SELF-IMAGINING, RECOGNITION MEMORY, AND PROSPECTIVE MEMORY IN MEMORY-IMPAIRED INDIVIDUALS WITH NEUROLOGICAL DAMAGE

By

Matthew D. Grilli

A Master's Thesis Submitted to the Faculty of the

DEPARTMENT OF PSYCHOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

MASTERS OF ARTS

In the Graduate College

THE UNIVERSITY OF ARIZONA

2009

STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the department or the Dean of the Graduate College when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: _______Matthew D. Grilli______________

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

______________________________ ________________________

Dr. Elizabeth Glisky
Professor of Psychology

Date

TABLE OF CONTENTS

TABLE OF CONTENTS – *CONTINUED*

TABLE OF CONTENTS – *CONTINUED*

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES – *CONTINUED*

ABSTRACT

The present project investigated the reliability and robustness of a new mnemonic strategy – “self-imagination” – in a group of memory-impaired individuals with neurological damage. Despite severe memory deficits, almost all of the participants demonstrated a “self-imagination effect” (SIE) for recognition memory in study 1. Moreover, the ability to benefit from self-imagination was not affected by the severity of the memory deficit. In study 3, more than half of the participants showed a SIE on a task of event-based prospective memory. The data from study 2 suggest the SIE is not attributable to semantic processing or emotional processing and indicate that self-imagination is distinct from other mnemonic strategies. Overall the findings from the present studies implicate self-imagination as a new and effective mnemonic strategy. The data also indicate that when it comes to memory there is something special about processing information in relation to the self.

BACKGROUND

Self-referential processing enhances memory to a greater degree than semantic processing, a phenomenon known as the "self-reference effect" (SRE) (Rogers, Kuiper & Kirker, 1977; Kuiper & Rogers, 1979; Bellezza, 1984; Maki & McCaul, 1985; for a review, see Symons & Johnson, 1997). In a typical test of the SRE participants are instructed to encode material using one of several different orienting tasks. For example, participants might be instructed to judge a series of trait adjectives according to structural format (*e.g.* "Is the word written in capital letters?"), semantic meaning (*e.g.* "Is the dictionary definition of this word positive?"), and self-relevance (*e.g.* "How well does this word describe you?"). In paradigms of this sort it is repeatedly shown that participants are more likely to recall and recognize material encoded with self-referential processing than they are material encoded with semantic or structural processing, hence the SRE. The SRE is very reliable and robust as it is found in multiple domains, modalities, and conditions (Symons & Johnson, 1997).

A great deal of research attempts to explain the mechanism of the SRE. Rogers, Kuiper, and Kirker (1977) originally posited that the self possesses special mnemonic qualities. According to Rogers *et al*. (1977) the self serves as a "superordinate schema" that permits access to unique encoding and retrieval mechanisms. A different interpretation is that the SRE is attributable to a deep level of processing, and not special mechanisms of the self, per se (Klein & Loftus, 1988; Klein & Kihlstrom, 1986). According to this view, processing information self-referentially evokes an extensive amount of elaboration and organization. Therefore, an encoding strategy that matches the elaborative and organizational qualities of self-referential processing will presumably generate an equivalent mnemonic advantage. For instance, processing information in relation to an intimate other person is found to produce a mnemonic benefit similar or equal to self-referential processing (*i.e*. “other-reference effect” or ORE) (Lord, 1980; Lord, 1987; Klein & Kihlstrom, 1986).

More recently, functional neuroimaging research has provided insight into the cognitive and neural correlates of self-referential processing. A number of studies show the neural correlates of self-referential processing are related to cortical midline structures, particularly the medial prefrontal cortex and precuneus (Summerfield, Hassabis, & Maguire, 2008; Shacter, Addis, & Buckner, 2008; Northoff *et al.*, 2006; Amodio & Frith, 2006; Gillihan & Farah, 2005). The cortical midline recruitment pattern is found in a variety of cognitive tasks thought to rely on self-referential processing such as judging trait adjectives (Johnson *et al.*, 2002), introspecting (Gusnard *et al.*, 2001), imagining the future (Summerfield *et al.*, 2008), taking a different perspective (D’Argembeau *et al.*, 2007), and retrieving autobiographical memories (Cabeza & St. Jacques, 2007). Critically, cortical midline structures are not exclusively related to self-referential processing as these regions are also implicated in other person processing. This has led some to contend that the pattern of cortical activation is better characterized as a representation of person or social processing (Gillihan & Farah, 2005). Therefore, while informative, the functional neuroimaging research does not elucidate whether self-referential processing is related to special memory mechanisms or the mechanisms responsible for semantic elaboration and organization. In contrast to the large amount of research focused on explaining the mechanism of the SRE, very little research asks who may benefit from self-referential processing.

I. THE SRE AND MEMORY IMPAIRED INDIVIDUALS

Surprisingly, few studies test the SRE in individuals who are in particular need of memory enhancement such as persons with declining and deficient memory. In fact, nearly all demonstrations of the SRE are made in healthy, young adults (Symons & Johnson, 1997). A few studies have investigated the SRE in older adults (Mueller, Wonderlich, & Dugan, 1986; Gutchess, Kensinger, & Schacter, 2007; Glisky & Marquine, 2009), a population that can be broadly characterized as experiencing a certain degree of memory decline. These studies have found that older adults show a SRE for the recall of trait adjectives (Mueller *et al.*, 1986; Gutchess *et al.*, 2007), the SRE is sustained well into advanced age (75+ years old) (Glisky & Marquine, 2009), and the SRE is found even in older adults with lower than average memory functioning as determined by neuropsychological assessment (Glisky & Marquine, 2009).

In an effort to find new ways to improve memory functioning in individuals with brain damage, Marquine and Glisky (2005) tested the SRE in a group of individuals with neurological damage of various etiologies. Each individual in the study was experiencing a memory deficit which was defined as at least a 1 standard deviation difference between their pre-morbid intelligence quotient (IQ) and their general memory index (GMI) from the Wechsler Memory Scale (WMS-III) (Wechsler, 1997). The individuals with neurological damage and a group of healthy, age-matched controls were instructed to judge trait adjectives according to their structural features, semantic meaning, and self-relevance. The memory-impaired individuals demonstrated a SRE (corrected recognition of traits encoded with self-referential processing minus corrected recognition of traits encoded with semantic processing) of similar magnitude to the healthy controls on a recognition memory test of the trait adjectives. In a follow-up study, Marquine (2008) replicated the SRE in memory-impaired individuals using a more difficult cued-recall task. Therefore there is evidence, albeit preliminary, implicating self-referential processing as a powerful encoding strategy for individuals with neurological damage.

II. EMOTIONAL PROCESSING AND MEMORY-IMPAIRED INDIVIDUALS

In addition to investigating the consistency of the SRE, Marquine (2008) was further interested in exploring the effect of emotion on memory. There is extensive evidence to show emotion enhances memory (Kensinger, Garoff-Eaton, & Schacter, 2007; Kensinger, 2004; Maratos & Rugg, 2001; Davidson, McFarland, & Glisky, 2006), a phenomenon that may be referred to as the “emotional enhancement effect” (EEE), and a number of studies show that memory-impaired individuals benefit mnemonically from emotion (Burton, *et al.*, 2004; Frank & Tomaz, 2003; Hamman, Cahill, McGaugh, & Squire, 1997; Hamman, Cahill, & Squire, 1997; Phelps, LaBar, & Spencer, 1997). In an incidental encoding task of negatively and neutrally valenced sentences, Marquine (2008) tested the effect of emotion on memory in individuals with neurological damage. Two findings from this study are worth noting. First, emotion improved memory as the memory-impaired individuals remembered a higher proportion of sentences describing emotional events than sentences describing neutral or non-emotional events. The findings show emotion enhances memory in individuals with neurological damage of various etiologies and may be a viable method for rehabilitating memory in memory-impaired individuals. Second, there was suggestive evidence that emotional processing was related to self-referential processing. In the patient group, the SRE and EEE were correlated although non-significantly ($r = .30$). Marquine (2008) postulated that it may be that self-referential processing is inherently emotional and that the SRE may be partly attributable to emotional enhancement effects.

STUDY 1

I. INTRODUCTION

The principal aim of study 1 was to investigate further the consistency and robustness of the SRE in individuals with brain damage using a different method for testing self-referential processing, *i.e.* imagination. Imagining oneself at the scene of an elaborate event is thought to evoke numerous cognitive processes including self-referential processing (Schacter, Addis, & Buckner, 2008; Hassabis, Kumaran, & Maguire, 2007; Spzunar *et al.*, 2007; Summerfield *et al.*, 2008). For example, if asked to imagine a child playing on the gymnasium at the park, one will presumably construct the spatial context of a park, project the self into the context, and envisage a child engaged in an activity on the gymnasium. Imagining oneself at this event will likely recruit cognitive processes such as visual imagery (Rubin *et al.*, 2003) and spatial imagery (Hassabis, Kumaran, & Maguire, 2007) to construct the park scene, semantic and autobiographical retrieval to create details consistent with a park scene (Wheeler *et al.*, 1997), and self-referential processing to project the self into the scene and imagine the episode unfold (Buckner & Carroll, 2007; Abraham, von Cramon, & Schubotz, 2008). In order to imagine such an event the imaginer must integrate multimodal details into a cohesive, vivid episode (Hassabis *et al.*, 2007) and process the scene self-referentially. In study 1 we tested the mnemonic utility of what we refer to as “self-imagining,” or the imagining of an elaborative event from a realistic, self-relevant perspective.

There is extensive evidence to show that visual imagery is an effective encoding strategy for remembering a wide range of materials (Glisky & Glisky, 2008). Visual imagery requires mentally visualizing the to-be-remembered material and connecting the image of that material to an appropriate retrieval cue such as a spatial location (*i.e.* Method of Loci), a keyword (*i.e.* peg-word method), or a distinguishing characteristic (*i.e.* simple imagery or for the learning of name-face associations). According to A.R. Luria, the famous mnemonist “S” used imagery to aid in memorizing and recalling material (Luria, 1968). As Luria described it “When S. read through a long series of words, each word would elicit a graphic image […] He would distribute [the images] along some roadway or street he visualized in his mind. Sometimes this was a street in his home town.” (p. 32). When Luria would later ask S. to recall the word list, S. would mentally “stroll” down the street, recalling words as he passed by them. The mnemonic benefit of visual imagery is reported in numerous populations including individuals with neurological damage (Manesse, Hux, & Snell, 2005; Thone & Glisky, 1995; Twum, 1994) and in some instances is shown to be superior to other encoding strategies such as rote rehearsal (Wilson & Kapur, 2008; Wilson, 1987).

The majority of studies on the role of self-referential processing in imagery compare self to other person processing with imagery (Lord, 1980; Lord, 1987; Brown, Keenan, & Potts, 1986; Aron *et al*., 1991; Foley *et al.*, 1999; Czienskowski & Giljohann, 2002). In the initial study designed to test the SRE with imagery Lord (1980) instructed participants to imagine either the self interacting with an object from an outside of the body vantage point (*i.e.* observer or third person perspective) or a different person interacting with an object (*i.e.* Walter Cronkite). Lord (1980) predicted that individuals would not benefit as much from self imagery since it is not typical to view the self from an observer perspective. In agreement with his prediction, Lord (1980) found a reversal of the SRE as evidenced by better memory for items encoded with other person imagery than self imagery. Data from subsequent research are mixed as some studies replicate Lord's findings (Aron *et a.l*, 1991; Czienskowski & Giljohann, 2002) and others do find a SRE with imagery (Brown, Keenan, & Potts, 1986; Foley *et al.*, 1999). It is important to note that the SRE may be attenuated in the early experiments of self and other imagery for a couple of reasons. First, Lord (1980) and related studies instructed participants to envisage the self from an observer perspective, a manipulation that reduces the phenomenology of imagery (Piolino *et al.*, 2006; Robinson & Swanson, 1993) and likely affects the realistic nature of the experience. Second, Foley *et al.* (1999) found that individuals spontaneously process other-person imagery in relation to the self. It may therefore be very difficult to separate self-referential processing from other person imagery, and benefits may depend on instructions, namely whether one imagines oneself in the event (i.e., observer perspective) or imagines the event through one's own eyes (i.e., field perspective).

Imagining may also be impaired in some individuals with neurological damage, particularly those individuals exhibiting very severe memory deficits. Neuropsychology, patient studies, and now neuroimaging findings converge on the conclusion that imagination involves regions of the brain that are implicated in the memory network. Studies of amnesic patients provided an early indication that self-imagination might rely on the same brain regions as episodic memory. Endel Tulving described the amnesic patient K.C. as incapable of remembering his past or imagining his future (Rosenbaum *et* *al.*, 2005; Tulving 1985). Similar deficits in memory and imagination are mentioned in patients with Korsakoff's amnesia (Talland, 1965), a patient with amnesia due to anoxic injury (Klein, Loftus, & Kihlstrom, 2002) and in a group of amnesic patients with isolated damage to the hippocampus (Hassabis, Kumaran, Vann, & Maguire, 2007). If individuals with severe memory deficits are impaired in self-imagination, it may be reasonable to predict that they will not benefit from self-referential processing with self-imagination. However, studies from our laboratory suggest that patients with severe memory deficits can benefit from self-referential processing. So it may be that some memory-impaired individuals can benefit from self-imagining, although perhaps to a lesser degree than individuals who are not experiencing memory deficits.

Study 1 tested the mnemonic effect of self-imagining in memory-impaired individuals with neurological damage. This study was also designed to explore further the relation of emotional processing to memory and to the SRE using the self-imagining paradigm. Our hypotheses were: 1) Memory-impaired individuals with neurological damage would benefit from self-imagining, 2) emotional material would be better remembered than non-emotional material, and 3) the memory enhancement effects in these two conditions would be correlated.

II. METHOD

A. Participants

Fourteen individuals with neurological damage of mixed etiology (11 TBI) participated in the study. Individuals were recruited from the pool of participants in our laboratory and from acquired brain injury support-groups in the community. Memory impairment was designated as a 1 standard deviation difference (*i.e.* 15 points) between pre-morbid intelligence measured with the North American Adult Reading Test (NAART) (Spreen & Strauss, 1998) and memory functioning measured with the general memory index from the Wechsler Memory Scale III (WMS-III) (Wechsler, 1997). To be included in the experiment participants had to have been at least one year removed from injury. Table 1 shows the etiology, estimated pre-morbid IQ, general memory index (GMI), and the size of the memory impairment (*i.e.* IQ-GMI) for each participant. As can be seen, the majority of participants (n = 10) have a fairly severe memory disorder, with a GMI 30 or more points lower than the IQ.

Table 1. Participant Descriptive Characteristics

Patient	Etiology	IQ	GMI	IQ - GMI
PAT004	TBI	125	96	29
PAT012	TBI	125	110	15
PAT015	TBI	101	54	47
PAT016	Aneurysm	127	81	46
PAT023	TBI	110	98	20
PAT027	Anoxia	104	70	34
PAT054	TBI	122	92	30
PAT056	TBI	104	69	35
PAT058	TBI	102	63	39
PAT059	TBI	107	70	37
PAT060	TBI	115	73	42
PAT061	Tumor	101	57	44
PAT062	TBI	97	78	19
PAT064	TBI	98	51	47
Mean	--------	110.5	77	34.6

Note. IQ = NAART FSIQ; GMI = General Memory Index score (WMS-III); TBI = traumatic brain injury.

B. Neuropsychological Measures

In addition to the WMS-III and the NAART, participants were administered a battery of neuropsychological tests used to derive two composite scores. One composite score represents frontal lobe function (FL factor) and the other represents medial temporal lobe function (MTL Factor) (Glisky, Polster, & Routhieaux, 1995; Glisky & Kong, 2008; Glisky & Marquine, 2009). The neuropsychological tests that contribute to the FL factor are the Modified Wisconsin Card Sorting Task (WCST) (Hart, Kwentus, Wade, & Taylor, 1988), Mental Control (WAIS-III), Mental Arithmetic (WAIS-R) (Wechsler, 1981), the total number of words generated in a test of word fluency (FAS) (Spreen & Benton, 1977), and Digit Span Backwards (WMS-III). The neuropsychological tests that contribute to the MTL factor are Logical Memory I – First recall (WMS-III), Verbal Paired Associates I (WMS-III), Faces I (WMS-III), California Verbal Learning Test – Long Delay Cued Recall (CVLT) (Delis, Kramer, Kaplan, & Ober, 1987), and the Visual Paired Associates II (WMS-R) (Wechsler, 1987).

The composite scores represent the average z score from the neuropsychological tests loading on each factor. Neuropsychological test scores from a group of healthy individuals (n = 14) matched for age, sex, IQ, and years of education were included as a normative sample in the pool of participants used to derive the z scores. Table 2 shows the mean age, education level, pre-morbid IQ, and neuropsychological factor scores for the group of individuals with neurological damage in comparison to the normative sample. As can be seen, the individuals with neurological damage have severe memory deficits and impairment on some tests of frontal lobe function.

Table 2. Mean (std) Descriptive Characteristics and Neuropsychological Data

	Participants	Normative Sample
Descriptive Characteristics		
Age	44.4 (11.8)	44 (13)
Education Level	14.3 (2.8)	15 (3)
Estimated IQ	110.5 (11.2)	112.1 (9.4)
Neuropsychological Measure		
Frontal Lobe Factor	-.23 (.78)	.23 (.79)
Medial Temporal Lobe Factor	-.61 (.61)	.61 (.61)***

*** = < .001

C. Materials

Experimental stimuli were sentences similar in length and ratings of concreteness. Sentences were also previously rated on pleasure, arousal, and valence and were divided into four lists of 28 sentences matched on these variables (see Davidson, McFarland, & Glisky, 2006 for a detailed description). Half of the sentences in each list were neutral and half were emotional with a negative valence. Sentences that received the highest scores on arousal and the lowest scores on pleasure were chosen as the emotional sentences. Sentences that received the lowest scores on arousal and intermediate scores on pleasure were chosen as neutral sentences. The neutral and emotional sentences were randomly mixed.

D. Procedures

After providing informed consent, participants intentionally encoded sentences under 2 separate instructions. For the first group of 28 sentences participants were instructed to “count the number of syllables in the sentence and decide if there are more than 12 syllables.” Participants had 10 seconds to record a decision for each trial and the sentence remained on the screen for the entire 10 seconds. This baseline-structural study phase took approximately 5 minutes to complete. After a two minute distracter task, participants took a yes-no recognition memory test for 56 sentences (28 new, 28 old).

For the second set of 28 sentences participants were instructed to “imagine you are at the scene described by the sentence. Imagine with as much detail as possible.” Pre-study practice trials ensured that the participant understood the instructions and how to engage in self-imagination. Participants had 10 seconds to imagine the event, and the sentence remained on the screen for the entire 10 seconds. Participants were advised to close their eyes while imagining to aid image construction, but this was not required. A “beep” signaled that it was time to move on to the next trial. The self-imagining study phase took approximately 5 minutes to complete and was followed by a two minute distracter task and a yes-no recognition memory test for 56 sentences (28 new, 28 old). Sentences were counter-balanced across participants such that each sentence appeared in each encoding condition an equal number of times and as an old or new sentence at test an equal number of times.

After completion of the study, participants were again presented the sentences from the self-imagining portion of the experiment. Participants were instructed to re-imagine the event and rate the image for vividness and detail using a 5-point scale ranging from “I cannot imagine the event at all” to “the event is very detailed and vivid.” The purpose of the imagery rating portion of the experiment was twofold: first, to ensure that all participants could consistently generate images, and second, to explore the possibility that imagery vividness was correlated with memory. The vividness rating portion of the experiment was administered after the initial study-test phase in order to control the presentation time during the study phase and keep it constant across conditions.

III. RESULTS

In order to test the effect of self-imagining and the role of emotion on memory, data were analyzed using a 2 (encoding task) x 2 (emotion) repeated measures ANOVA. Hit rates and false alarm rates are shown in Table 3.

Table 3. Hit Rates (std) and False Alarm Rates (std) for Recognition Memory of Emotional and Non-Emotional Sentences in the Structural and Self-Imagination Tasks

Independent Variables	Hits	False Alarms
Structural Encoding Task		
Emotional Sentences	.69 (.12)	.08 (.08)
Non-Emotional Sentences	.61 (.07)	.07 (.09)
Self-Imagination Encoding Task		
Emotional Sentences	.90 (.08)	.05 (.07)
Non-Emotional Sentences	.90 (.10)	.05 (.06)

A. False alarm rates

A repeated measures ANOVA showed there was no significant difference in false alarm rates for encoding task, F (1, 13) = 1.61, p = .23, or for emotion, F (1, 13) = .05, p = .83. There was not a significant interaction F(1, 13) = .89, p = .77. Analyses of hits and corrected recognition (hits minus false alarms) were therefore similar. Only the analyses of corrected recognition are reported.

B. Corrected recognition data

Figure 1 shows the mean corrected recognition for emotional and non-emotional sentences in the structural and self-imagining encoding tasks. A repeated measures ANOVA revealed a main effect of encoding task, *F* (1, 13) = 47.75, *p* < .001. The data show a "self-imagination effect" (SIE) as self-imagining led to higher levels of memory than structural-baseline processing. There was no significant main effect of emotion, *F* (1, 13) = 3.18, *p* = .098, but there was a significant interaction of emotion and encoding task, *F* (1, 13) = 4.69, *p* = .05. Follow-up t-tests indicated the presence of a baseline "emotional enhancement effect" (EEE) as emotional material led to higher levels of memory than non-emotional material in baseline-structural processing, *t* (13) = 2.23, *p* < .05, but no effect of emotion in the self-imagining condition, *t* (13) = -.114, *p* = .911.

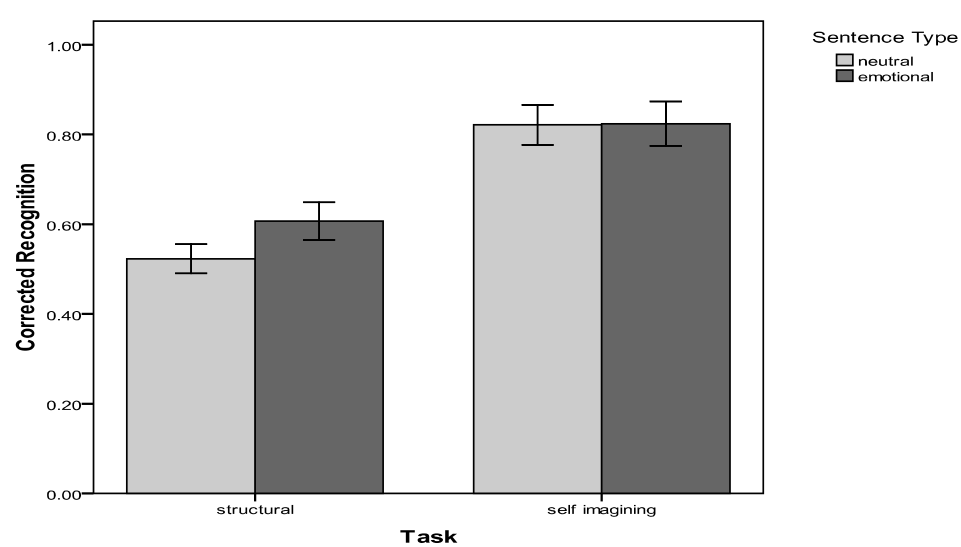


Figure 1. Mean proportion for corrected recognition of neutral and emotional sentences encoded in the structural and self-imagining tasks.

C. Relation of SIE to the EEE

Marquine (2008) posited that the benefits associated with self-referential processing may be partly attributable to emotional responses related to the self. To test the possibility that self-referential processing is related to emotional processing, we computed a Pearson product-moment correlation between the SIE (corrected recognition in the self-imagining condition minus corrected recognition in the structural condition) and the EEE (corrected recognition of emotional material minus corrected recognition of non-emotional material). Because the EEE was found only in the structural condition, the EEE was computed only in the structural condition. The size of the SIE was not related to the size of the EEE, $r = -.13$, $p = .661$ (Figure 2).

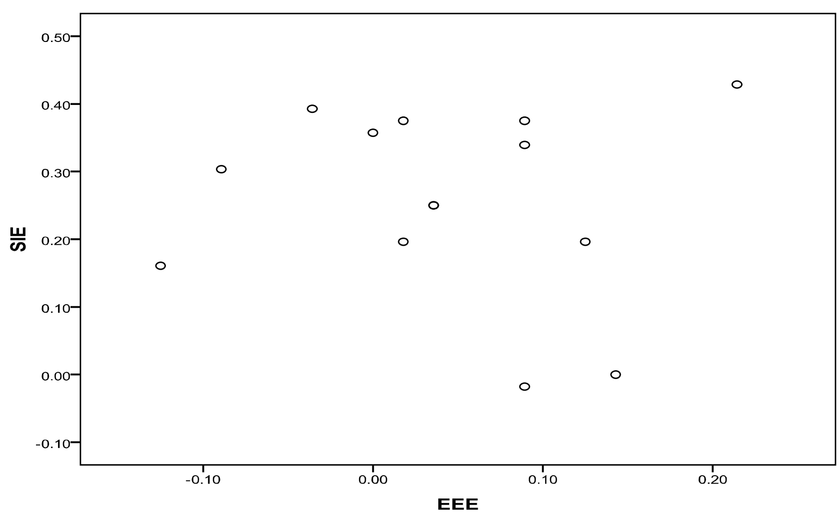


Figure 2. Relation of SIE to the EEE for each individual.

We also used the composite scores derived from the neuropsychological test battery and the imagery vividness ratings to conduct several exploratory analyses. We did not have specific hypotheses regarding the composite scores. The relation of frontal lobe and medial temporal lobe function to both the SIE and the EEE were empirical questions.

D. Relation of memory functioning to the EEE and the SIE

To explore the relation of memory functioning to the enhancing effect of emotion, we computed a Pearson product-moment correlation between the MTL factor and the EEE. The size of the EEE was significantly correlated with the memory composite, $r = .535$, $p < .05$. The data show that those individuals with better memory functioning as measured by the MTL factor experienced a greater benefit from the emotionality of the sentence context (see figure 3a). To explore the relation of memory functioning to the enhancing effect of self-imagining, we computed a Pearson product-moment correlation between the MTL factor and the SIE. The magnitude of the SIE was not significantly related to the memory composite, $r = .32$, $p = .27$ (figure 3b). Participants benefited equally from self-imagining regardless of their memory functioning as determined by the neuropsychological measures.

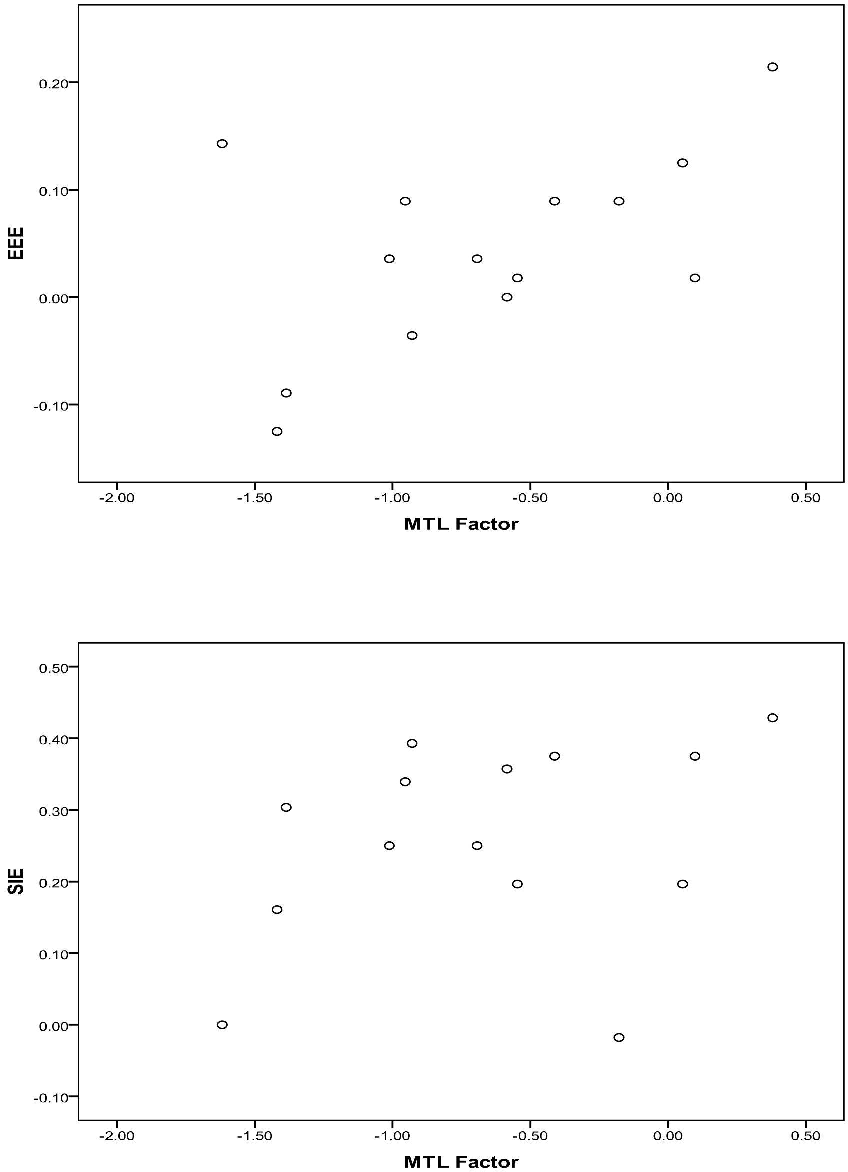


Figure 3a and 3b. Relation of memory functioning to the EEE for each individual (3a) and relation of memory functioning to the SIE for each individual (3b).

E. Relation of frontal lobe functioning to the EEE and SIE

We used the FL factor to explore the relation of frontal lobe functioning to the two memory enhancement effects. We computed a Pearson product-moment correlation between the FL factor and the EEE. The size of the EEE was not significantly correlated with the FL factor, $r = .243$, $p = .4$ (see figure 4a). We also computed a Pearson product-moment correlation between the FL factor and the SIE. Like the EEE, the size of the SIE was not significantly correlated with the FL factor, $r = .26$, $p = .37$ (see figure 4b).

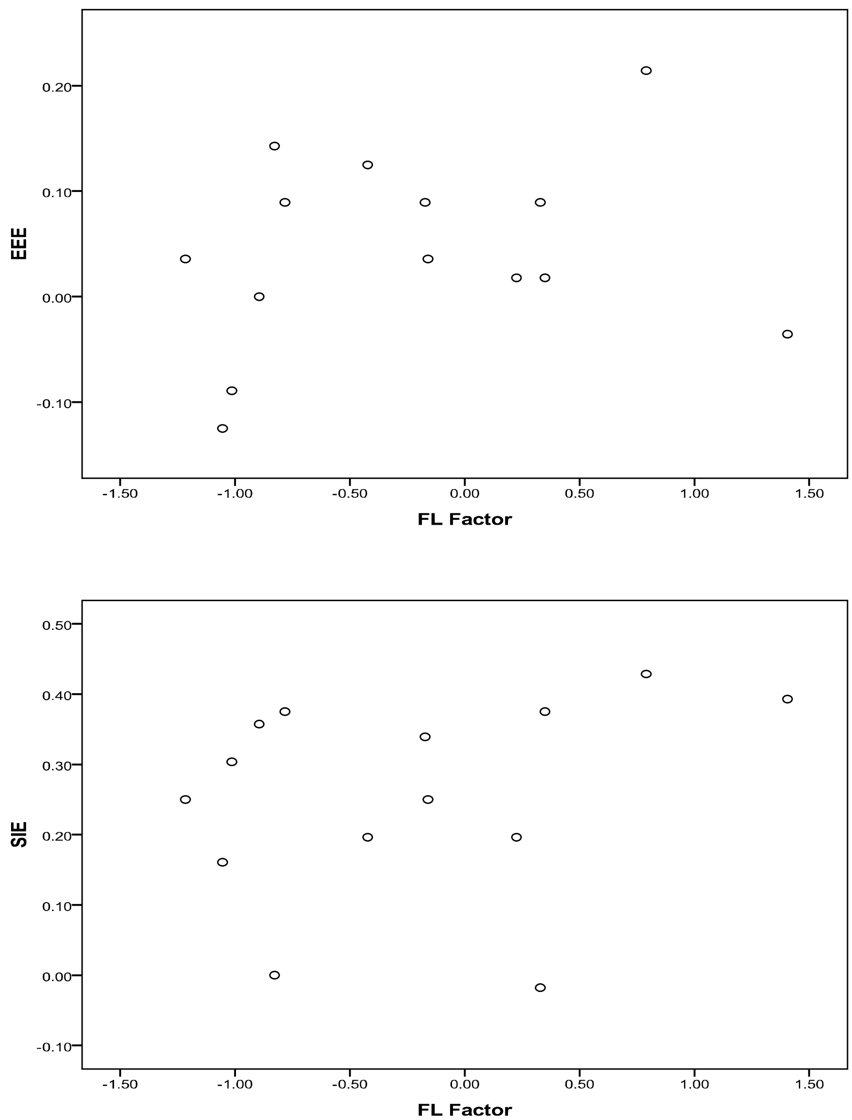


Figure 4a and 4b. Relation of frontal lobe functioning to the EEE (4a) for each individual and the relation of frontal lobe functioning to the SIE (4b) for each individual.

F. Relation of imagery vividness and detail to the SIE

To explore the relation of imagery vividness and detail to the benefit of self-imagining, we computed a Pearson product-moment correlation of each participant's mean rating of imagery vividness/detail to the size of their SIE. Three of the fourteen participants did not take part in the imagery rating portion of the experiment, two because of fatigue and one participant declined to re-imagine the emotional sentences. The size of the SIE was not significantly correlated with the mean rating of imagery vividness and detail, *r* = .13, *p* = .75 (figure 5).

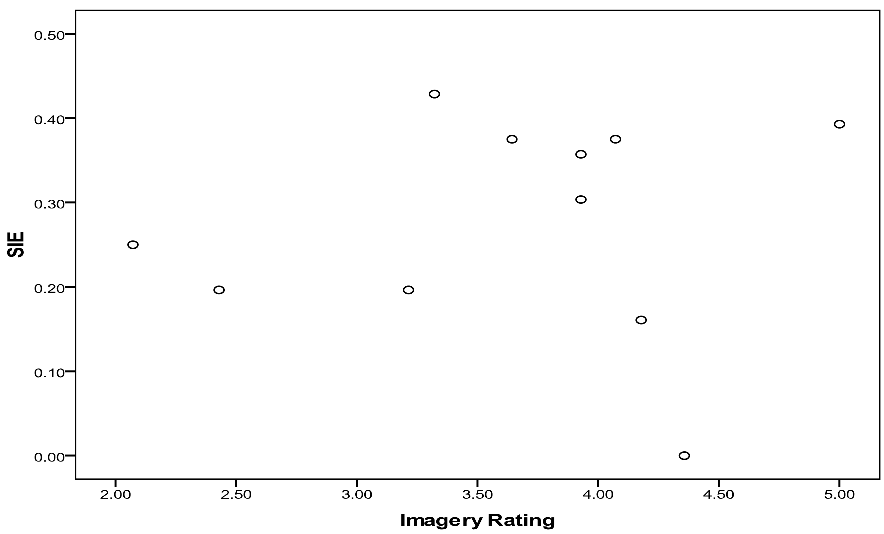


Figure 5. Relation of imagery vividness score to SIE.

IV. DISCUSSION

Despite memory deficits, 12 of the 14 participants demonstrated a "self-imagination effect" or SIE. This robust finding confirms our hypothesis that self-imagining would improve memory. PAT064 showed no difference between self-imagining and structural processing and PAT054 benefited less from self-imagining. These two participants consistently generated images, and their images were as vivid as those of the other participants. So their failure to benefit from self-imagining was not due to impairment in imagining. It may be that these individuals benefited less from self-referencing as a result of extensive damage to cortical midline structures, resulting in damage to self-schemas. At this time, however, structural imaging data are not available for either individual.

To our knowledge, the present study is the first to demonstrate a memory enhancing effect for something like self-imagining in memory-impaired individuals with neurological damage. It appears that self-referential imagination of a scene makes the scene very memorable. In this study, participants were not constrained in the perspective they took while imagining. They were simply told to "imagine you are at the scene described by the sentence." Nevertheless, most people reported that they viewed the scene through their own eyes—a field perspective—found to be particularly effective for retrieval of autobiographical memories (Piolino *et al.*, 2006). These findings are thus consistent with previous results showing that when information is processed in reference to the self and viewed from a field perspective, it is particularly memorable.

A number of interpretations of the SRE have been proposed. In the present study, we attempted to test one of these interpretations—the possibility that the SRE may be partly attributable to emotional responses that are activated during self-processing (Northoff *et al*., 2006). A number of studies show that emotion can improve memory in individuals with neurological damage (Marquine, 2008; Burton, *et al.*, 2004; Frank & Tomaz, 2003; Hamman, *et al.*, 1997; Hamman, Cahill, & Squire, 1997; Phelps *et al.*, 1997). Similarly, in the present study, we found enhanced memory performance in the baseline condition when the stimuli were emotional. Contrary to our expectations, however, in the self-imagining task non-emotional material was remembered as well as emotional material and there was no correlation between the EEE and the SIE. We had speculated that an emotional context would lead to better memories for material encoded self-referentially, and prior research suggested that the SRE might be related to emotional processing (Marquine, 2008). This was not the case, however, in the present study. Instead the findings call into question the feasibility of a strict emotional explanation of the SRE. First, the ability to benefit from self-referential processing was not affected by the emotionality of the materials, and second, memory for emotional materials at baseline was well below that which was achieved with self-imagining. A different possibility, then, is that self-referential processing is inherently emotional, and it may evoke an affective component no matter what. The affective component of self-referential processing may subsequently contribute to the SRE regardless of the material's emotional content. It simply overwhelms the much smaller effect attributable to emotion under baseline conditions.

While not investigated here, there is a different interpretation of the SRE that has been around for a long time, namely that the SRE is attributable to a deeper or more elaborative level of processing. It is well known that information processed at a deep semantic level is more memorable than information processed at a shallow, perceptual level, *i.e.* the "levels of processing" (LOP) effect (Craik & Lockhart, 1972; Craik & Tulving, 1975). Because we have extensive amounts of self-knowledge, information considered in relation to the self can be more elaborated and meaningful and thus more memorable (Craik & Tulving, 1975). As a result, the SRE may be a product of more semantic processing and not a "superordinate" self-schema. This explanation cannot be ruled out in the present study, but will be explored further in study 2.

In contrast to the interpretation we have put forth—that is, the SIE is related to self-referential processing—one might argue the SIE can be credited to the benefit of visual imagery. It is true that self-imagining involves a visual imagery component, and as discussed visual imagery is known to benefit memory. The data from the present study, however, are not completely consistent with what we know regarding the mnemonic benefit of visual imagery in memory-impaired populations. First, prior studies show the quality of visual imagery mediates subsequent remembering (Dirkx & Craik, 1992). In contrast to this, the findings here indicate visual imagery vividness has no influence on the SIE. Second, individuals with the most severe memory deficits are found to benefit less from visual imagery encoding techniques (Richardson, 1995; Wilson, 1987; Gade, 1994). Yet, nothing in the data suggests this was the case in the present study. If the SIE was only attributable to visual imagery, then individuals who consistently generated images of a lower quality and/or those individuals with the most severe memory deficits should have benefited less from self-imagining.

We found a single dissociation of the relation between memory functioning as measured by the MTL factor and the EEE and SIE. The EEE, but not the SIE, was correlated with general memory functioning as measured by the MTL factor. Individuals who scored higher on the MTL factor showed a greater benefit from the emotionality of the material than did individuals who scored lower on the MTL factor. In contrast, self-imagining provided substantial memory benefits for almost all individuals irrespective of their general memory ability. The relation of the EEE but not the SIE to general memory functioning indicates that self-referential processing is less dependent upon ordinary memory functioning, and can be taken as evidence that self-referential processing is accessing distinct mnemonic mechanisms, potentially related to a self-schema (Rogers *et al.*, 1977).

The lack of a correlation between memory functioning and the SIE is also intriguing from the perspective of memory rehabilitation. Nearly all of the individuals benefited from self-imagining and the magnitude of the mnemonic boost was not related to the severity of their memory deficit or frontal lobe functioning as measured by the FL factor. Historically, mnemonic strategies produce variable success for individuals with neurological damage (Glisky & Glisky, 2008), and the effectiveness of mnemonics is thought to be somewhat limited by the location and extent of damage (Wilson, 1987). Self-imagining, however, equally benefited individuals with damage of various etiologies and was not related to memory or frontal lobe functioning.

One question raised by the results of the present study is why almost all of the participants were able to consistently generate images while past research suggests that imagining ability is deficient in memory-impaired persons. There are several possible explanations for this: First, there may be differences in the severity of the memory deficit across studies. Reports of individuals demonstrating a complete inability to imagine have come from studies of amnesic patients (Hassabis *et al.*, 2007; Tulving, 1985). In contrast, we tested a sample of individuals who, although they appeared to have severe memory deficits as indicated by the IQ/GMI difference, their deficits may have fallen short of profound amnesia. Second, there may be differences in lesion location. Previous studies have almost all involved participants with hippocampal lesions. In our sample, the majority of the participants had suffered traumatic brain injuries (TBIs), likely causing more widespread and diffuse damage, so that memory problems may be associated with damage to regions other than the hippocampus, particularly areas of prefrontal cortex. Finally, in previous studies, people were either asked to imagine themselves in familiar places or imagine their own personal future. These kinds of instructions may have induced greater retrieval from episodic/autobiographical memory than the instructions given in the present experiment, which may have induced retrieval of more semantic information.

There are a couple of limitations to the methodological design. The failure to find a relation between imagery ability and the SIE may be in part due to the fact that we used a subjective measure of imagining. It is entirely possible that what one person describes as very vivid a different person will characterize as somewhat vivid or not very vivid.

Also, collecting the subjective ratings after the initial study-test phase has both its advantages and disadvantages. One disadvantage is the participants could alter the imagined event the second time around, adding more details or elaborating more on the event (Addis, Pan, Vu, Laiser, & Schacter, 2008). Interpretation of the lack of a relation between imagery ability and the SIE should take these limitations into consideration.

STUDY 2

I. INTRODUCTION

As mentioned, there are a number of interpretations for the mechanism of the SRE. One interpretation suggests the SRE is attributable to a deeper and more elaborative level of processing. According to this interpretation, self-knowledge promotes the use of ordinary memory mechanisms related to semantic elaboration and organization, and therefore the SRE is a consequence of more, or perhaps deeper, semantic processing and not unique mechanisms of the self. The behavioral and cognitive neuroscience data on the mechanisms of the SRE struggle to provide clear evidence in favor of this interpretation or the interpretation that the self is related to special mechanisms.

Functional neuroimaging research casts an interesting light on the neural correlates of semantic and self-referential processing and provides evidence of both similarities and differences between these tasks. In a fMRI study, Kelley *et al.* (2002) scanned participants while they made judgments about trait adjectives with 3 orienting tasks: self-referential (*e.g.* "Does this adjective describe you?"), other-referential (*e.g.* "Does this adjective describe U.S. President Bush?"), and structural (*e.g.* "Is the adjective in upper or lower case?"). On a subsequent memory test outside of the scanner, the participants demonstrated an ORE and SRE, and both the ORE and the SRE were associated with increased activation in the left inferior prefrontal cortex (PFC), an area of the brain believed to support deep semantic elaboration. In comparison to the neural correlates of the ORE, the SRE was also associated with increased activation in the ventral medial PFC. So in this study the SRE, in addition to being associated with a region thought to be important for deep semantic elaboration, also appeared to recruit a disparate region of the brain not traditionally viewed as part of the semantic processing network, namely the ventral medial PFC. Of course, we do not know if this increased activation is causally linked to subsequent memory, but it is an indication that there may be differences between self-referential and semantic processing. A follow-up study also pointed to the ventral medial PFC as a region potentially important for successful encoding of self-referential information (Heatherton *et al.*, 2006).

Glisky and Marquine (2009) used a neuropsychological approach to test the mechanisms of semantic and self-referential processing. In this study, older adults judged trait adjectives by deciding if the adjectives described themselves, had positive dictionary definitions, or were in upper case. The older adult cohort was split into four groups according to their performance on 2 composite scores of neuropsychological function: the FL factor and MTL factor. This study found that the MTL factor was related to the LOP effect but not the added benefit of the SRE. Like the neuroimaging research, however, this study cannot say for certain the SRE is linked to distinct memory mechanisms. Nonetheless, the data indicate the presence of potential differences in the way semantic and self-referential processing enhance memory.

The principal aim of study 2 was to investigate the possibility that the SIE found in study 1 is related to deeper semantic processing. To address this aim, we tested the effect of a deep semantic processing task on recognition memory for a second set of neutral and emotional sentences in a group of memory-impaired individuals. We were primarily interested in investigating two outcomes: First, the magnitude of the LOP effect in comparison to the SIE found in study 1, and second, the relation of the FL and MTL factor scores to the LOP effect. We predicted that the memory-impaired individuals would demonstrate a LOP effect, and the LOP effect would be smaller in magnitude than the SIE found in study 1. The relations of the FL and MTL factor scores to the LOP effect were empirical questions, and thus we did not have specific hypotheses for these analyses.

Study 2 was also designed to test further the effect of emotion on memory in a LOP paradigm. In study 1 emotion enhanced baseline memory performance but not memory for material encoded self-referentially, findings that imply the EEE is overwhelmed by the SRE. How emotion is related to the LOP effect, however, is unclear, and the findings from previous research are mixed (Reber *et al.*, 1994; Jay *et al.*, 2008). We tested the effect of emotion on the LOP effect with the emotional and neutral sentences.

II. METHOD

A. Participants

Twelve individuals with neurological damage of mixed etiology (10 TBI) participated in the study. A majority of the participants were from study 1, but 3 were unable to return for a second testing session and 1 new participant was included. Inclusion criteria were the same as in study 1. Table 4 shows the etiology, estimated pre-morbid IQ, general memory index (GMI), and the size of the memory impairment for each participant. A majority of the participants (n = 7) had a GMI score 30 or more points lower than the estimated pre-morbid IQ.

Table 4. Participant Descriptive Characteristics

Patient	Etiology	IQ	GMI	IQ-GMI
PAT004	TBI	125	96	29
PAT012	TBI	125	110	15
PAT015	TBI	101	54	47
PAT016	Aneurysm	127	81	46
PAT023	TBI	118	98	20
PAT056	TBI	104	69	35
PAT058	TBI	103	63	40
PAT059	TBI	107	70	37
PAT060	TBI	115	73	42
PAT062	TBI	97	78	19
PAT064	TBI	98	51	47
PAT065	Anoxia	98	79	19
Mean	-------	110	77	33

Note. IQ = NAART FSIQ; GMI = General Memory Index score (WMS-III); TBI = traumatic brain injury.

B. Neuropsychological Measures

In addition to the WMS-III and the NAART, participants were administered the additional subtests of the frontal and medial temporal lobe factors (see study 1 for more details). Neuropsychological test scores from a group of healthy individuals (n = 12) matched for age, sex, IQ, and years of education were included as a normative sample in the pool of participants used to derive the z scores. Table 5 shows the mean age, years of education, pre-morbid IQ, memory composite score, and frontal lobe composite score.

Table 5. Mean (std) Descriptive Characteristics and Neuropsychological Data.

	Participants	Normative Sample
Descriptive Characteristics		
Age	47.5 (8.7)	47.7 (9.9)
Education Level	14.7 (2.5)	14.8 (3.2)
Estimated IQ	110 (11.7)	111.5 (9.9)
Neuropsychological Measure		
Frontal Lobe Factor	-.26 (84)	.26 (.59)
Medial Temporal Lobe Factor	-.65 (.64)	.65 (.41)***

*** = < .001

C. Materials

As in study 1, experimental stimuli were sentences similar in length and ratings of concreteness. The sentences were split into 4 groups of 28 sentences matched on length, concreteness, pleasantness, arousal, and valence. Half of the sentences in each group were neutral and half were emotional with a negative valence.

D. Procedures

After providing informed consent, participants intentionally encoded sentences under 2 instructions. The instructions for the first group of 28 sentences were the same as in study 1. Participants had to “count the number of syllables in the sentence and decide if there are more than 12 syllables.” Participants had 10 seconds to record a decision for each trial and the sentence remained on the screen for the entire 10 seconds. The baseline-structural study phase took approximately 5 minutes to complete and was followed by a two minute distracter task and a yes-no recognition memory test for 56 sentences (28 new, 28 old).

For the second group of 28 sentences, participants were instructed to “decide if the italicized sentence ‘fits in’ with the rest of the short story.” Participants were warned that only memory for the italicized sentence would be tested, but it was important to read the whole story before making a decision. A pilot study found that the participants could read on average three sentences within 10 seconds. Therefore, each short story was made of two descriptive sentences and one italicized, target sentence. The italicized sentence was placed after the descriptive sentences to better ensure that the participants read the entire short story before making a decision. All participants reported to be able to read the short stories within the allotted time. The descriptive sentences were similar in length to the italicized sentences and were chosen to match the emotionality of the target sentence. Half of the italicized sentences were paired with congruent descriptive sentences and half were not. In other words, for half of the trials the target neutral and emotional sentences were semantically related to the descriptive sentences and half the target sentences were not. The 5 minute semantic study phase was followed by a 2 minute distracter task and a yes-no recognition memory test for 56 sentences (28 new, 28 old). Sentences were counter-balanced across participants such that each sentence appeared in each encoding condition an equal number of times and as an old or new sentence at test an equal number of times.

III. Results

In order to test the effect of semantic processing and the role of emotion on memory, data were analyzed using a 2 (encoding task) x 2 (emotion) repeated measures ANOVA. Hit rates and false alarm rates are shown in Table 6.

Table 6. Hit Rates (sd) and False Alarm Rates (sd) for Recognition Memory of Emotional and Non-Emotional Sentences in the Structural and Semantic Tasks

Independent Variables	Hits	False Alarms
Structural Encoding Task		
Emotional Sentences	.71 (.13)	.08 (.10)
Non-Emotional Sentences	.61 (.1)	.12 (.11)
Semantic Encoding Task		
Emotional Sentences	.76 (.10)	.10 (.11)
Non-Emotional Sentences	.75 (.17)	.10 (.13)

A. False alarm rates

A repeated measures ANOVA showed there was no significant difference in false alarm rates for encoding task, F (1, 11) = .04, p = .85, or for emotion, F (1, 11) = 1.1, p = .32. There was not a significant interaction F(1, 11) = .35, p = .57 . Analyses of hits and corrected recognition (hits minus false alarms) were similar and thus only the analyses of corrected recognition are reported.

B. Corrected recognition data

Figure 6 shows the mean corrected recognition (hits minus false alarms) for emotional and non-emotional sentences in the structural and semantic encoding tasks. A repeated measures ANOVA revealed a main effect of encoding task, F (1, 11) = 6.13, $p < .05$. The data show a "level of processing" effect as semantic processing led to better memory than structural processing. There was a marginally significant main effect of emotion, F (1, 11) = 4.0, $p = .07$, such that emotional material was better remembered than non-emotional material. There was no significant interaction of emotion and encoding task, F (1, 11) = 1.99, $p = .19$.

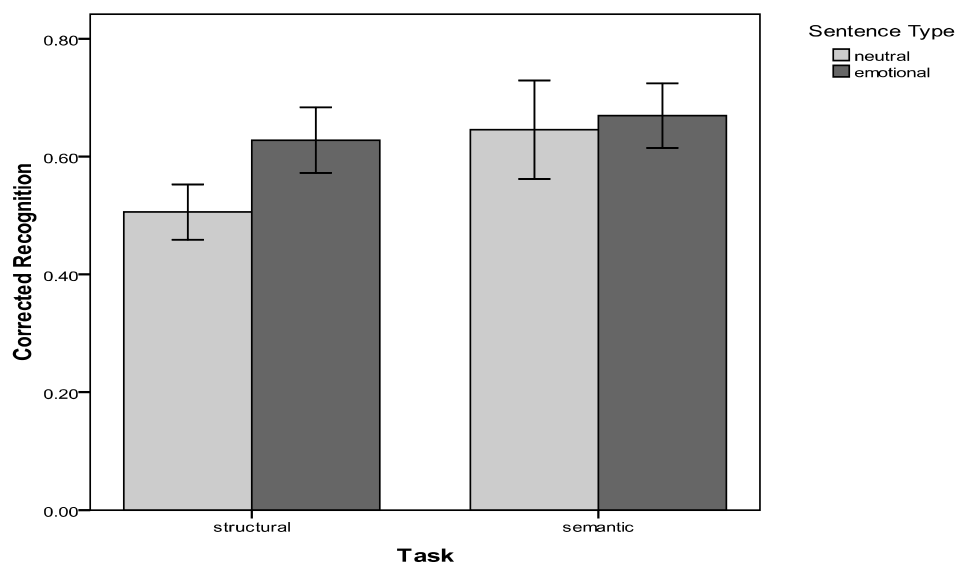


Figure 6. Mean proportion of corrected recognition for emotional and non-emotional sentences in the semantic and structural encoding tasks.

C. Relation of semantic context congruency to recognition memory.

Staresina, Gray, and Davachi (2009) found that semantic context congruency affected memory such that items paired with congruent contexts were more memorable than items paired with incongruent contexts, a finding they referred to as the "congruency subsequent memory effect" (cSME). To test for the presence of the cSME in the present study, we compared recognition memory for the sentences imbedded in a congruent story context to sentences imbedded in an incongruent story context. A t-test revealed that memory for congruent context was not significantly different from incongruent context, t (11) = 1.64, p = .23. The participants equally remembered the sentences regardless of the semantic context congruency. As in experiment 1, we used the neuropsychological composite scores to conduct several exploratory analyses.

D. Relation of memory functioning to the EEE and LOP effect

To explore the relation of memory functioning to the enhancing effect of emotion, we computed a Pearson product-moment correlation between the EEE and the MTL factor. The size of the EEE was not significantly correlated with memory functioning, r = -.14, p =.69 (see figure 7a). To test the relation of memory functioning to the enhancing effect of semantic processing, we computed a Pearson product-moment correlation between the LOP effect (corrected recognition from the semantic processing condition – corrected recognition from the structural processing condition) and the MTL factor. The size of the LOP effect was significantly correlated with memory functioning, r = .67, p < .05 (see figure 7b). The data show that those individuals with better memory functioning as measured by the MTL factor benefited more from semantic processing than the individuals with poorer memory functioning.

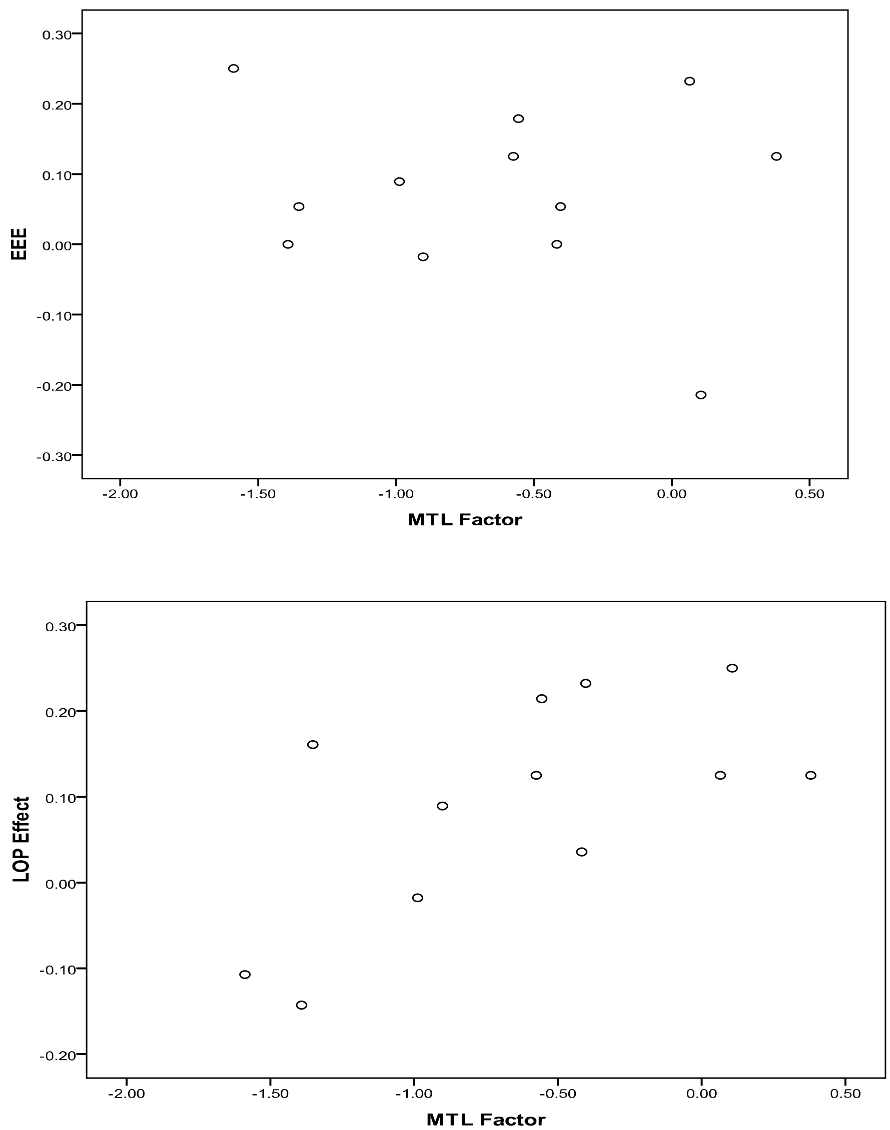
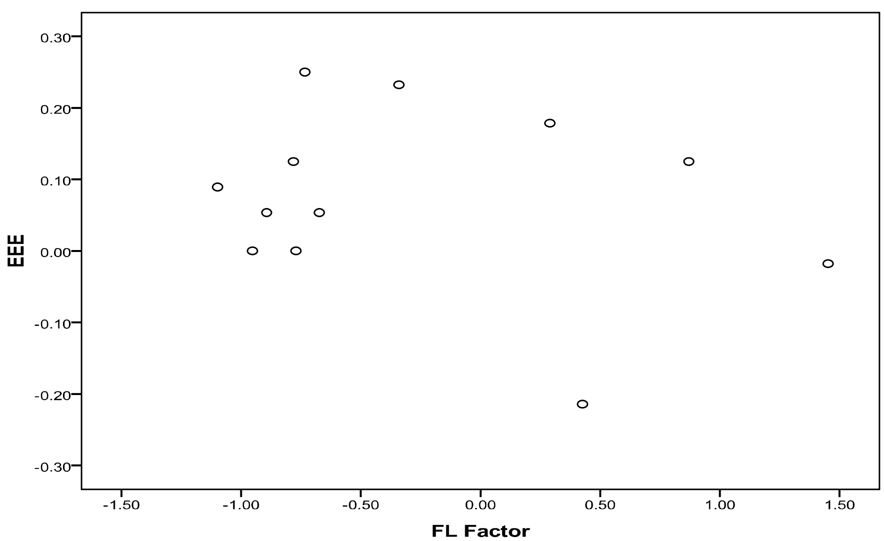


Figure 7a and 7b. Relation of memory functioning to the EEE for each individual (7a) and relation of memory functioning to the SIE for each individual (7b).

E. Relation of frontal lobe functioning to the EEE and LOP effect.

To explore the relation of frontal lobe functioning to the effect of emotion on memory, we computed a Pearson product-moment correlation between the FL factor and the EEE. The EEE was not significantly related to the FL factor, $r = -.27$, $p = .42$ (see figure 8a). A Pearson product-moment correlation between the FL factor and the LOP effect also was not significant, $r = .38$, $p = .25$ (figure 8b).



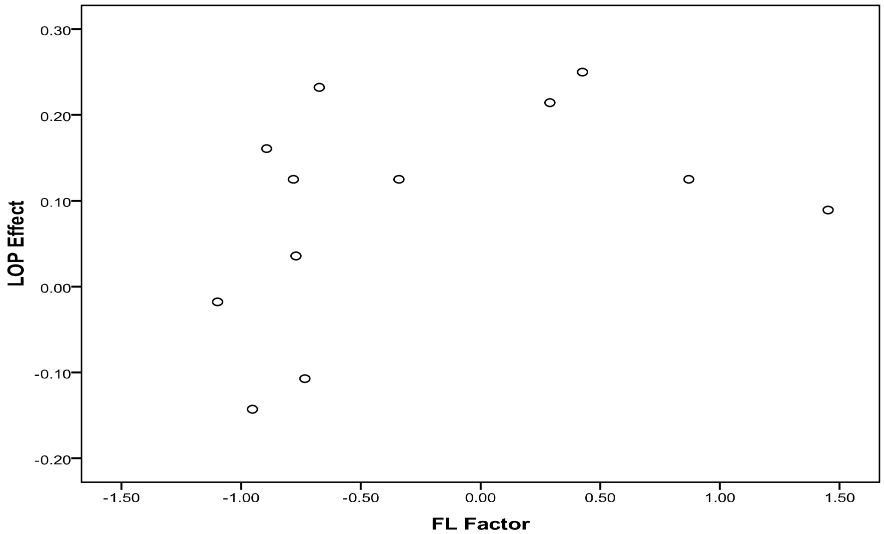


Figure 8a and 8b. Relation of frontal lobe functioning to the EEE (8a) and the relation of frontal lobe functioning to the SIE (8b).

IV. DISCUSSION

In agreement with our hypothesis, semantic processing enhanced recognition memory in the group of individuals with neurological damage. The data reveal a "levels of processing" (LOP) effect as sentences encoded in the semantic processing task were remembered at a higher proportion than sentences encoded in the structural task. Overall, the findings are consistent with previous research to show that information encoded with a great deal of meaning and elaboration can be more memorable. In this study 9 of the 12 memory-impaired participants benefited from semantic processing, and 3 participants experienced a cost from semantic processing. Although it is an across study comparison, it is worth noting that 2 of these participants benefited from self-imagination in study 1, an indication that these 2 participants can enhance their memories with a self-referential mnemonic strategy.

We sought out to test the LOP effect for sentence recognition in order to investigate the interpretation that the SIE is related to a deep level of processing and not qualitatively distinct mechanisms of the self. In a number of ways, the data indicate that the mechanisms of self-imagination are different from semantic elaboration. Although a majority of the participants demonstrated a LOP effect, the size of the effect was a third of the benefit associated with self-imagination in study 1. In addition to this, a smaller proportion of the memory-impaired participants benefited from semantic processing, despite similar memory impairments as determined by neuropsychological assessment. Furthermore, the inferiority of the LOP effect in comparison to the SIE cannot be attributed to differences in baseline memory (*i.e.* corrected recognition in the structural encoding task), which overall was identical to study 1.

Additional evidence indicates that the benefit of self-imagination is distinct from semantic processing. In contrast to the SIE, the LOP effect was shown to be dependent on basic memory functioning. In other words, those individuals with the most severe memory deficits benefited less from using semantic elaboration to process the sentences. Memory functioning, however, did not affect the SIE found in study 1, an indication that the benefit of thinking in relation to the self is not easily attributed to deeper semantic processing. In study 2 the participants elaborated on the sentences and thought of their semantic meaning for just as much time as was taken by self-imagination in study 1, but they did so without explicitly involving self-referential processing. Relatively speaking, self-imagination appears to be a powerful encoding mechanism, and the data indicate that the SIE is due to more than just a deeper level of semantic processing.

The effect of emotion on memory in the LOP paradigm was marginally significant. However, the findings suggest the EEE was weakened with a deeper level of semantic processing. In fact, the EEE in the structural task was 4 times the size of the EEE in the semantic task. Additionally, fewer participants demonstrated an EEE in the semantic task than in the structural task. It is possible then that the benefit of emotion on memory is attenuated when a deeper level of processing is used.

In study 2 the benefit of emotion on memory was not affected by general memory functioning, a finding that is in contrast to the results from study 1. It is not clear why this is the case, but it may be a consequence of the small participant pool. With small numbers of participants and large variability in performance, significance is difficult to obtain, and one or two individuals can have a large effect. It is probably best, therefore, to view this relation as variable across individuals.

STUDY 3

I. INTRODUCTION

Prospective memory is the ability to formulate intentions and realize them at a future time (Kliegel & Martin, 2003; Kvavilashvili & Ellis, 1996). For instance, planning to purchase milk on the way home from work may be a good intention, but it can only be realized if remembered while driving by the market after a period of delay. Remembering a future intention can be based on event or time (West, 2005). Event-based prospective memory refers to future intentions that are associated with an external cue such as remembering to mail a letter after seeing a post office box, and time-based prospective memory describes future intentions that are not readily associated with an external prompt, such as remembering to attend a faculty meeting at 5pm.

In certain circumstances prospective memory failures can seriously impact a person's quality of life by compromising physical health (*e.g.* poor medical adherence), social interactions (*e.g.* forgetting to attend social gatherings), and psychological well-being (*e.g.* feeling less independent) (Thone-Otto & Walther, 2001; Kinsella *et al*, 1996). Furthermore, prospective memory failures can greatly influence the effectiveness of rehabilitation interventions. The benefit of using a daily planner to monitor medicine adherence, appointments, and social events is limited by the ability to prospectively remember to reference the planner at the appropriate time.

Extensive evidence implicates the frontal lobes as closely related to prospective memory. Aging research shows that prospective memory is negatively affected by reduced frontal function. Using a neuropsychological approach, McFarland & Glisky

(2009) and McDaniel *et al.* (1999) demonstrated that older adults with below average scores on the FL factor perform more poorly on tasks of time and event-based prospective memory in comparison to older adults with above average scores on the FL factor. Functional neuroimaging reveals the frontal lobes contribute to prospective memory in several ways. In a functional magnetic resonance imaging (fMRI) study of prospective memory, Simons *et al*. (2006) showed that activation during the recognition of an intention in the frontal polar region is reactivated at the moment of realization. Also, studies of patients with isolated lesions to the frontal lobes demonstrate various types of impairment in prospective memory (Cockburn, 1995; Bisiacchi, 1996; Burgess *et al.*, 2001).

Ellis (1996) and Kliegel *et al.* (2004) contend prospective memory consists of 4 stages: intention formation, intention retention, intention re-instantiation, and intention execution. In the first 2 stages a plan is created for remembering the future intention, and the intention is kept in mind during ongoing tasks. For example, a plan might be made for how to remember to stop at the grocery store on the way home from work and throughout the day the plan may be referenced to determine if it is an appropriate moment to realize the intention. In the third stage, the ongoing task is interrupted at the appropriate moment in order to complete the delayed intention, and in the last stage, the intention is realized according to plan.

There is evidence to suggest that “implementation intentions” are an effective method for formulating plans for future intentions and can be used as a mnemonic strategy for enhancing event-based prospective memory (Gollwitzer, 1999). To use an implementation intention one must bind the future intention to the contextual cues that will coincide with the intention and develop a plan for how to realize the delayed intention. So the intention to take daily medication in the morning can be associated with a dependable contextual cue and a plan for realizing the intention, such as deciding to take the medication right before brushing one's teeth in the morning. Traditionally, implementation intentions have come in the form of verbal statements such as "When I see x, then I will do y" (Schweiger & Gollwitzer, 2007).

The imagination of the self simulating a future intention is postulated to be a type of implementation intention and may engage several mechanisms important for the enhancement of event-based prospective memory (Schacter, Addis, & Buckner, 2008). For one thing, there is a flood of research showing the brain is adaptively designed to imagine and plan for what may come in the future (Schacter, Addis, & Buckner, 2007; Buckner & Carroll, 2007; Szpunar, Watson, & McDermott, 2007). There is also some indication that the frontal polar region (BA 10) serves as a common mechanism for the imagination system and prospective memory as both cognitive tasks activate the frontal poles in neuroimaging studies (Okuda *et al.*, 2003; Burgess *et al.*, 2001). Koriat *et al.* (1990) argue that envisioning the future scenario is the most effective way to encode the visual-spatial details of an event, and there is also evidence that imagination involves the hippocampus, a region of the brain believed to be important for the binding of disparate elements into a cohesive unit (Hassabis *et al*, 2007). Finally, thinking in terms of the self during the formulation of a plan for the future intention may enhance prospective memory since self-imagination of the scene of the future intention may evoke thoughts, feelings, and visual-spatial features from a self-relevant perspective, all of which may enhance the encoding of the plan or serve as personal contextual cues.

Preliminary evidence suggests self-imagining is an effective method for improving prospective memory in a different population known to experience memory problems, *i.e.* older adults (Liu & Park, 2004; Chasteen, Park, & Schwarz, 2001). Liu and Park (2004) instructed a group of older adults to imagine the context in which they would need to conduct a blood test, the events that would likely lead up to the realization of the delayed intention, and the administration of the blood test. A second group of older adults were instructed to consider the positives and negatives of administering the blood tests, and a third group simply agreed to participate. Older adults in the imagination group remembered significantly more prospective memory targets than the older adults in the other 2 groups. Chasteen *et al.* (2001) found a similar enhancement effect for a laboratory-based prospective memory task.

Although there is evidence suggestive of these beneficial effects of implementation intentions, memory deficits may be a limiting factor in individuals with neurological damage. We do not know if individuals with severe memory deficits will be able to bind the future intention with the contextual cues. Evidence suggests that damage to the hippocampus can greatly impair the ability to bind disparate pieces of information into a single memory trace (Troyer *et al.*, 2008). Not being able to link the intention to its contextual cues and store that association may result in remembering a cue as important for realizing a planned intention, but not being able to remember the intention, or alternatively remembering the future intention, but not remembering when it is to be enacted.

In study 3 we tested the effect of self-imagining on event-based prospective memory in a group of memory-impaired individuals with neurological damage. We had two hypotheses. First, we predicted self-imagining would enhance prospective memory. In accordance with previous research and the results from study 1, we believed the SIE would be effective irrespective of frontal or medial temporal lobe functioning as measured by the factor scores. We did, however, recognize that some individuals with very severe memory deficits may not be able to bind the future intention with the contextual cues of the intention and therefore not show the SIE. Second, based on findings from prior studies using the factor scores in an experimental paradigm similar to the one used in the present study, we predicted that frontal lobe functioning would be related to prospective memory in the absence of implementation intentions.

II. METHOD

A. Participants

In this study we tested 12 individuals with neurological damage of mixed etiology. The inclusion criteria were the same as studies 1 and 2 and table 5 shows the etiology, estimated pre-morbid IQ, general memory index, and the size of the memory impairment for each participant. As is revealed by Table 7, half of the participants (n = 6) had a fairly severe memory deficit as indicated by a General Memory Index score 30 or more points lower than the estimated pre-morbid IQ.

Table 7. Participant Descriptive Characteristics

Patient	Etiology	IQ	GMI	IQ-GMI
PAT004	TBI	125	96	29
PAT012	TBI	125	110	15
PAT016	Aneurysm	127	81	46
PAT023	TBI	118	98	20
PAT056	TBI	104	69	35
PAT057	TBI	114	67	47
PAT058	TBI	103	63	40
PAT059	TBI	107	70	37
PAT061	Tumor	101	57	44
PAT062	TBI	97	78	19
PAT063	TBI	106	81	25
PAT065	Anoxia	98	79	19
Mean	--------	110	79	31

Note. IQ = NAART FSIQ; GMI = General Memory Index score (WMS-III); TBI = traumatic brain injury.

B. Neuropsychological Measures

All of the participants had taken part in study 1, study 2 or both. As a result, we had neuropsychological test data from each participant for the WMS-III, NAART, and the additional subtests of the FL and MTL factor scores. Neuropsychological test scores from a group of healthy individuals (n = 12) matched for age, sex, IQ, and years of education were included as a normative sample in the pool of participants used to derive the z scores. Table 8 shows the mean age, years of education, pre-morbid IQ, memory composite score, and frontal lobe composite score. The only significant difference between the groups was in the medial temporal lobe factor.

Table 8. Mean (std) Descriptive Characteristics and Neuropsychological Data.

	Participants	Normative Sample
Descriptive Characteristics		
Age	49.75 (14.9)	47.7 (9.9)
Education Level	14.7 (2.5)	14.8 (3.2)
Estimated IQ	110.5 (11.1)	111.5 (9.9)
Neuropsychological Measure		
Frontal Lobe Factor	-.22 (.82)	.22 (.60)
Medial Temporal Lobe Factor	-.60 (.59)	.60 (.49)***

*** = < .001

C. Materials and Procedures

The experimental paradigm included a computerized background task that was a multiple choice test of trivia, facts, and general knowledge (McDaniel *et al.*, 1999). Each question was 1 or 2 sentences long and had 4 answer choices. Each question appeared alone on the screen for 4 seconds. Next, the answer choices appeared with the question and the participants had 8 seconds to make a response. Participants indicated their answer choice by pressing one of four labeled keys (A, B, C or D) on the keyboard. Feedback was provided. Participants were instructed to answer each question to the best of their ability and that the goal of the task was to receive the highest score possible.

Imbedded within the multiple choice test were 8 questions containing the word “president” or “state.” Participants were told that we were also interested in testing how well they could remember to do something in the future and so they should press the “1” key each time the word “president” (or state) appeared in a question. The target words were separated by approximately 5 minute intervals. The questions appeared in a random order and each test phase took 40 minutes to complete. The experiment was separated into two testing sessions spaced 14 to 17 days apart. In session 1 half of the participants were given self-imagination instructions and half were given rote-rehearsal instructions. Half of the participants in each instructional condition were told to respond to the word “president” and half were told to respond to “state.” In the second session, instructional conditions and target words were reversed, and the trivia questions were new.

Each testing session contained a different 45 second pre-experiment instruction. In the rote-rehearsal condition, participants were given a sheet summarizing the instructions of the experiment and were asked to rehearse the instructions out-loud. The instruction sheet summarized both the goal of the general knowledge test and the prospective memory task. In the self-imagination condition, participants were instructed to imagine they were taking part in the general knowledge test. They were instructed to imagine seeing trivia questions and imagine themselves answering the questions. Next, they were instructed to imagine seeing the target word imbedded in a trivia question and imagine themselves immediately pressing the 1 key. Participants were instructed to imagine the scenario as though they were actually completing the general knowledge test using as much detail as possible and imagining the scene from a field perspective. After the pre-experiment exercise, participants were administered the recall portion of the Rey Auditory Verbal Learning Test (RAVLT) (Rey, 1964). The RAVLT is a memory test of 16 unrelated concrete nouns. The memory test served as a 12 minute delay between the pre-experiment exercise and the start of the general knowledge task. No reminder was provided regarding the prospective memory task before the start of the general knowledge task. At the end of the testing session, the experimenter asked the participant to summarize the aim of the experimental session. The query tested memory for the prospective memory task.

III. RESULTS

In order to test the effects of self-imagination and rote-rehearsal on prospective memory we analyzed the data using a one-way repeated measures ANOVA. A Pearson product-moment correlation was used to analyze the relation of ongoing task performance to prospective memory performance. Also, a series of Pearson product-moment correlations were used to test the relation of the MTL and FL factor scores to prospective memory performance and to test the relation of the factor scores to the SIE.

A. Effect of self-imagining on prospective memory

Figure 9 shows the mean proportion of prospective memory target words remembered by the participants in the rote-rehearsal and self-imagination tasks. A one-way repeated measures ANOVA revealed a main effect of task, $F(1, 11) = 11.52$, $p = .006$. The data show a SIE for prospective memory as self-imagining before the start of the experiment led to a higher rate of remembering than rehearsing the instructions.

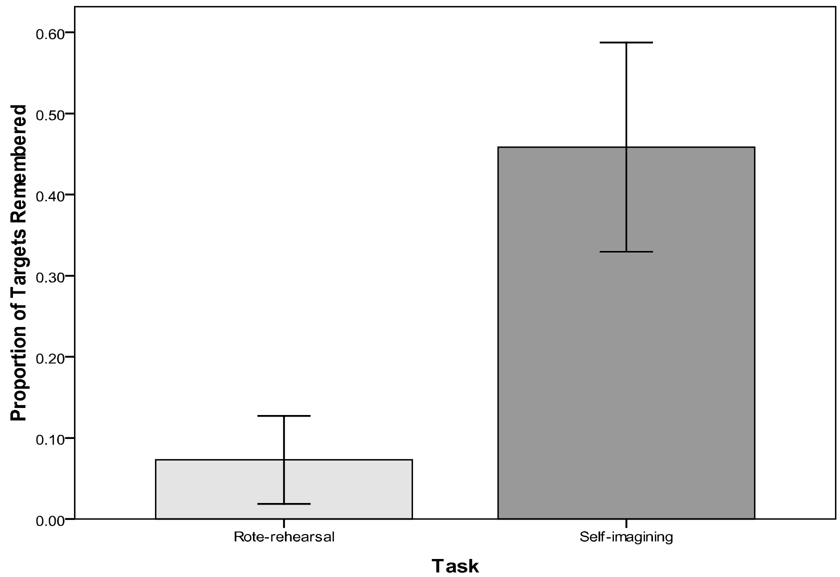


Figure 9. Mean proportion of the prospective target words remembered in the rote-rehearsal and self-imagination tasks.

B. Relation of ongoing task performance to prospective memory

To test the possibility that ongoing task performance affected prospective memory, data were analyzed using a Pearson product-moment correlation between prospective memory and ongoing task performance. Performance on the ongoing task was not correlated to prospective memory performance, r = .098, p = .65 (figure 10).

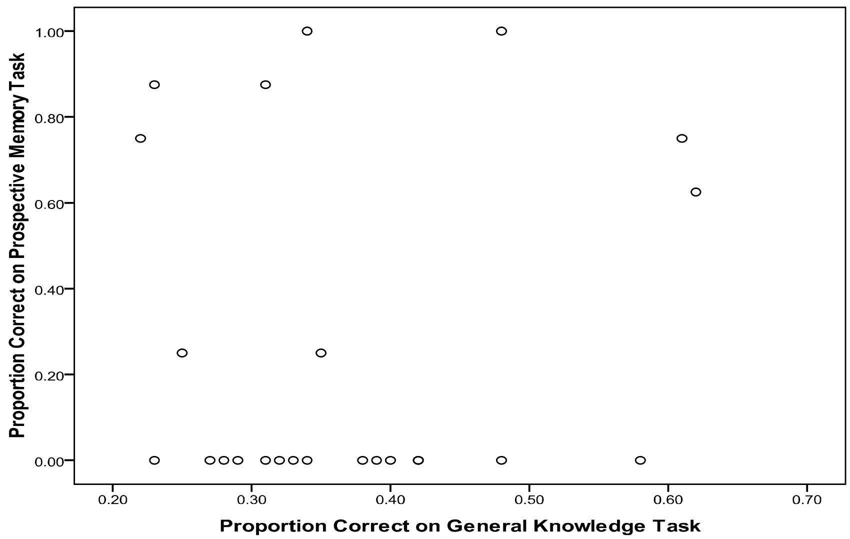


Figure 10. Relation of performance on the prospective memory task to the general knowledge task.

C. Relation of frontal lobe functioning to prospective memory

To investigate the relation of frontal lobe function to prospective memory, we computed a Pearson product-moment correlation between the FL factor and prospective memory in the two tasks separately. The FL factor was not significantly correlated with prospective memory in the rote-rehearsal task, $r = .3$, $p = .34$, or in the self-imagination task, $r = .31$, $p = .33$ (figure 11a, b). Note, however, that in the rehearsal condition, only two individuals remembered any prospective memory tasks, and so the correlation is not meaningful. Similarly in the self-imagination condition, 5 out of the 12 participants scored 0 and 6 were close to ceiling, again calling into question the validity of any correlation.

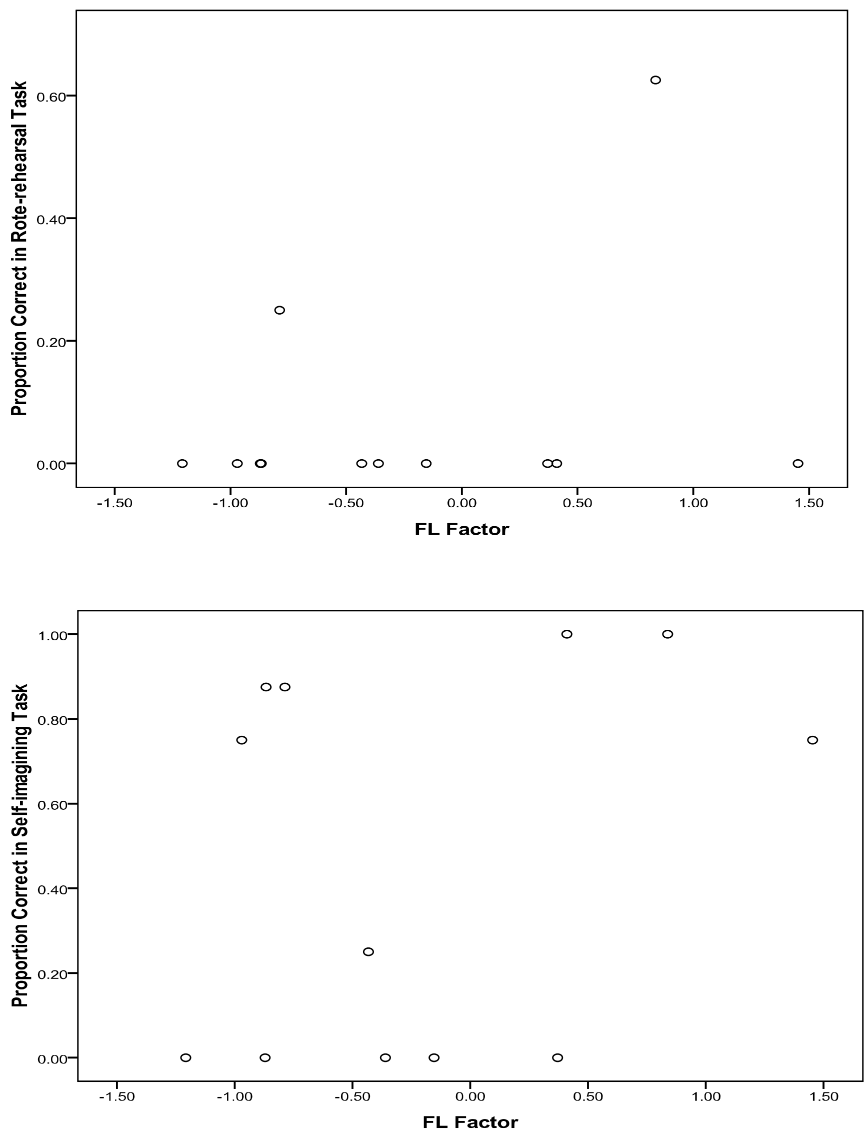


Figure 11a and 11b. Relation of FL factor to prospective memory performance in the rote-rehearsal (11a) and self-imagination (11b) tasks.

D. Relation of memory functioning to prospective memory

To test the relation of memory functioning to prospective memory performance, we computed Pearson product-moment correlations between the MTL factor and the two prospective memory tasks separately. The MTL factor was not significantly correlated with prospective memory in the rote-rehearsal task, $r = .5$, $p = .1$ (figure 12a) or the self-imagination task, $r = .23$, $p = .48$ (figure 12b). These correlations, however, are not very meaningful for the same reasons described above.

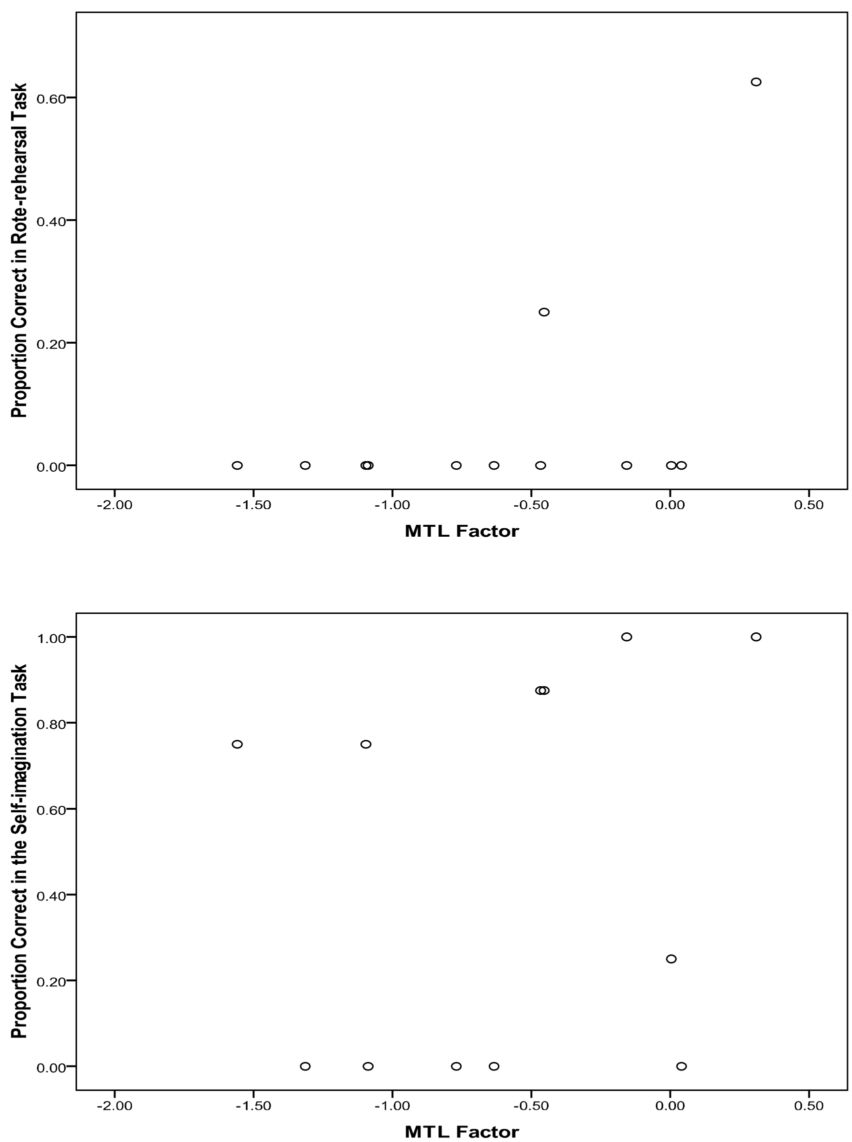
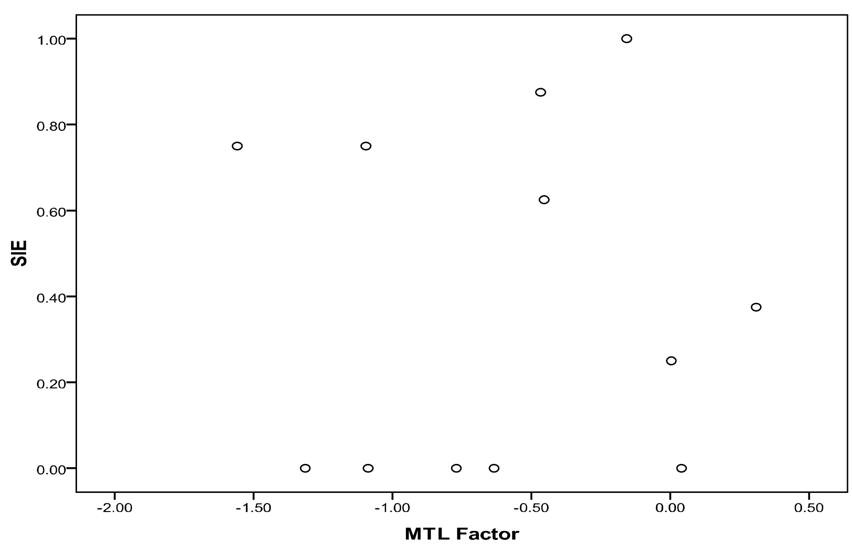


Figure 12a and 12b. Relation of MTL factor to prospective memory in the rote-rehearsal (12a) and self-imagination (12b) tasks.

E. Relation of SIE to MTL and FL functioning.

The relation of the SIE to the MTL and FL factors was analyzed with Pearson product-moment correlations in order to test the possibility that the SIE (prospective memory performance in the self-imagination task – prospective memory performance in the rote-rehearsal task) was influenced by memory or frontal lobe functioning. The relation of the SIE to the MTL factor was not significant, $r = .09$, $p = .96$, and the relation of the SIE to the FL factor was not significant, $r = .2$, $p = .53$ (figures 13a, b). However, once again these correlations are based on very small numbers.



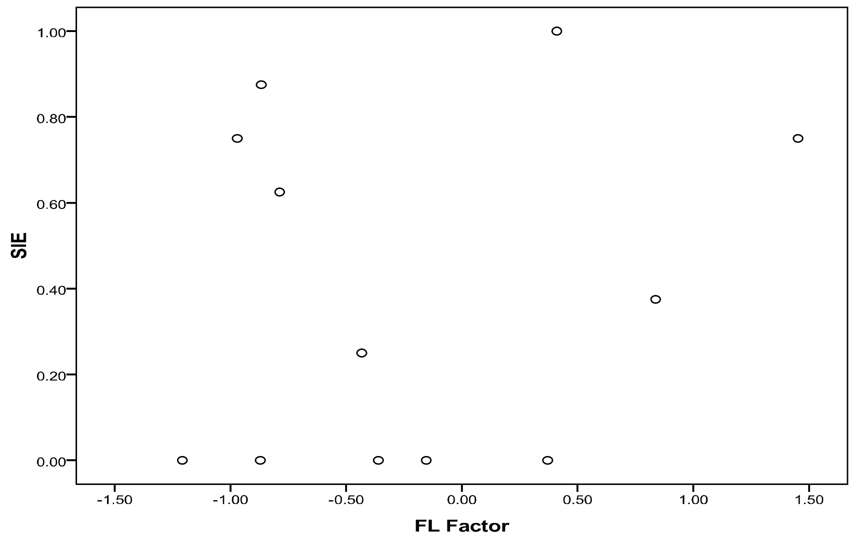


Figure 13a, and 13b. Relation of SIE to the MTL factor (13a) and to the FL factor (13b).

F. Effect of the memory deficit on the ability to benefit from self-imagination.

As mentioned in the introduction, we recognized that some individuals with very severe memory deficits may not be able to bind the future intention with the contextual cues of the intention, and as a result these individuals may fail to demonstrate the SIE. In order to test this possibility, we separated the participants into two groups: those who did show a SIE (n = 7) and those who did not show a SIE (n = 5). We computed an independent-samples t-test to determine whether the severity of the memory deficit in the group of individuals who did benefit from self-imagination was different from the group of individuals who did not benefit from self-imagination. The t-test revealed a marginally significant effect, t (11) = -2.02, p = .07. Those individuals who did not benefit from self-imagination had on average more severe memory deficits than those individuals who did benefit from self-imagination.

IV. DISCUSSION

The present study found a SIE for prospective memory in memory-impaired individuals with neurological damage. A majority of the participants benefited from self-imagination, which led to a 6-fold increase in prospective remembering in comparison to the rote-rehearsal task. Prospective memory performance in the self-imagination task was strikingly different from the rote-rehearsal task, and only 2 participants remembered even a single prospective memory target in the rote-rehearsal task. The inability to remember to press the 1 key for the target word in the rote-rehearsal task demonstrated by most of the participants characterizes the severity of their prospective memory impairments, and highlights the effectiveness of self-imagination.

The results replicate the findings from past studies to test the effect of self-imagination on prospective memory (Liu & Park, 2004; Chasteen *et al.*, 2001), and the findings reveal that self-imagination enhances a very difficult type of memory in at least some individuals with severe memory deficits. Moreover, the results extend our knowledge of the utility of self-imagination for memory-impaired individuals as the SIE has now been found for prospective memory in addition to recognition memory. Demonstrating the SIE for different types of memory is important for understanding the robustness of the effect and can have implications for its use in rehabilitation. It appears that self-imagination not only enhances memory for an event (*e.g.* study 1), but also improves memory in some individuals for what to do when that event is encountered.

In the present study we asked the participants to self-imagine a future event, and we asked them to imagine the event in a relatively familiar context, that being the room in which the experiment would take place. It is thought that we imagine future scenarios by recombining or reconstructing events, and that we do this by accessing details from autobiographical and episodic memory (Addis *et al.*, 2008). It is thus likely that in the process of self-imagining the participants accessed recent and salient cues for the construction of the event and because these contextual cues were encoded self-referentially, they may have been particularly memorable. In addition to this, the participants were asked to use self-imagination to simulate an action sequence, in this instance pressing the 1 key after seeing the word “president” or “state.” In contrast, in study 1 the participants were simply asked to self-imagine the scene as though they were an observer to the event. It is possible then that the self-imagination of an action sequence makes a future intention even more memorable than it would be if the individual imagined someone else completing the intention. The findings indicate that the self-imagination of the scene of a future intention and maybe the simulation of the intention greatly increases the likelihood of accomplishing that goal.

The implications of the findings are potentially far-reaching. Many individuals with neurological damage struggle to live independently as a result of deficits in prospective memory. While preliminary, the results from the present study suggest we might be able to use self-imagination as an intervention to improve prospective memory in individuals with neurological damage. For example, to improve medical adherence a patient can be instructed to imagine the self in the context of the future intention, such as in the kitchen pouring the first cup of coffee. The patient can then be asked to use self-imagination to integrate the habitual behavior (*e.g.* drinking coffee in the morning) with the intention (*e.g.* taking medication). Additionally, it is possible that such an intervention could be implemented in a laboratory setting as opposed to in the home since the participant need only imagine the self in the context of the future intention.

Not all individuals benefited from self-imagining. In fact, 5 out of the 12 participants failed to remember a single prospective target word in the rehearsal and self-imagining tasks. It is interesting to consider why the case may be that nearly half of the participants demonstrated such a profound prospective memory deficit, despite the use of a mnemonic strategy. One interpretation is that some individuals fail to bind the future intention to its contextual cues. Naveh-Benjamin (2007, 2000) contends that the types of episodic memory impairments seen in older adults are due to a deficit in the binding of the item to its contextual details, a phenomenon he refers to as the “Associative Deficit Hypothesis” (ADH). Of course, we tested individuals with neurological damage and not older adults. Yet, the profile of memory problems exhibited by older adults is in many ways similar to that of individuals with neurological damage, and while the ADH is traditionally evoked in reference to source and associative memory, prospective memory requires the binding of item to context, as well. So self-imagining may enhance the encoding of the future intention and the contextual cues, but a sub-set of individuals may still fail to bind these two elements together in memory. Interestingly, comments made by a couple of participants in the present study suggest this may be the case. At the end of the self-imagination study session PAT016 reported that she remembered she needed to press the 1 key, but forgot the target word, and PAT056 stated that he remembered the target word, but could not recall what key to press.

The data show that the individuals who did not benefit from self-imagination had on average more severe memory deficits than the individuals who did benefit from self-imagination. The findings can be interpreted as evidence in support of the ADH, meaning some individuals with more severe memory deficits may have failed to bind the intention with the contextual cues of the intention. A different interpretation is that these individuals forgot the prospective memory task entirely, and thus floor performance was due to a lack of memory for the prospective task and not a deficit in the ability to bind the intention to its contextual cues. However, all 5 of the participants who did not benefit from self-imagination made reference to the prospective memory task in the post-experiment query.

The failure to benefit from self-imagination may also be attributed to other cognitive processes thought to be important for prospective memory, which may affect prospective memory irrespective of intention formation. For instance, inhibition is required in order to disengage from the ongoing task and complete the prospective memory task. It may be the case that certain individuals cannot inhibit the ongoing task, possibly due to more frontal lobe damage, and that their profound deficit is unrelated to intention formation. A different cognitive process that might play a role is what Craik (1986) referred to as self-initiated retrieval. Prospective memory tasks do not incorporate a built-in retrieval mode, meaning there is no explicit instruction to engage in a memory search (Tulving, 1983), and thus retrieval in a prospective memory task requires the establishment of a self-initiated retrieval mode. Self-initiated retrieval is thought to be a particularly difficult task to undergo and it may be the case that some individuals failed to self-initiate the retrieval mode, despite the elaborate intention formation. These other processes, however, are thought to be related to prefrontal function, and in the present study, we found no relation between the FL factor scores and prospective memory performance.

We did not find a significant relation of the FL factor or MTL factor to prospective memory in the rote-rehearsal or self-imagining tasks. Previous research reports that higher scores on the FL factor correlate with better prospective memory performance in tasks where participants are not given a mnemonic strategy (McFarland & Glisky, 2009; McDaniel *et al*., 1999). We predicted that the FL factor would be related to prospective memory performance in the rote-rehearsal condition, but this effect was not obtained. It is likely, however, that frontal lobe function did not influence prospective memory in the present study because so many participants were at floor performance. The lack of a relation between the SIE and the factor scores is consistent with study 1, but it is difficult to interpret the results in light of the floor performance.

The last topic to touch on is the fact that the general knowledge task was very difficult for the memory-impaired individuals as they answered correctly on average 37 percent of the questions. This level of performance is similar to young adults but lower than what has been found with older adults (McFarland & Glisky, 2009), and the difficulty of the task may be related to a number of things including the rapid pace of the general knowledge test. The difficult nature of the general knowledge test implies that the cognitive demands for the ongoing task were high, something that may have influenced the amount of cognitive resources allocated to the prospective memory task. However, performance on the ongoing task was not correlated with prospective memory, and thus we can conclude that poor prospective memory performance in the study done here was not due to the difficulty of the ongoing task.

GENERAL DISCUSSION

For over 30 years we have known that using self-referential processing at encoding enhances memory to a greater degree than most mnemonic strategies and yet there is a paucity of studies testing the SRE in memory-impaired individuals (Marquine & Glisky, 2005; Marquine, 2008). The studies done here replicate prior research on the SRE in memory-impaired individuals and extend our knowledge of its effect in several ways. First, we showed that self-imagining is a robust and reliable method for enhancing memory in memory-impaired individuals, more so than emotional processing (study 1), semantic processing (study 2), or rote-rehearsing (study 3). Second, we found data to suggest the SRE is not entirely attributable to the affective component of self-referencing. Third, the data reveal that self-imagining enhances memory for individuals who do not benefit from other encoding strategies. In addition to this, study 3 exemplifies the potential application of self-imagining, and opens doors to future research aimed at enhancing everyday memory functioning in very meaningful ways. The data from the present project also extend our knowledge of the mnemonic benefit of emotional processing. We found and replicated a baseline EEE for sentence recognition in memory-impaired individuals with neurological damage. It is therefore possible that emotional processing can be incorporated into a larger memory rehabilitation program.

The last point to be made is that the data from these studies support the notion that the self may be special in the context of memory. It may be the case that the mechanism of the SRE relates to special encoding and retrieval properties, meaning a qualitatively distinct self schema. Using a neuropsychological approach we showed that ordinary memory functioning mediates the effectiveness of semantic and emotional encoding strategies but not self-referential processing. This implies that self-referential processing utilizes distinct mechanisms in memory that are less dependent on general memory function. While additional research is obviously warranted, we think that as a whole the data from the reported studies implicate the self as possessing qualitatively distinct and superior mnemonic properties.

I. FUTURE DIRECTIONS

A. The neural correlates of the SRE vs. the LOP effect

It may be helpful to use neuroimaging techniques to investigate the neural substrates of the regions contributing to subsequently remembered material. Previous research has found that the neural correlates of successfully remembered items encoded at a shallow level of processing constitute a sub-set of the neural correlates associated with successfully remembered items encoded with deeper levels of processing (*i.e.* "subsequent memory effect", Otten, Henson, & Rugg, 2001; Uncapher & Rugg, 2008). It would be interesting to contrast the neural correlates of successfully remembered material encoded with semantic processing to those of self-referential processing in order to see if the two processes are dissociable at the level of their neural substrates.

B. Self-imagining in a memory training project

Having demonstrated the SIE for prospective memory, it will also be interesting to test the possibility that training programs using self-imagining can improve common everyday memory problems and enhance spontaneous strategy use. Most tests of prospective memory involve accomplishing an external action such as pressing the 1 key when a target word appears on the screen or taking medication in the morning with breakfast. It is also possible that self-imagining could improve prospective memory for self-initiated cognitive processes such as using an encoding strategy to help in remembering information. For example, by using self-imagining we might be able to train memory-impaired individuals to use encoding strategies when entering a specific room in the laboratory or when trying to remember a particular type of information (*e.g.*

If I am trying to memorize verbal-paired associates, then I will think of a sentence that connects the two words in a logical way).

REFERENCES

Abraham, A., & von Cramon, D.Y. (2009). Reality = relevance? Insights from spontaneous modulations of the brain's default network when telling apart reality from fiction. *PLos ONE, 4 (3),* e4741.

Abraham, A., von Cramon, D.Y., & Schubotz, R.I. (2008). Meeting George Bush versus meeting Cinderella: the neural response when telling apart what is real from what is fictional in the context of our reality. *Journal of Cognitive Neuroscience, 20 (6),* 965-976.

Addis, D.R., Pan, L., Vu, M.A., Laiser, N., & Schacter, D.L. (2008). Constructive episodic simulation of the future and the past: Distinct subsystems of a core brain network mediate imagining and remembering. *Neuropsychologia,* epub ahead of print.

Amodio, D. M., & Frith, C. D. (2006). Meetings of minds: the medial frontal cortex and social cognition. *Nature Reviews of Neuroscience, 7,* 268-277.

Aron, A., Aron, E., Tudor, M., & Nelson, G. (1991). Close relationships as including other in the self. *Journal of Personality and Social Psychology, 60,* 241-253.

Bellezza, F.S. (1984). The self as a mnemonic device: The role of internal cues. *Journal of Personality and Social Psychology, 47,* 506-516.

Bisiacchi, P.S. (1996). The neuropsychological approach in the study of prospective memory. In M. Brandimonte,, G.O. Einstein, & M.A. McDaniel (Eds.), *Prospective Memory: Theory and applications* (pp. 297-318). Mahwah, NJ: Erlbaum.

Buckner, R.L., & Carroll, D.C. (2007). Self-projection and the brain. *Trends in Cognitive Sciences, 11 (2)*, 49-57.

Burgess, P.W., Quayle, A., & Frith, C.D. (2001). Brain regions involved in prospective memory as determined by positron emission tomography. *Neuropsychologia*, *39,* 545-555.

Burton, L. A., Bernstein Vardy, S., Frohlich, J., Dimitry, D., Wyatt, G., Rabin, L., & Labar, D. (2004). Affective tasks elicit material-specific memory effects in temporal lobectomy patients. *Journal of Clinical and Experimental Neuropsychology, 26* (8), 1021-1030.

Brown, P., Keenan, J.M., & Potts, G.R. (1986). The self-reference effect with imagery encoding. *Journal of Personality and Social Psychology, 51,* 897-906.

Cabeza, R., & St. Jacques, P. (2007). Functional neuroimaging of autobiographical memory. *Trends in Cognitive Sciences, 11,* 219-227.

Chasteen, A.L., Park, D.C., & Schwarz, N. (2001). Implementation intentions and facilitation of prospective memory. *Psychological Science,* 6, 457-461.

Cockburn, J. (1995). Task interruption in prospective memory: A frontal lobe function? *Cortex*, *31*, 87-97.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning & Verbal Behavior, 11*, 671-684.

Craik, F.I.M. (1986). A functional account of age differences in memory. In F. Klix & H. Hagendorf (Eds.), *Human memory and cognitive capabilities: Mechanisms and performance* (pp. 409-422). North-Holland; Elsevier Science Publishers, B.V.

Craik, F.I.M., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology: General, 104,* 268-294.

Czienskowski, U., & Giljohann, S. (2002). Intimacy, concreteness, and the self-reference effect. *Experimental Psychology, 49,* 73-79.

D'Argembeau, A., Ruby, P., Collete, F., Degueldre, C., Balteau, E., Luxen, A., Maquet, P., & Salmon, E. (2007). Distinct regions of the medial prefrontal cortex are associated with self-referential processing and perspective taking. *Journal of Cognitive Neuroscience, 19,* 935-944.

Davidson, P.S., McFarland, C.P., & Glisky, E.L. (2006). Effects of emotion on item and source memory in young and older adults. *Cognitive, affective & behavioral neuroscience, 6,* 306-322.

Delis, D.C., Kramer, J., Kaplan, E., & Ober, B.A. (1987). *The California Verbal Learning Test*. San Antonio, TX: Psychological Corporation.

Dirkx, E., & Craik, F.I. (1992). Age-related differences in memory as a function of imagery processing. *Psychology and Aging, 7 (3),* 352-358.

Ellis, J. (1996). Prospective memory or the realization of delayed intentions: A conceptual framework for research. In M. Brandimonte, G.O. Einstein, & M.A. McDaniel (Eds.), *Prospective memory: Theories and Applications* (pp. 1-22). Mahwah, NJ: Lawrence Erlbaum.

Frank, J. E. & Tomaz, C. (2003). Lateralized impairment of the emotional enhancement of verbal memory in patients with amygdala-hippocampus lesion. *Brain & Cognition, 52*, 223-230.

Foley, M.A., Belch, C., Mann, R., & McLean, M. (1999). Self-referencing: How incessant the stream? *American Journal of Psychology, 112*, 73-96.

Gade, A. Imagery as a mnemonic aid in amnesia patients: Effects of amnesia subtype and severity. In M.J. Riddoch and G.W. Humphreys (Eds.), *Cognitive Neuropsychology and Cognitive Rehabilitation* (pp. 571-589). Lawrence Erlbaum, Hove, 1994.

Gillihan, S. J., & Farah, M. J. (2005). Is self special? A critical review of evidence from experimental psychology and cognitive neuroscience. *Psychological Bulletin, 131*, 76-79.

Glisky, E.L., & Glisky, M.L. (2008) Memory rehabilitation in older adults. In D.T. Stuss, G. Winocur, & I.H. Robertson (Eds.), *Cognitive Neurorehabilitation: Evidence and Application (Second Edition)* (pp. 522-540). New York, NY: Cambridge Press.

Glisky, E.L., & Kong, L.L. (2008). Do young and older adults rely on different processes in source memory tasks? A neuropsychological study. *Journal of Experimental Psychology, Learning, Memory, and Cognition, 34 (4)*, 809-822.

Glisky, E.L., & Marquine, M.J. (2009). Semantic and self-referential processing of positive and negative trait adjectives in older adults. *Memory, 17 (2)*, 144-157.

Glisky, E.L., Polster, M.R., & Routhieaux, B.C. (1995). Double dissociation between item and source memory. *Neuropsychology, 9*, 229-235.

Gollwitzer, P.M. (1999). Implementation intentions: Strong effects of simple plans. *American Psychology, 54,* 493-503.

Gusnard, D.A., Akbudak, E., Shulman, G.L., & Raichle, M.E. (2001). Medial prefrontal cortex and self-referential mental activity: Relation to a default mode of brain activity. *Proceeds of the National Academy of Science, USA, 98,* 4259-4264.

Gutchess, A.H., Kensinger, E.A., & Schacter, D.L. (2007). Aging, self-referencing, and medial prefrontal cortex. *Social Neuroscience, 2,* 117-133.

Hamann, S. B., Cahill, L., & Squire, L. R. (1997). Emotional perception and memory in amnesia. *Neuropsychology, 2*, 104-113.

Hamann, S. B., Cahill, L., McGaugh, J. L. & Squire, L. R. (1997). Intact enhancement of declarative memory for emotional material in amnesia. *Learning and Memory, 4,* 301-309.

Hart, R.P., Kwentus, J.A., Wade, J.B., & Taylor, J.R. (1988). Modified Wisconsin Card Sorting Test in elderly normal, depressed, and demented patients. *Clinical Neuropsychologist, 2,* 49-56.

Hassabis, D., Kumaran, D., & Maguire, E.A. (2007). Using imagination to understand the neural basis of episodic memory. *The Journal of Neuroscience, 27,* 14365-14374.

Hassabis, D., Kumaran, D., Vann, S.D., & Maguire, E.A. (2007). Patients with hippocampal amnesia can not imagine new experiences. *Proceeds of the National Academy of Science, USA*, *104*, 1726-1731.

Heatherton, T.F., Wyland, C.L., Macrae, C.N., Demos, K.E., Denny, B.T., & Kelley, W.M. (2006). Medial prefrontal activity differentiates self from close others. *Scan, 1,* 18-25.

Jay, T., Caldwell-Harris, C., & King, K. Recalling taboo and nontaboo words. *American*

Journal of Psychology, 121 (1), 83-103.

Johnson, S.C., Baxter, L.C., Wilder, L.S., Pipe, J.G., Heiserman, J.E., & Prigatano, G.P. (2002). Neural correlates of self-reflection. *Brain, 125,* 1808-1814.

Kelly, W.M., Macrae, C.N., Wyland, C.L., Caglar, S., Inati, S., & Heatherton, T.F. (2002). Finding the self? An event-related fMRI study. *Journal of Cognitive Neuroscience, 14,* 785-794.

Kensinger, E.A. (2004). Remembering emotional experiences: the contributions of valence and arousal. *Reviews in the Neurosciences, 15,* 241-251.

Kensinger, E.A., Garoff-Eaton, R.J., & Schacter, D.L. (2007). How negative emotion enhances the visual specificity of a memory. *Journal of Cognitive Neuroscience, 11,* 1872-1887.

Kinsella, G., Murtagh, D., Landry, A., Homfray, K., Hammond, M., O'Bierne, L., Dwyer, L., Lamont, M. & Ponsford, J. (1996). Everyday memory following traumatic brain injury. *Brain Injury, 10,* 499-507.

Kliegel, M., Eschen, A., & Thone-Otto, A.I.T. (2004). Planning and realization of complex intentions in traumatic brain injury and normal aging. *Brain and Cognition*, *56*, 19-27.

Kliegel, M., & Martin, M.M. (2003). Prospective memory research: Why is it relevant? *International Journal of Psychology, 38,* 193-194.

Kliegel, M., Eschen, A., & Thone-Otto, A.I.T. (2004). Planning and realization of complex intentions in traumatic brain injury and normal aging. *Brain and Cognition*, *56,* 43-54.

Klein, S.B., & Kihlstrom, J.F. (1986). Elaboration, ogranization, and the self-reference effect in memory. *Journal of Experimental Psychology: General, 115,* 26-38.

Klein, S.B., & Loftus, J. (1988). The nature of self-referent encoding: The contributions of elaborative and organisational processes. *Journal of Personality and Social Psychology, 55,* 5-11.

Klein, S.B., Loftus, J., & Kihlstrom, J.F. (2002). Memory and temporal experience: The effects of episodic memory loss on an amnesic patient's ability to remember the past and imagine the future. *Social Cognition, 20,* 353-379.

Koriat, A., Ben-Zur, H., & Nussbaum, A. (1990). Encoding information for future action: Memory for to-be-peformed tasks versus memory for to-be-recalled tasks. *Memory and Cognition, 18,* 568-578.

Kuiper, N.A., & Rogers, T.B. (1979). Encoding of personal information: Self—other differences. *Journal of Personality and Social Psychology, 37,* 499-514.

Kvavilashvili, L., & Ellis, J. (1996). Varieties of intention: Some distinctions and classifications. In M. Brandimonte, G.O. Einstein, & M.A. McDaniel (Eds.), *Prospective memory: Theory, and applications* (pp. 23-51). Mahwah, NJ: Erlbaum.

Lord, C.G. (1980). Schemas and images as memory aids: Two modes of processing social information. *Journal of Personality and Social Psychology, 38,* 257-269.

Lord, C.G. (1987). Imagining self and others: Reply to Brown, Keenan, and Potts (1986). *Journal of Personality and Social Psychology, 38,* 445-450.

Liu, L.L. & Park, D.C. (2004). Aging and medical adherence: The use of automatic processes to achieve effortful things. *Psychology and Aging*, 19, 318-325.

Luria, A.R. (1968). His Memory. In A.R. Luria (Ed.), *The Mind of a Mnemonist* (pp. 29-38). Cambridge, MA: Harvard University Press.

Maki, R.H., & McCaul, K.D. (1985). The effects of self-reference versus other reference on the recall of traits and nouns. *Bulliten of the Psychometric Society, 23,* 169-172.

Manasse, N.J., Hux, K., & Snell, J. (2005). Teaching name-face associations to survivors of traumatic brain injury: A sequential treatment approach. *Brain Injury, 19,* 623-641.

Maratos, E.J., & Rugg, M.D. (2001). Electrophysiological correlates of the retrieval of emotional and non-emotional context. *Journal of Cognitive Neuroscience*, *13,* 877-891.

Marquine, M.J. (2008). Self-knowledge and self-referential processing in memory disorders: Implications for neuropsychological rehabilitation. *Dissertation Abstracts.*

Marquine, M. J., & Glisky, E. L (2005). *Self-knowledge and the self-reference effect in memory-impaired individuals.* Paper presented at the International Neuropsychological Society, St. Louis, MO.

McDaniel, M. A., Glisky, E. L., Rubin, S. R., Guynn, M. J., & Routhieaux, B. C. (1999). Prospective memory: A neuropsychological study. *Neuropsychology, 13*, 103-110.

McFarland, C.P., & Glisky, E.L. (2009). Frontal lobe involvement in a task of time-based prospective memory. *Neuropsychologia,47,* 1660-1669.

Mueller, J.H., Wonderlich, S., & Dugan, K. (1986). Self-referent processing of age-specific material. *Psychology and Aging, 1,* 293-299.

Naveh-Benjamin, M., Brav, T.K., & Levy, O. (2007). The associative memory deficit of older adults: The role of strategy utilization. *Psychology and Aging, 22,* 202-208.

Naveh-Benjamin, M. (2000). Adult age differences in memory performance: Tests of an associative deficit hypothesis. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 26,* 1170-1187.

Northoff G., Heinzel, A., de Greck, M., Bermpohl, F., Dobrowolny, H., & Panksepp, J. (2006). Self-referential processing in our brain – A meta-analysis of imaging studies on the self. *NeuroImage, 31*, 440-457.

Okuda, J., Fujii, T., Ohtake, H., Tsukiura, T., Tanji, K., et al. (2003). Thinking of the future and the past: The role of the frontal pole and the medial temporal lobes. *Neuroimage, 19,* 1369-1380.

Otten, L.J., Henson, R.N., & Rugg, M.D. (2001). Depth of processing effects on neural correlates of memory encoding: relationship between findings from across- and within-task comparisons. *Brain, 124 (2),* 399-412.

Phelps, E. A., LaBar, K. S., & Spencer, D. D. (1997). Memory for emotional words following unilateral temporal lobectomy. *Brain & Cognition, 35*, 85-109.

Piolino, P., Desgranges, B., Clarys, D., Guillery-Girard, B., Taconnat, L., Isingrini, M., & Eustache, F. (2006). Autobiographical memory, autonoetic consciousness, and self-perspective in aging. *Psychology and Aging, 21,* 510-525.

Powell, J., Letson, S., Davidoff, J., Valentine, T., & Greenwood, R. (2008). Enhancement of face recognition learning in patients with brain injury using three cognitive training procedures. *Neuropsycholgical rehabilitation, 18 (2),* 182-203.

Reber, R., Perrig, W.J., Flammer, A., & Walther, D. (1994). Levels of processing and memory for emotional words. *Swiss Journal of Psychology, 53 (2),* 78-85.

Rey, A. (1964). *L'Examen Clinique en Psychologie* [The Clinical Examination in Psychology]. Paris: Press Universitaire de France.

Richardson, J.T.E. (1995). Special issue: The neuropsychology of mental imagery. *Neuropsychologia, 33,* 1345-1357.

Robinson, J.A., & Swanson, K.L. (1993). Field and observer modes of remembering. *Memory, 1,* 169-184.

Rogers, T. B., Kuiper, N. A., & Kirker, W. S. (1977). Self reference and the encoding of personal information. *Journal of Personality and Social Psychology, 35,* 677–688.

Rosenbaum, R.S., Kohler, S., Schacter, D.L., Moscovitch, M., Westmacott, R., et al. (2005). The case of K.C.: Contributions of a memory-impaired person to memory theory. *Neuropsychologia, 43,* 989-1021.

Rubin, D.C., Schrauf, R.W., & Greenberg, D.L. (2003). Belief and recollection of autobiographical memories. *Memory and Cognition, 31,* 887-901.

Schacter, D.L., Addis, D.R., & Buckner, R.L. (2008). Episodic simulation of future events: Concepts, data, and applications. *Annals of the New York Academy of Science, 1124,* 39-60.

Schacter, D.L., Addis, D.R., & Buckner, R.L. (2007). Remembering the past to imagine the future: The prospective brain. *Nature Reviews: Neuroscience, 8,* 657-661.

Schweiger, G., & Gollwitzer, P. (2007). Implementation intentions: a look back at fifteen years of progress. *Psicothema, 19 (1),* 37-42.

Simons, J.S., Scholvinck, M.L., Gilbert, S.J., Frith, C.D, & Burgess, P.W. (2006) Differential components of prospective memory? Evidence from fMRI. *Neuropsychologia,* 44, 1388- 97.

Spreen, O., & Benton, A.L. (1977). *Neurosensory Center Comprehensive Examination for Aphasia* (NCCEA). Victoria: University of Victoria Neuropsychology Laboratory.

Spreen, O., & Strauss, E. (1998). *A Compendium of Neuropsychological Tests: Second Edition*. New York, NY: Oxford University Press

Staresina, B.P., Gray, J.C., & Davachi, L. (2009). Event congruency enhances episodic memory encoding through semantic elaboration and relational binding. *Cerebral Cortex, 19,* 1198-1207.

Summerfield, J.J., Hassabis, D., & Maguire, E.A. (2008). Cortical midline involvement in autobiographical memory. *Neuroimage* (epub ahead of print).

Symons, C. S., & Johnson, B. T. (1997). The self-reference effect in memory: A meta-analysis. *Psychological Bulletin, 121*, 371-394.

Szpunar, K.K., Watson, J.M., & McDermott, K.B. (2007). Neural substrates of envisioning the future. *Proceeds of the National Academy of Science, USA, 104,* 642-647.

Talland, G.A. (1965). *Deranged memory: A psychonomic study of the amnesic syndrome.*

New York and London: Academic Press.

Thone, A.I.T., & Glisky, E.L. (1995). Learning of name-face associations in memory-impaired patients: A comparison of different memory training procedures. *Journal of the International Neuropsychological Society, 1,* 29-38.

Thone-Otto, A.I.T., Walther, K. (2003). How to design an electronic memory aid for brain injured patients: Considerations on the basis of a model of prospective memory. *International Journal of Psychology, 38,* 236-244.

Troyer, A.K., Murphy, K.J., Anderson, N.D., Hayman-Abello, B.A., Craik, F.I.M., & Moscovitch, M. (2008). Item and associative memory in amnestic mild cognitive impairment: Performance on standardized memory tests. *Neuropsychology, 22,* 10-16.

Tulving, E. (1985). Memory and consciousness. *Canadian Journal of Psychology, 26,* 1-12.

Tulving, E. (1983). *Elements of episodic memory*. New York: Oxford University Press.

Twum, M. (1994). Role of imagery and verbal labeling in the performance of paired associate tasks by persons with closed head injury. *Journal of Clinical and Experimental Neuropsychology, 16,* 630-639.

Uncapher, M.R., & Rugg, M.D. (2008). Fractionation of the component processes underlying successful episodic encoding: a combined fMRI and divided-attention study. *Journal of Cognitive Neuroscience, 20 (2),* 240-254.

Wechsler, D. (1981). *Weschler Adult Intelligence Scale-Revised*. New York: Psychological Corporation.

Wechsler, D. (1987). *The Wechsler Memory Scale-Revised*. San Antonio, TX: The Psychological Corporation.

Wechsler, D. (1997). *Wechsler Memory Scale-Third Edition: Administration and scoring manual*. San Antonio, TX: The Psychological Corporation.

West, R. (2005). The neural basis of age-related declines in prospective memory. In Cabeza, R., Nyberg, L., & Park, D. (Eds.), *Cognitive Neuroscience of Aging* (pp. 246-266). New York, NY: Oxford University Press, Inc.

Wheeler, M.A., Struss, D.T., & Tulving, E. (1997). Toward a theory of episodic memory: the frontal lobes and autonoetic consciousness. *Psychological Bulletin, 121,* 331-354.

Wilson, B.A. (1987). *Rehabilitation of Memory*. New York, NY: Guildford Press.

Wilson, B.A., & Kapur, N. (2008). Memory rehabilitation for people with brain injury. In D.T. Stuss, G. Winocur, & I.H. Robertson (Eds.), *Cognitive Neurorehabilitation: Evidence and Application (Second Edition)* (pp. 522-540). New York, NY: Cambridge Press.