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Concsious Replay during Rest and Relational Processing

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CONCSIOUS REPLAY DURING REST AND RELATIONAL PROCESSING

By

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in partial fulfillment of the
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Jane C. Komsky defended this thesis on May 13, 2015.

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ABSTRACT

Engaging in a period of rest following encoding has been shown to lead to better retention on a subsequent recall test than performing an inter-test task. Brain imaging studies have shown that there is reactivation during post-encoding rest of brain areas that were active during initial encoding, and this process has been attributed to memory consolidation, leading to the improvements in recall. The present study investigated the conscious thoughts that occur during wakeful rest following encoding and how they relate to memory on a delayed recall test. Recall was tested in younger adults across two tests separated by a rest period while verbalizing conscious thoughts or engaging in a visuospatial task while verbalizing thoughts. Experiment 1 demonstrated hypermnesia, an increase in recall over repeated testing, for the rest but not task condition and demonstrated a relationship between recall improvement and the amount of replay during the delay. Experiment 2 aimed to replicate the findings of Experiment 1 and further explored the role of conscious replay in relational processing.

CHAPTER ONE

INTRODUCTION

Memory consolidation is a process of stabilizing memories following encoding (cf. Dewar, Cowan, & Della Sala, 2007; Dudai, 2004). Dewar and her colleagues investigated memory consolidation using a multiple test paradigm in numerous experiments with older adults and amnesics (e.g., Dewar, Della Sala, Beschin, & Cowan, 2010; Dewar, Garcia, Cowan, & Della Sala, 2009; Dewar, Pesallaccia, Cowan, Provinciali, & Della Sala, 2012; Dewar, Alber, Butler, Cowan, & Della Sala, 2012). In Dewar, Alber, et al., (2012), older adults were presented with a short story and then had an initial free recall test for the details of that story. Then, participants either rested quietly for 10 minutes with their eyes closed or they performed a spot-the-difference task, in which they were presented with a series of two similar images on a computer screen and were to identify the differences between them. After the delay period, participants were read a second short story, had a recall test for the details of that story, and again had a 10-minute delay in which they engaged in the opposite instructions, either rest or the spot-the-difference task. Following this second delay, they had a surprise delayed recall test for the details of the first story and then for the second story. The purpose of including the immediate recall test was to reduce anticipation of the delayed recall test. The older adults scored lower on the delayed test than the immediate recall test for both stories, but the story followed by rest was better retained at the time of the delayed test than the story followed by the spot-the-difference task. In a post-experimental questionnaire, most participants reported not thinking about the stories during the delay periods, and when the data for those who did report thinking about the stories was excluded, the same pattern of results remained. Thus, the authors claim that the benefit of post-encoding resting is not a result of rehearsal during the delay period.

Dewar, Alber, et al. (2012) attributed the memory enhancement seen in their study following rest versus a task to a process of automatic memory consolidation and not to intentional rehearsal of the stories during the rest period. However, brain imaging studies have demonstrated that the same brain areas that are activated during encoding are also activated during a post-encoding rest period (Diba & Buzsaki, 2007). Activation in those brain areas during rest predicts later recall for the encoded material, suggesting that a rest period following encoding can enhance memory through neural replay (Takashima et al., 2006; Tambini, Ketz, & Davachi, 2010). Mednick, Cai, Shuman, Anagnostaras, and Wixted (2011) suggest that this neural reactivation is opportunistic, meaning that recently encoded information is consolidated when the hippocampus is not occupied with another task, and, similarly, Dewar, Alber, et al. propose that the memory enhancement seen following rest is due to an increased opportunity for memory consolidation during rest than during a task.

Tambini et al. (2010) found that there is a direct relationship between the strength of neural reactivation during rest and later recall for that material. They presented participants with scene-face image pairs and object-face image pairs in blocks while in an fMRI scanner. The participants were not instructed to memorize the pairs and were not informed of the upcoming recall test, but during presentation of the image pairs, participants performed encoding tasks. For the scene-face pairs, participants were to visualize the person in the scene and respond whether the person would be happy or unhappy to be in that environment. For the object-face pairs, participants were to visualize the person manipulating the object and respond whether the person would be likely or unlikely to be found manipulating that object.

Following presentation of each block of stimuli, the participants engaged in a rest period, and after the completion of the scene-face and object-face blocks with corresponding rest periods, the participants were presented with an associative memory test outside of the scanner in which they decided if the presented pair matches one that they saw in the scanner or if one or both of the images were changed. Tambini et al. (2010) found that the different brain areas activated for the different stimuli during encoding mapped onto the brain areas reactivated during post-encoding rest. The performance on the memory test for the image pairs correlated with the strength of brain activation of the corresponding areas during the rest period in the scanner immediately following encoding of that block. In a post-experimental questionnaire, none of the 16 participants reported thinking about the experimental stimuli during the post-encoding rest periods. These results support Dewar, Alber, et al.'s (2012) notion that wakeful rest leads to superior strengthening of memory traces by non-conscious consolidation processes. However, in the present study, I argue that a retrospective report is not sufficient to determine conscious thoughts after 20 minutes or longer, as used in these experiments.

In an initial study, I investigated the post-encoding delay further using a similar paradigm to Dewar, Alber et al. (2012) but with younger adults. The study used concurrent talk aloud protocols to assess whether conscious replay of the recently encoded material during the delay was associated with the boost in memory performance over the delay in prior consolidation studies. Participants were presented with a series of images mainly from the International Affective Picture System (Lang, Bradley, & Cuthbert, 1995) followed by an immediate recall test for a description of each image. Then, for ten minutes, participants either rested quietly, rested and were instructed to talk aloud any thoughts that come to mind, or played the game Tetris and engaged in talking aloud. The talk aloud instructions were to say anything that comes to mind, and if an image from the set they saw earlier came to mind, then to mention the image. Finally, participants had a surprise delayed recall test for the images.

My results showed a similar pattern to that of Dewar, Alber et al. (2012). Participants in both rest conditions had better performance on the delayed recall test than those in the Tetris condition. When comparing the rest quietly and rest with talk aloud conditions, the talk aloud instructions were not reactive. Critically, the talk aloud protocols were coded to determine how many times each image was consciously replayed during the delay, and contrary to Dewar, Alber et al.'s retrospective reports, I found that participants were indeed thinking about the encoded material during the delay and that more replay of the images occurred during rest than Tetris. However, rather than showing less forgetting following rest as in the case of older adults, the younger adult participants showed hypermnesia following rest.

While ability to recall information generally decreases over time, hypermnesia is the increase in recall over repeated tests without additional study. A typical hypermnesia paradigm involves an encoding session followed by multiple tests either consecutively or with intertest delays (e.g., Erdelyi & Becker, 1974; Roediger & Thorpe, 1978; Roediger & Payne, 1982; Payne, Anastasi, Blackwell, & Wenger, 1994; Mulligan, 2006). Hypermnesia is a combined result of reminiscence, the recall of not-previously recalled items on a subsequent test, and forgetting, not recalling items on a subsequent test that were recalled on a previous test (Ballard, 1913). Roediger and Thorpe (1978) have stipulated that hypermnesia is a result of speeded retrieval, because experimental procedures that produce hypermnesia generally have time-limited free recall tests. Their work finds that participants output items more quickly on subsequent recall tests than on initial tests, leaving more time to output new items not previously recalled, leading to the hypermnesia. While this is certainly a compelling point, in my unpublished study, I found hypermnesia using free recall tests which had no time limitations for the participants, so it would have been unlikely that their search was constrained by speed of recall alone.

Payne, Anastasi, Blackwell, and Wenger (1994) showed that hypermnesia for both pictures and words was blocked by intertest tasks of the same modality as the encoding material. For example, recall on a subsequent test was no different from recall on a preceding test for encoded images when participants engaged in a visuospatial task between tests, such as a picture-naming, and the same held for encoded words when the inter-test task was semantic, such as word fragment completion. However, hypermnesia does occur when the encoded material and the inter-test task are of different modalities. Shaw and Bekerian (1991) argue that an intertest task that is similar in modality to the encoded items would decrease the effectiveness of retrieval cues used on the delayed test. By performing an intertest task that is similar to the encoding phase, the search set is increasing, so delayed recall is less successful. Payne et al. (1994) similarly argued that the cognitive processes engaged during the intertest delay produce interference by altering context and by increasing the amount of information stored, decreasing successful retrieval of items. If it were just a matter of recall time, as Roediger and Thorpe (1978) argued, then modality match/mismatch shouldn't affect recall performance because the same retrieval practice would occur under both conditions. My unpublished experiment used Tetris, which is a visuo-spatial task, and successfully blocked hypermnesia. The experiments of this proposal will also utilize visuo-spatial inter-test tasks to block hypermnesia for encoded images.

Importantly, my prior study found conscious replay of the images during the intertest delay which does not appear to be intentional rehearsal, and that replay of the images is significantly decreased by performing a visuospatial task. The present series of studies are aimed at further investigating how conscious replay affects delayed recall performance and whether conscious replay can account for the pattern of results seen in both the hypermnesia and memory consolidation literatures.

CHAPTER TWO

EXPERIMENT 1

I attempted to generalize the results of my initial study using different encoding materials with a different delay filler task and to look at the association between replay and category clustering during recall. The new encoding materials were 36 images from four different categories. Processing relations between items within a list is beneficial for later recall (e.g., Mandler, 1967). Thus, when presented with a list of items from set categories (i.e., animals, vehicles, foods, and people), individuals will have greater recall test performance when the recalled items are more clustered by category, as measured by the adjusted ratio of clustering (ARC) score (Roenker, Thompson, & Brown, 1971). Elaborative, item-specific conscious replay during a delay may provide extra support for gains on a subsequent test by creating additional retrieval cues for each item or by strengthening items via retrieval, and simultaneously the replay may increase relational processing by leading to discovery of relations between items, as measured by ARC scores on recall tests, and prevent losses on a delayed test.

Experiment 1 investigates whether there is a relationship between conscious replay of the encoded items and category clustering on the delayed recall test and whether the differences in delayed recall in rest versus task-filled delays result from differences in relational processing between conditions, as well as explore how individual differences play a role. If there is an increase in clustering on the delayed versus immediate recall test following rest compared to following a task, and further if that clustering is related to conscious replay of items, then this would provide support for the hypothesis that conscious replay leads to further elaboration of the encoded items beyond what was done at initial encoding. Such a process could be viewed as a mechanism of memory consolidation.

Alternatively, it could be argued that the difference in memory performance between rest and task conditions found in my previous work is that the participants in the task condition are simply becoming fatigued by the delay task and are thus terminating their memory search on the delayed recall test more quickly than those in the rest condition. To test for this hypothesis, the experiment was modified to record free recall search exit latency, which is the span of time from the last item recalled until search is stopped as denoted by the participant as being done with the recall test (Dougherty & Harbison, 2007; Harbison, Davelaar, Dougherty, 2008).

Experiment 1 also addressed the question of whether there are individual differences in performance. Three individual difference measures were used, including the Cognitive Reflection Test (CRT) (Frederick, 2005), the Need For Cognition (NFCog) scale (Cacioppo & Petty, 1982), and the Need for Closure (NFCl) scale (Kruglanski, Webster, & Klem, 1993). The CRT was originally developed as a measure of cognitive reflection and decision-making ability. Individuals who score high on the CRT are engaging decision-making cognitive processes that are slower and more reflective, also called System 2 processes, and those that score low on the CRT are engaging processes to make faster decisions with less consideration, also called System 1 processes. While the CRT measures observed behavior on three problems, the NFCog scale is a self-report measure of how much one likes to think abstractly. Participants who are more reflective of their time in the experiment may be more likely to engage in conscious replay of the images and think about the experiment during resting, making context reinstatement at the time of the delayed test easier. The NFCl scale was designed to measure one’s preferences for giving any answer when faced with a decision versus the ambiguity and uncertainty of waiting to respond. The NFCl scale is similar, although scored inversely, to the CRT, in that a high score represents a preference to give quick answers when faced with a decision and a low score represents a tolerance for uncertainty in decision-making. The NFCl scale has been shown to correlate with free recall search exit latency (Harbison, Dougherty, Davelaar, & Fayyad, 2009), which is the amount of time elapsed from the last item recalled to the time the search is concluded by the participant.

I propose that clustering of images on recall tests will increase over the delay for the rest, but not task condition, due to conscious replay in the rest but not task condition. Second, I propose that CRT and NFCog will predict an increase in conscious replay over the delay in the rest condition. Third, I am investigating whether recall search exit latency on the delayed recall test will differ between the conditions.

CHAPTER THREE

METHODS – EXPERIMENT 1

Participants

Data was collected from 80 Florida State University undergraduates (50 females; mean age = 19.6, range 18-25, *SD* = 1.5). Participants were compensated with research credit towards coursework in a psychology course or $10 for one hour.

Procedure

Participants were presented with 36 neutral and positively-valenced images from the International Affective Picture System (Lang, Bradley, & Cuthbert, 1995) and an internet search. The 36 images were evenly distributed across four categories: animals, foods, people, and vehicles. Each image was presented for six seconds in a random order and following each image, participants were asked to rate the image for emotional arousal. The purpose of the rating was to increase memory retention for the subsequent recall tests.

Following the encoding phase, an immediate recall test was administered in which participants had no time restriction, and were instructed to let the experimenter know when they were finished recalling items. After the immediate recall test, there was a 10-minute delay during which half of the participants either rested in a recliner chair with their eyes closed and the lights dimmed and were instructed to speak aloud any thoughts that come to mind for the delay and the other half of the participants performed a clock task while speaking aloud any thoughts that come to mind. The clock task is a visuo-spatial task and was used in previous studies (e.g., Payne et al., 1994) to prevent hypermnesia for images and instead lead to a similar amount of recall over the delay (but see Mulligan, 2006). In the task, participants are presented with a digital time (e.g., 5:30) and are instructed to visualize a clock-face with the minute-hand and hour-hand at the appropriate locations for the presented time. They are instructed to visualize the hour-hand pointing directly at the hour for this task, and not at a fractional distance between two numbers on the clock (e.g., for the example 5:30, the hour hand would be on the 5 and not halfway between 5 and 6).Then, participants are instructed to count the number of minutes on the visualized clock face between the minute-hand and the hour-hand, always reporting the shortest distance between them (e.g., the solution to 5:30 would be 5, because there are 5 minutes between the minute-hand at 6 and the hour-hand at 5). The clock task was self-paced and participants had 10-minutes to complete as many of the clock task problems as they could. The clock task was expected to produce the same pattern of results as Tetris had, namely, prevent hypermnesia.

The delay was followed by a recall test identical to the immediate recall test. After the delayed test, participants were asked to rate to what extent they had expected to be retested on the images they had studied on a seven-point scale, with one indicating certain that there would not be another test, four indicating uncertain whether there would be another test, and seven indicating certain that there would be another test. Lastly, participants completed the CRT, NFCog, and NFCl.

CHAPTER FOUR

RESULTS – EXPERIMENT 1

Initial Analysis

Four participants were removed from analyses due to not following instructions during recall tests or the talk-aloud phase. Before proceeding to data analysis, it is important to note the nature of the clock task. The clock task was selected as the delay filler task due to its use in the past as a visuo-spatial task that blocks hypermnesia for images (e.g., Payne et al., 1994). However, early in data collection, I found that there are alternate strategies to complete the clock task which bypasses the visuo-spatial component. From the talk aloud protocols collected during the task, 33% of the task condition participants were solving the clock task problems using mathematical formulas, rather than a visuo-spatial manipulation of an imaginary clock face. In considering Payne et al.'s evidence of how delay tasks affect hypermnesia, I removed these participants from analysis and tested an additional 11 participants. Of those 11, one implemented a math strategy, resulting in a total of 35 participants in the task condition who appeared to be using the visual strategy as instructed.

Data analyses were conducted on 73 participants, with 38 participants in the rest condition and 35 in the clock task condition. Initial analyses found that three participants (one in the rest condition and two in the task condition) had recall test performance that was more than two standard deviations away from the mean (one above in the rest condition and two below in the task condition) and were removed from subsequent analyses.

Expectation Ratings

Following Dewar, Alber et al. (2012), participants who reported expectation of a delayed recall test were dropped from analyses. Ten participants (four in the rest condition and six in the task condition) reported an expectation rating of 5, 6, or 7, on a scale from 1, certainty that memory for the images would not be tested again, to 7, certainty that memory for the images would be tested again, where 4 indicated uncertainty that memory for the images would be tested again. These participants were excluded from further analysis because they indicated expectation of a delayed test, following the procedure of Dewar, Alber et al., due to the potential for different cognitive processes, such as deliberate rehearsal, being in play when expecting further testing.

Recall Test Performance and Conscious Replay

Recall performance is shown in Figure 1. A 2 X 2 ANOVA, with recall test (immediate, delayed) as a within-subjects factor and condition (rest, task) as a between-subjects factor on recall performance, showed a significant main effect of recall test, $F(1, 58) = 10.23$, $p < .01$, and no significant effect of condition, $F(1, 58) = 1.67$, $p = .20$. There was no significant interaction between recall test and condition on recall performance, $F(1, 58) = .60$, $p = .44$. A main effect of condition and an interaction between recall test and condition were predicted, as was found in the initial study, but were not found in the present experiment. Follow-up comparisons were

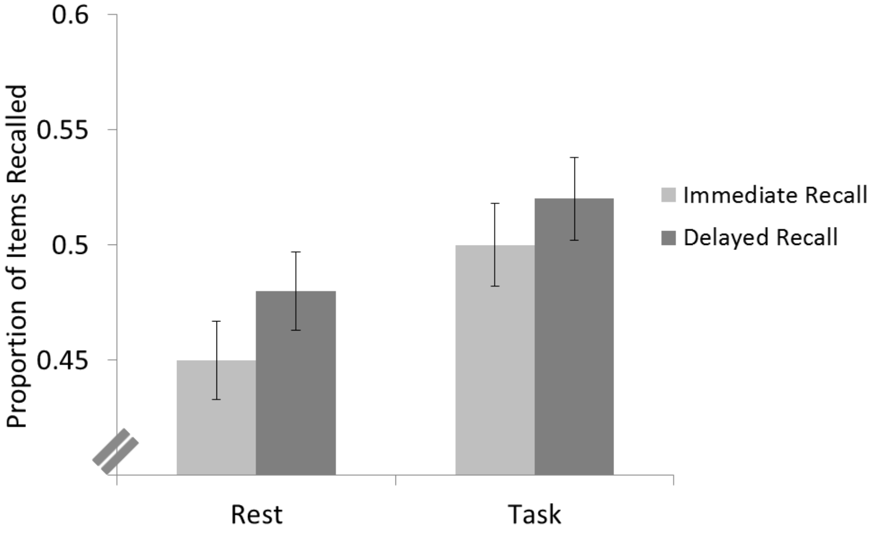

Figure 1. Images recalled in the rest and task conditions in Experiment 1 on the immediate versus delayed recall tests. Error bars represent standard errors.

images in the rest condition, $t(32) = -3.05$, $p < .01$, but not in the task condition, $t(26) = -1.58$, $p = .13$, which fits the predicted pattern of results.

The conscious replay of the images during the delay was quantified by counting the total number of unique image stimuli mentioned during the delay. Two raters coded separately and any discrepancies were resolved by a third rater. The conscious replay of the images during the delay period was significantly greater in the rest condition ($M = 8.4$, $SD = 6.7$) than the task condition ($M = .2$, $SD = .8$), $F(1, 58) = 41.04$, $p < .01$. Further, there was a significant positive linear relationship between delayed recall performance and amount of conscious replay of the images when controlling for immediate recall performance in the rest condition, $\beta = .23$, $t(32) = 2.77$, $p < .05$, but not in the task condition, $\beta = .08$, $t(26) = .80$, $p = .43$. The results from my previous work were replicated, showing that conscious replay of recently encoded information does occur during an intertest delay while resting and that replay could be contributing to the recall boost on the delayed recall test. In the clock task condition, replay is blocked, as is hypermnesia, when removing the participants who did not follow instructions on the clock task and those who reported expecting a delayed recall test.

Hypermnesia is a result of a combination of new items recalled on a delayed test that were not recalled on an immediate test, referred to as gains, and old items that were recalled on the immediate test that were not recalled on the delayed test, referred to as losses. Thus, in order to see a hypermnesic effect, gains must be greater than losses. The number of unique images replayed during the delay were positively related to the gains across the tests in the rest condition, $\beta = .37$, $t(32) = 2.20$, $p < .05$, but not in the task condition, $\beta = .01$, $t(26) = .06$, $p = .96$. There was no relationship between conscious replay and losses in the rest, $\beta = -.01$, $t(32) = -.64$, $p = .95$, nor task, $\beta = -.21$, $t(26) = -1.05$, $p = .30$, conditions. Thus, it appears that the contribution that replay was making to the hypermnesia in the rest condition was in the form of more gains rather than fewer losses across the delay period.

Clustering

As expected, there were no significant differences in ARC scores on the immediate recall test between the conditions, $t(58) = -.78$, $p = .44$. A 2 X 2 ANOVA, with recall test (immediate, delayed) as a within-subjects factor and condition (rest, task) as a between-subjects factor on ARC scores, showed a significant main effect of test, $F(1, 58) = 10.44$, $p < .01$, and no significant effect of condition, $F(1, 58) = 0.10$, $p = .92$. There was a marginally significant interaction between test and condition on ARC score, $F(1, 58) = 3.29$, $p = .08$. Follow-up comparisons by condition showed a significant increase in ARC score over the delay in the rest condition, $t(32) = -3.78$, $p < .01$, but not in the task condition, $t(26) = -.95$, $p = .35$, as predicted. Further, conscious replay predicted ARC scores on the delayed recall test in the rest condition, $\beta = .45$, $t(32) = 2.84$, $p < .01$. The relationship between replay and categorical clustering on the delayed test further supports that the replay may be leading to elaboration on the items during the delay that results in discovering new associations between category members.

Individual Differences

Three participants skipped one or more items on the individual difference measurements and their data for those scales were not included. There was no significant difference between conditions on scores on the CRT, $t(56) = -1.56$, $p = .13$, on NFCog, $t(57) = -1.71$, $p = .09$, nor on NFCl, $t(56) = .61$, $p = .55$.

Table 1 shows the Pearson correlations between CRT, NFCog, conscious replay, and gains and losses on the delayed recall test. It was predicted that CRT and NFCog would predict replay, though this was not supported. However, CRT did have a strong negative relationship with losses, such that those scoring higher on the CRT showed fewer losses.

Table 1. Correlations between replay, gains, and losses and CRT and Need for Cognition scores.

Rest		
	CRT	NFCog
Conscious Replay	-0.01	-0.02
Gains	-0.06	0.27
Losses	-0.46**	0.12
Task		
	CRT	NFCog
Conscious Replay	0.01	-0.03
Gains	0.29	0.10
Losses	-0.21	-0.07

** $p < .01$

Search Exit Latency

Contrary to the argument that a task could be leading participants to be more fatigued and thus less motivated to continue a recall search on the delayed test, there was no significant difference in delayed recall search exit latency, the time elapsed from the last item recalled until search is stopped, between conditions, $t(58) = 1.55$, $p = .13$, with 30.5 ($SD = 24.0$) seconds in the rest condition and 22.2 ($SD = 16.0$) seconds in the task condition. The present experiment replicated the finding that search exit latency is inversely related to NFCl on the immediate recall test, $\beta = -.34$, $t(57) = -2.73$, $p < .01$(Dougherty & Harbison, 2007). However, there was no relationship between NFCl and search exit latency on the delayed test in neither the rest, $\beta = -.20$, $t(31) = -1.14$, $p = .27$, nor task conditions, $\beta = -.07$, $t(25) = -.32$, $p = .75$.

CHAPTER FIVE

DISCUSSION – EXPERIMENT 1

The first aim of the present experiment was to replicate the results from my unpublished work with new encoding materials as well as a new filled-delay task. In the unpublished study, I found conscious replay during the inter-test delay and that more replay was found in the rest condition than the task condition. In the present study, hypermnesia was found only in the rest condition and not the clock task condition, which replicated the previous findings. However, several participants were dropped from the analysis due to expecting a second recall test to occur or not following instructions in the clock task. Due to this limitation, Experiment 2 will aim to conceptually replicate the pattern of results in Experiment 1.

In Experiment 1, participants exhibited more conscious replay in the rest condition than the task condition, and further, the amount of replay during the delay predicted hypermnesia in the rest condition. The conscious replay data are in accord with the observations of brain imaging studies that show reactivation of brain areas during rest as were active during encoding (e.g., Tambini et al., 2012) indicating that replay is occurring.

The hypermnesia found in the present study is lower than that found in the previous study which used non-categorized images for encoding. One possible explanation for why there was no significant effect of condition on recall performance over the delay is that the magnitude of the hypermnesia in the rest condition is diminished due to the increase in relational processing between the categorized items, because relational processing promotes fewer losses over multiple tests, while item-specific processing promotes gains (Burns, 1993; Klein, Loftus, Kihlstrom, & Aseron, 1989).

Beyond replicating previous results, the present experiment aimed to explore what factors are contributing to the hypermnesic effect in the rest condition. Experiment 1 investigated how clustering items into categories on the recall tests changes over the delay and how that clustering affects recall. As predicted, clustering of images on the recall tests increased across the delay in the rest condition but not in the task condition, and further, the clustering on the delayed test was related to the amount of conscious replay in the rest condition. These results support the idea that replay is leading to further elaboration of the encoded items beyond elaboration done at encoding. Elaborating on an item during the delay may lead to remindings of other related images that were encoded, increasing the formation of relations between items and thus clustering on the delayed test.

From the present results it appears that conscious replay facilitates discovering organization of the recently encoded materials, leading to more clustered output on the delayed test. It is possible that when replaying an image, a reminding of a related item is evoked, which may be an image that was not recalled on the immediate test, leading to a gain on the subsequent test. In the task condition, there were few replayed items, and those that were replayed may not evoke remindings of other items due to attentional demands of the task, and thus hypermnesia is not being seen in the task condition.

An alternate explanation of the memory boost being seen following rest but not following a task could be that participants in the task condition are fatigued from the task which would be reflected as shorter search exit latency on the delayed recall test than those in the rest condition. The search exit latencies were recorded for the immediate and delayed recall tests and there was no difference in search exit latency between conditions, so it seems unlikely that the task condition is becoming more fatigued by the task and thus truncating their recall on the delayed test.

Expectation of a delayed recall test was predictive of delayed recall performance in the task condition. In the post-experimental questionnaire, participants were asked to report to what extent they were expecting the second recall test to occur. The question was asked to be able to address concerns that participants were anticipating the delayed test and thus were intentionally rehearsing the images during the delay. However, there is indeed no relationship between expectation of the second test and amount of conscious replay during the delay, suggesting that conscious replay is not deliberate rehearsal.

One possible explanation for the results is the ease of maintaining study context during the delay and reinstating context during the second test differs between the conditions. Context-dependent memory has been well-established in the literature for both physical contexts (e.g., Godden & Baddeley, 1975) as well as mental context (e.g., Smith, 1979; Sahakyan & Kelley, 2002). In the rest condition, reflecting on the recent experience of studying the items and being tested on them, as evidenced by the amount of conscious replay, maintains the initial study context during the delay, which aids recall in the delayed test. However, in the task condition, participants replayed the images less and reflected less on the previous phases of the experiment, leading to less maintenance of the encoding context resulting in more difficulty in reinstating that context at the delayed recall test. Such effects would account for why participants who had been expecting another recall test showed more hypermnesia in the task condition, because they were able to reinstate the study context more easily than participants who thought they didn't need to remember those images any longer.

The clock task used in this experiment has been used in previous hypermnesia studies as well to mixed results. Payne et al. (1994) used the clock task as a visuo-spatial task in his experiment demonstrating a lack of hypermnesia on a delayed recall test for images following the clock task. However, Mulligan (2006) also implemented a clock task delay filler and found hypermnesia for images over the delay, which might be due to a subset of the participants performing the task mathematically, rather than visually.

The present experiment was able to assess strategies used during the clock task because concurrent verbal reports were being collected, and two main strategies became apparent. One was the visuo-spatial strategy that participants were instructed to use, involving mentally visualizing a clock face and manipulating the hands on the clock. But another strategy was also being used which involved no visuo-spatial component, but rather arithmetic. The mathematical strategy was to convert the hour presented (e.g., 5 for 5:30) and multiply it by 5, converting it to minutes. Then, one can subtract the minutes given (e.g., 30) from the hour in minute-units (e.g., 25) and take the absolute value to get the answer to the problem. Then, if the result is greater than 30, they would need to subtract 30 to get the shortest distance between the hands, as instructed.

The alternate strategy which by-passes the visuo-spatial component of the clock task may be the cause of conflicting data in the literature regarding how the clock task functions as an inter-test filler task. Because I was able to determine through verbal reports how the clock task was being performed, I was able to exclude participants who were openly using this alternate strategy. While it was fairly easy to discern if a participant was using a mathematical strategy when their arithmetic was correct, it became more difficult if their arithmetic or mathematical strategy was incorrect, because there were participants whose verbal reports consisted of a long series of numbers that may have been a non-visuospatial strategy. These participants were not excluded from analyses, since there was no direct evidence of using an alternate strategy. Based on Payne's work with matched and mismatched encoding to inter-test task modalities and the effect on resulting hypermnesia, it is possible that participants using the math strategy in the clock task contributed to the small memory boost seen in the task condition.

CHAPTER SIX

EXPERIMENT 2

Experiment 1 showed that conscious replay is related to hypermnesia, but how it affects delayed memory performance is still unclear. Replay may be promoting relational processing between the encoded information, as seen with an increase in clustering on the delayed recall test in the rest condition which relates to the amount of conscious replay, while there is no change in clustering performance over tests in the task condition. Additionally, CRT scores related to fewer losses across the delay, which has been shown to be a function of increased relational processing between encoded items (Burns, 1993; Klein, Loftus, Kihlstrom, & Aseron, 1989). Zaromb and Roediger (2010) found that repeated testing of a categorized list increases the number of categories recalled as well as the clustering of items into categories on the recall tests, suggesting that intertest replay may act as an additional test, contributing to the relational processing of the encoded material.

The purpose of Experiment 2 is to replicate Experiment 1 using a different task, because the clock task was not exclusively a visuo-spatial task. Additionally, in Experiment 2, I will further investigate the relationship between replay and relational processing. Hunt and Seta (1984) showed that an orienting task affects recall performance for a list of words that belong to set categories by influencing the type of encoding processing involved, and the type of processing will further depend on the number of members of each category. They found that rating the pleasantness of each word presented when categories were small promoted item-specific processing, while sorting words when categories were large promoted relational processing. Further, performing pleasantness ratings when categories were large and sorting words when categories were small promoted both item-specific and relational processing, which lead to superior performance than promoting only one type of processing. Hunt and Seta suggest that the category size impacts the encoding processes because if list items belong to large categories, then attention will be more easily directed to the shared features, while smaller categories would be less likely to engage the encoding of relational information, because the categorical relation would not be noticed, and instead would focus attention on individual item features.

In Experiment 1, participants were presented with large categories (nine members), leading to relational processing for both the rest and task conditions. However, participants also did an emotional response rating orienting task for each image, leading to item-specific processing as well, which when combined with relational processing resulting from a related list, promotes a higher level of recall than study of a list which promotes one type of encoding processing alone (Einstein & Hunt, 1980; Klein, et al., 1989). Because participants were already doing both item-specific and relational processing at encoding, there would be fewer relations to discover during the delay, which may explain the small amount of hypermnesia over the delay in the rest condition in Experiment 1. In the unpublished study, images did not belong to set categories, which Hunt and Seta depicted as a category size of one, promoting item-specific processing alone, providing an opportunity for replay to enhance memory more over the delay through discovery of categories in subjective organization and post-encoding relational processing.

In Experiment 2, participants will encode images that belong to small categories and uncategorized images. The non-category images are expected to undergo some subjective organization, which would be similar to consisting of small categories, thus both category and non-category images are expected to be encoded using primarily item-specific processing alone with an orienting task of pleasantness ratings. Without relational processing at encoding, I predict discovery of relations during the rest delay, leading to hypermnesia. I hypothesize that there will be hypermnesia in the rest condition, but not the task condition, and further, the rest condition will show more hypermnesia for the category images than the non-category images, because of the larger potential to find relations between the items. I predict that there will be no hypermnesia for either the category or non-category items in the task condition, because participants will not have the benefit of relational processing during the delay.

CHAPTER SEVEN

METHODS – EXPERIMENT 2

Participants

Data was collected from 52 Florida State University undergraduates (36 females; mean age = 19.6, range 18-24, *SD* = 1.4). Participants were compensated with research credit towards coursework in a psychology course or $10 for one hour.

Procedure

The procedure for Experiment 2 is similar to that of Experiment 1. Participants underwent an encoding phase, an immediate recall test, a 10-minute delay, a delayed recall test, and completed the CRT. During the delay, participants either rested as they did in Experiment 1, or they played a visuo-spatial game, Tetris, for ten minutes. Both conditions spoke aloud their thoughts during the delay. The main manipulation of interest in Experiment 2 was the encoding materials. The encoding materials consisted of two item types: categorized and non-categorized. Participants were presented with 18 images which belonged to six categories of three images each. Another 18 non-categorized images were presented as well and did not belong to a specific category with other images in the study.

Seventy-two images were used and consisted of 24 categories (e.g., musical instruments, nature, sports) with three images per category. Each participant was presented with one image from each of 18 categories and three images from each of the remaining six categories. The categories were evenly counterbalanced across participants to contribute either one or three images. Images that belonged to the same category appeared 8 ± 2 images apart from each other.

CHAPTER EIGHT

RESULTS – EXPERIMENT 2

Initial Analysis

Data analyses were conducted on 52 participants, with 26 participants in the rest condition and 26 in the Tetris condition. Initial analyses found that one participant (in the rest condition) had recall test performance that was more than two standard deviations above the mean and was removed from subsequent analyses.

Recall Test Performance and Conscious Replay

Recall performance is shown in Figure 2 for overall recall and Figure 3 for recall by item type. A 2 X 2 X 2 ANOVA, with recall test (immediate, delayed) as a within-subjects factor, item type (category, non-category) as a within-subjects factor, and condition (rest, task) as a between-subjects factor on recall performance, showed a significant main effect of recall test, *F*(1, 49) = 12.45, $p < .01$, and item-type, *F*(1, 49) = 35.92, $p < .01$, but no significant main effect

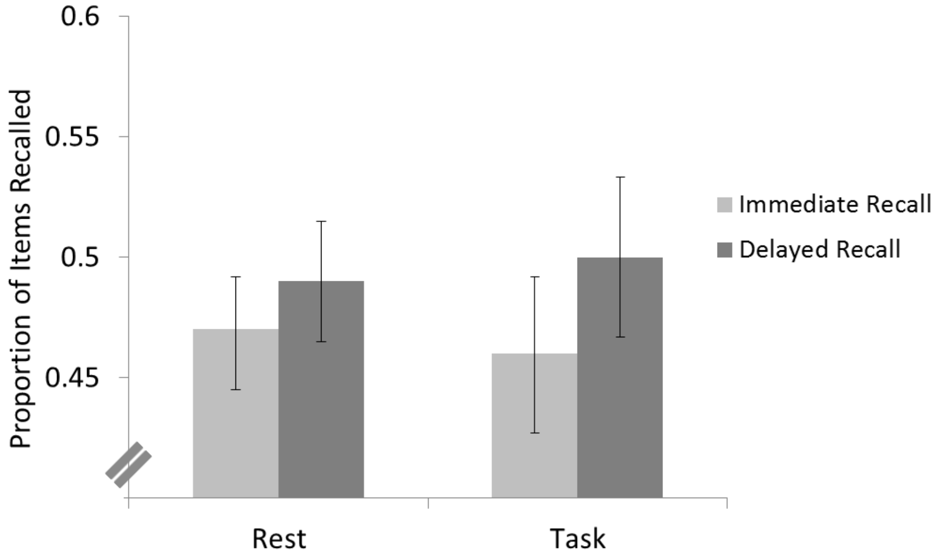

Figure 2. Proportion of images recalled for Experiment 2 between rest and task conditions on immediate and delayed recall tests. Error bars represent standard errors.

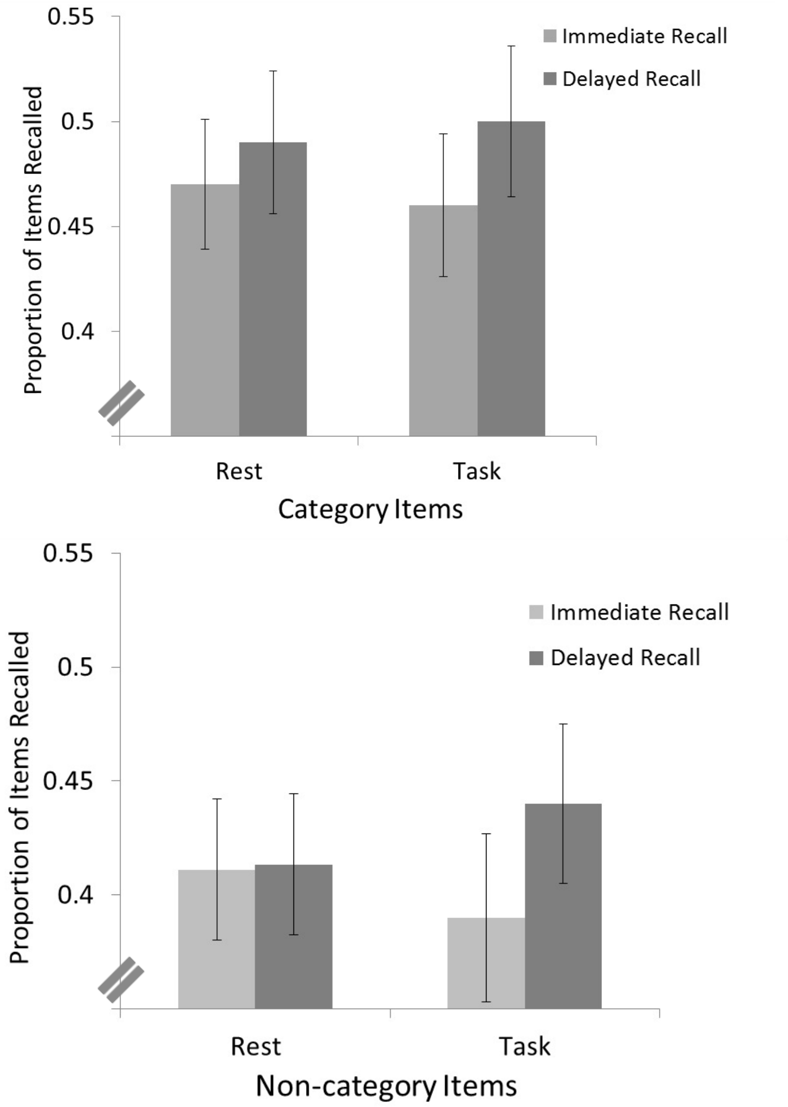

Figure 3. Proportion of images recalled in Experiment 2 for category and non-category images by condition. Error bars represent standard errors.

of condition, *F*(1, 49) < .01, *p* = .99. There was no significant two-way interaction between recall test and condition, *F*(1, 49) = 1.56, *p* = .22, nor an interaction between item type and condition, *F*(1, 49) = .01, *p* = .94. There was also no significant three-way interaction, *F*(1, 49) = 1.49, *p* = .23. Follow-up comparisons were conducted on the two conditions separately. A paired t-test revealed hypermnesia for the encoded images in the task condition, *t*(25) = -3.36, *p* < .01, but not in the rest condition, *t*(24) = -1.58, *p* = .13, which is the opposite of the predicted pattern of results. A paired t-test also revealed that there was a trend for hypermnesia for the category images in both the rest, *t*(24) = -2.03, *p* = .05, and task, *t*(25) = -1.82, *p* = .08, conditions. For non-category images, there was no hypermnesia in the rest condition, *t*(24) = -.13, *p* = .90, but significant hypermnesia in the task condition, *t*(25) = -2.80, *p* < .05.

The conscious replay of the images during the delay was coded with the same process as in Experiment 1. The conscious replay of the images during the delay period was significantly greater in the rest condition (*M* = 6.7, *SD* = 5.0) than the task condition (*M* = 1.6, *SD* = 3.0), *F*(1, 50) = 19.40, *p* < .01. Unlike in Experiment 1, there was no significant linear relationship between delayed recall performance and amount of conscious replay of the images when controlling for immediate recall performance in the rest condition, *β* = .01, *t*(24) = .06, *p* = .96, nor in the task condition, *β* = -.08, *t*(25) = -1.09, *p* = .23. Additionally, the conscious replay of the category images during the delay period was significantly greater in the rest condition (*M* = 3.8, *SD* = 3.8) than the task condition (*M* = .88, *SD* = 1.6), *F*(1, 50) = 13.71, *p* < .01. There was no significant linear relationship between delayed recall performance of the category images and amount of conscious replay of the category images when controlling for immediate recall performance of the category images in the rest condition, *β* = -.06, *t*(24) = -.57, *p* = .57, nor in the task condition, *β* = -.09, *t*(25) = -.89, *p* = .38. The conscious replay of the non-category images during the delay period was significantly greater in the rest condition (*M* = 3.8, *SD* = 2.0) than the task condition (*M* = .73, *SD* = 1.6), *F*(1, 50) = 17.53, *p* < .01. There was a significant linear relationship between delayed recall performance of the non-category images and amount of conscious replay of the non-category images when controlling for immediate recall performance of the non-category images in the rest condition, *β* = .22, *t*(24) = 1.16, *p* < .05, but not in the task condition, *β* = -.07, *t*(25) = -.75, *p* = .46.

The number of unique images replayed during the delay were not related to the gains across the tests in the rest condition, $\beta = .03$, $t(24) = .15$, $p = .88$, nor in the task condition, $\beta = .01$, $t(25) = .05$, $p = .96$. There was also no relationship between conscious replay and losses in the rest condition, $\beta = .02$, $t(24) = .07$, $p = .95$, though there was a significant positive relationship in the task condition, $\beta = .48$, $t(25) = 2.68$, $p < .05$.

Clustering

Due to the mix of category and non-category images in the free recall tests, the ARC scores were calculated differently than in Experiment 1 which followed Roenker, Thompson, and Brown (1971). To calculate the ARC scores, the non-category items were dropped from the recall sequence, so that the score is based solely on the sequence of items belonging to the categories. The change in calculation is further discussed in the Discussion section below.

Figure 4 depicts the ARC scores by condition. As expected, there were no significant differences in ARC scores on the immediate recall test between the conditions, $t(49) = .80$, $p = .43$. A 2 X 2 ANOVA, with recall test (immediate, delayed) as a within-subjects factor and

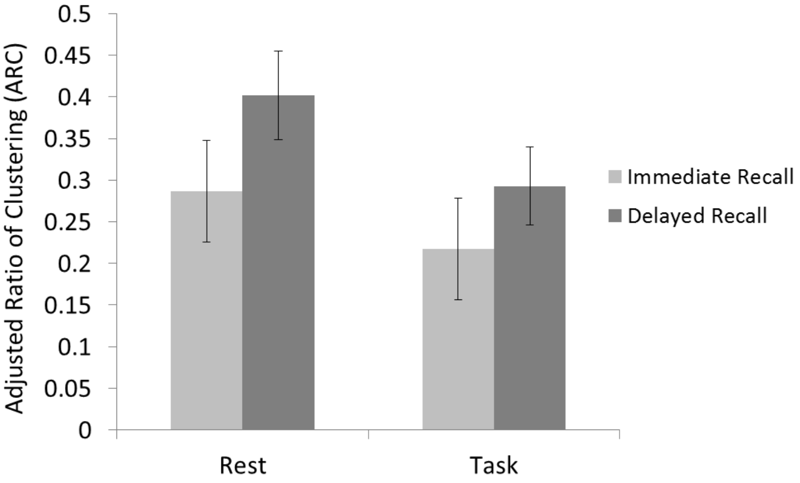

Figure 4. Adjusted Ratio of Clustering (ARC) scores in Experiment 2 for the immediate and delayed recall tests by condition. Error bars represent standard errors.

condition (rest, task) as a between-subjects factor on ARC scores, showed a marginally significant main effect of test, *F*(1, 49) = 3.69, *p* = .06, and no significant effect of condition, *F*(1, 49) = 2.11, *p* = .15. There was no interaction between test and condition on ARC score, *F*(1, 49) = .16, *p* = .69. Follow-up comparisons by condition showed no significant increase in ARC score over the delay in the rest condition, *t*(24) = -1.58, *p* = .13, nor in the task condition, *t*(25) = -1.12, *p* = .27. Conscious replay did not predict ARC scores on the delayed recall test controlling for ARC on the immediate recall test in the rest condition, β = -.24, *t*(24) = -1.15, *p* = .26, as it had in Experiment 1.

Due to the adjustment in calculating ARC scores, the number of categories recalled and the average number of items recalled per recalled category were also assessed for additional insight (figure). A 2 X 2 ANOVA, with recall test (immediate, delayed) as a within-subjects factor and condition (rest, task) as a between-subjects factor on number of categories, showed a marginally significant main effect of test, *F*(1, 49) = 3.72, *p* = .06, and no significant effect of condition, *F*(1, 49) = .57, *p* = .45. There was no interaction between test and condition on the number of items recalled per recalled category, *F*(1, 49) = .46, *p* = .50.

Table 2. Number of categories recalled (out of six) and number of items recalled per recalled category (out of three) by condition for the immediate and delayed recall tests (with *SDs*).

Categories Recalled		
	Test 1	Test 2
Rest	5.12 (.97)	5.36 (.81)
Task	5.00 (.94)	5.12 (.95)
Items Recalled Per Recalled Category		
	Test 1	Test 2
Rest	1.85 (.34)	1.90 (.40)
Task	1.92 (.47)	1.99 (.47)

A 2 X 2 ANOVA, with recall test (immediate, delayed) as a within-subjects factor and condition (rest, task) as a between-subjects factor on number of items recalled per recalled category, showed a marginally significant main effect of test, *F*(1, 49) = 2.90, *p* = .10, and no significant effect of condition, *F*(1, 49) = .44, *p* = .51. There was no interaction between test and condition on the number of items recalled per recalled category, *F*(1, 49) = .09, *p* = .76.

CHAPTER NINE

DISCUSSION – EXPERIMENT 2

The hypotheses for Experiment 2 were not supported. It was predicted that presenting images that belong to either small categories or non-category images would lead to a large boost in hypermnesia in the rest condition, but no hypermnesia in the task condition. However, there was no hypermnesia in the rest condition and a small amount of hypermnesia in the task condition, driven by small hypermnesia for the non-category images. Further, the relationship between hypermnesia and conscious replay in the rest condition that was found in Experiment 1 with large category members was not found in Experiment 2 for the small category members as was predicted, though it was found for the non-category images.

While the hypotheses for Experiment 2 were not supported, the results present new areas of exploration. The results of Experiment 1 suggested that the small amount of hypermnesia in the rest condition may be due to participants discovering relations between items in the list immediately during encoding, so that minimal additional relational processing was accomplished during the delay, leading to a smaller boost in hypermnesia than previously seen with emotionally valenced, non-category images. Experiment 2 was meant to manipulate the processing strategy used during encoding, so that less relational processing would occur at encoding, providing more opportunity to discover relations during the delay (see Hunt & Seta, 1984). However, the lack of a large boost in hypermnesia in the rest condition may be due to a mix of encoding strategy, with some participants noticing the relations between category items while others did not, rather than a general decrease in formation of relations. Such a split in strategy during encoding would lead to those noticing the category memberships engaging in relational processing so that they appear more like the participants in Experiment 1, with small hypermnesia for category images in the rest condition, and those not noticing the relations engaging more in item-specific processing, and thus leading to less searching for and discovery of relations among the items.

Additionally, conscious replay of images is a measure of the amount of thoughts about the images, rather than indicative of a specific strategy. If participants are engaging in further relational processing during the delay, then they would be expected to be reflecting on mainly the category items, while those engaging in item-specific processing during the delay would be expected to reflect on both the category and non-category items. The mix of type of processing during the delay can account for the lack of relationship between the amount of replay of category items and hypermnesia in the rest condition for the category images in Experiment 2 while Experiment 1 had a positive relationship, due to the differential effects of item-specific and relational processing on hypermnesia for category items (see Otani & Hodge, 1991). It would also account for the significant relationship between replay of non-category items and hypermnesia for non-category items, because the replay includes primarily participants engaging in item-specific processing.

The unexpected hypermnesia in the task condition presents a conflict with the literature. As presented earlier, Payne et al. (1994) and Shaw and Bekerian (1991) have found that hypermnesia for images is blocked by a visuo-spatial intertest task. In light of the results of the present experiment, this does not appear to be case with the present materials. In a similar experiment in my previous work, Tetris was a task that successfully blocked hypermnesia for emotionally valenced, non-category images, though in Experiment 2, Tetris did not block hypermnesia for images that included category members. Payne et al. (1994) previously argued that the intensity of the task is not important for blocking hypermnesia, but rather the modality.

However, from the results of Experiments 1 and 2, it appears that cognitive resources devoted to the task may be a factor in determining hypermnesia. In Experiment 1, the clock task was a task with high cognitive demands during which conscious replay was mostly precluded, while during Tetris, the task is less demanding and the results from Experiment 1show a larger amount of replay during Tetris than was seen during the clock task in Experiment 2.

From the results of Experiment 2, it appears that a visuo-spatial task does not necessarily block hypermnesia for images, contrary to prior findings. Additionally, resting following encoding is not leading to a large boost in memory for images that belong to categories (either large or small) as was found in my prior work with emotionally-valenced, non-category images.

CHAPTER TEN

GENERAL DISCUSSION

The present set of experiments was aimed at exploring the role of conscious replay during wakeful rest. Previous research into consolidation has reported that conscious rehearsal of the recently encoded information does not occur during wakeful rest as evidenced by retrospective reports. However, using concurrent verbal protocols, Experiment 1 showed that conscious replay occurs during wakeful rest and plays an important role in the memory boost seen following the delay. Additionally, Experiment 1 provides evidence that replay promotes relational processing. Experiment 2 aimed to extend the results of Experiment 1 by replicating the results with a task that must be completed visuo-spatially, unlike the clock task which can be completed mathematically and circumvent the visuo-spatial component, and to investigate whether replay will focus on category images or will also reflect elaborative thoughts of non-category images.

Contrary to expectation, the results of Experiment 2 did not complement those of Experiment 1. It is possible that whether participants noticed the categories in Experiment 2 or not caused a split in type of processing which lead to an averaging of differential performance on the recall tests by participants who engaged in either relational or item-specific processing. This issue could be addressed by modifying the experimental design to having two different item type conditions and observing recall between subjects, rather than within, when encoding either category or non-category images. By having the two item types be manipulated within subjects, it is difficult to accurately assess clustering on the recall tests for the category items, and the change in clustering could provide a good measure of whether participants are engaging in more or less relational processing between tests, as was seen in Experiment 1.

While there are methodological changes that can result in improvements in data analysis, the task condition results from Experiments 1 and 2 provide interesting insight regarding the mechanism of an intertest task in blocking hypermnesia. A possible explanation for the hypermnesia seen in the task condition in both experiments is that finding relations between items does not require visualizing the images. Determining category membership may rely more on semantic information than visual information, thus a lower intensity visuo-spatial task, such as Tetris, may allow for thoughts of semantic relations between items, such as reflecting on how two items were both modes of transportation.

Several findings of interest were uncovered in this series of experiments. First, and of particular importance, is that there is conscious replay of recently encoded information during an intertest wakeful rest period, contrary to conclusions in previous research which used retrospective reports, rather than concurrent protocols (Dewar, Alber, et al., 2012; Tambini et al., 2010). Second, Experiment 1 replicated the relationship between intertest conscious replay and hypermnesia during wakeful rest that was found in my previous unpublished study, and extended that finding to show a relationship between semantic clustering, as measured by ARC, and the amount of conscious replay, suggesting that replay may be promoting relational processing of recently encoded information. Third, hypermnesia appears to be quite low when the encoded materials are category members, as compared to the memory boost seen in my previous work with emotionally-valenced, non-category images. The results of Experiments 1 and 2 are inconclusive as to why this is the case, though there appears to be support that category members do not benefit from the wakeful rest delay as much as non-category members due to an immediate discovery of the relations between images at encoding, leading to little benefit from the additional relational processing provided by the delay. And finally, hypermnesia for images can be found when using a visuo-spatial intertest task under certain circumstances. As discussed above, this may be due to the semantic nature of the relationships between items, leading to semantic processing of the images during the delay which would not be affected by a visuo-spatial task, as reported by Payne et al. (1994).

This series of experiments underscores the importance of further investigation of the hypermnesic effect. The mechanism of hypermnesia and its relationship to memory consolidation is still yet to be understood, though the present experiments provide a direction for exploration.

APPENDIX A

IRB APPROVAL MEMO

The Florida State University
Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
(850) 644-8673 · FAX (850) 644-4392

APPROVAL MEMORANDUM

Date: 1/30/2015

To: Jane Komsky

Address: Florida State University Department of Psychology, 1107 W. Call Street Tallahassee, FL 32306-4301
Dept.: PSYCHOLOGY DEPARTMENT

From: Thomas L. Jacobson, Chair

Re: Use of Human Subjects in Research
Remembering and Forgetting 2

The application that you submitted to this office in regard to the use of human subjects in the proposal referenced above have been reviewed by the Secretary, the Chair, and one member of the Human Subjects Committee. Your project is determined to be Expedited per per 45 CFR § 46.110(7) and has been approved by an expedited review process.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals, which may be required.

If you submitted a proposed consent form with your application, the approved stamped consent form is attached to this approval notice. Only the stamped version of the consent form may be used in recruiting research subjects.

If the project has not been completed by 1/29/2016 you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the Committee.

You are advised that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report, in writing any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the Chair of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should reviewprotocols as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Human Research Protection. The Assurance Number is FWA00000168/IRB number IRB00000446.

Cc: Colleen Kelley, Advisor
HSC No. 2015.14567

APPENDIX B

SAMPLE CONSENT FORM

FSU Human Subjects Committee approved on 1/30/2015. Void after 1/29/2016. HSC # 2015.14567

I freely and voluntarily consent to be a participant in the research project entitled “Remembering and Forgetting.” This project is being conducted by Jane Komsky, a doctoral student in Psychology, and Dr. Colleen M. Kelley, who is a faculty member in the Department of Psychology at Florida State University.

Procedures

The purpose of this research is to better understand the process of memory consolidation.
In this experiment, I will read short stories, rate pictures of faces and objects or faces, or view photographs and describe them, and then be tested on my ability to recall this material. Some of the photographs that you may view are emotionally relevant, such as images of threatening animals and mutilated bodies. Additionally, I may be asked to compare similar photographs and detect the differences between them or play the game, Tetris. I may be asked to rest for a period of time during which I would talk aloud any thoughts that come to mind and/or press a button when having certain thoughts. I will answer two short questionnaires about my behavior and preferences. This experiment will last approximately 60 minutes.

Risks

The study has few potential risks beyond those encountered in everyday life using computers, memory, and attention. I may experience some frustration during the memory recall tests and some embarrassment if having my voice tape recorded. Additionally, I may be shown images of a disturbing nature that may pose minor psychological stress. You are free to stop participating at any time.

Confidentiality

My responses will be recorded by a computer onto a data file which will be associated with a unique number code, but there will be no link between this code and my identity. I understand this experiment may require my voice and speech to be recorded, and the experimenters have taken steps to ensure confidentiality, including identifying the recordings by a unique code which is not linked to my identity, keeping the recordings secure in the Kelley memory lab suite, and transcribing the recordings to text so that the audio files may be deleted within one year. The transcriptions will be de-identified and will be kept for 10 years, until July 2022.

Compensation

I will be compensated with research credit for General Psychology or extra-credit in another psychology course whose instructor provides this option. Credits are earned at the rate of ½ credit for every half hour of participation, for a total of 1 credit for a 1-hour experiment. Additionally, I may also benefit from learning about memory consolidation. Alternately, I may be offered monetary compensation, at a rate of $5.00 per half-hour for a total of $10.00 for a 1-hour experiment, instead of class credit.

Voluntary Participation

My consent may be withdrawn at any time without prejudice, penalty, or loss of benefits to which I am otherwise entitled (i.e., I will receive full payment or credit for the time I have participated).

Contact Information

If I had any questions about this consent form, I asked them, and they were answered to my satisfaction. I may contact Dr. Colleen M. Kelley, *****@***********, or Jane Komsky, *****@***********, for answers to questions about this research.

If I have questions about my rights as a subject/participant in this research, or if I feel that I have been placed at risk, I can contact the Chair of the Human Subjects Committee, Institutional Review Board, through the Office of the Vice President for Research at 850-644-8633.

Statement of Consent

I have read and understand this consent form, and I am 18 years or older.

(Participant Signature)	(Print Name)	(Date)

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BIOGRAPHICAL SKETCH

Jane C. Komsky is a graduate student in cognitive psychology at Florida State University. She received a bachelor's degree in psychology and applied biology from the Georgia Institute of Technology in 2009, as well as a master's degree in bioinformatics in 2011, and she is currently receiving a master's degree in cognitive psychology from Florida State University. Jane currently works with Dr. Colleen Kelley, focusing her research on memory consolidation and in particular the role that involuntary memories of recently learned information play in long-term recall. She is also studying how being reminded of previously learned material during study of related material affects later recall. Jane has experience working in human factors engineering for both younger and older adults with accessibility issues stemming from cognitive impairments, such as traumatic brain injury, Alzheimer's Disease and Parkinson's Disease. She has worked closely with continuing care retirement communities (CCRCs) and assisted living facilities to promote healthy aging for older adult residents through better design.