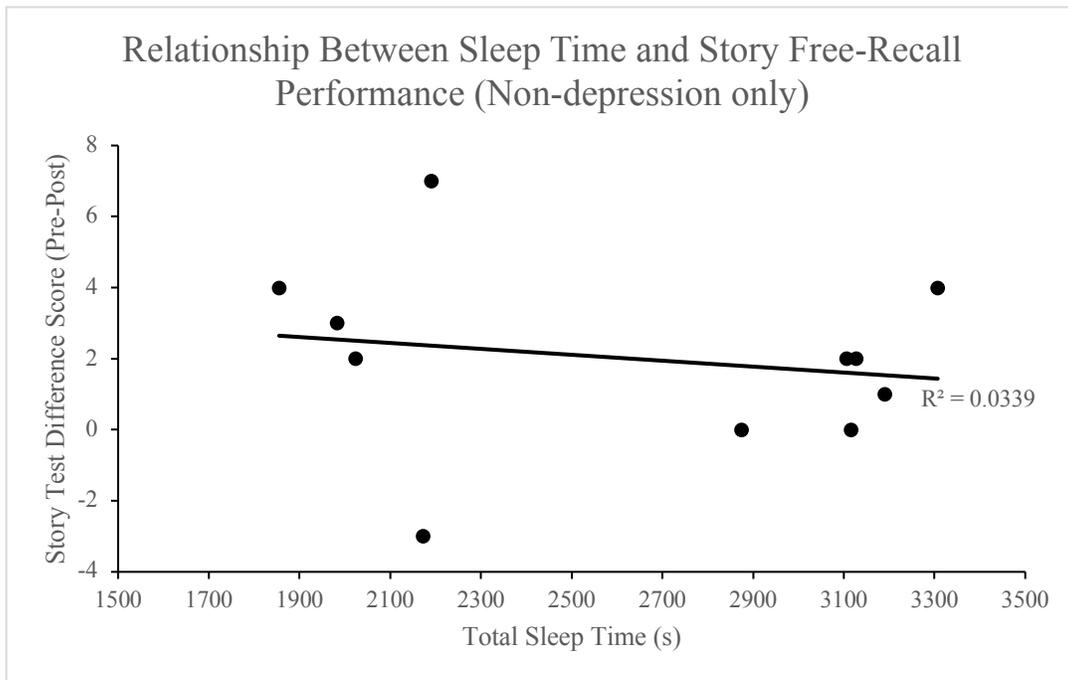


Figure 8. Pearson correlation between total sleep time (TST) and difference score on the story free-recall test ($r = -.205$).

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A)



B)

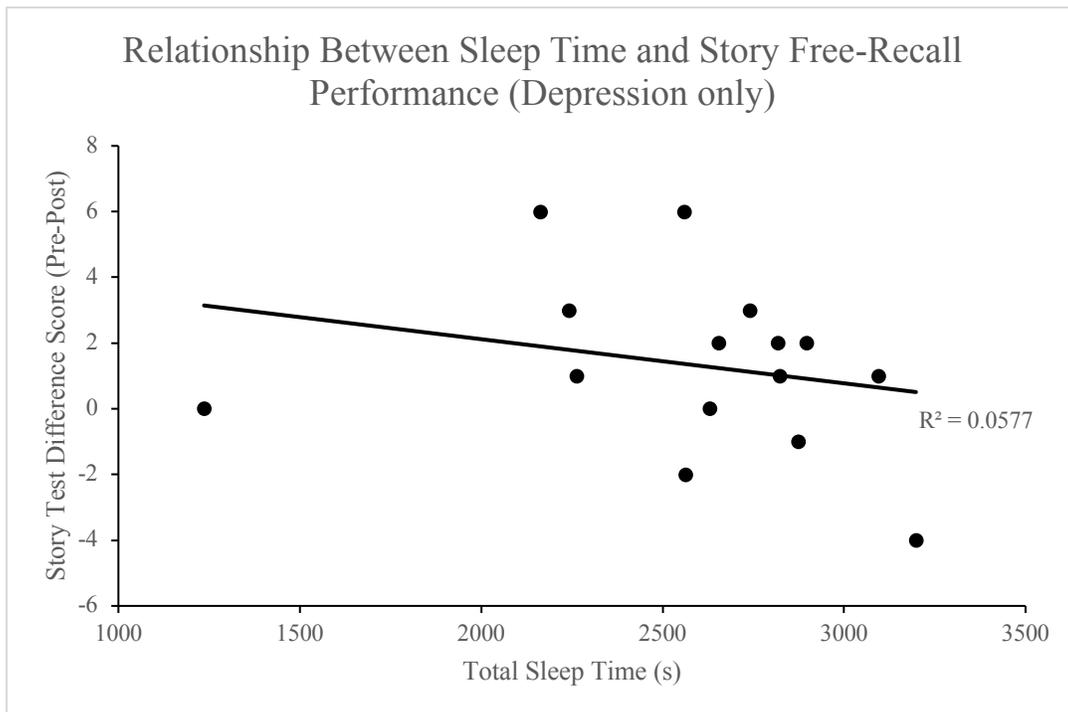


Figure 9. (A) Pearson correlation between total sleep time (TST) and difference score (pre-condition - post-condition) on the story free-recall test in participants in the Non-depression group only ($r = -.184$). (B) and the Depression group only ($r = -.240$)

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There was a significant negative correlation between TST and difference scores on the paired associates task, $r = -.451$, $p = .021$, indicating that, as the amount of sleep obtained within the 60-minute sleep opportunity increased, the decay in performance from pre-condition test to post-condition test decreased (Figure 10). There were also similar medium sized correlations between TST and paired associates differences scores in nappers who were in the Non-depression group ($r = -.427$, $p = .190$) and nappers who were in the Depression group ($r = -.478$, $p = .072$), however, neither of these correlations were significant (Figure 11A & 11B).

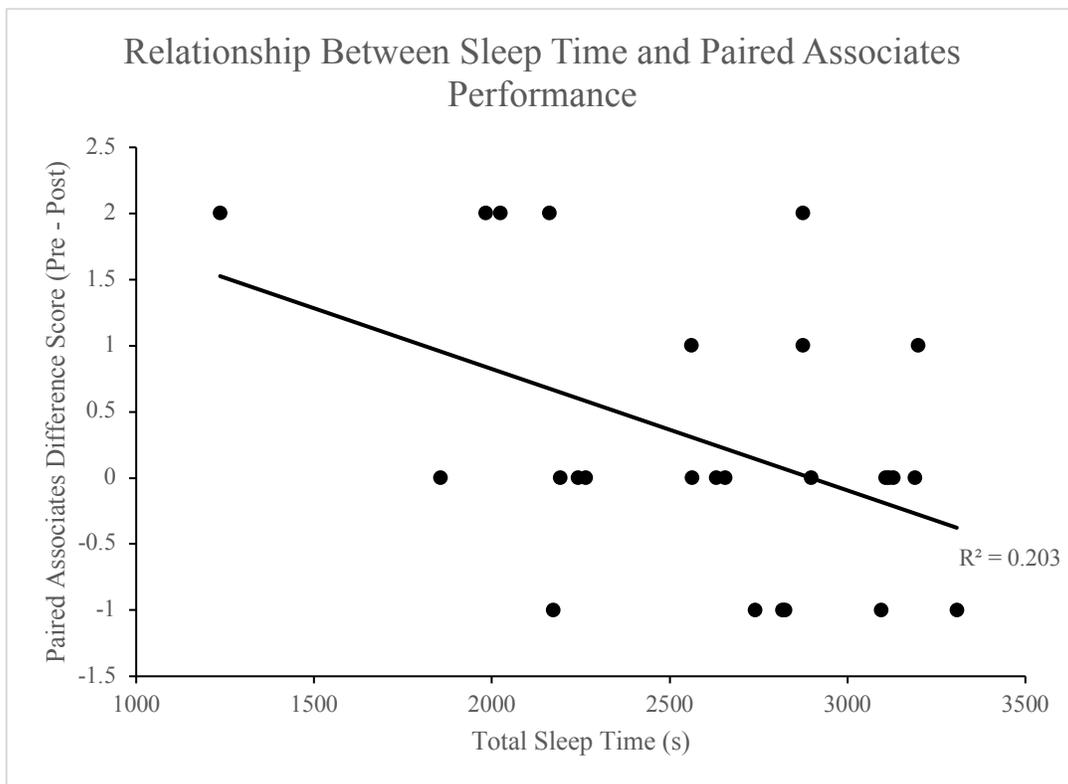
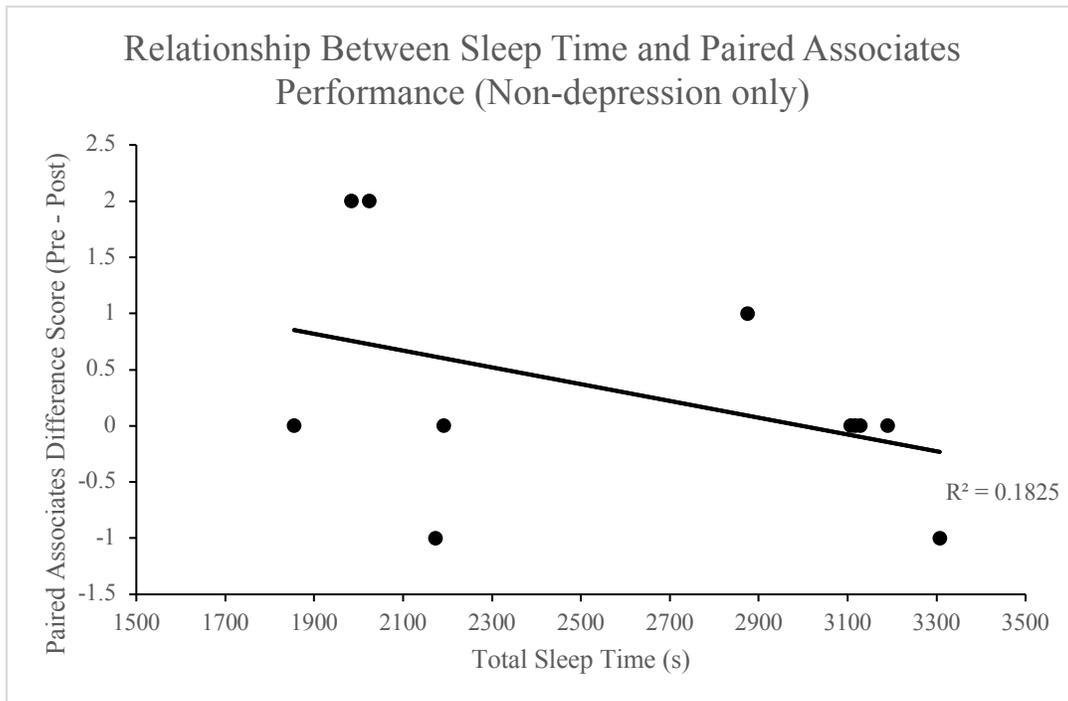


Figure 10. Pearson correlation between TST and difference scores on the paired associates task ($r = -.451$).

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A)



B)

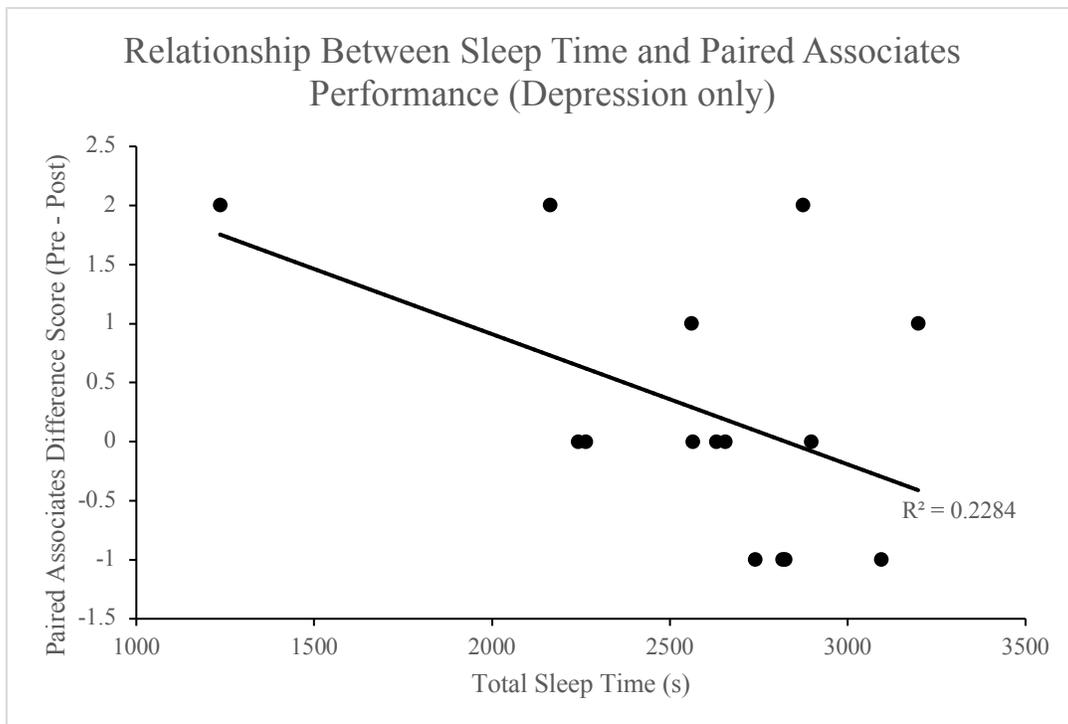


Figure 11. (A) Pearson correlation between TST and difference scores on the paired associates task in participants in the Non-depression group only ($r = -.427$) and (B) in participants in the Depression group only ($r = -.478$)

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Within the group of nappers who entered SWS, memory decay on the story free-recall test was negatively correlated with the percentage of time spent in SWS (% SWS), $r = -.515$, $p = .024$ (Figure 12). There was also a moderate negative correlation between % SWS and memory decay on the paired associates task, $r = -.352$, $p = .140$. This correlation was nonsignificant. But given that light sleep competes with SWS during the 60-minute sleep opportunity, this relationship was supplemented by a significant positive correlation between percentage of time spent in stage 1 sleep (% Stage 1) and memory decay on the paired associates task, $r = .474$, $p = .040$. The correlations between % SWS and performance on both the story free-recall test and the paired associates task indicate that there is less memory decay after higher amounts of SWS. Also, within nappers who entered SWS, significant negative correlations were found between TST and memory decay on the story free-recall test ($r = -.503$, $p = .028$) and the paired associates task ($r = -.507$, $p = .027$). However, similar significant relationships were not found in nappers who did not enter SWS (story free-recall test: $r = -.015$, $p = .975$; paired associates task: $r = -.382$, $p = .398$).

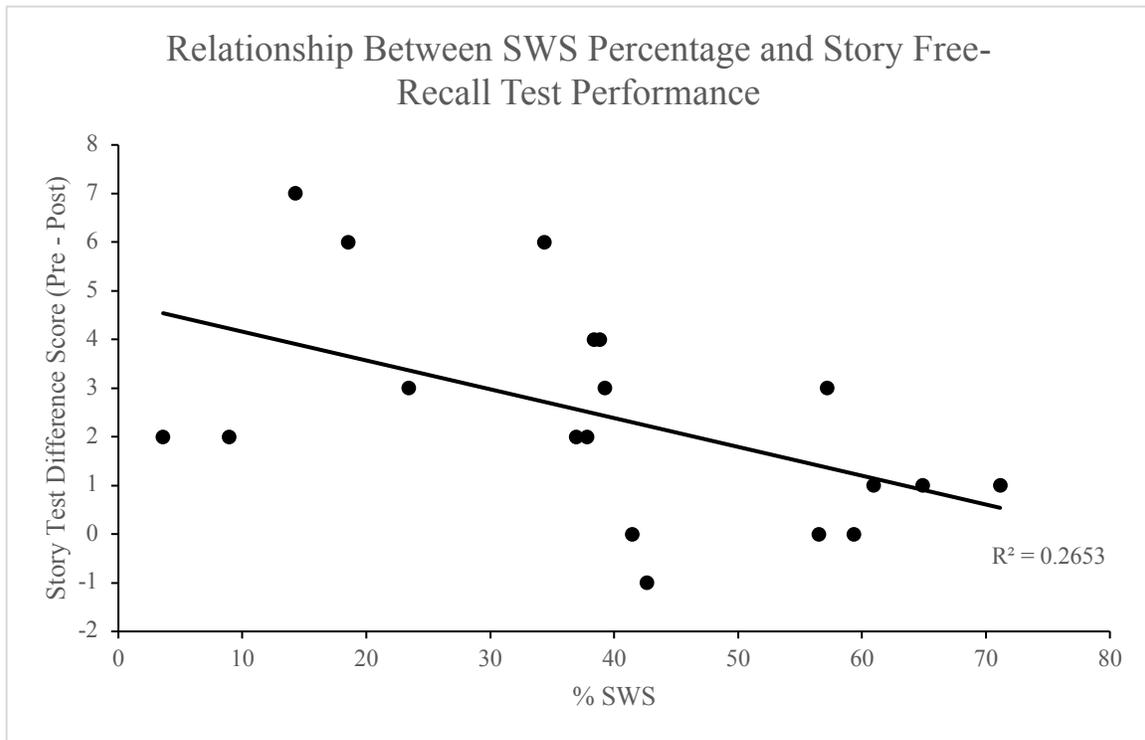


Figure 12. Pearson correlation between % SWS and difference score on the story free-recall test in participants who entered SWS ($r = -.515$).

There was minimal association between depressive symptom severity, as measured using the BDI, and difference scores on the story free-recall test ($r = -.052, p = .698$) in all participants. A small negative relationship was found when considering only the depression group ($r = -.099, p = .577$). On the paired associates task, negative relationships with BDI were found in all participants ($r = -.256, p = .052$) and the depression group ($r = -.329, p = .058$). We also observed a small positive relationship between BDI scores across all participants and memory performance (raw scores) averaged over both timepoints for both the story free-recall test ($r = .100, p = .455$) and the paired associates task ($r = .100, p = .456$).

Chapter 4: Discussion

The primary objective of this study was to develop a new measure to assess memory consolidation of clinically-relevant, depression-related information. Next, given that memory deficits are commonly associated with depression (Ilsley, Moffoot, & O'Carroll, 1995; Marazziti et al., 2010), we examined whether individuals with depression and/or elevated BDI scores display impairments on our newly developed memory tests when compared to participants with no history of depression. Lastly, we were also interested in studying whether the widely reported benefits of napping on memory consolidation apply to our sample of individuals by comparing memory retention over a 60-minute period consisting of either a nap or wakefulness.

We predicted that a 60-minute nap opportunity would produce protective effects for memory retention that exceed those seen with an equal period of wakefulness. While we expected no difference in scores between participants in the two conditions (wake vs. napping) at the pre-condition test, we predicted that scores at the post-condition test would be lower for participants in the wake condition. However, in contrast to the widely reported benefits of napping on memory recall (Schabus, Hödlmoser, Pecherstorfer, & Klösch, 2005; Tucker et al., 2006), our results showed that recall performance on both the story free-recall test and the paired associates task did not differ between participants who were allowed a nap and those who stayed awake during the 60-minute interval at either timepoint. Regardless of which group participants were in or what condition they were assigned to, memory recall decreased significantly from the pre-condition test to the post-condition test for both memory tests. This suggests that, for our memory tests, napping did not prevent memory decay in either non-depressed participants or participants in the Depression group.

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Because individuals with depression also commonly display cognitive impairments, we predicted that participants in our Depression group would exhibit poorer recall performance compared to non-depressed participants, regardless of timepoint or condition. Surprisingly, our results showed the opposite effect; on the paired associates task, participants in the Depression group performed slightly better than non-depressed participants, although this difference was not statistically significant. However, on the story free-recall test, participants in the Depression group scored significantly higher at both the pre-condition and post-condition tests compared to participants in the Non-depression group. In addition, participants in the Depression group performed comparably to non-depressed participants on both the HVLТ and WRAT, suggesting that this effect was not due to obvious differences in baseline cognitive ability.

Correlations Between Sleep and Memory

Although we did not find an interaction between the time point of testing and the experimental condition to directly support the protective effect of napping on memory retention or consolidation, we observed some interesting results regarding the participants' performance on our memory tests and their sleep characteristics. There was a small negative correlation between memory decay on both the story free-recall test and paired associates task (represented by the difference between the pre-condition test score and post-condition test score) and TST within the 60-minute interval; this negative relationship was also present when both groups of participants (non-depressed or depressed) were examined in isolation. For the paired associates task, we noted a significant negative correlation between TST and memory decay, a relation that was present in both groups of participants. These negative relationships suggest that longer TST is associated with lower levels of memory decay over time. This finding is in line with a growing body of literature reporting that declarative memory decay is reduced by a daytime nap (Lemos,

Weissheimer, & Ribeiro, 2014; Seeck-Hirschner et al., 2010; Tucker et al., 2006). Importantly, these data also provide some evidence that, despite the nonsignificant interaction effect, sleep may indeed play a role in protecting memory.

There was also a significant negative correlation between the percentage of SWS obtained during the nap and memory decay on the story free-recall test, as well as a moderate negative relationship between percentage of SWS and memory decay on the paired associates task. However, we did not find significant correlations between memory decay and percentage of stage 2 sleep. Within nappers who entered SWS, there were also significant negative correlations between TST and memory decay on both the story free-recall test and the paired associates task but these relationships were not found in nappers who did not enter SWS. Taken together, these results suggest that the level of memory recall performance may be related to the amount of SWS. The current literature on the benefits of different sleep stages for the protection of declarative memory remains inconsistent, as there have been studies in support of both stage 2 sleep (Gais, Mölle, Helms, & Born, 2002; Schabus et al., 2004) and SWS (Gais & Born, 2004; Marshall et al., 2006). The current findings lend support to the hypothesis that SWS during a nap exerts an effect to reduce memory decay over time.

Correlations Between BDI and Memory

We observed negative relationships between depression symptom severity and memory decay on both the story free-recall test and the paired associates task. Within our depression group, we observed a negative association between BDI scores and memory decay on both the story memory test and paired associates task but this relationship was not found in the non-depression group. These relationships suggest that higher BDI scores, or more severe levels of depressive symptoms, may be associated with a reduced decay and overall better recall of the

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clinically-relevant material learned in the two memory tests. This relationship may be due to the personal relevance of the material to individuals with higher BDI scores, thus making the material more salient and memorable. This is supported by the small positive associations we observed between BDI scores and memory performance on both memory tests based on raw scores averaged across timepoints.

Emotional Relevance of Learned Material

One of the most surprising findings to emerge from this study was that participants in the Depression group exhibited significantly better memory performance on the clinically relevant memory tests than non-depressed participants. This result contradicts much of the existing literature showing that individuals with depression tend to experience memory impairments compared to individuals without depression (Rock et al., 2014; Sternberg & Jarvik, 1976). However, many studies in the past assessed memory using tests with neutral or nonsense information, leading to the speculation that the emotional relevance of the depression-related material in our novel memory tests may have contributed to the unexpected boost in memory performance for participants with depression.

The valence of information and the level of arousal that information evokes have both been believed to contribute to an enhancement of the ability to recollect those stimuli (Kensinger & Corkin, 2003; Ochsner, 2000). In other words, information that is personally relevant and arousing to individuals will most likely be recalled more easily than neutral information. Because the material in our memory tests was depression-related, this hypothesis most likely explains the unexpected increase in memory recall in the Depression group compared to the Non-depression group. However, it is of interest to note that the increase in memory recall in the Depression group over the Non-depression group remained consistent over time (i.e., pre- and post-

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condition). Given that information valence and arousal can benefit information recall, we would expect that memory performance in the Non-depression group decreases more dramatically over time as the information may not be as relevant or arousing as for participants in the Depression group. However, our results did not reflect this assumption as there was no significant difference in the magnitude of memory decay over time between the two groups.

Some research suggests that the consolidation of emotional memories may be most effective during periods of sleep that contain high amounts of REM sleep (Wagner, Gais, & Born, 2001). While declarative memory consolidation generally relies on the hippocampus, emotional memory formation also recruits the amygdala, which has been speculated to contribute to the enhanced formation of emotional memories relative to neutral memories (Hamann, Ely, Grafton, & Kilts, 1999). In addition, the magnitude of emotional memory consolidation has been found to be positively correlated with both the amount of REM sleep and also the extent of pre-frontal theta wave activity during REM sleep (Nishida, Pearsall, Buckner, & Walker, 2008). Harrington, Johnson, Croom, Pennington, and Durrant (2018) also found that REM sleep and SWS may play different roles in emotional and neutral information consolidation in individuals with depression. These researchers noted better consolidation of neutral information during SWS in participants with high BDI scores, suggesting that the beneficial effect of SWS on emotionally neutral memory consolidation may be more pronounced in individuals who display depressive symptoms than individuals who do not. Further, these researchers found a positive relationship between REM density (the frequency of rapid eye movements during REM sleep) and consolidation of emotional material. Given that the material in our memory tests likely carried emotional valence for at least one (Depression) group of participants, we were unable to test the effect of SWS on neutral information in individuals with depression. Additionally, the 60-minute

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nap condition did not allow sufficient time for participants to enter REM sleep, thus precluding any opportunity to compare the effects of REM sleep on emotional memory consolidation across the different groups. This feature of the experimental design may explain why we did not observe any differences in performance over time between the two groups of participants.

Implications

One of the major contributions of the current study to the existing research on sleep and memory in different populations is the development of two novel depression-relevant memory tests: a story free-recall test and a paired associates task. The majority of currently used memory tests in sleep and memory research employ neutral or nonsense information, whereas our new memory tests were developed with the dual purpose of both assessing memory and educating individuals about depression. Although the paired associates paradigm is well established in this field of research, we developed our own paired associates task to be depression-relevant. The delivery of our story memory test also attempted to mimic a one-on-one cognitive remediation therapy session with a psychologist, and the content of both tests was designed so that participants could learn and retain valuable information. The story free-recall test, in particular, could be a more ecologically valid way to measure memory performance for future studies.

The findings from this study also contribute to the existing literature on sleep, memory, and depression. Participants in our Depression group did not display any memory impairments on our two memory tests in comparison to participants in our Non-depression group, contrary to what we initially predicted. Instead, the Depression group demonstrated comparable performance on the paired associates task and superior memory recall on the story free-recall test at both the pre-condition and post-condition time points. Better memory performance may be explained by the valency of the information to participants with depression (Hamilton & Gotlib, 2008). This

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finding may be particularly important because it could potentially provide information with regard to the content used in future memory tests. If certain stimuli or types of information are more memorable to certain populations, clinicians could benefit from taking this information into consideration when treating patients. This finding may also have implications for future research as memory performance in different populations may be, at least in part, related to the specific test material employed.

Although we did not find a significant overall effect of napping on memory consolidation, our correlational analyses revealed negative relationships between sleep duration and memory decay in all nappers. Participants who napped for longer within the 60-minute sleep opportunity tended to show less decay in performance on both the story free-recall test and the paired associates task over time. This provides support for the benefits of napping on memory (Kurdziel, Duclos, & Spencer, 2013; Maquet, Peigneux, Laureys, & Smith, 2002).

It is noteworthy that the relation between sleep duration and memory stability was also apparent when only considering the nappers who entered SWS but not for nappers who did not enter SWS. Within the nappers who entered SWS, we also observed negative relationships between percentage of SWS obtained and memory decay over time for both tests. These results are consistent with findings that support the role of SWS in memory consolidation (Gais & Born, 2004; Tucker et al., 2006), suggesting that a daytime nap containing SWS may be more beneficial in protecting against memory decay than a nap with no SWS.

We observed a negative relationship between BDI scores and memory decay on our paired associates task but not the story learning free-recall test. This suggests that deficits in memory may not be directly associated with depressive symptoms and that depressive symptom severity may only be one of multiple factors affecting memory consolidation.

Limitations

Although our findings may have important implications for the effects of napping on memory in different populations, it is also important to consider the limitations of the current study. The relatively small sample size and homogenous demographic may have limited the experiments' ability to detect the presence of an effect, as shown by our relatively small effect sizes. Participants were young adults receiving a postsecondary education, raising the possibility that their cognitive abilities and many other characteristics may not be representative of the general population. Within our sample, we also did not assess comorbid symptoms (Alfano, Ginsburg, & Kingery, 2007) or medications (Wichniak, Wierzbicka, Walecka, & Jernajczyk, 2017), both of which may affect sleep and cognitive functioning.

A further limitation of the present study is that participants completed their post-condition memory tests shortly after waking and removal of the EEG electrodes. Due to the relatively short duration (about five minutes) between waking and post-condition testing, participants may have experienced sleep inertia, i.e., a state of decreased arousal after waking up from sleep, which may negatively affect cognitive performance (Wertz, Ronda, & Czeisler, 2006). We did not employ a specific protocol to dissipate sleep inertia following the 60-minute sleep opportunity, raising the possibility that decreased arousal and/or impaired cognition may have contributed to the significant decay in memory over time in our sample of nappers. Considering that longer sleep times were associated with less memory decay, it may be beneficial to increase the duration of the nap opportunity to allow participants to cycle out of SWS, which would make it possible for the experimenters to awaken participants from a lighter stage of sleep. In this regard, it is noteworthy that awakening during SWS has been found to lead

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to more sleep inertia than awakening during stage 1, stage 2, or REM sleep (Tassi & Muzet, 2000).

Finally, as discussed, the content of both the story free-recall test and the paired associates task was depression-related, and the personal relevance of this material may have created an attentional or other bias in participants in the Depression group, leading to higher performance scores compared to the Non-depression group. The memory tests were designed to be clinically-relevant in hopes of introducing a new set of measures for clinical use. However, without tests containing neutral information, we were unable to compare memory performance between groups on different types of material. Thus, we were not able to conclude whether the boost in memory performance observed in the Depression group was due a general advantage in memory consolidation compared to the Non-depression group, or due to the saliency of the specific material contained in our memory tests. The ecological validity of our novel measures is also only speculative as we did not perform tests of validity. However, we believe the delivery of the story learning free-recall test via a conversational style and the educational aspect of both our memory tests make our measures more generalizable to every day experiences than many of the existing memory tests being used.

Future Directions

To increase the generalizability of the current findings, future research should recruit a larger sample of participants of more diverse backgrounds, allowing the sample to be more representative of both the general public and the population of depressed individuals. It may also be beneficial to explore differences in memory performance on the clinically-relevant memory test between participants in partial remission, complete remission, and in current episode. Research has shown that cognitive dysfunctions may persist even after remission (Kaneda, 2009;

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Neu et al., 2005) but the difference in memory performance between patients in full remission or partial remission is less clear (Hammar & Ardal, 2013; Lahr, Beblo, & Hartje, 2005).

Future research should also take steps to minimize the effects of sleep inertia. Although the exact time course for sleep inertia to dissipate is yet to be agreed upon, the general consensus seems to be that cognitive performance is worst immediately upon waking and slowly improves as sleep inertia dissipates over time (Werth, Achermann, Dijk, & Borbély, 1995; Jewett et al., 1999). Certain post-sleep activities, such as eating or showering, have been speculated to dissipate sleep inertia, but results in this area of research have not been entirely conclusive (Jewett et al., 1999). Therefore, the best way to minimize the effects of sleep inertia on performance may be to delay the post-condition test and allow sleep inertia to dissipate naturally. Minimizing sleep inertia may also help to better clarify the beneficial effects of napping on memory of clinically-relevant information and, if such effects are further supported in the future, the possibility of including napping into the process of cognitive remediation could be explored.

Finally, neutral versions of the two memory tests should be developed and used alongside the clinically-relevant tests to act as a point of reference. This methodological modification may aid in providing a better understanding of strategies to improve memory consolidation in different populations, especially for the purposes of rehabilitation.

Chapter 5: Conclusion

The goal of the current study was to examine whether napping could provide a protective effect on memory for clinically-relevant information in both non-depressed individuals and individuals with depression. While the initial analysis did not reveal beneficial effects of napping on memory, subsequent correlational analyses suggested that napping, indeed, appears to enhance memory consolidation, at least for certain types of information. However, the various limitations of the study, as discussed above, need to be taken into consideration when drawing conclusions from the work presented in this thesis. Clearly, further research is needed to clarify the relationship between napping and clinically-relevant memory, particularly in individuals with depression.

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Appendix A: Study Forms

Demographics Form

Participant Information Survey

1. Name (First/Last): _____

2. Do you take naps on a regular basis (on average at least once/week for the last 2 months)?

YES NO

3. Do you have a current, medical diagnosis of any neurological, psychiatry, or psychological conditions (circle one)?

YES NO

4. Do you have a current diagnosis for a sleep disorder and/or are you taking any prescription medication that could affect sleep (circle one)?

YES NO

IMPORTANT: If you answered “NO” to Question 2 and “YES” to either Question 3 or 4, please do not continue with this questionnaire and talk to the investigator.

5. Age (in years): _____

6. Gender (circle one): Male Female Other

7. Handedness (circle): Right Left Both

8. Is English your first language (circle one): YES NO

9. On average, how often do you nap in one week: _____

10. At what time do you typically start your nap: _____

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11. For how long do you typically nap? _____

12. At what time do you typically go to sleep? _____

At what time do you typically get up? _____

13. How would you characterize your typical sleep quality (circle one)?

A. I have no trouble sleeping and usually feel that I get enough sleep and am well-rested.

B. I generally sleep well, but occasionally suffer from lack of enough sleep.

C. My sleep is quite mixed; at times I sleep well, but at other times, I suffer from sleep loss and tiredness.

D. I am a poor sleeper and it is rare for me to get enough sleep and feel well-rested.

E. I suffer from chronic sleep loss and feel that my daytime functioning is impaired due to the poor quality of my sleep.

Introduction and Consent Form

LETTER OF INFORMATION / CONSENT

A Study of “**Memory Consolidation of Clinical Information**”

Principal Investigator: Dr. Hans Dringenberg
Department of Psychology
Queen’s University
Kingston, Ontario, Canada
613-533-6215
E-mail: dringenb@queensu.ca

Co-Investigators: Lilian Laferriere
Department of Psychology
Queen’s University
Kingston, Ontario, Canada

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613-533-6215

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Edwyn Lo
Department of Psychology
Queen's University
Kingston, Ontario, Canada
613-533-6000 ex. 74968
E-mail: 16el31@queensu.ca

BACKGROUND INFORMATION:

You are invited to take part in a study directed by Ms. Lilian Laferriere, Mr. Edwyn Lo, Dr. Hans Dringenberg and Dr. Christopher Bowie.

Ms. Laferriere or her delegate will read through this consent form with you and answer any questions you may have.

DETAILS OF THE STUDY:

Study Aim

The goal of this study is to assess and compare memory recall for clinical information presented in a video between participants who are allowed to sleep (an approximately 60 min nap) and those who stay awake for an equivalent time period.

Study Procedures

Your participation in this study will require two sessions: one will last for 60 minutes, the other approximately 2 hours.

If you decide to participate, one the first day you will be asked to:

1. Answer some demographic questions.
2. Complete a brief test of general cognitive ability.
3. Complete a brief interview with a graduate student.

On the second day, you will be asked to:

1. Watch a video that discusses cognitive dysfunction in individuals with depression.
2. Be set up with an EEG apparatus to record brain activity.
3. Spend 1 hour in a secure, private Neuroplasticity Lab bedroom, where you will be asked to either nap, or remain awake by watching a nature video (you are randomly assigned to one of these conditions by the experimenters following your initial visit to the lab; however, you will not be informed of your assignment until your second visit to the lab).
4. Answer some questions about the video you watched and have your responses electronically recorded.

Are there any risks to doing this study?

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There are no known risks to participating in this study.

Are there any benefits to doing this study?

This study does not provide any direct benefits to its participants; however, it will provide further information regarding consolidation of clinical information.

Confidentiality

Confidentiality will be protected to the fullest extent possible.

The information you provide will not have your name or any identifying information on it. Instead, we will assign you a random code. This code is linked to your name in our locked laboratory on a password-protected computer. All of the forms, even though they only have a code, are kept in a locked cabinet where only Ms. Lilian Laferriere, Mr. Edwyn Lo, Dr. Dringenberg, Dr. Bowie, and other authorized members of their research team have access to them. Information kept on a computer will be protected by a password. Once the study is complete, an archive of the data, without identifying information, will be stored for at least 10 years and may be stored indefinitely.

Participation and Withdrawal

Your participation in this study is voluntary. It is your choice to be part of the study or not. If you decide to be part of the study, you can decide to stop (withdraw) at any time, even after signing the consent form or part-way through the study. If you decide to withdraw, there will be no consequences to you. In cases of withdrawal, any data you have provided will be destroyed, unless you indicate otherwise. Your right to withdraw from the study and to have your data destroyed will terminate one (1) week after you have completed the study. If you do not want to answer some of the questions you do not have to, but you can still be in the study. Your decision whether or not to be part of the study will not affect your compensation.

Payment or Reimbursement

If you are a participant recruited from the Psychology Subjects Pool, you will be compensated for your time with 2.0 course credits towards your PSYC 100 or 200 class, as well as \$10.

If you are a participant not recruited from the Psychology Subjects Pool, you will receive \$30 as compensation for your time.

How do I find out what was learned in this study?)

I expect to have this study completed by September 2019. If you would like a brief summary of the results, please contact any of the investigators to let us know how you would like them sent to you.

Questions about the Study

Any questions about study participation may be directed to Dr. Hans Dringenberg at dringenb@queensu.ca or 613-533-6215. Any ethical concerns about the study may be directed to the General Research Ethics Board Chair at chair.GREB@queensu.ca or 1-844-535-2988 (toll free in North America).

CONSENT

I have read and understood the information presented in the information letter about a study being conducted by Dr. Hans Dringenberg, Ms. Lilian Laferriere, and Mr. Edwyn Lo of Queen's University. I have had the purposes and procedures of this study explained to me. I have been given sufficient time to consider the above information and to seek advice if I chose to do so. I have had the opportunity to ask questions about my involvement in this study and to receive additional details I requested. I understand that if I agree to participate in this study, I may withdraw from

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the study at any time. I am voluntarily signing this form. I have been given a copy of this form. I agree to participate in the study.

If at any time I have further questions, problems, or adverse events, I can contact:

Dr. Hans Dringenberg, Supervisor at 613-533-6215

Or

GREB Chair at 1-844-535-2988 (Toll-free in North America)

By signing this consent form, I am indicating that I have read the above statements and freely agree to participate in this study.

Signature of Participant

Date

Debriefing Form

“Memory Consolidation of Clinical Information”

Thank you for participating in our study!

The purpose of our experiment was to determine whether a one-hour nap would improve the **memory consolidation of clinical information** regarding cognition in depression. Your first appointment was intended to determine your napping habits, your baseline verbal memory abilities, and your mood status (Beck Depression Inventory and the MINI Psychiatric interview). The MINI Interview was conducted as a routine screening device and was not intended to be diagnostic. It was during your second appointment that the experimental manipulation occurred. There were two conditions in this study: napping and awake control. All participants watched the same video, were set up with the EEG, and were asked the same follow up questions to test recollection of the information presented; however, some participants were asked to nap while others were allowed to spend the time in the lab room in whatever way they wished. The group you were assigned to was random and is not expected to impact you in any way outside of the study.

All of the information we collected today will be kept strictly confidential. You are not identified on any of the testing materials, nor will you be identified in future publications of our findings. You may request a copy of the study’s results by contacting Dr. Dringenberg at the Neuroplasticity Lab (dringenb@queensu.ca) or 613-533-6215. Because we are still running participants through the study, we ask for you **NOT TO DISCUSS** the study with others. Thank you for your understanding and cooperation.

Any questions about the study and your participation in it may be directed to Dr. Hans Dringenberg and his team at the email above. Any ethical concerns about the study may be

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directed to the Chair of the General Research Ethics Board at [1-844-535-2988](tel:1-844-535-2988) (toll-free in North America) or Chair.GREB@queensu.ca. We are required to keep track of adverse events that may have taken place as a result of participation in our study. In the unlikely event that such an incident occurs as was not noted during the study, please contact GREB or the Neuroplasticity Lab.

Thank you again for your participation. Your interest and enthusiasm are greatly appreciated.

Dr. Hans Dringenberg, Professor & Supervisor
Ms. Lilian Laferriere, Undergraduate student
Mr. Edwyn Lo, M.Sc. student

Appendix B: Clinical Memory Test Materials

Story Free-Recall Test Script

“My name is Janet Shelby. I used to be a nurse on the internal medicine floor at a downtown Edmonton Hospital, for 15 years. I was the most valued nurse for seven years in a row. I always arrived for work 20 minutes early to review all of my patient files, and I was very precise at administering medication. When I first experienced depression about five years ago, I started having trouble paying attention. I would forget simple instructions from others, such as the time of the weekly team meetings. I got so frustrated that I started avoiding any new tasks, which caused me to really doubt myself. Now I am in cognitive remediation, and I’ve been doing that for three months. The strategies I’ve learned have helped me with my confidence, and my concentration.”

Story Test Rubric

<i>Phrase/ Thematic Unit</i>	<i>2-Point Response</i>	<i>1-Point Response</i>	<i>Score</i>
<i>Janet Shelby</i>	Janet AND Shelby	Janet OR Shelby, OR close variant (Ex. Janice Shelby, Janet Shelley, Janet, Mrs. Shelby)	2 1 0

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<i>Used to be a Nurse</i>	Used to be a Nurse	The idea of being a nurse in the past	2	1	0
<i>Internal Medicine</i>	Internal Medicine	Close variant of internal medicine (Ex. Internal ward, medicine floor)	2	1	0
<i>Downtown Edmonton Hospital</i>	Downtown, Edmonton, Hospital	2/3 words; Downtown hospital, Edmonton Hospital, Downtown Edmonton	2	1	0
CONTENT	The idea of being a nurse AND of working in a hospital	The idea of being a nurse OR working in a hospital	2	1	0
<i>15 years</i>	15 years	Any amount of time in the teens year range (Ex. 13 years)	2	1	0
<i>Most Valued Nurse</i>	Most valued AND Nurse	Idea of most valued OR best nurse (Ex. Best nurse award)	2	1	0
<i>7 Years in a Row</i>	Notion of 7 years AND that they were consecutive	Seven years OR any number <u>in a row</u>	2	1	0
<i>20 Minutes Early</i>	20 Minutes AND early	The notion of being between 10-30 minutes early	2	1	0
<i>Review Patient Files</i>	Review AND Patient Files	The notion of reviewing or preparing OR patient files (ex. Organize patient files, review patient medication)	2	1	0
<i>Precise at Administering Medications</i>	Precise AND Administering AND Medication	Synonym of precise + close variant of administering medication (ex. Accurately Delivering medication)	2	1	0
CONTENT	Notion of being good at job, recognized for performance	Notion of being good at job OR recognized for performance	2	1	0
<i>First Experienced Depression 5 Years Ago</i>	Idea that Depression Started AND 5 Years Ago	Depression started OR some mental illness 5 years ago (ex. Depression a few years ago)	2	1	0
<i>Trouble Paying Attention</i>	Trouble Paying Attention	Close variant of difficulty with attention (Ex. Problems listening to others)	2	1	0
<i>Forget Simple Instructions</i>	Forget Simple Instructions	The idea of forgetting something, or instructions	2	1	0
<i>Time of Weekly Team Meeting</i>	Time of Weekly Team Meeting	Time of meeting OR weekly meeting OR team meeting OR meeting	2	1	0
<i>Felt frustrated</i>	Felt Frustrated	Any synonym for frustrated (Ex. Stressed, aggravated)	2	1	0

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<i>Avoid any New Tasks</i>	Avoid any New Tasks	The idea of avoiding things	2	1	0
<i>Doubt Myself</i>	Doubt Myself, Doubt Herself	Close synonym of doubt (ex. lose confidence in myself)	2	1	0
CONTENT	Experiencing depression AND cognitive difficulties (Ex. Trouble paying attention OR forgetting simple things) AND mood disturbance (ex. Frustration, doubting self)	Experiencing depression AND ONE OF (1) cognitive difficulties (ex. Trouble paying attention OR forgetting simple things) (2) mood disturbance (ex. Frustration, doubting self)	2	1	0
<i>Cognitive Remediation</i>	Cognitive Remediation OR Cognitive Rehabilitation	Cognitive OR cognition AND a close variant of therapy (Ex. cognitive therapy, cognitive training)	2	1	0
<i>Three Months</i>	Three Months	Between 2-4 months, or the notion of a couple of months	2	1	0
<i>Strategies</i>	Strategies	Synonym for strategies (Ex. Techniques, mechanisms)	2	1	0
<i>Concentration and Self-Confidence</i>	Concentration AND Self-Confidence	Concentration OR self-confidence	2	1	0
CONTENT	The notion of cognitive treatment AND improvements	The notion of cognitive treatment OR improvements	2	1	0

Participant ID: _____

Pre- or Post- Condition Test (**Circle one**)

Total Score 1 (w/ content): _____

Total Score 2 (w/content): _____

Total Score 1 (no content): _____

Total Score 2 (no content): _____

Final Score (no content): _____/42

Paired Associates: _____/10

Paired Associates Task Word List

Working Memory- Chunking

Isolation- Group Activities

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Long-Term Memory- Rehearsal

Divided Attention- Multitasking

Planning- Making Lists

Emotional Regulation- Breathing

Verbal Fluency- Mock Interviews

Self-Restraint- Mindfulness

Processing Speed- Computer Games

Lethargy- Sleep Hygiene

Appendix C: Descriptive Statistics of Performance on Memory Tasks

Table 4

Participant Performance on Clinical Memory Tasks Before and After 60-minute Condition

Measure	Group	Condition	Mean (SD)	N
Story Free-Recall (Pre-Condition)	Non-depression	Nap	18.45 (6.15)	11
		Wake	17.08 (5.87)	13
		Total	17.71 (5.91)	24
	Depression	Nap	20.87 (5.50)	15
		Wake	19.95 (4.99)	19
		Total	20.35 (5.16)	34
Story Free-Recall (Post-Condition)	Non-depression	Nap	16.45 (5.47)	11
		Wake	13.62 (4.57)	13
		Total	14.92 (5.10)	24
	Depression	Nap	19.00 (6.05)	15
		Wake	17.68 (5.48)	19
		Total	18.26 (5.69)	34
Paired Associates (Pre-Condition)	Non-depression	Nap	5.45 (2.21)	11
		Wake	6.38 (2.82)	13
		Total	5.96 (2.55)	24
	Depression	Nap	6.27 (2.19)	15
		Wake	6.58 (2.34)	19
		Total		

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		Total	6.44 (2.25)	34
Paired Associates (Post-Condition)	Non-depression	Nap	5.18 (2.40)	11
		Wake	5.85 (2.76)	13
		Total	5.54 (2.57)	24
	Depression	Nap	6.13 (2.75)	15
		Wake	6.00 (2.36)	19
		Total	6.06 (2.50)	34

Note. The maximum possible scores for the story free-recall test and the paired associates task were 42 and 10, respectively.

Appendix D: Ethics Clearance

December 22, 2017
 Dr. Hans Dringenberg
 Professor
 Department of Psychology
 Queen's University
 Humphrey Hall
 Kingston, ON, K7L 3N6

GREB Ref #: GPSYC-839-17; TRAQ # 6022219

Title: "GPSYC-839-17 The Impact of Sleep on Consolidation of Clinical Information"

Dear Dr. Dringenberg:

The General Research Ethics Board (GREB), by means of a delegated board review, has cleared your proposal entitled "GPSYC-839-17 The Impact of Sleep on Consolidation of Clinical Information" for ethical compliance with the Tri-Council Guidelines (TCPS 2 (2014)) and Queen's ethics policies. In accordance with the Tri-Council Guidelines (Article 6.14) and Standard Operating Procedures (405.001), your project has been cleared for one year. You are reminded of your obligation to submit an annual renewal form prior to the annual renewal due date (access this form at <http://www.queensu.ca/traq/signon.html>; click on "Events"; under "Create New Event" click on "General Research Ethics Board Annual Renewal/Closure Form for Cleared Studies"). Please note that when your research project is completed, you need to submit an Annual Renewal/Closure Form in Romeo/traq indicating that the project is 'completed' so that the file can be closed. This should be submitted at the time of completion; there is no need to wait until the annual renewal due date.

You are reminded of your obligation to advise the GREB of any adverse event(s) that occur during this one year period (access this form at <http://www.queensu.ca/traq/signon.html>; click on "Events"; under "Create New Event" click on "General Research Ethics Board Adverse Event Form"). An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a

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substantial change in approach to a participant(s). You are also advised that all adverse events must be reported to the GREB within 48 hours.

You are also reminded that all changes that might affect human participants must be cleared by the GREB. For example, you must report changes to the level of risk, applicant characteristics, and implementation of new procedures. To submit an amendment form, access the application by at <http://www.queensu.ca/traq/signon.html>; click on "Events"; under "Create New Event" click on "General Research Ethics Board Request for the Amendment of Approved Studies". Once submitted, these changes will automatically be sent to the Ethics Coordinator, Ms. Gail Irving, at the Office of Research Services for further review and clearance by the GREB or GREB Chair.

On behalf of the General Research Ethics Board, I wish you continued success in your research.

Sincerely,

Joan Stevenson, Ph.D.
Interim Chair
General Research Ethics Board

c: Ms. Lilian Laferriere, Dr. Christopher Bowie, Mr. Edwyn Lo, and Ms. Melissa Milanovic,
Co-investigators
Dr. Leandre Fabrigar, Chair, Unit REB