IMAGINING A BETTER MEMORY: THEORETICAL AND CLINICAL IMPLICATIONS OF THE SELF-IMAGINATION EFFECT IN MEMORY

by

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ABSTRACT

Prior research suggests that aspects of self-knowledge are relatively intact in many memory-impaired patients with acquired brain injury. Therefore, cognitive strategies that rely on preserved mechanisms of the self may be particularly effective in this population. The three studies presented in this dissertation investigated the practical utility and mnemonic mechanisms of a novel cognitive strategy designed to capitalize on self-referential processing: *self-imagination*. Study 1 investigated the effect of self-imagining on cued recall in memory-impaired patients with acquired brain injury and healthy controls. Sixteen patients and sixteen healthy controls intentionally encoded word pairs under four separate conditions: visual imagery, semantic elaboration, other person imagining, and self-imagining. The results revealed that self-imagining enhanced cued recall more than the other encoding conditions in patients and healthy controls. Study 2 was an initial investigation of the effect of self-imagining on free recall. Twenty healthy adults intentionally encoded word pairs under four conditions: self-imagining, a self-descriptiveness task thought to rely on access to semantic information in self-knowledge, an autobiographical memory task requiring retrieval of a self-relevant episodic memory, and a structural processing task. The results demonstrated that self-imagining improved free recall more than the other encoding conditions in healthy adults. Study 3 investigated the effect of self-imagining on free recall in memory-impaired patients with acquired brain injury and healthy controls. Fifteen patients and fifteen healthy controls intentionally encoded personality trait adjectives under five conditions: a self-imagining task, a self-descriptiveness task, an episodic autobiographical memory task, a semantic

elaboration task, and a phonemic processing task. The results revealed that the advantage of self-imagining over the other cognitive strategies extended to free recall in patients. Furthermore, the results indicated that the mnemonic benefit of self-imagining was partly attributable to preserved mechanisms associated with the retrieval of semantic information in self-knowledge. The findings from this dissertation indicate that self-imagining is a self-referential cognitive strategy that generates robust and reliable mnemonic improvement in memory-impaired patients with acquired brain injury and healthy controls. Cognitive strategies that involve preserved mnemonic mechanisms of the self, such as self-imagination, may provide a new direction in cognitive rehabilitation.

LITERATURE REVIEW

I. Memory Improvement in Brain-Injured Patients

Numerous studies with healthy adults have demonstrated that traditional cognitive strategies such as visual imagery and semantic elaboration are successful encoding methods for enhancing memory (Baddeley, Eysenck, & Anderson, 2009; Bower, 1970; Craik & Tulving, 1975; De Beni & Moè, 2003; Worthen & Hunt, 2011). In fact, visual imagery strategies have been used to improve memory for a wide range of materials including word lists and word pairs, name-face associations (Groninger, Groninger, & Stiens, 1995; Thoene & Glisky, 1995), and intention-action pairs such as those involved in prospective memory tasks (Chasteen, Park, & Schwarz, 2001; Liu & Park, 2004). Substantial research has also led to the conclusion that semantic elaboration strategies, which rely on verbal skills, provide robust mnemonic benefits over non-semantic cognitive strategies – a phenomenon known as the levels of processing effect (Craik, 2002; Craik & Lockhart, 1972). The success of cognitive strategies is thought to be partly attributable to the fact that they usually involve the encoding of meaningful and elaborative cues that are readily available later to assist in the retrieval of to-be-remembered information (Glisky & Glisky, 2008). For example, learning a name-face association may be enhanced by linking a visual image of the person's name to a facial feature that is distinctive and meaningfully related to the name and therefore available to serve as a memorable retrieval cue of what otherwise may be an arbitrary association.

Although traditional cognitive strategies have elicited robust and reliable benefits in healthy adults, efforts to enhance memory with these strategies in memory-impaired

patients with acquired brain injury have had limited and variable success (Glisky, 2004; Richardson, 1995). Indeed, visual imagery and semantic elaboration strategies have been effective in some studies (Cermak & Reale, 1978, Experiment 3; Glasgow, Zeiss, Barrera, & Lewinsohn, 1977; for a review, see Wilson, 2009) but not others (Cermak, 1982; Cermak & Reale, 1978, Experiments 1 and 2; Keane et al., 1997), and patients with mild or moderate memory deficits usually benefit more than patients with severe memory deficits (Benedict & Wechsler, 1992; Gade, 1994; Ryan & Ruff, 1988), although not always (Thoene & Glisky, 1995). These findings have led to the suggestion that the learning and use of cognitive strategies may depend on memory functions that are often compromised by brain injuries and may therefore have limited value in memory rehabilitation (Glisky, 2004; Richardson, 1995). Patients with severe memory deficits may not have sufficient residual memory function to benefit mnemonically from the elaborative encodings, and benefits experienced by patients with mild or moderate memory deficits may be relatively small and variable.

In contrast to traditional cognitive strategies, other methods such as vanishing cues (Glisky, 2004; Glisky, Schacter, & Tulving, 1986) and errorless learning (Baddeley & Wilson, 1994; Clare, Wilson, Carter, Roth, & Hodges, 2002) have approached memory improvement in patients with acquired brain injury from a different angle. Instead of relying on residual memory functions, these methods have capitalized on the notion that other intact cognitive functions may compensate for impaired memory abilities. For instance, vanishing cues and errorless learning were developed to enhance memory in memory-impaired patients by focusing on implicit memory processes, which are usually

spared by neurological damage (for a review, see Schacter, Chiu, & Ochsner, 1993; Warrington & Weiskrantz, 1968). Although methods that depend on implicit memory may be time-consuming and effort-intensive, they have been shown to improve memory in patients with acquired brain injury of various etiologies (Clare et al., 2002; Lubinsky, Rich, & Anderson, 2009; Wilson & Kapur, 2008), and patients with severe memory deficits have benefited as well (Evans et al., 2000). Therefore, the success of these methods provides a clear message: strategies that incorporate cognitive or memory mechanisms that are spared in neurological damage may be particularly effective.

II. A Model of Self and Memory

The relation of self and memory has long fascinated psychologists. In *Principles of Psychology* (1890), William James suggested that memory in general may play an important role in the development and stability of what he referred to as the "empirical self" or "me." Nearly a century later, several researchers proposed that autobiographical memory in particular might have an important relation with the self. Robinson (1986) contended that the ability to maintain a stable sense of self might depend on access to autobiographical memory, and Baddeley (1988) suggested that autobiographical memory might function as a "repository for those experiences that constitute one's self-concept" (pg. 13) – an idea elaborated on by Neisser (1988). This dissertation will build on the notion that the sense of self and autobiographical memory may be interconnected.

It has been suggested that autobiographical memory may be composed of both semantic information and episodic information (Conway & Pleydell-Pearce, 2000; Klein, 2010; Neisser, 1988). Although several terms have been used in the literature, this

dissertation will refer to semantic information in autobiographical memory as *semantic self-knowledge* and episodic information in autobiographical memory as *episodic self-knowledge*. Semantic self-knowledge is thought to include conceptual information that is abstracted from personal experiences and stored in semantic memory. Researchers have suggested that semantic self-knowledge may include general factual knowledge (e.g. I was born in California) (Tulving, 1985), identity roles (e.g. I am a graduate student) (Conway, 2005), and personality traits (e.g. I am conscientious) (Klein & Lax, 2010). Episodic self-knowledge, on the other hand, is believed to represent self-relevant memories that have a specific time and location (Tulving, 1983; Wheeler, Stuss, & Tulving, 1997). Memories in episodic self-knowledge are thought to incorporate records of emotion, personal thoughts, and sensory-perceptual details. Memories in episodic self-knowledge are typically vividly "re-experienced" or remembered when they are retrieved (Wheeler et al., 1997).

Studies of brain-injured patients have revealed that semantic self-knowledge may be relatively well preserved in the face of severe deficits in episodic self-knowledge. For instance, Cermak and O'Connor (1983) reported that S.S. – a 50 year-old man who developed severe retrograde and anterograde amnesia after he contracted herpes simplex encephalitis – had no episodic memories, and thus he based autobiographical memory retrieval exclusively on a "personal pool of generalized knowledge about himself" (p. 230). Rathbone, Moulin, and Conway (2009) described a similar case of relatively preserved semantic self-knowledge in patient P.J.M. – a 38 year-old woman with retrograde amnesia. Rathbone and colleagues (2009) found that patient P.J.M. could

retrieve semantic information about herself including autobiographical facts (e.g. I am the survivor of an accident), identity roles (e.g. I am an academic, I am a mother) and personality traits (e.g. I am active). In contrast to her preserved semantic self-knowledge, P.J.M. demonstrated a severely impaired ability to remember episodic memories from which these personal facts were derived. Further evidence of spared semantic self-knowledge in memory-impaired patients comes from neuropsychological research on trait self-knowledge. In a series of case studies, Klein and colleagues have demonstrated that semantic self-knowledge of one's own personality traits is spared in memory-impaired patients with acquired brain injury (for a review, see Klein & Gangi, 2010). Furthermore, Marquine (2009) found evidence of consistent semantic self-knowledge in a group of 12 memory-impaired patients with acquired brain injury of various etiologies.

Additional research on autobiographical memory has indicated that the neural correlates of episodic self-knowledge and semantic self-knowledge may be partly distinct. For instance, Rosenbaum and colleagues (2008) demonstrated that episodic self-knowledge impairment, but not semantic self-knowledge impairment, was related to hippocampal volume loss in four amnesic patients. Consistent with these results, in a recent meta-analysis of functional neuroimaging research on autobiographical memory in healthy individuals, Svoboda, McKinnon, and Levine (2006) found that episodic autobiographical memory retrieval was associated with the medial temporal lobe more than semantic self-knowledge retrieval. Therefore, these results suggest that semantic self-knowledge may depend less on the medial temporal lobe than episodic self-knowledge.

Thus, for several decades, researchers have speculated that the self may be represented in memory by semantic self-knowledge and episodic self-knowledge, and findings from neuropsychological research and functional neuroimaging studies imply that these two components of autobiographical memory may represent distinct aspects of the self. Semantic self-knowledge may represent what will be referred to as the *semantic self*: a component of the self construct that is maintained and updated by semantic self-knowledge in autobiographical memory, including autobiographical facts, identity roles, and personality traits. The semantic self may be relatively well preserved in many memory-impaired patients with acquired brain injury. In fact, Klein and colleagues (Klein, Cosmides, Costabile, & Mei, 2002) have proposed that specialized learning systems may support the acquisition and retrieval of semantic self-knowledge (in particular trait self-knowledge) in memory-impaired patients. Episodic memories that are stored in autobiographical memory may represent what will be referred to as the *episodic self*: a component of the self construct that is maintained and updated by episodic information in autobiographical memory. The episodic self may be disproportionately disrupted relative to the semantic self in many memory-impaired patients with acquired brain injury, and the episodic self may be more dependent on the medial temporal lobe than the semantic self. This dissertation will explore the feasibility of the distinction between the semantic self and the episodic self.

III. Self-Referential Processing and the Self-Reference Effect

A. Behavioral Studies

Numerous studies have demonstrated that encoding information self-referentially is a successful cognitive strategy (Bellezza, 1992; Klein, Loftus, & Burton, 1989; Maki & McCaul, 1985; Rogers, Kuiper, & Kirker, 1977). In fact, self-referential strategies provide a mnemonic advantage over other cognitive strategies including semantic elaboration and other-person processing – a phenomenon referred to as the "self-reference effect" (for a review, see Symons & Johnson, 1997). Self-referential processing has demonstrated robust and reliable effects with a variety of self-referential encoding tasks, materials, and retrieval demands. The effect of self-referential processing on memory has also experienced a recent upsurge of interest in the literature.

Self-referential strategies thought to involve the processing of semantic self-knowledge have enhanced memory in previous research. For instance, numerous studies have demonstrated that determining the self-descriptiveness of personality traits, a cognitive task believed to rely on the processing of semantic self-knowledge, is an effective self-referential strategy (Rogers, Kuiper, & Kirker, 1977; for a review, see Symons & Johnson, 1997). Although deciding whether a personality trait describes oneself may involve retrieving an episodic memory (e.g. you may decide that "generous" is self-descriptive because you remember a specific occasion when you donated money to a charitable foundation at the grocery store), multiple studies with healthy individuals have demonstrated that self-descriptiveness tasks of personality traits rely primarily on the retrieval of semantic self-knowledge (For a review, see Klein & Lax, 2010).

Recent research with memory-impaired individuals provides additional evidence to suggest that the mnemonic benefit of a self-descriptiveness judgment is related to

semantic self-knowledge. Marquine (2009) investigated trait self-knowledge and the self-reference effect using a self-descriptiveness task in memory-impaired patients with acquired brain injury of various etiologies. The results revealed that the patients benefited mnemonically from self-descriptive judgments and that the magnitude of the benefit was correlated with preserved semantic self-knowledge as measured by trait self-knowledge accuracy. Therefore, findings from healthy individuals and memory-impaired patients suggest that self-descriptiveness judgments of personality traits probably involve the retrieval of information included in semantic self-knowledge, and the processing of semantic self-knowledge – or semantic self-referential processing – enhances memory.

Despite the fact that most of the research on the self-reference effect has employed self-descriptiveness tasks, research with healthy individuals has also shown that processing information in relation to episodic self-knowledge effectively enhances memory (Bower & Gilligan, 1979; Klein & Kilhstrom, 1986; for a review, see Symons & Johnson, 1997). For instance, studies have demonstrated a mnemonic advantage of self-referential processing by instructing participants to retrieve specific events from autobiographical memory that are related to personality traits (e.g. Remember an event from your past when you acted out this personality trait) (Klein, Loftus, & Burton, 1989; Miall, 1986). Therefore, previous research has shown that processing information in relation to the episodic self – or episodic self-referential processing – elicits a self-reference effect.

Although both semantic self-referential processing and episodic self-referential processing presumably involve relating information to the self, previous research

suggests that the semantic self and episodic self do not rely on identical mnemonic mechanisms. Klein and colleagues (Klein, Loftus, & Burton, 1989) designed a study based on the notion that if two cognitive strategies tap into completely redundant mnemonic mechanisms, then using both cognitive strategies at encoding will not result in better memory than using one of the two cognitive strategies at encoding. However, if the strategies have partly non-overlapping mnemonic mechanisms, then using both strategies at encoding will result in greater memory than either strategy alone. Based on this rationale, Klein and colleagues' (1989) investigated whether semantic self-referential processing and episodic self-referential processing have redundant mnemonic mechanisms. In their study, participants encoded personality trait words by a) determining the self-descriptiveness of the personality trait (i.e. semantic self-referential processing), b) remembering an episode from autobiographical memory that was related to the personality trait (i.e. episodic self-referential processing), or c) determining the self-descriptiveness of the personality trait and remembering an episode from autobiographical memory (i.e. a combined semantic and episodic self-referential condition). Although mean free recall performance in the semantic self-referential processing condition was not significantly different from the episodic self-referential processing condition, both were outperformed by the combined semantic and episodic self-referential condition. Based on these findings, the authors concluded that semantic self-referential processing and episodic self-referential processing depend partly on unique mnemonic mechanisms. Indeed, if the benefits of semantic self-referential

processing and episodic self-referential processing involved completely redundant mechanisms, then the combined task would not have resulted in better memory.

Although a great deal of research has been conducted on self-referential processing, the mechanisms of the self-reference effect remain a topic of debate. Rogers and colleagues (1977) suggested that the self-reference effect may be attributable to special encoding and retrieval mechanisms associated with a superordinate self-schema – a notion that is similar to Klein and colleagues' contention that the self may engage specialized learning systems. Other researchers have argued that ordinary semantic elaboration and organizational processes may explain the self-reference effect (Gillihan & Farah, 2005; Greenwald & Banaji, 1989). The fact that intimate other-person processing has been found to attenuate and occasionally eliminate the mnemonic advantage of self-referential processing has been taken as support of the latter position. In addition, Klein and Loftus (1988) have demonstrated that the self-reference effect can be eliminated if comparison tasks combine semantic elaboration and organizational processes. These results, however, do not necessarily rule out the possibility that the self-reference effect involves special mechanisms. Indeed, equivalent memory performance between two tasks does not prove that the two tasks involve the same mnemonic mechanisms.

B. Functional Neuroimaging Studies

Researchers have recently turned to functional neuroimaging techniques in an effort to advance our understanding of the neural substrates of self-referential processing and the mechanisms of the self-reference effect. Findings from these studies indicate that

there is a self-referential processing network in the brain composed of cortical midline structures including medial prefrontal cortex (mPFC) and precuneus (Amodio & Frith, 2006; Northoff et al., 2006; Szpunar et al., 2007). In addition, research suggests that both semantic self-referential processing and episodic self-referential processing recruit mPFC. Indeed, functional neuroimaging studies that have required participants to make self-descriptiveness judgments of personality traits have consistently identified mPFC as a neural substrate (Heatherton et al., 2006; Macrae, Moran, Heatherton, Banfield, & Kelley, 2004; Kelley et al., 2002; Powell et al., 2010). Similarly, other research has concluded that the mPFC is one of the brain regions recruited during the retrieval of episodic autobiographical memories (Cabeza & St. Jacques, 2007; Svoboda et al., 2006). Therefore, although the semantic self and the episodic self may rely on partly distinct neural regions, the mPFC may be an important common substrate.

The self-reference effect has been linked to the mPFC in studies that have employed self-descriptiveness tasks. For example, functional neuroimaging research has demonstrated that mPFC activity predicts subsequent memory performance in healthy individuals (Macrae et al., 2004). In addition, a recent study conducted by Philippi and colleagues (Philippi, Duff, Denburg, Tranel, & Rudrauf, in press) reported that six patients with mPFC damage and normal memory functioning failed to demonstrate an advantage of semantic self-referential processing relative to other-person processing, whereas patients with brain damage outside of mPFC demonstrated the typical self-reference effect. Therefore, the findings from neuropsychological and functional neuroimaging research suggest that the mnemonic benefit of semantic self-referential

processing is associated with mPFC. To my knowledge no study has investigated the neural substrates of the self-reference effect with an episodic autobiographical memory task. Therefore, whether the mnemonic advantages of both semantic self-referential processing and episodic self-referential processing are mediated by mPFC activity remains unknown.

The debate about whether the self relies on special mnemonic processes has not been resolved by functional neuroimaging research. The fact that self-referential processing is linked to cortical midline structures, whereas semantic elaboration is related to left inferior prefrontal cortex (Kapur et al., 1996; Poldrack et al., 1999; for a review, see Rugg, Otten & Henson, 2002), seems to be inconsistent with the notion that self-referential processing involves ordinary semantic elaboration and organizational processes. However, the regions associated with self-referential processing have been implicated in emotional processing, social processing (Gillihan & Farah, 2005), and evaluative processing (Legrand & Ruby, 2009). Therefore, neither behavioral studies with healthy individuals nor functional neuroimaging research have provided unequivocal evidence in support of an explanation for the advantage of self-referential processing. Nevertheless, research with patient populations may shed new light on this debate, an idea addressed in this dissertation.

IV. The Potential of Self-Referential Strategies in Memory-Impaired Patients

Despite the robust benefits of self-referential strategies in healthy individuals, little research has focused on the mnemonic effect of self-referential processing in memory-impaired populations. As such, it is unclear whether equivalent benefits would

occur in individuals with memory deficits or if, as with other cognitive strategies, such effects would be smaller and more variable in an impaired group. However, a number of recent studies have investigated the effect of self-referential processing on memory in healthy aging older adults (Dulas, Newsome, & Duarte, 2011; Glisky & Marquine, 2009; Gutchess, Kensinger, & Schacter, 2010; Gutchess, Kensinger, Yoon, & Schacter, 2007; Hamimi, Serbun, & Gutchess, 2011; Rosa & Gutchess, 2011). These studies suggest that self-referential processing improves memory in healthy aging older adults under a variety of task demands, materials, and encoding tasks. Furthermore, preliminary evidence indicates that the advantage of self-referential processing may be unaffected by memory decline associated with normal aging (Glisky & Marquine, 2009).

Marquine (2005; 2009) was the first to investigate the effects of self-referential processing on memory in memory-impaired patients with acquired brain injury. In an initial study, Marquine and Glisky (2005) investigated the self-reference effect with the oft-used self-descriptiveness judgment task of personality traits. The results revealed an advantage of self-referential processing in recognition memory relative to semantic elaboration. In a follow-up study by Marquine (2009), memory-impaired patients and healthy controls were instructed to encode verb-noun phrases (e.g. ride a camel) by making personality judgments in relation to the self (e.g. are you the type of person to ride a camel?), by making personality judgments in relation to a well-known intimate other (e.g. is your mother the type of person to ride a camel?), or by counting the number of syllables in the verb-noun phrase. The results demonstrated an advantage of self-referential processing in cued recall relative to the syllable counting baseline task,

although there was no difference between self and other person processing. Given that the self-referential tasks in these two studies both appeared to emphasize the processing of information in semantic self-knowledge, these results suggest that semantic self-referential processing may enhance memory in memory-impaired patients with acquired brain injury. To my knowledge no study has investigated the mnemonic effect of episodic self-referential processing in memory-impaired populations.

Therefore, preliminary research from memory-impaired populations suggests that, in contrast to traditional cognitive strategies, self-referential strategies may be particularly effective in memory-impaired individuals with acquired brain injury for at least two reasons: First, self-referential strategies typically generate substantial mnemonic enhancements, and second, memory mechanisms related to the self may be intact in many memory-impaired patients with acquired brain-injury.

V. The Development of the Self-Imagination Technique

Findings from neuropsychology, functional neuroimaging, and cognitive psychology have indicated that imagination and memory depend on similar cognitive and neural mechanisms. For instance, previous research has revealed that patients with episodic memory deficits demonstrate similar impairments in the ability to imagine novel events (Hassabis, Kumaran, Vann, & Maguire, 2007; Tulving, 1985; Addis, Sacchetti, Ally, Budson, & Schacter, 2009; Gamboz et al., 2010). In addition, substantial functional neuroimaging research has revealed that imagination and memory recruit a common set of brain regions, including the hippocampus, medial prefrontal cortex, lateral temporal cortex, posterior cingulate, and inferior parietal lobule (for a review, see Schacter, Addis,

& Buckner, 2007). Furthermore, factors that influence the phenomenology of memory such as age of the individual, neuropsychological functioning, and instructions have been shown to similarly influence the phenomenology of imagination (Addis, Wong, & Schacter, 2008; D'Argembeau & van der Linden, 2004; D'Argembeau, Ortoleva, Jumentier, and Van der Linden, 2010).

The surge of interest in imagination has resulted in the emergence of a number of theories to explain the imagination-memory relation. Schacter and Addis' (2007) constructive episodic simulation hypothesis contends that the imagination of an event involves the retrieval and recombination of details from episodic memory, as well as cognitive processes similar to episodic memory, such as self-referential processing and imagery. Hassabis and Maguire (2007) have proposed that a common mechanism of imagination and memory may be the involvement of scene construction. In addition, Buckner and Carroll (2007) have suggested that imagination and memory may similarly rely on the ability to mentally project the self into a remembered or an imagined event. Although researchers have acknowledged the potential role of the self, very little is known about the type of self-referential processing that may be involved in imagination.

It is reasonable to postulate that semantic self-referential processing might contribute to our ability to imagine events from a personal perspective. For example, if asked to imagine that you are enjoying a day at the beach, you may access semantic self-knowledge of your personality traits and identity roles to know whether you are the type of person who would most likely spend your time surfing or drinking a piña colada under a beach umbrella. You also may retrieve information from lifetime periods in semantic

self-knowledge (e.g. when I lived in Newport Beach) or knowledge of personal goals to aid in the construction and elaboration of the imagined scenario (D'Argembeau & Mathy, 2011).

Self-imagining may involve a number of cognitive components related to the episodic self. For instance, based on the constructive episodic simulation hypothesis, the imagination of an event may rely on the retrieval of details from episodic autobiographical memories, at least in individuals with normal episodic memory function. In addition, self-imagination, like episodic memory, is believed to involve mentally projecting the self into a visual-spatial context (Buckner & Carroll, 2007). Mentally placing the self into a spatial scene may encourage the imaginer to process sensory-perceptual details in relation to the self, which may result in a highly self-referential experience of the imagined event. Furthermore, previous research has demonstrated that imagining an event from a personal perspective may evoke experiential details that are related to the self including one's thoughts, feelings, and sensory experiences (D'Argembeau et al., 2010).

Because imagination may rely on a considerable amount of self-referential processing, we (Grilli & Glisky, 2010) speculated that the imagination of an event from a personal perspective might serve as an effective self-referential strategy in many memory-impaired patients with acquired brain injury. To test the mnemonic benefit of imagination, we developed an encoding strategy that involved imagining to-be-remembered information from a personal perspective. We referred to the strategy as "self-imagination" to emphasize the hypothesized role of self-referential processing.

In an initial study of self-imagination (Grilli & Glisky, 2010), 14 memory-impaired individuals with acquired brain injury of various etiologies and 14 healthy control participants intentionally encoded sentences using three orienting tasks: a structural-baseline task (i.e. Decide whether there are more than 14 syllables in this sentence), a semantic elaboration task (i.e. Decide whether the target sentence matches the story), and a self-imagination task (i.e. Imagine you are at the scene being described by the sentence). On a yes-no recognition memory test, all 14 memory-impaired individuals demonstrated a mnemonic advantage for self-imagination in comparison to semantic elaboration – a self-imagination effect (SIE) – and similar results were found in the healthy controls. Additional findings revealed that the magnitude of the SIE was not influenced by severity of memory-impairment or subjective ratings of imagery vividness, although benefits of semantic elaboration were smaller in individuals with severe memory deficits. Based on these findings, we suggested that, as hypothesized, the advantage of self-imagination in recognition memory may be attributable to mnemonic mechanisms related to the self, and self-imagining may be a very effective mnemonic strategy in memory-impaired individuals.

PURPOSE OF THE PRESENT RESEARCH

Although the results from Grilli and Glisky (2010) are promising, questions remain regarding the practical utility and mnemonic mechanisms of self-imagining. For instance, although Grilli and Glisky (2010) measured recognition memory after a brief delay, demands on memory in everyday life usually involve fewer environmental cues and longer retention intervals. In addition, alternative explanations for the mechanisms of the SIE are plausible. Grilli and Glisky (2010) did not include an "other-imagining" encoding task, and therefore could not rule out the possibility that the SIE was partly attributable to person processing in general and not the self per se. Similarly, although imagery ratings were not significantly correlated with the SIE, the extent to which the SIE could be explained by benefits of simple visual imagery was not directly assessed. Because of these alternative explanations, the notion that the advantage of self-imagination is attributable to self-referential processing must remain tentative. In addition, Grilli and Glisky (2010) did not investigate the type of self-referential processing that may be involved in self-imagining. As mentioned, it is believed that the self may be represented in memory by both semantic self-knowledge and episodic self-knowledge. Whether the mnemonic benefit of self-imagining relies more on the processing of the semantic self or the episodic self is unknown.

Therefore, the studies presented in this dissertation were designed to address three principal aims. First, this research attempted to investigate further the practical utility of self-imagination as a valid strategy for memory improvement in memory-impaired patients with acquired brain injury. To address this aim, the effectiveness of self-

imagination was investigated with different materials and more difficult retrieval demands. Second, the studies presented in this dissertation attempted to elucidate the cognitive mechanisms of the SIE. To address this aim, self-imagining was compared to other cognitive tasks, including tasks designed to rely on semantic elaboration, simple visual imagery, other-person imagining, and standard self-referential processing. Neuropsychological data were collected on both patients and controls. Third, the studies presented in this dissertation were designed in an effort to shed new light on the debate about whether the self involves special mnemonic mechanisms or ordinary elaboration and organizational processes. To address this aim, patients and controls were tested.

STUDY 1: THE EFFECT OF SELF-IMAGINING ON IMMEDIATE AND DELAYED CUED RECALL

I. Introduction

Study 1 took several steps to address the practical utility of self-imagination. This study included a cued recall memory task, which is typically more difficult than recognition memory and represents another type of memory demand experienced in everyday life. In addition, in an effort to investigate the effect of retention interval on the SIE, cued recall was measured after short (2 minutes) and long (30 minutes) delays in the patient group. Furthermore, we selected an experimental paradigm that simulated a type of memory problem that could be plausibly addressed in cognitive rehabilitation. We used object and location word pairs as the materials, and we measured the ability to recall the location of objects.

Study 1 was also designed to investigate the feasibility of a number of critical alternative explanations for the SIE. A simple visual imagery task was included to assess the extent to which the magnitude of the SIE may be attributable to mnemonic mechanisms of visual imagery. A semantic elaboration task was included in an attempt to replicate and bolster the results from Grilli and Glisky (2010). Finally, an other-imagining task was included to investigate whether the benefit of the SIE was attributable to the processing of an imagined event in relation to a person and not the self, per se.

Based on previous research, self-imagining was hypothesized to enhance cued recall more than other-imagining, semantic elaboration, and visual imagery in the memory-impaired patients and the healthy controls. Whether the latter three encoding

strategies would differ from each other was an empirical question. Because previous research found that the SIE was not attenuated by severity of memory impairment (Grilli & Glisky, 2010), we expected to replicate this result in the present study.

II. Methods

A. Participants

Sixteen patients, ages 38 to 65 (7 male/9 female), with acquired brain injury of mixed etiology (12 with traumatic brain injury [TBI]), and sixteen healthy controls (6 male/10 female) matched in age, education, and IQ (as shown in Table 1) participated in the study. Individuals were recruited from the pool of participants in our laboratory (11 of the memory-impaired patients participated in Grilli & Glisky, 2010) and from brain injury support groups in the greater Tucson, Arizona area.

Table 1.

Mean (and Standard Deviation) Descriptive Characteristics and Neuropsychological Data for Memory-Impaired and Healthy Control Participants

	Memory-Impaired	Healthy Control	P-Value
Descriptive Characteristics			
Age	49.9 (7.4)	49.4 (12.4)	= .89
Education Level	15.0 (2.1)	15.6 (1.7)	= .36
Estimated IQ (NAART)	109.6 (10.6)	110.3 (7.0)	= .85
Memory Composite	-.63 (.66)	.63 (.39)	< .001
Executive Functioning Composite	-.35 (.83)	.35 (.43)	< .01

Notes. IQ = Intelligence Quotient; NAART = North American Adult Reading Test

To be included in the study, the brain-injured patients had to have a memory impairment, which was designated as a 1 standard deviation difference (i.e. 15 points) between pre-morbid intelligence estimated with the North American Adult Reading Test (NAART) (Spreen & Strauss, 1998) and memory functioning measured with the General Memory Index (GMI) from the Wechsler Memory Scale III (3rd ed.; WMS-III; Wechsler, 1997), and be at least one year post-trauma. Table 2 shows the etiology, location of neurological damage when available, years that have passed since injury, gender, age, estimated pre-morbid IQ, GMI, and the size of the memory impairment (i.e., IQ – GMI) for each memory-impaired patient.

Table 2.

Descriptive Characteristics for Memory-Impaired Patients

Participant	Etiology	Neurological Damage	Years Since Injury	Gender	Age	IQ	GMI	IQ – GMI
1	TBI	rFL/rTL/Diffuse	24	Male	44	125	110	15
2	TBI	rFL/diffuse	29	Female	53	125	96	29
3	TBI		32	Male	50	97	78	19
4	TBI		16	Female	53	103	63	40
5	Tumor	TLs/rFL	12	Female	55	95	70	25
6	Aneurysm	FLs	22	Male	46	127	81	46
7	Anoxia		36	Female	54	98	79	19
8	TBI	FLs (r > l)	27	Female	46	115	73	42
9	TBI	FLs/rTL/Diffuse	11	Female	47	118	98	20
10	TBI		18	Male	42	107	70	37
11	TBI		25	Female	38	98	51	47
12	TBI	rTLs/FLs	9	Male	57	106	89	17
13	TBI		4	Female	58	110	78	32
14	TBI	FLs	3	Male	65	108	91	17
15	TBI		9	Female	38	118	100	18
16	Encephalitis		4	Male	52	104	86	18
Mean (SD)			17.6 (10.6)		49.9 (7.4)	109.6 (10.6)	82.1 (15.1)	27.6 (11.4)

Notes. TBI = traumatic brain injury; r = right; l = left; FL = frontal lobe; TL = temporal lobe

B. Neuropsychological Measures

Memory-impaired and healthy control participants were administered a battery of neuropsychological tests designed to measure intellectual functioning (i.e. NAART), and to derive two composite scores that have been hypothesized to measure executive functioning and general memory functioning (Glisky & Kong, 2008; Glisky, Polster, & Routhieaux, 1995). Individuals with neurological damage and healthy controls completed the neuropsychological testing when they initially enrolled in our laboratory, which occurred between 2005 and 2010, with 12 of the patients and 13 of the controls tested within two years of participating in the present study. All memory-impaired patients were at least 1.5 years post-injury at time of testing and were deemed to be cognitively stable at that time. Because encoding and retrieval strategies depend at least partly on prefrontal brain regions and many of our patients had damage to these areas, we wanted to assess whether impaired executive function might affect their ability to benefit from self-imagination. We therefore constructed a composite measure of executive function based on five tests previously found to cluster together in factor analysis (Glisky et al., 1995, 2001) and hypothesized to reflect some aspects of executive function associated with working memory (Glisky & Kong, 2008). The neuropsychological tests included in the executive functioning composite were the Modified Wisconsin Card Sorting Task (WCST) (Hart, Kwentus, Wade, & Taylor, 1988), Mental Control (WMS-III) (Wechsler, 1997), Mental Arithmetic from the Wechsler Adult Intelligence Scale – Revised (WAIS-R) (Wechsler, 1981), the FAS test of word fluency (Spreen & Benton, 1977), and Digit Span Backwards (WMS-III) (Wechsler, 1997). The neuropsychological

tests included in the memory composite were Logical Memory I – First recall (WMS-III), Verbal Paired Associates I (WMS-III), Faces I (WMS-III), the California Verbal Learning Test (CVLT) Long Delay Cued Recall (Delis, Kramer, Kaplan, & Ober, 1987), and Visual Paired Associates II from the Wechsler Memory Scale – Revised (WMS-R) (Wechsler, 1987). The composite scores represent the average z-scores from the neuropsychological tests contributing to each factor relative to the entire sample of participants (n = 32). As shown in Table 1, the brain-injured patients were significantly impaired on the memory composite, t (24.3) = 6.51, $p < .001$, and the executive functioning composite, t (22.6) = 3, $p < .01$, relative to the control group.

C. Materials

Experimental stimuli were 64 object-location word pairs, which were separated into 4 lists of 16 matched on concreteness, imageability, and length. The object words were selected through the MRC Psycholinguistic Database Version II (Coltheart, 1981) and were previously rated on concreteness and imageability (on scales ranging 100 = minimum to 700 = maximum). Object words were rated as highly concrete with a mean concreteness rating of 597.05 and highly imageable with a mean imageability rating of 589.72. Object words were matched with unique spatial locations that, based on pilot testing, were rated as moderately related to the objects. Examples of word pairs are "crown – museum" and "typewriter – attic." Word pairs were randomly mixed for each participant and presented visually on a HP laptop computer with DMASTR DirectX (DMDX; Forster & Forster, 2003).

D. Procedures

Participants provided written informed consent prior to taking part in the study and all data were collected in compliance with regulations of the University of Arizona Institutional Review Board. For the memory-impaired patients, the study was divided into two sessions administered one week apart. Each session was approximately 60 minutes in duration and consisted of two study-test phases, one for each encoding condition. To limit carry-over effects, the first study phase in each session was either a visual imagery or a semantic elaboration encoding condition and the second study phase was either an other-imagining or a self-imagining encoding condition. Word pairs were counterbalanced across encoding conditions, and encoding conditions were counterbalanced across sessions such that visual imagery and semantic elaboration were paired with other- and self-imagining an equal number of times. Each study phase consisted of 16 target word pairs presented between two primacy and two recency buffer word pairs and was preceded by three practice trials so that participants were fully informed of the nature of the memory test.

Target word pairs were presented one at a time in the middle of the screen for seven seconds before a "beep" signaled the conclusion of the trial. In the visual imagery study phase, participants were instructed to form a visual image of the object in the spatial location and maintain the visual image for the remainder of the trial. For each trial, the statement "Form a visual image of the object in the spatial location" appeared on the top of the screen. In the semantic elaboration study phase, participants were instructed to generate a sentence that incorporated the object and spatial location in a

meaningful way and to say the sentence aloud. For each trial, the statement "Say a sentence that uses the object and the spatial location" appeared on the top of the screen. In the other-imagining study phase, participants were instructed to imagine with as much detail as possible Arnold Schwarzenegger interacting with the object in the spatial location. Participants were encouraged to imagine the event realistically and as though it could actually take place. Arnold Schwarzenegger was selected for the other-imagining task because he is generally well known for his roles in a variety of contexts (i.e. actor, politician, and athlete) and he has experienced a relatively high degree of exposure in multiple media outlets for the past several decades. All participants were able to form a vivid visual image and demonstrate general knowledge of Arnold Schwarzenegger. For each trial, the statement "Imagine Arnold Schwarzenegger interacting with the object in the spatial location" appeared on the top of the screen. In the self-imagining study phase, participants were instructed to imagine they were interacting with the object in the spatial location. Participants were encouraged to imagine the event from a realistic, personal perspective by including thoughts, feelings, and sensory experiences that they themselves might have if they were actually interacting with the object in the spatial location. For each trial, the statement "Imagine you are interacting with the object in the spatial location" appeared on the top of the screen. In the visual imagery, other-imagining, and self-imagining study phases, participants were encouraged to close their eyes to assist in image construction, but this was not mandatory.

Each study phase, which was about 5 minutes in duration, was followed by 2-minutes of counting backwards and a short delay cued recall test for the 16 target word

pairs presented in the study phase. Object words were presented visually as cues and participants had to recall aloud the spatial location word that was paired with each object word. The cued recall test was self-paced such that participants had as much time as they needed to name the location word or say that they could not remember. The experimenter recorded responses, but no feedback was provided. After completion of the short delay cued recall test for the second study phase in a session, participants were engaged in a 30 minute computerized trivia game, which required participants to answer multiple-choice general knowledge questions by making button presses on a keyboard. The trivia game was followed by a self-paced test of long delay cued recall for the 16 target word pairs that were from the first study phase and then the 16 target word pairs that were from the second study phase. As before, object words appeared in the center of the screen and participants were instructed to "recall the spatial location that was paired with this object."

The control group was administered a modified version of the experiment that, based on pilot testing, was designed to equate performance with the short delay cued recall test in patients. In a single 50 minute session, all four encoding conditions – visual imagery, semantic elaboration, other-imagining, and self-imagining – were blocked and administered in a continuous study phase that was approximately 20 minutes in duration. The study phase, which was preceded by three practice trials for each encoding condition, required participants to intentionally encode 16 word pairs under each encoding condition. Each word pair was presented for five seconds and the target word pairs appeared between two primacy and two recency buffer word pairs. Word pairs were

counterbalanced across encoding conditions, and the order of encoding conditions was counterbalanced across the study phase. On completion of the study phase, control participants were engaged in a 15 minute computerized trivia game, which required participants to answer multiple-choice general knowledge questions by making button presses on a keyboard. After the trivia game, they were administered a self-paced cued recall test for all 64 target word pairs under the same instructions as the memory-impaired participants. Word pairs were tested in a quasi-random order such that word pairs from the initial two blocks of the study phase were tested before word pairs from the other two blocks. Thus the control group received a single list of 64 word pairs blocked by encoding condition followed by a 15-minute retention interval and a single cued recall test, whereas the patient group was administered 4 separate study-test lists of 16 word pairs with a 2-minute study-test interval and a longer 30 minute delay.

III. Results

A. Effects of Encoding Conditions on Cued Recall

Table 3 shows the mean proportion correct on the cued recall tests as a function of encoding condition for the memory-impaired patients (short and long delays) and healthy controls. Short delay cued recall in the memory-impaired patients was compared to cued recall in the healthy controls using a 4 (encoding condition) X 2 (group) mixed analysis of variance (ANOVA). The results demonstrated a main effect of encoding condition, F (3, 90) = 13.32, $p < .001$, $\eta^2 = .31$; no effect of group, F (1, 30) = .25, $p = .63$; and no interaction, F (3, 90) = .74, $p = .53$. Because list length and retention interval were different in the two groups, absolute performance levels were not compared across

groups. We note only that the lack of a significant difference between the groups indicates that we were successful at equating performance levels. The significant effect of encoding condition was explored further using a priori comparisons, which revealed that self-imagining led to higher performance than other-imagining, t (31) = 7.45, p < .001, semantic elaboration, t (31) = 3.22, p < .01, and visual imagery, t (31) = 3.02, p < .01. In addition, other-imagining resulted in significantly poorer performance than visual imagery, t (31) = 4.12, p < .001, and semantic elaboration, t (31) = 2.54, p < .05, which did not differ. The lack of an interaction between group and condition indicated that the relative effectiveness of the encoding strategies was similar in the two groups.

Table 3.
Mean Cued Recall (and Standard Deviations) in the Visual Imagery, Semantic Elaboration, Other-Imagining, and Self-Imagining Conditions in the Memory-Impaired and Healthy Control Participants

	Memory-Impaired		Healthy Control
Encoding Task	Short Delay	Long Delay	15-Min Delay
Visual Imagery	.50 (.29)	.43 (.30)	.57 (.15)
Semantic Elaboration	.49 (.32)	.45 (.33)	.55 (.21)
Other-Imagining	.43 (.29)	.39 (.29)	.41 (.18)
Self-Imagining	.61 (.27)	.56 (.28)	.65 (.15)

We also analyzed the effect of delay in the memory-impaired group. A 4 (encoding condition) X 2 (delay) repeated measures ANOVA revealed a significant effect

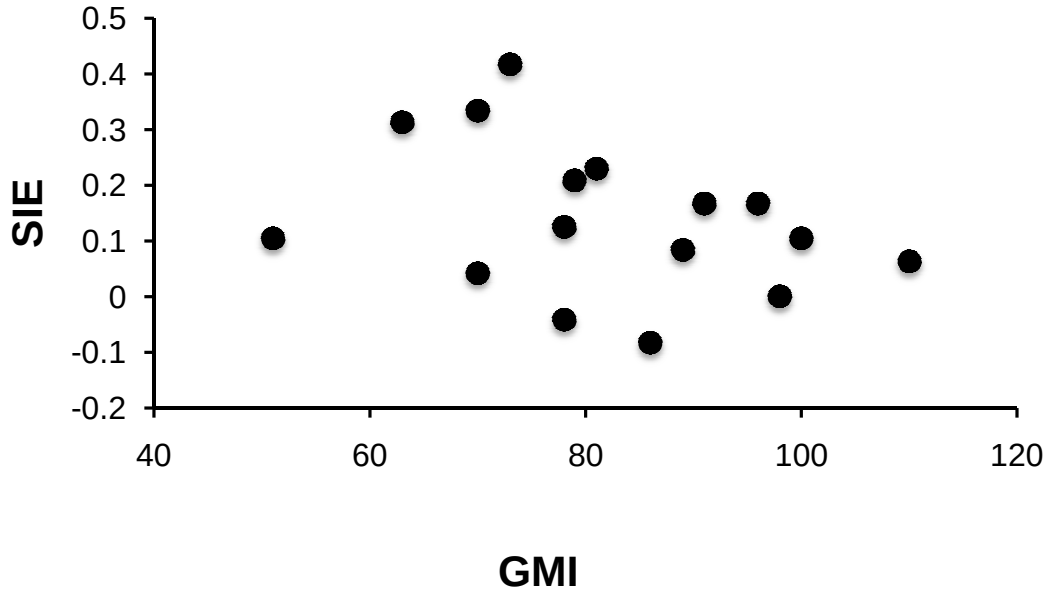
of encoding condition, F (3, 45) = 5.05, $p < .01$, $\eta^2 = .25$; a significant effect of delay, F (1, 15) = 22.84, $p < .001$, $\eta^2 = .60$; and no interaction, F (3, 45) = .71, $p = .55$. The memory-impaired patients showed a small but significant decline in performance across the 30-minute retention interval irrespective of encoding condition.

B. Relation of SIE to Neuropsychological Functioning

Pearson product-moment correlations were performed to examine whether the SIE was correlated with IQ, memory functioning as measured by the memory composite, or executive functioning as measured by the executive functioning composite. The SIE was derived by averaging performance in the other three encoding conditions (i.e. other-imagining, semantic elaboration, and visual imagery) and subtracting it from performance based in the self-imagining condition. The SIE in the patient group was based on performance in the short delay, since this measure was matched to the control group. We collapsed across groups to increase sample size and because composite scores were derived from the entire study sample. The magnitude of the SIE was not significantly correlated with IQ, $r = .19$, $p = .29$, memory functioning, $r = -.04$, $p = .81$, or executive functioning, $r = .04$, $p = .83$. Because we had GMI scores for the memory-impaired patients and we had investigated the correlation between the GMI and the SIE in our previous study (Grilli & Glisky, 2010), we further tested whether severity of memory deficit as measured by the GMI was correlated with the SIE in our patient group. Although not significant, the moderate but negative correlation between GMI scores and the SIE, $r = -.35$, $p = .18$, indicated that the *advantage* of self-imagining over the other encoding conditions was not attenuated by severity of memory impairment (see Figure

1). In fact, similar to our previous study (Grilli & Glisky, 2010), the trend in the data suggested that the SIE was slightly larger in individuals with poorer memory functioning.

Figure 1. Relation of the self-imagination effect (SIE) to memory deficit as measured by general memory index (GMI) scores.



IV. Discussion

A. Self-Imagining and Cued Recall

An accumulation of evidence has indicated that knowledge of oneself is preserved in many memory-impaired patients with acquired brain injury (Cermak & O'Connor, 1983; Klein & Lax, 2010; Rathbone et al., 2009). Therefore, cognitive strategies that

take advantage of encoding and retrieval mechanisms related to the self may be particularly effective in this population. The findings from the present study replicate previous research (Grilli & Glisky, 2010) showing that imagining an event from a realistic, personal perspective is a successful encoding strategy in memory-impaired patients with acquired brain-injury. The results also provide new evidence that self-imagining elicits a robust advantage over and above other encoding strategies and that this benefit occurs irrespective of severity of memory impairment and in a difficult retrieval task – cued recall. In fact, as hypothesized, the SIE in the patient group was not significantly different from the healthy controls with 14 of the 16 memory-impaired patients showing the effect, further validating self-imagining as a strategy for improving memory in individuals with neurologically-based memory deficits. In addition, the magnitude of the SIE withstood a 30-minute delay in the patient group.

B. Mechanisms of the SIE

The present study also sheds some light on the possible mnemonic mechanisms of the SIE, and calls into question several alternative explanations for the advantage of self-imagining. First, although the ability to imagine an event from a personal perspective presumably involves a visual imagery component, the mnemonic effect of self-imagining was superior to visual imagery. The fact that people demonstrated a substantial advantage of self-imagining relative to visual imagery suggests that, although benefits of visual imagery may contribute to the overall mnemonic effect of self-imagining, the added advantage of self-imagining appears not to be attributable to visual imagery. Second, findings from the present study, consistent with previous research (Grilli &

Glisky, 2010), suggest that the advantage of self-imagining is not attributable solely to semantic elaboration. Both memory-impaired and control participants showed higher levels of cued recall after self-imagining than after semantic elaboration. Thus, although self-imagining may include the generation of semantic details, the added benefit of self-imagining appears to depend on something other than semantic processing. Third, data from the present study indicate that imagining from a personal perspective produced greater cued recall than imagining in relation to another well-known person. Thus, although previous research has demonstrated that visualizing materials in reference to well-known people enhances memory (Aron, Aron, Tudor, & Nelson, 1991; Czienskowski & Giljohann, 2002; Lord, 1980), the present results indicate that the self provides benefits beyond those that might be associated more generally with person processing.

Instead, the findings from the present study are consistent with the hypothesis that the advantage of self-imagining over these other strategies is a result of encoding and retrieval mechanisms related to the self, which may be preserved in memory-impaired patients. For instance, mnemonic mechanisms related to the semantic self might contribute to the SIE. Indeed, as mentioned previously, semantic self-knowledge appears to be preserved in many memory-impaired patients with acquired brain injury and therefore may provide an effective encoding and retrieval cue. On the other hand, the advantage of self-imagining may be partly attributable to the episodic self. For example, the imagination of oneself interacting with an object in a spatial location may involve the retrieval and recombination of details from episodic self-knowledge. These details may

be very memorable and thus readily accessible at retrieval. However, the fact that the magnitude of the SIE was not attenuated in patients with more severe episodic memory deficits seems inconsistent with this interpretation. Nevertheless, the present study cannot rule out an episodic self-referential processing explanation of the SIE. It is also possible that an "emotional self" may contribute to the advantage of self-imagining. Previous research has demonstrated that autobiographical events retrieved from one's own personal perspective evoke greater emotional responses than autobiographical events retrieved from an impersonal perspective (Bagri & Jones, 2009; McIsaac & Eich, 2002), and numerous studies have indicated that emotion has the capacity to enhance memory in memory-impaired patients (Burton et al., 2004; Grilli & Glisky, 2010; Hamann, Cahill, McGaugh, & Squire, 1997; Marquine, 2009). Elaborate events imagined from a self-relevant perspective may be more emotionally salient and therefore more memorable.

These ideas are, of course, speculative, and further research is necessary to explore more directly the mechanisms underlying the SIE and address alternative explanations. For example, the effect of including personal thoughts, feelings, and sensory experiences remains unclear since the other-imagining instructions did not require participants to simulate Arnold Schwarzenegger's thoughts and feelings. However, dissociating the self from the simulation of another's psychological state and experiences may be difficult (Mitchell, Macrae, & Banaji, 2006).

One question raised by the present study is why the other-imagining task was inferior to visual imagery and semantic elaboration. One possibility is that the other-imagining task, by including another person as the focus of encoding, attenuated self-

referential processing relative to the other encoding conditions. The semantic elaboration task did not preclude participants from generating sentences that referenced the self, and although the visual imagery task did not make reference to a personal perspective, people may find it difficult to engage in visual imagery that does not include a personal viewpoint at least to some degree (Legrand & Ruby, 2009). Thus, visual imagery and semantic elaboration may have retained some elements of self-referential processing whereas other-imagining may have reduced such processing.

C. Self and Memory

In regards to the debate about whether the self involves special mnemonic processes, the present study does not provide strong evidence in favor of either position. The magnitude of the SIE was not attenuated by memory functioning, which is a notable deviation from previous research on semantic elaboration strategies in memory-impaired patients. However, the fact that the present study lacks a baseline task prevents an analysis of whether the benefit of semantic elaboration was differentially influenced by memory functioning. Furthermore, the overall pattern of cued recall across the different encoding conditions in the patient group did not significantly differ from the control group. The inclusion of a baseline task in subsequent research may help deal with this limitation.

STUDY 2: A PRELIINARY INVESTIGATION OF THE EFFECT OF SELF-IMAGINING ON FREE RECALL

I. Introduction

In an effort to continue to investigate the practical boundaries of the SIE, Study 2 was an initial test of the effect of self-imagining on free recall. Study 2 was also designed to investigate the relation of the SIE to benefits of semantic self-referential processing and episodic self-referential processing. As mentioned in the Literature Review, findings from previous research suggest that self-descriptiveness tasks of personality traits involve the processing of semantic self-knowledge. In contrast, episodic autobiographical retrieval tasks of personality traits are believed to involve episodic self-referential processing. Therefore, in the present study self-imagining was compared to a self-descriptiveness task and an episodic autobiographical retrieval task.

Self-imagining, semantic self-referential processing, and episodic self-referential processing were hypothesized to result in better free recall than a baseline task. Based on previous research (Klein et al., 1989), semantic self-referential processing and episodic self-referential processing were hypothesized to result in equivalent free recall. Whether the mnemonic effectiveness of self-imagining would be different from semantic self-referential processing and episodic self-referential processing was an empirical question.

II. Methods

A. Participants

Twenty undergraduates recruited from the Psychology Department subject pool participated in this study.

B. Materials

Experimental stimuli were 96 trait adjectives selected from a pool of normalized personality trait words (Anderson, 1968), which were separated into four lists of 24 matched on meaningfulness, valence, and word length. Each list contained eight positive, eight neutral, and eight negative trait words. Because trait adjectives included in Anderson (1968) were rated and ranked on likeability, 32 words from words 1 to 185 were selected as positive words (e.g. intelligent, friendly), 32 words from words 186 to 370 were selected as neutral words (e.g. serious, obedient), and 32 words from words 371 to 555 were selected as negative words (e.g. obnoxious, malicious).

C. Procedure

The study included four encoding conditions that were divided into separate intentional encoding study/test phases. Each study phase was preceded by 3 practice trials, and 24 target trait adjectives were presented between 2 primacy and 2 recency buffer words. In each study phase, trait adjective words were presented in the middle of the computer screen for 7 seconds and a "beep" signaled the end of the trial. Words were randomly mixed for each participant and presented visually on a Dell desktop computer with DMDX (Forster & Forster, 2003).

In the structural-baseline condition, participants were instructed to "count the number of consonants and vowels and decide if there is an even or odd number of each." Participants made a button press (odd/odd, even/even, even/odd or odd/even) to designate their answer. In the semantic self-referential processing condition, participants were instructed to "decide how well this trait adjective describes you." Participants made a

button press (1 = not at all, 2 = somewhat, 3 = quite a bit, 4 = definitely) to designate their answer. In the episodic self-referential processing condition, participants were instructed to "remember an event from your life when you acted out this trait adjective." In the self-imagining condition, participants were instructed to "imagine you are acting out this trait adjective." The pre-study practice trials ensured that all participants were able to remember or imagine events related to the personality traits. Participants were instructed to press the "X" key if they were not able to remember an event in the episodic self-referential processing condition or imagine an event in the self-imagining condition. Each study phase was followed by an immediate free recall test. Participants completed a one-minute digit cancellation task between study conditions. Trait adjectives were counterbalanced across participants such that each trait adjective appeared in each encoding condition an equal number of times, and order of encoding conditions was counterbalanced across participants.

In order to investigate further the extent to which benefits of self-imagining may be attributable to cognitive processes thought to be involved in episodic self-referential processing, participants were presented with 24 additional trait adjectives after the completion of the final test phase. For 12 trait adjectives (4 positive, 4 neutral, 4 negative), participants were instructed to remember an event from their life when they expressed the trait adjective, and for the other 12 trait adjectives (4 positive, 4 neutral, 4 negative) participants were instructed to imagine that they were acting out the trait adjective. After 7 seconds of remembering/imagining the trait adjective, participants rated the event for a number of phenomenological characteristics including visual detail

(1 = none, 3 = a little bit, 5 = quite a bit, 7 = a lot), clarity of location (1 = not at all, 3= a little bit, 5 = quite a bit, 7 = very much), clarity of time of day (1 = not at all, 3 = a little bit, 5 = quite a bit, 7 = very much), feeling of emotion (1 = none, 3 = a little bit, 5 = quite a bit, 7 = a lot), and feeling of realistically re-experiencing/experiencing the event (1 = not at all, 3 = a little bit, 5 = quite a bit, 7 = very much). To measure the contributions of cognitive components believed to be involved in mental projection, participants also rated the event for feeling of being physically present in the event (1 = not at all, 3 = a little bit, 5 = quite a bit, 7 = very much), and perspective taken (1 = always through my own eyes, 3 = mostly through my own eyes, 5 = mostly from another person's perspective, 7 = always from another person's perspective).

III. Results

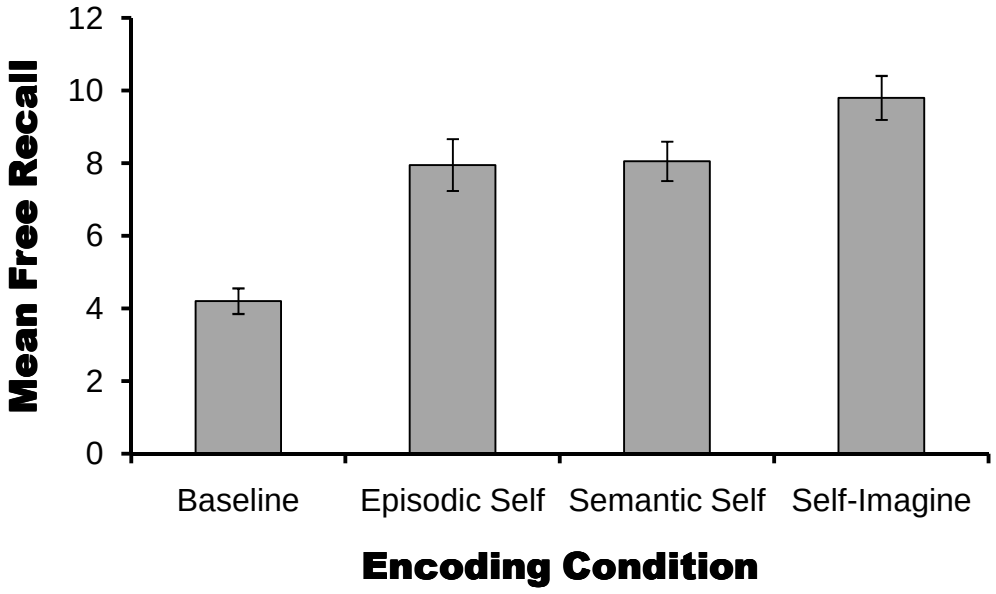
All participants were able to retrieve an episodic memory on each trial in the episodic self-referential processing condition and imagine an event on each trial in the self-imagining condition.

A. Effect of Encoding Condition on Free Recall

Figure 2 depicts mean free recall performance in the different encoding conditions. A repeated measures ANOVA demonstrated a main effect of encoding condition, F (3, 57) = 24.02, $p < .001$, $\eta^2 = .56$. Subsequent contrasts revealed that free recall performance in self-imagining was greater than semantic self-referential processing, F (1, 19) = 9.61, $p < .01$, $\eta^2 = .34$; and episodic self-referential processing, F (1, 19) = 8.53, $p < .01$, $\eta^2 = .31$; which did not differ, F (1, 19) < 1. Furthermore, the

baseline task resulted in poorer free recall than self-imagining, semantic self-referential processing, and episodic self-referential processing, all *p*'s < .001.

Figure 2. Free recall in the self-imagining, semantic self-referential processing, episodic self-referential processing, and baseline conditions. Error bars represent standard errors of the mean.



B. Relation of the Semantic Self and the Episodic Self to Self-Imagining

Pearson product-moment correlations investigated whether the advantage of self-imagining (i.e. self-imagining condition minus baseline condition) was related to the advantages of the traditional self-referential strategies (i.e. episodic self-referential

processing condition minus baseline condition and semantic self-referential processing condition minus baseline condition). The results revealed that the mnemonic advantage of self-imagining was significantly correlated with the advantages of episodic self-referential processing, $r = .69$, $p < .01$, and semantic self-referential processing, $r = .65$, $p < .01$.

C. Effect of Valence of Materials

Repeated measures ANOVAs, which were run to investigate whether the valence of materials (i.e. positive, neutral, and negative) affected performance in any of the encoding conditions (i.e. baseline, semantic self-referential processing, episodic self-referential processing, and self-imagining), revealed no significant effects, all F's < 1.

D. Relation of Self-Imagining to Ratings

Pearson product-moment correlations were conducted to explore whether self-imagining was related to self-reported phenomenological and mental projection ratings. Self-imagining was marginally correlated with mean self-reported emotional response when imagining events, $r = .42$, $p = .07$. Individuals who reported experiencing overall greater emotional responses when imagining the self from a personal perspective tended to recall more from self-imagining than individuals who were less emotionally responsive (Figure 3). None of the other phenomenological or mental projection ratings approached significance, all p's > .15.

Figure 3. Relation of mnemonic benefit of self-imagining to mean self-reported emotional response when imagining the self acting out personality traits.

E. Relation of Episodic Self-Referential Processing to Ratings

Pearson product-moment correlations explored whether episodic self-referential processing was related to the self-reported phenomenological and mental projection ratings. None of the phenomenological or mental projection ratings approached significance, all *p*'s > .13.

IV. Discussion

A. Self-Imagining and Free Recall

Study 2 presents novel evidence showing that self-imagining outperforms traditional self-referential strategies in free recall. Although numerous studies have found robust benefits with traditional self-referential strategies, the present study demonstrates that imagining an event from a personal perspective results in even better

memory. One plausible explanation for why self-imagining may be superior to semantic self-referential processing and episodic self-referential processing is that self-imagining may combine mnemonic mechanisms of the semantic self and the episodic self. In the present study, the advantages of semantic self-referential processing and episodic self-referential processing were both significantly related to the advantage of self-imagining. Therefore, self-imagining may tap into a type of self-referential processing that relies on mnemonic mechanisms related to the semantic self and episodic self, and the advantage of self-imagining may be partly attributable to the fact that self-imagining may involve both types of self-referential processing. However, without a non self-referential comparison task, such as semantic elaboration, this conclusion must remain tentative.

Although self-imagining may involve mechanisms of both the semantic self and episodic self, the SIE in memory-impaired patients and healthy controls may rely differentially on the episodic self and semantic self. For example, in brain-injured patients with episodic memory impairment, self-imagining may be largely dependent on semantic self-referential processing and only receive small benefits from episodic self-referential processing. Therefore, the results from study 2 raise the following question: Does self-imagining rely more on the semantic self or the episodic self in memory-impaired patients with acquired brain injury?

B. Self-Imagining and Patients: Evidence of a Semantic Self?

Findings from previous research in our laboratory suggest that self-imagining may rely more on the semantic self in patients with memory deficits. Study 1 demonstrated that brain-injured patients with episodic memory impairment experience robust benefits

from self-imagining in comparison to other cognitive strategies including visual imagery and semantic elaboration. In addition, the advantage of self-imagining has been found to be independent of memory functioning, whereas benefits from other strategies have been shown to be smaller in patients with more severe memory deficits – a finding that is consistent with previous research on improving memory with traditional cognitive strategies in brain-injured patients. Based on these results, Grilli and Glisky have postulated that self-imagining may rely on mnemonic mechanisms that are preserved in many memory-impaired patients, suggesting that self-imagining may rely more on the semantic self than the episodic self. As mentioned, previous research has demonstrated that many memory-impaired patients have preserved semantic self-knowledge – the semantic self. On the other hand, many memory-impaired patients with acquired brain injury have a severely impaired ability to retrieve episodic memories in autobiographical memory – the episodic self. Therefore, although semantic self-referential processing and episodic self-referential processing may rely on equally effective mnemonic mechanisms, self-imagining may depend largely on – or entirely on – the semantic self in memory-impaired patients with acquired brain injury for three reasons: 1) self-imagining may tap into self-referential processing, 2) self-imagining may be attributable to intact mnemonic mechanisms, and 3) the semantic self appears to be relatively well preserved in memory-impaired patients in comparison to the episodic self.

C. The Advantage of Self-Imagining in Free Recall

The results from the present study raise another question with theoretical and clinical implications: Is the advantage of self-imagining over other self-referential

strategies in free recall preserved in memory-impaired patients with acquired brain injury? From a theoretical perspective, investigating self-imagining, semantic self-referential processing, and episodic self-referential processing in memory-impaired patients may provide a unique opportunity to uncover the relative contributions of the semantic self and episodic self to self-imagining. As mentioned, previous research suggests that the semantic self may be well preserved in memory-impaired patients, whereas the episodic self may be impaired in this population. Therefore, how self-imagining is affected in memory-impaired patients relative to healthy controls may depend on whether the SIE is more attributable to the semantic self or the episodic self. For example, if the mnemonic effects of self-imagining and semantic self-referential processing are relatively intact in comparison to episodic self-referential processing in memory-impaired patients, then self-imagining may be related to the semantic self more than the episodic self. On the other hand, if self-imagining relies more on the episodic self than the semantic self, then one possibility is that the mnemonic effects of self-imagining and episodic self-referential processing may be disproportionately attenuated relative to semantic self-referential processing in memory-impaired patients.

From a clinical perspective, in order to further assess the usefulness of self-imagining in memory rehabilitation it is important to investigate the effect of self-imagining on free recall in memory-impaired patients. If the SIE is relatively well preserved, then self-imagining may be a particularly effective strategy for memory rehabilitation, especially if the advantage of self-imagining is independent of memory and executive functioning.

STUDY 3: SELF-IMAGINING, SELF-REFERENTIAL PROCESSING, AND FREE RECALL IN BRAIN-INJURED INDIVIDUALS AND HEALTHY CONTROLS

I. Introduction

Building on the results from Studies 1 and 2, Study 3 was designed to further assess the practical utility of the self-imagination technique. The present study tested the effect of self-imagination on free recall in memory-impaired patients with acquired brain injury and healthy controls. Free recall, in addition to being very difficult, is often required in everyday life. Whether self-imagining improves free recall in memory-impaired patients, therefore, has important implications for understanding the feasibility of applying the self-imagination technique in cognitive rehabilitation.

The fact that self-imagining enhanced memory more than traditional self-referential strategies in Study 2 is noteworthy, given the large body of research demonstrating the superiority of these traditional self-referential strategies. Study 3 investigated whether the advantage of self-imagining relative to traditional self-referential strategies was maintained in memory-impaired patients with acquired brain injury. Study 3 also investigated whether the SIE was more attributable to mnemonic mechanisms of the semantic self or the episodic self in memory-impaired patients. The results from Study 2 suggest that the SIE may involve mechanisms of both the semantic self and the episodic self in healthy individuals. However, since many memory-impaired patients have an impaired episodic self but a relatively preserved semantic self, it may be the case that patients will rely more on the semantic self than the episodic self during self-imagination.

In addition, Study 3 attempted to shed new light on an old debate: Are the mnemonic mechanisms of the self special? Although several researchers have postulated that self-referential processing may involve special learning and memory mechanisms (Glisky & Marquine, 2009; Klein et al., 2004; Rogers et al., 1977), other researchers have contended that the advantage of self-referential processing is attributable to more of the same semantic elaboration and organizational processes capitalized on by other cognitive strategies (Gillihan & Farah, 2005; Greenwald & Banaji, 1989). Neither behavioral studies with healthy individuals nor functional neuroimaging research have been able to provide strong evidence in favor of one position or the other.

Another method for tackling this debate is to investigate memory-impaired patients with acquired brain injury. Previous research has demonstrated that semantic elaboration strategies are typically less effective in memory-impaired patients with acquired brain injury relative to healthy individuals. In contrast, emerging research indicates that self-referential strategies such as semantic self-referential processing (Marquine, 2009) and self-imagining (Grilli & Glisky, 2010) appear to be very effective in memory-impaired patients, suggesting that self-referential strategies may not rely on the same elaborative and organizational processes as other strategies. However, no study has investigated whether the benefit of semantic elaboration is *disproportionately* attenuated in comparison to self-referential processing in memory-impaired patients with acquired brain injury. Although Marquine (2009) investigated the effectiveness of self-referential processing in memory-impaired patients with acquired brain injury and healthy controls, the study did not include a task that clearly relied on semantic

elaboration. Furthermore, although self-imagining appears to be very effective in brain-injured patients with memory deficits, no study has directly compared absolute performance levels between patients and controls. In an initial study of self-imagining (Grilli & Glisky, 2010), differences in false alarms rates between patients and controls prevented a direct comparison of encoding strategy effectiveness, and Study 1 cannot address whether semantic elaboration is disproportionately lower relative to self-imagining because of between-group methodological differences and the lack of a baseline task. Although Study 3 was not able to administer the same methodology to both patients and controls, a baseline task was included so that the pattern of performance could be compared between patients and controls. If self-referential strategies tap into mnemonic mechanisms that are better preserved in memory-impaired patients than semantic elaboration, then the mnemonic benefit of semantic elaboration may be disproportionately lower relative to mnemonic benefits of self-referential processing in this population.

Study 3 was also designed to address a limitation of Study 2. In Study 2, the baseline and semantic self-referential processing tasks required four-option responses on each trial, whereas the episodic self-referential processing and self-imagining tasks required no button-press response at all. Given that this research is interested in investigating mnemonic mechanisms, such differences between encoding conditions is problematic for interpretation. To rectify this limitation, the encoding conditions in Study 3 all required a one-option button press.

In order to address the aims of Study 3, the mnemonic effectiveness of a baseline task, semantic elaboration, semantic self-referential processing, episodic self-referential processing, and self-imagining were investigated in memory-impaired patients and healthy controls with a free recall memory task. In the patient group, self-imagining and semantic self-referential processing were hypothesized to be better preserved in comparison to episodic self-referential processing for three reasons: 1) research in our laboratory suggests that self-imagining may tap into mnemonic mechanisms that are preserved in memory-impaired patients, 2) self-imagining may rely on self-referential processing, and 3) previous research suggests that the semantic self may be relatively well preserved in memory-impaired patients. Whether self-imagining would outperform semantic self-referential processing in the patients was an empirical question. In the healthy controls, based on previous research, the semantic self-referential processing condition and the episodic self-referential processing condition were hypothesized to result in similar memory performance, and self-imagining was hypothesized to outperform these two self-referential processing strategies.

To investigate further the cognitive mechanisms of the mnemonic benefit of self-referential processing, we investigated whether the self-descriptiveness of the to-be-remembered information influenced the magnitude of the memory effects. If any of the encoding conditions require accessing a self-schema in semantic memory, then to-be-remembered information that is self-descriptive and thus congruent with the self-schema may be elaborated on to a greater degree and may be more memorable than information that is not self-descriptive. Given that semantic self-referential processing is believed to

involve the retrieval of semantic information in self-knowledge, it was predicted that the self-descriptiveness of the to-be-remembered information would be related to the benefit of semantic self-referential processing such that self-descriptive information would be more memorable than non self-descriptive information. Furthermore, because self-imagining may be primarily related to the semantic self in memory-impaired patients, a similar effect of self-descriptiveness was expected in the self-imagining condition in the patient group. Whether semantic elaboration would be disproportionately lower in memory-impaired patients relative to the self-referential strategies was an empirical question addressed in Study 3.

The present study also investigated the relation of the memory effects to neuropsychological functioning. Given the results of previous research on self-imagining, the magnitude of the SIE was expected to be unrelated to executive functioning or memory functioning. Consistent with the results of Grilli and Glisky (2010), the benefit of semantic elaboration was predicted to be smaller in individuals with poorer memory functioning. In addition, it was predicted that the benefit of episodic self-referential processing would be attenuated in patients with poorer memory functioning.

II. Methods

A. Participants

Fifteen patients, ages 39 to 65 (7 male/8 female), with acquired brain injury of mixed etiology (13 with traumatic brain injury [TBI]), and fifteen healthy controls (7 male/8 female) matched in age, education, and IQ (as shown in Table 4) participated in

the study. Individuals were recruited from the pool of participants in our laboratory and from brain injury support groups in the greater Tucson, Arizona area.

Table 4.

Mean (and Standard Deviation) Descriptive Characteristics and Neuropsychological Data for Memory-Impaired and Healthy Control Participants

	Memory-Impaired	Healthy Control	P-Value
Descriptive Characteristics			
Age	51.3 (7.2)	50.7 (9.6)	p = .87
Education Level	15.2 (2.0)	15.9 (1.6)	p = .32
Estimated IQ (NAART)	111.1 (10.0)	112.1 (9.8)	p = .80
Memory Composite	-0.60 (.6)	0.60 (.3)	p < .001
Executive Functioning Composite	-0.36 (.8)	0.36 (.5)	P < .01

Notes. IQ = Intelligence Quotient; NAART = North American Adult Reading Test

To be included in the study, patients with acquired brain injury had to have a memory impairment, which was designated as a 1 standard deviation difference (i.e. 15 points) between pre-morbid intelligence estimated with the North American Adult Reading Test (NAART) (Spreen & Strauss, 1998) and memory functioning measured with the General Memory Index (GMI) from the Wechsler Memory Scale III (3rd ed.; WMS-III; Wechsler, 1997), and be at least one year post-trauma. Table 5 shows the etiology, location of neurological damage when available, years that have passed since

injury, gender, age, estimated pre-morbid IQ, GMI, and the size of the memory impairment (i.e., IQ – GMI) for each memory-impaired patient.

Table 5.

Descriptive Characteristics for Memory-Impaired Patients

Participant	Etiology	Neurological Damage	Years Since Injury	Gender	Age	IQ	GMI	IQ – GMI
1	TBI	rFL/diffuse	31	Female	55	125	96	29
2	TBI		16	Female	53	103	63	40
3	TBI	FLs/rTL/Diffuse	14	Female	50	118	98	20
4	TBI	FLs (r > l)	30	Female	49	115	73	42
5	TBI	rTLs/FLs	9	Male	57	106	89	17
6	Aneurysm	FLs	22	Male	56	127	81	46
7	TBI	rFL/rTL/Diffuse	26	Male	46	125	110	15
8	Anoxia		38	Female	56	98	79	19
9	TBI		28	Female	41	98	51	47
10	TBI		22	Male	46	107	70	37
11	TBI		10	Female	39	118	100	18
12	TBI		5	Female	59	110	78	32
13	TBI	FLs	3	Male	65	108	91	17
14	TBI		35	Male	53	97	78	19
15	TBI		4	Male	44	112	79	33
Mean (SD)			17.6 (10.6)		51.3 (7.2)	111.1 (10.0)	82.4 (15.3)	28.7 (11.6)

Notes. TBI = traumatic brain injury; r = right; l = left; FL = frontal lobe; TL = temporal lobe

B. Neuropsychological Measures

Memory-impaired and healthy control participants were administered a battery of neuropsychological tests designed to measure intellectual functioning (i.e. NAART), executive functioning, and memory functioning. All memory-impaired patients were at least 3 years post-injury at time of testing and were deemed to be cognitively stable at that time. Included in the neuropsychological battery were tests that contribute to the derivation of two composite scores that have been identified through factor analysis and hypothesized to measure executive functioning and general memory functioning, respectively (Glisky & Kong, 2008; Glisky, Polster, & Routhieaux, 1995). The executive functioning composite has been proposed to reflect aspects of executive function associated with the prefrontal cortex (Glisky & Kong, 2008; Glisky, Polster, & Routhieaux, 1995). The neuropsychological tests included in the executive functioning composite are the Modified Wisconsin Card Sorting Task (WCST) (Hart, Kwentus, Wade, & Taylor, 1988), Mental Control (WMS-III) (Wechsler, 1997), Mental Arithmetic from the Wechsler Adult Intelligence Scale – Revised (WAIS-R) (Wechsler, 1981), the FAS test of word fluency (Spreen & Benton, 1977), and Digit Span Backwards (WMS-III) (Wechsler, 1997). The memory composite has been hypothesized to reflect memory processes that are mediated by the medial temporal lobe (Glisky & Kong, 2008; Glisky, Polster, & Routhieaux, 1995). The neuropsychological tests included in the memory composite are Logical Memory I – First recall (WMS-III), Verbal Paired Associates I (WMS-III), Faces I (WMS-III), the California Verbal Learning Test (CVLT) Long Delay Cued Recall (Delis, Kramer, Kaplan, & Ober, 1987), and Visual Paired Associates II

from the Wechsler Memory Scale – Revised (WMS-R) (Wechsler, 1987). The average and standard deviation for each subtest was calculated based on the entire sample of participants (n = 30). Executive functioning and memory functioning composite scores were calculated for each participant by averaging the participant's z-scores on the neuropsychological tests that contribute to each composite. As shown in Table 4, the brain-injured patients were significantly impaired on the memory composite, t (28) = 6.82, $p < .001$, and the executive functioning composite, t (28) = 2.86, $p < .01$, relative to the control group.

C. Materials

Experimental stimuli were 120 trait adjectives selected from a pool of normalized personality trait words (Anderson, 1968). The trait adjectives were separated into 5 lists of 24 matched on meaningfulness, valence, and word length. Each list contained eight positive, eight neutral, and eight negative trait adjectives. The trait adjectives reported in Anderson (1968) were rated and ranked on likeability from 1 (most likeable) to 555 (least likeable). The pool of 120 trait adjectives included 40 words from words 1 to 185, which were selected as positive trait adjectives (e.g. intelligent, friendly), 40 words from words 186 to 370, which were selected as neutral trait adjectives (e.g. serious, obedient), and 40 words from words 371 to 555, which were selected as negative trait adjectives (e.g. obnoxious, malicious).

D. Procedures

The procedures were slightly different for patients and controls. For the memory-impaired patients, experimental testing was split into two sessions completed on

consecutive days. There were five encoding conditions in total. Three encoding conditions were completed in the first session, and two were completed in the second session. Each encoding condition included four intentional encoding study/test phases of six target trait adjectives (two positive, two neutral, and two negative) presented between two primacy and two recency buffer words. The study/test phases for each encoding condition were blocked, and each test phase was followed by a four-minute trivia game, which was included to prevent interference effects. Each encoding condition was preceded by a three-trial practice study/test phase. Words were randomly mixed for each participant and presented visually on a Dell desktop computer with DMDX (Forster & Forster, 2003).

On each trial, the target trait adjective was presented in the middle of the computer screen for 10 seconds and a "beep" signaled the end of the trial. In the baseline condition, the statement "try to think of words that rhyme with this personality trait" appeared above the target trait adjective. In the semantic elaboration condition, the statement "try to think of a definition of this personality trait" appeared above the target trait adjective. In the semantic self-referential processing condition, the statement "try to think about how well this personality trait describes you" appeared above the target trait adjective. In the episodic self-referential processing condition, the statement "try to remember an event from your life when you acted out this personality trait" appeared above the target trait adjective. In the self-imagining condition, the statement "try to imagine you are acting out this personality trait" appeared above the target trait adjective. The practice trials that preceded each encoding condition ensured that the patients

understood the instructions and how to perform the task. In previous research on self-imagining (Grilli & Glisky, 2010; Study 1), patients were instructed to imagine events by including personal thoughts, feelings, and sensory experiences. We removed this instruction from the present study to avoid any potential confound that it might have introduced in previous research.

On each trial, patients were instructed to press the "X" key once they generated a rhyme word, generated a definition, made a self-descriptiveness judgment, started to remember an event, or started to imagine an event. Patients were told that it was necessary to press the "X" key, because the experimenter needed to know whether they were able to complete the task on each trial. In addition, patients were told it was very important that they continue to perform the task after they press the "X" key, and they should not stop performing the task until the computer beeps. For example, patients were instructed to press the "X" key when they started to imagine themselves acting out a trait adjective and then to continue to imagine until the computer beeped.

Each study phase was followed by an immediate free recall test. In the free recall test, the experimenter said, "Please tell me all the words that you can recall," and the patients recalled words aloud. The experimenter recorded the responses, but no feedback was provided. The free recall tests were self-paced such that patients had as much time as they needed to respond. The free recall tests were discontinued when the patient could not recall anymore trait adjectives. Trait adjectives were counterbalanced across patients such that each trait adjective appeared in each encoding condition an equal number of times. Order of encoding conditions also was counterbalanced across patients.

After completing the final free recall test, the experimenter administered a yes-no self-descriptiveness task for all of the target trait adjectives (n = 120). In this portion of the experiment, patients were told to judge whether each trait adjective was self-descriptive or not self-descriptive. Patients were assured that no memory test would follow. For each trial, the question "does this trait describe you?" appeared on the top of the screen, and a target trait adjective appeared in the middle of the screen. Patients responded by pressing a key on the keyboard labeled "Yes" or "No." The task was self-paced such that the patients had as much time as needed to make a button press. Once a decision was made, another target trait adjective appeared in the middle of the computer screen. The order of the trait adjectives was random.

The methodology was modified for the healthy control group in order to make the free recall memory tasks of comparable difficulty. For the healthy controls, experimental testing was completed in a single session. Each of the five encoding conditions included a single intentional encoding study/test phase of 24 trait adjectives. Each study phase included two primacy and two recency buffer words, and each trial was seven seconds in duration. Each study phase was followed by an immediate free recall test, and then a four-minute trivia game. All other aspects of the methodology (e.g. practice study/test phase that preceded each encoding condition, encoding condition instructions, free recall instructions, counterbalancing, and final self-descriptiveness judgment task) were consistent with the methods used for the patients.

III. Results

A. Effect of Encoding Condition on Free Recall in Patients

Table 6 shows the free recall data split by encoding condition in patients and healthy controls. Between-group methodological differences prevented a direct comparison of absolute performance levels. Although the free recall scores for both groups are out of 24, the scores for patients in each condition were summed across four 6-item study-test trials, whereas those for controls were based on a single 24-item study-test trial. In the patient group, a one-way repeated measures analysis of variance (ANOVA) demonstrated a main effect of encoding condition, F (4, 56) = 17.35, $p < .001$, $\eta^2 = .55$. Subsequent contrasts revealed that self-imagining resulted in better free recall than baseline processing, F (1, 14) = 54.07, $p < .001$, $\eta^2 = .79$; semantic elaboration, F (1, 14) = 31.8, $p < .001$, $\eta^2 = .69$; episodic self-referential processing, F (1, 14) = 28.47, $p < .001$, $\eta^2 = .67$; and semantic self-referential processing, F (1, 14) = 5.46, $p < .05$, $\eta^2 = .28$. These results demonstrate that the advantage of self-imagining relative to other cognitive strategies extends to free recall in memory-impaired patients with acquired brain injury. In contrast to prior research with healthy adults, additional contrasts revealed that semantic self-referential processing enhanced free recall more than episodic self-referential processing, F (1, 14) = 4.73, $p < .05$, $\eta^2 = .25$, and episodic self-referential processing was not significantly different from semantic elaboration, F (1, 14) = 1.34, $p < .27$. Thus, in the memory-impaired patient group the mnemonic benefit of self-referential processing relative to semantic elaboration was evident only when it involved access to the semantic self. Finally, semantic elaboration and episodic self-referential processing

both resulted in better free recall than baseline processing, F (1, 14) = 5.16, $p < .05$, η^2 = .27 and F (1, 14) = 10.67, $p < .01$, η^2 = .43, respectively. Thus, the semantic elaboration and episodic self-referential processing strategies were not completely ineffective.

Table 6.
Mean Free Recall (and Standard Deviations) in the Baseline, Semantic Elaboration, Episodic Self-Referential Processing, Semantic Self-Referential Processing, and Self-Imagining Conditions in the Memory-Impaired and Healthy Control Individuals

Encoding Task*	Memory-Impaired	Healthy Control
Baseline	3.2 (1.6)	3.2 (2.2)
Semantic Elaboration	4.7 (2.7)	4.8 (1.7)
Episodic Self	5.7 (2.6)	6.3 (3.0)
Semantic Self	7.3 (3.7)	6.0 (1.7)
Self-Imagining	9.3 (3.4)	8.1 (2.5)

*Memory-impaired patients received four study-test trials of 6 items in each condition, whereas healthy controls received a single study-test trial of 24 items in each condition.

B. Effect of Encoding Condition on Free Recall in Healthy Controls

In the healthy controls, a one-way repeated measures ANOVA demonstrated a main effect of encoding condition F (4, 56) = 14.62, $p < .001$, η^2 = .51. Subsequent contrasts revealed that self-imagining resulted in better free recall than baseline processing, F (1, 14) = 33.42, $p < .001$, η^2 = .71; semantic elaboration, F (1, 14) = 20.96, $p < .001$, η^2 = .60; episodic self-referential processing, F (1, 14) = 7.53, $p < .05$, η^2 = .35;

and semantic self-referential processing, F (1, 14) = 11.15, $p < .01$, $\eta^2 = .44$. Similar to the patient data, these results indicate that the benefit of self-imagining relative to semantic elaboration extends to free recall in healthy adults. These results are also consistent with the patient data in showing that self-imagining enhances free recall more than traditional self-referential strategies. However, additional contrasts revealed that, unlike the patient data, free recall following semantic self-referential processing was not significantly different from free recall following episodic self-referential processing, F (1, 14) = 0.23, $p = .64$ and both enhanced free recall more than semantic elaboration, F (1, 14) = 5.56, $p < .05$, $\eta^2 = .28$ and F (1, 14) = 3.53, $p = .08$, $\eta^2 = .20$, respectively. Therefore, in contrast to the patient data, both of the traditional self-referential strategies demonstrated a self-reference effect relative to semantic elaboration. Finally, semantic elaboration resulted in better free recall than baseline processing, F (1, 14) = 11.29, $p < .01$, $\eta^2 = .45$.

C. Difficulty of the Encoding Tasks in Patients and Healthy Controls

Because participants were required to press the "X" key once they thought of a rhyme word, generated a definition, made a self-descriptiveness judgment, remembered an autobiographical event, or imagined an event, we were able to analyze whether participants found it easier to perform certain encoding tasks relative to others. Table 7 shows the mean number of trials successfully performed out of 24 in each encoding condition separated by patients and healthy controls. For one patient, a computer recording error occurred in the self-imagining condition only. Therefore, in Table 7 the self-imagining mean and standard deviation in the patient group is based on 14 data

points, and all analyses on the patient group in this sub-section are based on a sample size of 14.

Table 7.

Mean (and Standard Deviation) Number of Trials Successfully Performed out of 24 in Each Encoding Condition Separated by Memory-Impaired and Healthy Control Individuals

Encoding Condition	Memory-Impaired	Healthy Control
Baseline	12.5 (8.1)	15.2 (7.6)
Semantic Elaboration	22.9 (1.8)	21.1 (5.2)
Episodic Self	16.0 (7.7)	20.4 (4.8)
Semantic Self	21.9 (3.8)	23.3 (1.7)
Self-Imagine	21.1 (4.0)	21.5 (4.7)

A 2 (group) X 5 (encoding condition) mixed ANOVA was run with a Greenhouse-Geisser adjustment, because the assumption of sphericity in the encoding condition variable had been violated. The ANOVA demonstrated a main effect of encoding condition, F (2.62, 70.76) = 21.33, $p < .001$, $\eta^2 = .44$; no effect of group F (1, 27) = 1.2, $p = .28$; and a marginally significant interaction F (2.62, 70.76) = 2.51, $p = .07$, $\eta^2 = .09$. Overall, participants successfully completed fewer trials in the baseline condition than all other conditions, all p's < .01; and the only difference between groups was in the episodic self condition, t (28) = 1.87, $p = .07$. These findings indicate that both patients and controls were less successful at retrieving rhyme words relative to the

other encoding conditions, but the patient group had specific difficulties relative to controls retrieving episodic memories.

D. Effect of Trial Success on the Episodic Self in Patients

The patients in comparison to the controls had more difficulty successfully performing the episodic self-referential processing condition. Furthermore, the only difference in the overall pattern of results between the patients and the controls pertained to the relative effectiveness of the episodic self-referential processing condition. If successfully performed trials were better recalled than unsuccessfully performed trials, then the weaker enhancement demonstrated by the patients in the episodic self-referential processing condition may be attributable to task difficulty.

It was not possible to compare successful and unsuccessful trials in the semantic elaboration, semantic self-referential processing, and self-imagining conditions because a majority of the patients successfully performed every single trial in those conditions. Therefore, the unsuccessful trial calculations in these conditions would be based on very small sample sizes (n = 5). However, a paired samples t-test of successful and unsuccessful trials in the episodic self-referential processing condition was not significant, t (13) < 1, suggesting that successfully performed trials in the episodic self-referential processing condition were not more memorable than unsuccessfully performed trials. Furthermore, because all 15 of the patients successfully performed at least one trial in each of the semantic elaboration, episodic self-referential processing, and semantic self-referential processing conditions, and 14 patients had data for the self-imagining condition, additional paired samples t-tests were conducted to investigate the relative

effectiveness of episodic self-referential processing to these other encoding conditions on *successful trials only*. These statistical contrasts were consistent with the results of the ANOVA presented earlier. Therefore, the difference in the mnemonic effectiveness of the episodic self-referential processing condition in the patient group cannot be explained by task difficulty alone.

E. Relation of Neuropsychological Functioning to the Memory Effects

Pearson product-moment correlations were conducted to investigate the relation of neuropsychological functioning as measured by the memory composite and the executive functioning composite to the memory effects in patients and healthy controls. Patients and healthy controls were analyzed separately. All memory effects were calculated in relation to the baseline condition to take into account the different pattern of results found in the patients and healthy controls. The SIE was calculated by subtracting free recall in the baseline condition from free recall in the self-imagination condition. The semantic self-reference effect (i.e. SSRE) was calculated by subtracting free recall in the baseline condition from free recall in the semantic self-referential processing condition. The episodic self-reference effect (i.e. ESRE) was calculated by subtracting free recall in the baseline condition from free recall in the episodic self-referential processing condition. The "levels of processing effect" (i.e. LOP effect) was calculated by subtracting free recall in the baseline condition from free recall in the semantic elaboration condition.

Table 8.

Correlation Matrix of Neuropsychological Functioning and Memory Effects in Patients

	MCom	EFCom	SIE	SSRE	ESRE	LOP
MCom	---					
EFCom	.43	---				
SIE	.35	.70**	---			
SSRE	.29	.55*	.54*	---		
ESRE	.32	.70**	.64*	.65*	---	
LOP	-.10	.48	.44	.53*	.37	---

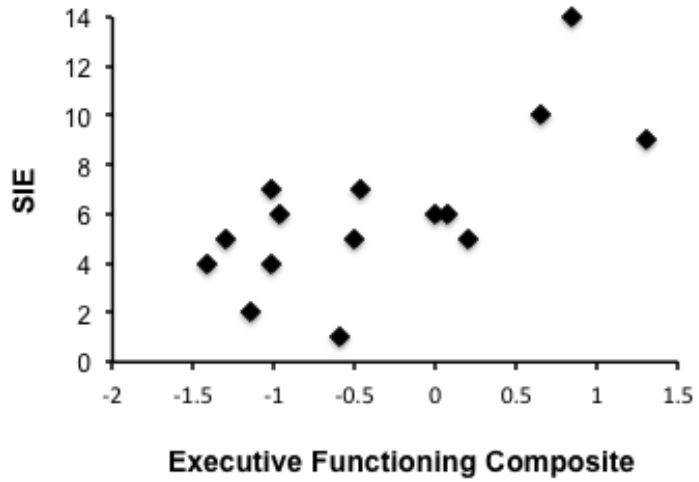
Note: * = p < .05; ** = p < .01; MCom = Memory Composite; EFCom = Executive Functioning Composite

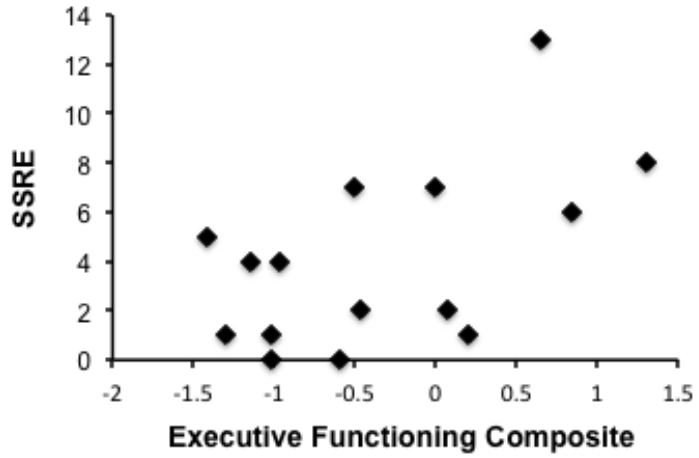
Table 8 shows a correlation matrix of neuropsychological functioning and the memory effects in the patients. The SIE was significantly correlated with the SSRE and the ESRE, but not the LOP effect (p = .10). The mechanisms of self-imagining, therefore, appear to be more closely related to the self-referential processing conditions than to semantic elaboration. Only the SSRE was significantly correlated with the LOP effect, suggesting these strategies may possess a common semantic processing component.

The executive functioning composite was significantly correlated with SIE, SSRE, and the ESRE. These results indicate that patients with poorer executive

functioning as measured by our composite benefited less from all three self-referential encoding strategies (see Figure 4a, b, and c) than patients with greater executive function. The memory composite was not significantly correlated with any of the memory effects. Because we have GMI scores for all of our patients, and we have included the GMI in previous research, we ran additional Pearson product-moment correlations between the GMI and the memory effects. None of the memory effects were significantly correlated with the GMI, all p's > .13.

Figure 4. Relation of EF composite to a) the SIE, b) the SSRE, and c) the ESRE.





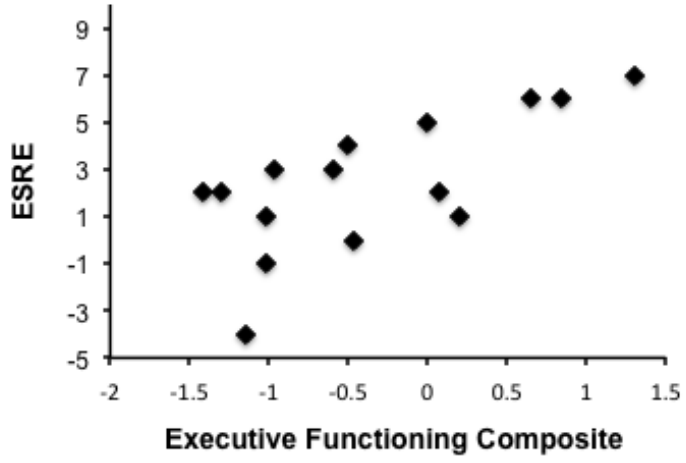


Table 9 shows the relation of neuropsychological functioning to the memory effects in the healthy controls. In contrast to the patients, the executive functioning composite was not significantly correlated with any of the memory effects. The SIE was significantly correlated with the SSRE, ESRE, and, in contrast to the patients, the LOP effect. Consistent with the patient results, the LOP effect was significantly correlated with the SSRE, but not the ESRE. Similar to the patients, none of the memory effects were significantly correlated with the memory composite.

Table 9.

Correlation Matrix of Neuropsychological Functioning and Memory Effects in Healthy Controls

	MCom	EFCom	SIE	SSRE	ESRE	LOP
MCom	---					
EFCom	.43	---				
SIE	-.01	.05	---			
SSRE	-.16	-.05	.66**	---		
ESRE	.25	.41	.66**	.65**	---	
LOP	-.37	-.34	.52*	.57*	.11	---

Note: * = $p < .05$; ** = $p < .01$; MCom = Memory Composite; EFCom = Executive Functioning Composite

F. Relation of Trait Self-Descriptiveness to the Memory Effects

As mentioned in the Introduction, to the extent that an encoding condition involves the processing of semantic information in the self-schema, to-be-remembered information that is self-descriptive and thus congruent with the self-schema may be more memorable than to-be-remembered information that is not self-descriptive and thus incongruent with the self-schema. To investigate whether this was the case in any of the encoding conditions included in the present study, the proportion of self-descriptive trait adjectives that was recalled and the proportion of non self-descriptive trait adjectives that was recalled was calculated for each encoding condition based on the trait adjective yes-no judgments made at the end of the experiment (see Table 10).

Table 10.

Mean (and Standard Deviation) Proportion of Self-Descriptive and Non Self-Descriptive Trait Adjectives Subsequently Recalled in the Memory-Impaired and Healthy Control Individuals

	Memory-Impaired		Healthy Control	
Encoding Condition	Self-Des.	Non Self-Des.	Self-Des.	Non Self-Des.
Baseline	.16(.12)	.11(.08)	.12(.10)	.15(.12)
Semantic Elaboration	.18(.11)	.24(.21)	.20(.10)	.21(.14)
Episodic Self	.22(.13)	.25(.14)	.26(.18)	.25(.16)
Semantic Self	.34(.17)	.22(.19)	.28(.09)	.23(.08)
Self-Imagine	.45(.16)	.31(.22)	.36(.15)	.30(.15)

To address the a priori hypotheses, paired samples t-tests analyzed whether trait adjective self-descriptiveness affected any of the memory effects in the patients or controls. In the patients, self-descriptive trait adjectives were recalled more than non self-descriptive trait adjectives in the self-imagining and semantic self-referential processing conditions, $t(14) = 2.16$, $p < .05$ and $t(14) = 2.51$, $p < .05$, respectively, but not in the episodic self-referential processing, semantic elaboration, or baseline conditions, all p's > .17. These results suggest that the benefits of self-imagining and semantic self-referential processing were uniquely related to the self-descriptiveness of the to-be-remembered information in the memory-impaired patients.

The relation of the memory effects to self-descriptiveness was slightly different in the healthy controls. Self-descriptive trait adjectives were better recalled than non self-descriptive trait adjectives in the semantic self-referential processing condition, $t(14) = 2.22$, $p < .05$, but not in the self-imagining, episodic self-referential processing, semantic elaboration, or baseline conditions, all p's > .23.

IV. Discussion

The present study addresses the practical feasibility of the self-imagination technique, uncovers mnemonic mechanisms of the SIE, contributes to our understanding of the relation between self and memory, and sheds light on the cognitive mechanisms of imagination.

A. The SIE and Free Recall

The findings indicate that the SIE extends to free recall in memory-impaired patients with acquired brain injury and healthy controls. Self-imagination enhanced free

recall more than semantic elaboration in 14 out of the 15 patients and 14 out of the 15 healthy controls. Furthermore, in both patients and healthy controls, self-imagination improved free recall more than traditional self-referential strategies, suggesting that the mnemonic benefit of self-imagination may be very powerful.

B. Mechanisms of the SIE

These results support the hypothesis that self-imagination is a self-referential mnemonic strategy. The present study revealed moderate to strong correlations between the SIE, SSRE, and the ESRE in patients and healthy controls. Furthermore, the correlations between the LOP effect and the SIE, SSRE, and ESRE were the weakest correlations amongst the memory effects in patients and healthy controls. These findings indicate that the mechanisms of self-imagining, semantic self-referential processing, and episodic self-referential processing overlap with each other more than they do with the mechanisms of semantic elaboration. Therefore, self-imagining and the traditional self-referential processing strategies may possess a common self-referential mechanism.

The neuropsychological findings suggest that the shared self-referential mechanism may be related to cognitive processes that are mediated by the prefrontal cortex. Indeed, in the patients, the executive functioning composite was significantly correlated with the mnemonic benefits of the three self-referential strategies. These results indicate that patients with poorer executive functioning benefited less from processing to-be-remembered information self-referentially. As mentioned in the Literature Review, previous research has implicated mPFC as an important neural substrate of self-referential processing (Amodio & Frith, 2006; Northoff et al., 2006;

Szpunar et al., 2007) and the SRE (Macrae et al., 2004; Philippi et al., in press). Moreover, in a recent investigation of the effect of brain-injury on imagination, Berryhill, Picasso, Arnold, Drowos, and Olson (2010) found that frontal patients made fewer comments about personal thoughts, emotions, actions, and sensory details during imagination in comparison to healthy controls, suggesting that the ability to imagine an event *in relation to the self* may be impaired in patients with PFC damage. In addition, Marquine (2009) demonstrated that the magnitude of the self-reference effect was smaller in brain-injured patients with poorer executive functioning. Therefore, the ability to process information in relation to the self may be impoverished in patients with compromised executive functioning, and thus patients with impaired prefrontal cortex functioning may demonstrate smaller mnemonic benefits from self-referential processing.

One possible explanation for the relation between our measure of executive function and the self-referential strategies in the patients is that these strategies might have involved substantial working memory components. For example, the ability to imagine oneself acting out a personality trait in an elaborative event might require one to maintain and manipulate a great deal of multimodal information in mind. In the present study, patients with poorer working memory might have been unable to establish or maintain a coherent and memorable event until the end of each encoding trial. A majority of the healthy controls had average to above average executive functioning, and therefore the demands of the self-referential strategies may not have affected performance in these individuals. Glisky & Kong (2008) speculated that their composite measure of prefrontal/executive function reflects executive processes associated with

working memory, and in a subsequent confirmatory factor analysis by McCabe et al., (2010), complex span tasks were found to be highly correlated with the frontal factor.

The findings from the present study also raise the possibility that patients and healthy controls may benefit from self-imagining for different reasons. Indeed, as hypothesized, the free recall results imply that the benefit of self-imagining may be related to mechanisms of the semantic self more than mechanisms of the episodic self in memory-impaired patients with acquired brain injury. In the patients, self-descriptive personality traits were recalled more than non self-descriptive personality traits in the self-imagining and semantic self-referential processing conditions, but not in the other encoding conditions. These results suggest that the benefits of self-imagining and semantic self-referential processing may rely on a common mechanism that is not involved in episodic self-referential processing or semantic elaboration in memory-impaired patients with acquired brain injury. In contrast, the healthy controls demonstrated a mnemonic advantage of self-descriptive traits relative to non self-descriptive traits only in the semantic self-referential processing condition. Therefore, the shared mechanism found in the memory-impaired patients appears not to have been prominent in the healthy controls.

What might account for the common mechanism of self-imagining and semantic self-referential processing in memory-impaired patients? One possibility is that these memory effects may be partly attributable to the processing of information in relation to a well-developed and organized self-schema. The fact that the semantic elaboration strategy was not similarly affected by self-descriptiveness suggests that the mechanism

underlying self-referential processing in patients may be qualitatively distinct from ordinary elaboration and organizational processes. Therefore, as originally proposed by Rogers and colleagues (1977), at least some types of self-referential processing may rely on a superordinate self-schema that allows very effective encoding and retrieval processes. Moreover, this superordinate self-schema may be intact in many memory-impaired patients with acquired brain injury.

Other findings cast more doubt on an episodic self-referential processing explanation of the SIE in patients. The attenuated benefit of episodic self-referential processing in the patients was the only difference in the overall pattern of results between patients and healthy controls. If the SIE was largely attributable to the episodic self in the patients, then the benefit of self-imagining should have demonstrated a similar drop in effectiveness. In addition, the patients found the episodic self-referential processing task to be more difficult to perform successfully than the self-imagining task. If the memory-impaired patients had relied mostly on episodic self-referential processing during self-imagining, then we might have expected these tasks to be equally difficult.

What might explain the superiority of self-imagining relative to traditional self-referential strategies in memory-impaired patients and healthy controls? Although the answer to this question cannot be ascertained without additional research, one possibility is that self-imagining may combine the benefits of self-referential processing and visual imagery. A recent study in healthy adults conducted by Martin, Schacter, Corballis, and Addis (2011) found that later remembered imagined events were rated as more vivid than later forgotten imagined events. Therefore, although Study 1 demonstrated that visual

imagery does not account for the magnitude of the SIE, it is possible that mechanisms of visual imagery contribute to the benefit of self-imagining.

Another explanation is that self-imagining may be particularly flexible in the type of self-referential information that is retrieved and incorporated into the imagined event. In other words, self-imagining may rely on *more* semantic self-referential processing or *more* episodic self-referential processing than the traditional self-referential strategies employed in the present study. For example, as mentioned in the Literature Review, self-imagining may involve the retrieval of semantic self-knowledge of personality traits, identity roles, and lifetime periods, whereas the trait self-descriptiveness task included in the present study may specifically target personality trait self-knowledge. Similarly, according to the episodic-simulation hypothesis, the imagination of an event may involve the retrieval and recombination of details from multiple episodic memories. Therefore, whereas the episodic self-referential processing task used in the present study restricted participants to a single episodic autobiographical memory, self-imagining may permit the flexible retrieval and recombination of a variety of details from multiple episodic memories. Thus, the advantage of self-imagining over traditional self-referential strategies may be related to the amount or variety of self-referential processing involved and thus the number or quality of retrieval cues that are later available.

C. Implications for Cognitive Rehabilitation

The findings from the present study bolster the possibility that the self-imagination technique may be adapted for cognitive rehabilitation. Indeed, the generation of a mnemonic benefit in free recall is promising from a rehabilitation

perspective. Thus far, research on self-imagining has revealed that the advantage of self-imagination can be elicited by memory-impaired patients with acquired brain injury under a variety of memory demands, with different materials, and in comparison to multiple cognitive strategies. Furthermore, the advantage of the self-imagination technique appears not to be attenuated by severity of memory deficit in brain-injured patients. However, the present study is the first to find that the magnitude of the SIE may be limited by executive functioning abilities. Therefore, although future research must determine how to optimize the benefits of self-imagination in a cognitive rehabilitation program and for whom these benefits are greatest, the present study suggests that the self-imagination technique may be relatively versatile and applicable to a wide range of patients, including individuals with severe memory deficits.

The present study may have implications for the future development of self-referential cognitive strategies. Indeed, the results of the present study indicate that not all types of self-referential processing are equally effective in memory-impaired populations. Although semantic self-referential processing may be particularly beneficial in brain-injured patients with memory deficits, episodic self-referential processing may be no more effective than ordinary semantic elaboration processes. The potential impact of these findings goes beyond brain injury, as substantial research has shown that many older adults experience a decline in episodic memory. It is possible that a similar dissociation in the usefulness of self-referential strategies may be found in older adults. Therefore, the findings from the present study suggest that efforts to improve memory with self-referential processing in individuals with episodic memory deficits may need to

target mechanisms of the semantic self as opposed to the episodic self. The self-imagination technique appears to be one such strategy.

D. Self and Imagination

The results from the present study contribute to our understanding of how memory-impaired patients with acquired brain injury may imagine events. D'Argembeau and Mathy (2011) recently investigated the involvement of autobiographical memory in the construction of imagined events in healthy adults from a cognitive psychology perspective. Based on their results, they concluded that the construction of an imagined event typically follows a generative process that begins with the retrieval of semantic self-knowledge and concludes with the incorporation of episodic details. Based on D'Argembeau and Mathy's (2011) interpretation, memory-impaired patients may be capable of constructing some semblance of an imagined event on the basis of semantic self-knowledge. Of course, depending on the location and extent of neurological damage, the imagined events of patients may have less episodic detail and spatial coherence than the imagined events of healthy adults (Addis, Sacchetti, Ally, Budson, & Schacter, 2009; Hassabis et al., 2007). Nevertheless, the results of the present study indicate that the memory-impaired patients' preserved mnemonic benefit of self-imagination was at least partly attributable to the processing of semantic self-knowledge. Therefore, the inability of memory-impaired patients to incorporate the same amount of episodic detail or spatial coherence as healthy adults into their imaginations may have negligible effects on the mnemonic benefit of self-imagination. However, a majority of

the patients included in the present study had TBIs, and thus whether other patient populations demonstrate similar results is unclear.

E. Self and Memory

The findings from the present study are consistent with the notion that semantic information and episodic information in autobiographical memory are dissociable and may be differentially accessible in memory-impaired patients with acquired brain injury (Conway, 2005). Indeed, the memory-impaired patients were more successful at performing the semantic self-referential processing task relative to the episodic self-referential processing task. The present study, therefore, supports prior patient studies to show that access to the semantic self is relatively preserved in comparison to the episodic self in brain-injured patients with episodic memory deficits. The fact that episodic autobiographical memory retrieval was less effective as an encoding strategy than semantic self-referential processing only in the patients provides additional support for the distinction between the semantic self and episodic self.

One of the aims of the present study was to address whether the self possesses special mnemonic mechanisms. The findings relevant to this aim are mixed. Although the free recall results indicate that the semantic self was well preserved in memory-impaired patients with acquired brain injury, so too was the benefit of semantic elaboration. Only the episodic self was disproportionately impaired in the patients, which may be an indication of qualitatively distinct mechanisms in this type of self-referential processing. The benefits of semantic self-referential processing and episodic self-referential processing were more closely related to each other than they were to the

benefit of semantic elaboration. However, the present study cannot rule out some of the alternative explanations that have been offered (i.e. person processing, emotional processing) based solely on the correlational analyses amongst the memory effects. Although it remains reasonable to postulate that a patient approach may shed new light on the debate over whether the self is special, future research may need to be more specific in the type of patient population that is selected. For instance, because self-referential processing is associated with mPFC, research on patients with selective damage to this region may be very informative (Philippi et al., 2011).

F. Theory on Trait Self-Knowledge

These results also contribute to theory on how we determine whether a personality trait is self-descriptive. The abstraction view of trait self-knowledge contends that a self-descriptiveness judgment of a personality trait is made by comparing the target personality trait to abstract representations of summary behaviors that are stored in semantic memory. Therefore, based on the abstraction view, it is not necessary to retrieve episodic memories to make self-descriptiveness judgments of personality traits. The fact that the patients found the self-descriptiveness task to be easier and more effective mnemonically than the episodic autobiographical retrieval task suggests that, consistent with previous research, self-descriptiveness judgments can be based on semantic self-knowledge and do not require episodic memory retrieval. Therefore, the findings from the present study may be interpreted as supportive of the abstraction view.

GENERAL SUMMARY

The research presented in this dissertation indicates that self-imagining may be useful as a rehabilitation strategy. Self-imagining generated superior mnemonic enhancement in cued recall (Study 1) and free recall (Studies 2 and 3) relative to other cognitive strategies in memory-impaired patients with acquired brain injury and in healthy controls. In addition, the mnemonic advantage of self-imagining was present after a relatively long delay (Study 1) and was unrelated to severity of memory impairment in patients with acquired brain injury (Studies 1 and 3).

This research also sheds light on the mechanisms of the SIE. The findings support the notion that self-imagining is a self-referential strategy, and they rule out a number of alternative explanations for the SIE, including ordinary semantic elaboration, simple visual imagery, and other-person processing. In addition, the research indicates that the SIE in memory-impaired patients with acquired brain injury might rely more on access to the semantic self than the episodic self. Neuropsychological findings suggest further that the ability to benefit mnemonically from self-referential strategies might rely at least partly on executive functions associated with prefrontal cortex.

In regards to whether the self accesses special mnemonic processes, the findings are less clear. The results from Study 3 suggest that self-referential strategies, although not completely redundant with each other, might share a common self-referential mechanism that is dissociable from ordinary semantic elaboration and organizational processes. On the other hand, in Study 3 the patients benefited from semantic elaboration as well as the self-referential strategies. Therefore, this dissertation was

unable to demonstrate that the benefit of self-referential processing may be preserved despite a diminished benefit of ordinary semantic elaboration.

LIMITATIONS AND FUTURE DIRECTIONS

One limitation of my research is that I have focused only on verbal materials. Future research should explore the mnemonic effectiveness of self-imagining on tasks that require visual memory such as scene recognition and name-face learning. Another limitation of my research is that I have focused on demonstrating effects of self-imagining after a single exposure to materials and after relatively brief delays. Future research should begin to explore the effectiveness of self-imagining in a rehabilitation program that involves training in a real-world learning context in which more complex materials must be learned and retained over longer delays.

I also would like to investigate the effect of self-imagining on memory in patients with mild cognitive impairment and AD. There is a great deal of interest in finding methods to alleviate the cognitive problems associated with these conditions. Although self-imagining may be helpful, there also are reasons to suspect that the benefit of self-imagining may be limited in AD patients. Therefore, rather than assume that other memory-impaired populations may benefit from self-imagining, I think it is necessary to investigate the utility of self-imagination in these populations directly. It would also be interesting to investigate whether self-referential strategies such as self-imagination improve the rate of learning in these patient populations since they are characterized by flat learning curves.

This dissertation cannot draw strong conclusions about the neural substrates of imagination, the self, or the SIE, as a majority of the patients included in Studies 1 and 3 have diffuse neurological damage caused by TBIs. An important next step would be to

investigate self-imagining in patients with isolated neurological damage to brain regions of theoretical interest, such as vmPFC and the hippocampus. Moreover, functional neuroimaging research in healthy adults and memory-impaired patients has great potential to provide a more precise understanding of the mechanisms of the SIE and cognitive rehabilitation in general.

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