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Source Memory and Generation Effects in Parkinson's Disease

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by

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Dedication

This project is dedicated to my parents, Marion and Roger Oelke, who have laid the groundwork for all my achievements with their steadfast love and support. It is also dedicated to Sharon Kha, who has shown me with wisdom and humor that it is possible to overcome any obstacle.

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Abstract

The primary aim of this study was to investigate source memory performance in individuals diagnosed with Parkinson's disease (PD). The secondary goal was to explore how memory was impacted when subjects were asked to generate responses during encoding. Fifty idiopathic PD patients and fifty healthy control subjects completed a task measuring item memory and source memory which also included a generation manipulation. Relative to controls, PD patients exhibited deficits in source memory but not item memory. Both groups demonstrated enhanced memory performance in the generative condition of the item memory task. The PD group displayed a marginally significant trend toward improvement in source memory when instructed to generate a response. These findings lend support to the notion of a selective pattern of source memory impairment in PD, highlighted by a dissociation between item and source memory performance. Generative tasks may be related to increased activation of key frontal regions that facilitate memory performance. These results could inform new perspectives for cognitive rehabilitation in PD, although further research is necessary.

Introduction

Within the past several decades, there has been an accumulation of research focusing on the cognitive deficits that can occur in patients with Parkinson's disease (PD). Most studies implicate the frontal lobes in contributing to these cognitive difficulties, which are often strikingly similar to other populations with frontal lobe deficits (Starkstein & Kremer, 2000; Taylor, Saint-Cyr, & Lang, 1986). One topic that has been relatively overlooked pertains to memory for contextual details associated with learned information, otherwise known as source memory. This type of memory processing is thought to be largely influenced by the frontal lobes, and therefore could provide a useful approach to advance the current understanding of cognitive impairments in PD.

Experiments of source memory can involve content that is produced by the subject, or alternately, material that is presented externally. The generation effect refers to a phenomenon in which individuals are better able to remember material that they have produced themselves (Slamecka & Graf, 1978) and has been demonstrated on tasks of free recall, cued recall, and recognition (Mulligan, 2001). However, findings have been mixed with respect to the generation effect in studies of source memory. The opposite pattern has been found in some studies (i.e., subjects demonstrate poorer source memory performance within conditions that elicit generation). This focus of research is particularly applicable to PD patients, because the nature of their deficits has often been

distinguished by a weakness on tasks in which internally-generated control is required, in contrast to improved performance when external cues are provided.

This paper will first provide general information about PD, including an outline of the main deficits, the course of progression, and the neurological pathways affected. Next, the characteristic pattern of cognitive impairments will be discussed, mainly focusing on executive functioning and memory deficits. The concept of source memory will be defined, followed by a review of studies that illustrate how various groups with frontal lobe deficits demonstrate impairments in source memory. The next section will reveal the role of the frontal lobes in source memory through neuropsychological and neuroimaging approaches. The generation effect will be defined and described, followed by a review of the small number of source memory studies that have already been conducted in patients with PD. The present study will seek to add to the literature by incorporating an examination of the effect of generation on source memory performance in PD patients.

Parkinson's Disease: Overview

Parkinson's disease (PD) is considered to be the second most common neurodegenerative disorder following Alzheimer's disease, occurring in approximately 1% of the population over age 60 (de Lau & Breteler, 2006). PD is diagnosed through neurological examination of several key clinical motor features. A classic presentation of PD involves slowed execution of movement, muscular rigidity, loss of postural reflexes, and resting tremor (Weintraub, Comella, & Horn, 2008). Notably, PD patients display difficulty in the spontaneous initiation of movement, and external cues can be beneficial in triggering movement. For example, Nieuwboer et al. (2007) exposed PD patients to a

3-week home intervention of rhythmical cueing provided by auditory, visual, and somatosensory devices designed to guide movement. Significant improvements in gait, freezing, and balance were found upon follow-up.

Neuropathology. The disease is characterized by deterioration of dopaminergic neurons within the substantia nigra. The reduction in dopamine interferes with the nigrastriatal pathway in the basal ganglia, resulting in movement disturbance (Gibb, 1992). The basal ganglia are a group of subcortical structures that play a critical role in initiating voluntary movement and planning and adjusting the force of subsequent motor output (Middleton & Strick, 1994). This brain region is known for controlling the execution of automated, learned responses. The basal ganglia are comprised of five separate regions that communicate in a network: the caudate, putamen, globus pallidus, subthalamic nucleus, and substantia nigra. The caudate and putamen are similar in nature and are generally referred to as a single structure (i.e., the striatum). An important pathway that involves the basal ganglia is known as the striato-pallido-thalamic loop (see Figure 1). This loop is thought to prepare information for cortical processing by integrating information from multiple brain regions. Dopamine is an important neurotransmitter in this pathway because it can serve to reinforce actions and can make it more likely that a certain response will occur in the future.

The motor system operates in a hierarchical manner, so control of functioning is distributed over various levels. The cortical regions are at the highest level and are involved in the planning and selection of various actions. The spinal cord is at the lowest level and is responsible for the execution of simple reflexes. The basal ganglia provide a

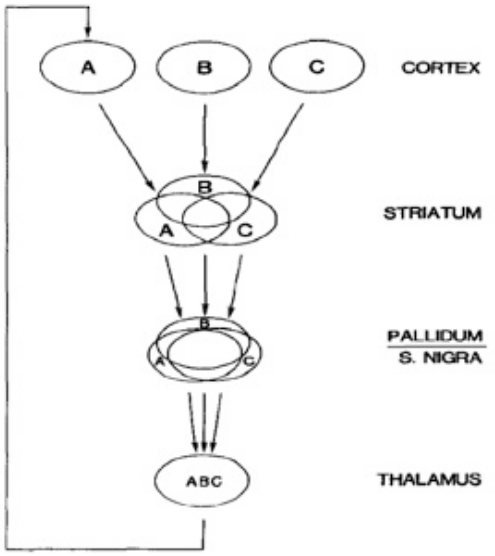

Figure 1. Generalized basal ganglia thalamocortical circuit. Reprinted from "Parallel organization of functionally segregated circuits linking basal ganglia and cortex," by G. E. Alexander, M. R. Delong, and P. L. Strick, 1986, *Annual Review of Neuroscience, 9,* p. 360. © 1986 by Annual Review of Neuroscience. Reprinted with permission.

middle linkage of these levels by connecting the general commands from the cortex with the specific execution of motor output.

The basal ganglia also appear to be involved in a variety of non-motor functions due to their afferent and efferent projections to other regions of the brain. In fact, there is evidence to suggest that the basal ganglia provide input to three regions of the prefrontal cortex via the thalamus: dorsolateral prefrontal cortex, lateral orbitofrontal cortex, and anterior cingulate cortex (see Figure 2). These prefrontal regions also project back to the basal ganglia to create a looped feedback circuit (Alexander, Delong, & Strick, 1986).

Cognitive impairments in PD. Based on these direct projections, many researchers have suggested that the basal ganglia have influence over the cognitive operations involving the frontal regions of the brain (e.g., Dubois & Pillon, 1997). In addition to the movement disturbance, it is also quite common for PD patients to

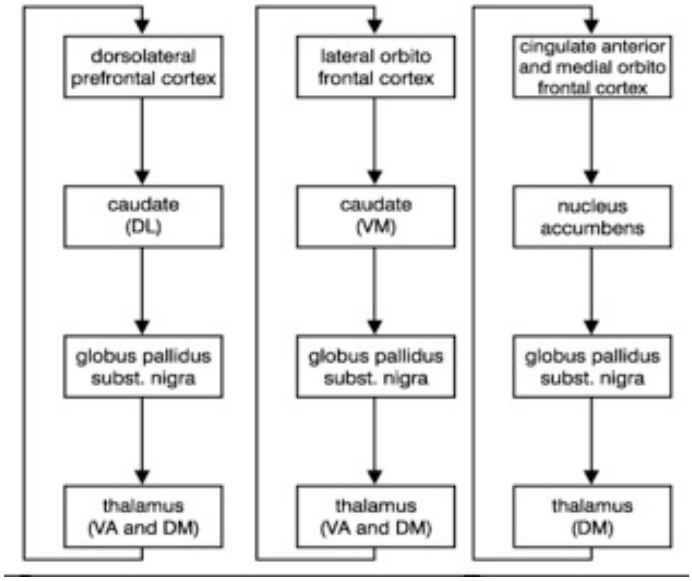

Figure 2. Frontal-striatal circuits (DL: dorsolateral; DM: dorsomedial; VL: ventrolateral; VA: ventroanterior; VM: ventromedial). Reprinted from "Relationship between obsessive-compulsive disorders and diseases affecting primarily the basal ganglia" by A. Maia, E. Barbosa, P. Menezes, and E. Filho, 1999, *Revista do Hospital das Clínicas, 54*(6), p. 216. © 1999 by University of Sao Paulo School of Medicine.

experience disruptions in certain aspects of cognitive functioning. However, only a subset of patients progress to meet criteria for dementia. Using standard clinical diagnostic criteria, Riedel et al. (2008) reported that the frequency of dementia in an outpatient sample of PD patients was 28.6%. Verleden, Vingerhoets, and Santens (2007) found that 51% of their PD sample demonstrated measureable impairment in one cognitive domain (most commonly executive functioning), and only 18% of the sample showed no significant impairment in any domain.

It seems that noticeable cognitive changes are present even at the earliest stages of disease. In a longitudinal study, Kandiah et al. (2009) reported that 31% of recently diagnosed PD patients experienced significant cognitive decline after about three years. In summary, cognitive impairment is quite common in PD, but it usually tends to be

restricted to certain domains. Therefore, the rest of this review will focus on the aspects of cognition that are most sensitive to decline in PD, not the more widespread changes that occur in the subset of patients with dementia.

Executive functioning. Executive functioning is generally considered to be the most defining characteristic in the spectrum of PD cognitive impairments. It is an overarching term used to describe a wide range of cognitive processes that can be employed to guide purposeful behavior (Chan, Shum, Toulopoulou, & Chen, 2008). Executive functioning is associated with the frontal lobes of the brain and includes a diversity of specific skills such as abstract reasoning, problem solving, planning and sequencing, sustaining attention, inhibition, altering behavior in response to feedback, multitasking, cognitive flexibility, and management of novel tasks (Miyake et al., 2000).

Executive functioning tends to deteriorate early in the progression of PD and appears to be more vulnerable to decline than other cognitive domains (Azuma, Cruz, Bayles, Tomoeda, & Montgomery, 2003). PD patients have demonstrated poor performance on various tasks that rely on executive abilities, such as set shifting (Cools, Barker, Sahakian, & Robbins, 2001; Muslimovic, Post, Speelman, & Schmand, 2005), working memory (Lewis et al., 2003), planning (Schneider, 2007), and attentional control (Brown & Marsden, 1988a; Werheid, Koch, Reichart, & Brass, 2007). Neuroimaging studies complement these findings, providing evidence that PD patients exhibit disruption to frontal regions such as the dorsolateral prefrontal cortex (Cools, Stefanova, Barker, Robbins, & Owen, 2002; Owen, Doyon, Dagher, Sadikot, & Evans, 1998), ventrolateral prefrontal cortex (Hershey et al., 2000; Monchi et al., 2004), and anterior cingulate cortex (Grossman, Crino, Reivich, Stern, & Hurtig, 1992; Schroeder et al., 2002).

Zgaljardic et al. (2006) designed a test battery to examine the executive functions of PD patients and categorized neuropsychological measures according to the three non-motor frontostriatal circuits described by Alexander et al. (1986). The tasks chosen to measure dorsolateral prefrontal cortex functioning were related to set shifting, working memory, intrinsic response generation, and conditioned associate learning. The tasks selected to characterize functioning of the anterior cingulate measured response monitoring, inhibition, initiation, and apathy. The tasks selected to characterize functioning of the orbitofrontal prefrontal cortex were associated with disinhibition, decision-making, impulsivity, and perseveration, as well as depressive symptomatology. It was revealed that PD patients performed significantly worse than controls on tests associated with all three circuits, but impairments were greatest for measures relating to the dorsolateral prefrontal cortex.

One major limitation of examining performance on complex cognitive tasks is that it can be challenging to understand how specific component processes may contribute to overall performance. This has been acknowledged as a problem within executive functioning research, and recent attempts have been made to delineate subcategories and identify overlapping constructs that make up this broad cognitive domain (Chan et al., 2008; Jurado & Rosselli, 2007; Suchy, 2009).

Memory. PD patients characteristically perform poorly on free recall tasks but tend to demonstrate near normal functioning on cued recall tasks and recognition tasks (Breen, 1993). It appears that PD patients have the ability to encode and consolidate information, but that retrieval is particularly difficult in situations where there is no provision of relevant cues.

Sagar, Cohen, Sullivan, Corkin, and Growdon (1988) examined remote memory abilities and found that memory for the content of the events was intact, yet PD patients had an impaired ability to remember the dates of events. This deficit not only applies to remote memories, but to new learning as well. Sagar, Sullivan, Gabrieli, Corkin, and Growdon (1988) gave PD patients a verbal recency discrimination task that assessed their ability to determine the order in which new information was presented. It was found that PD patients were impaired on the recency discrimination task while item recognition remained intact. In a functional magnetic resonance imaging (fMRI) study, PD patients and controls performed an event-sequencing task and it was observed that PD patients showed differences in activation within prefrontal regions, suggesting that processing may be less efficient for PD patients (Tinaz, Schendan, & Stern, 2008).

Buytenhuijs, Berger, Van Spaendonck, and Horstink (1994) administered a memory task that required an internally directed strategy of semantic organization for optimal performance. PD patients tended to rely on external strategies and recite the words in the order in which they were presented. This pattern reflects difficulty in areas that require controlled and effortful processing, especially when self-directed, strategic planning is needed. In a follow-up to this study, VanSpaendonck, Berger, Horstink, Borm, and Cools (1996) used the same memory task, but imposed an explicit cue to prompt subjects to recall the words in a semantic cluster. In another condition, the sequence of the word list presentation was changed for each trial to prevent subjects from recalling the words in serial order. Results indicated that the different cueing conditions impacted the performance of PD patients more than controls.

Theories of cognitive function in PD. Early research on the cognitive deficits of PD strove to establish patterns of impairment within various neuropsychological realms. Eventually, researchers gravitated toward attempts to describe the overall constellation of impairments. Brown and Marsden (1990) provide a listing of various explanations that have been offered in the literature to describe cognitive dysfunction in PD. These include: impaired performance on active memory tasks but normal performance on passive memory tasks; impairment on effort-demanding tasks but intact performance on automated tasks; impairment on set-shifting tasks; impairment on tasks where internal control of attention is required, but normal performance on tasks providing external stimulus control; impairment on tasks requiring self-initiated task preparation, but normal performance on tasks providing external cues; impairment on tasks requiring sequencing, temporal ordering, and recency discrimination; and impairment on tasks that measure frontal functioning.

While these approaches are promising interpretations of the cognitive deficits in PD, to date, the theoretical underpinnings have not yet been firmly established. Two review articles (Brown & Marsden, 1990; Taylor & Saint-Cyr, 1995) have highlighted a theory of processing resources that outlines the potential mechanisms behind the cognitive impairment of PD. This theory relates to the idea that PD patients have reduced central processing resources, and this general deficit could extend to other areas of cognitive function. Norman and Shallice's model of a Supervisory Attentional System (SAS) has been used to describe the central processor (Norman & Shallice, 1983). According to this account, the SAS is designed with the ability to override habitual or automatic actions based on the individual's priorities or changes in the environment.

There is a limit to the capacity of the SAS, so it is only recruited under the following conditions: 1) when decision-making is involved, and 2) during novel tasks in which no automatic response has been developed.

Shallice (1982) proposed that patients with lesions involving frontal systems may have a specific deficit in the SAS, and the system becomes overloaded during novel situations (i.e., when several response options are available and the individual must choose how they will react, or when environmental contingencies change). It is thought that the dorsolateral prefrontal cortex is involved in the central executive role of the SAS (Nathaniel-James & Frith, 2002), and there is evidence that disruption to this region of the brain occurs in PD (Cools et al., 2002; Owen et al., 1998; Zgaljardic et al., 2006).

Brown and Marsden (1988b) administered the Stroop task to a sample of PD patients and each subject completed a cued and an uncued form of the task. Throughout the experiment, the task demands alternated in two types of blocks. The first type of block resembled the Standard Stroop task, meaning that the names of different colors were printed on a sheet and the ink color conflicted with the content of the word (e.g., the word "red" presented in green ink). Subjects were asked to provide responses which were oriented to the ink color of the word. The second type of block was called the Inverse Stroop task, and participants were instructed to respond by reading each printed word aloud and ignoring the ink color. The relevant attribute switched after every 10 trials, and half the subjects began with the Standard Stroop while half began with the Inverse Stroop. In the cued condition, subjects were given guidance before each trial to remind them of the relevant attribute (either ink color or word). In the uncued condition,

no guidance was provided and subjects had to actively remember that the relevant attribute switched after every 10 trials.

The results of the Brown and Marsden (1988b) experiment demonstrated that PD patients provided with external cues displayed no difficulties in switching between activities as opposed to when they were required to rely upon self-directed cues. The authors suggested that impairment on tasks in which they must guide their own performance could be due to an underlying deficiency of attentional control mechanisms. They also argued that the primary basis of PD impairments on more complex executive tasks could be rooted in a deficit of internal control for regulating attentional processes.

More recent findings are also compatible with the theory of a deficit in internal attentional control. Werheid et al. (2007) utilized a task switching paradigm to demonstrate that PD patients have a reduced ability in self-initiated task preparation as opposed to externally-triggered task preparation. In accordance with these findings, neuroimaging research has provided evidence that internally generated and externally cued responses could be dissociable cognitive processes (Forstmann, Brass, Koch & von Cramon, 2005).

At present, the underlying basis of cognitive deficits in PD is still not fully understood. It is possible that a unitary theoretical interpretation cannot describe the basis of impairments for all PD patients and across various conditions. Multiple, complimentary theories may be needed to comprehensively account for the range of cognitive changes that can occur in the context of the PD disease process.

Source Memory Review

One type of memory functioning that seems to require complex, higher-order cognitive abilities is source memory. Surprisingly, this aspect of memory has been virtually ignored in the PD literature. This line of research could be worthwhile in adding to an understanding of the pattern of cognitive areas affected by PD, and also contribute to a refinement of the numerous interpretations of these cognitive deficits. Source memory can be defined as the process of recalling contextual features associated with the acquisition of semantic knowledge (Johnson, Verfaellie, & Dunlosky, 2008). These contextual features come from a variety of modalities surrounding an event, including perceptual information (e.g., sound, color, spatial or temporal context, semantic information), and internally generated information (e.g., cognitive operations, emotional reactions).

Theories of memory processes have acknowledged distinctions between factual and contextual information. Tulving (1972) described two kinds of declarative explicit memory: 1) semantic memory, involving the storage of general knowledge and information, and 2) episodic memory, involving records of personal experience, which can include details about time, location, and other aspects surrounding an event. The manner in which combinations of contextual features are bound together during encoding, and later retrieved, can make a particular episodic event distinguishable (Mitchell & Johnson, 2009).

The source-monitoring framework, proposed by Johnson, Hashtroudi, and Lindsay (1993), provides a method of systematically examining source memory processes. According to these authors, source monitoring is based on a combination of

memory characteristics and judgment processes. Source monitoring is presumed to be an effortful, agenda-driven type of remembering that recruits the frontal lobes by engaging decision-making processes in order to make source attributions.

The source-monitoring framework builds upon Johnson and Raye's (1981) theory of reality monitoring, which refers to the ability to discriminate between information produced internally and information that is perceived in the environment. The source-monitoring framework also defines two other conditions: one in which the individual must discriminate between information presented from two differing external sources, and the other in which the individual must differentiate between two different kinds of internally-generated sources. Normal subjects generally tend to perform better on reality-monitoring tasks (internal-external discrimination) compared to sources from within the same category (internal-internal discrimination or external-external discrimination). It has been theorized that the memory advantage on reality monitoring tasks is due to greater differences between the memory characteristics that must be distinguished (Johnson et al., 1993).

Impairments in patients with frontal deficits. Since there are very few reports to indicate how PD patients perform on tasks of source memory, it is useful to first examine how comparative populations perform on these tasks. Given that there is a wealth of evidence to support that frontal deficits are prominent in PD patients, it is informative to examine other groups with frontal lobe complications. Patients with frontal lobe lesions display a similar pattern of performance to that of PD patients on many neuropsychological measures. For example, cued recall and recognition of learned material is not drastically impaired in patients with frontal lobe lesions, yet they have

distinct difficulties in making recency and frequency judgments and organizing sequences of responses (Milner, Petrides, & Smith, 1985).

In several studies, it has been demonstrated that patients with frontal lobe lesions have difficulty remembering aspects regarding the context of presented information (Janowsky, Shimamura, & Squire, 1989; Milner et al., 1985; Schacter, Harbluk, & McLachlan, 1984; Shimamura, Janowsky, & Squire, 1990). This source memory impairment has also been shown in other patient groups with frontal lobe changes, such as individuals with Korsakoff's syndrome, schizophrenics, and individuals with obsessive-compulsive disorder (Brebion et al., 2000; Kim, Roh, Yoo, Kang, & Kwon, 2009; Shimamura & Squire, 1991). Considerable evidence has also suggested that the normal aging process impacts source memory performance (McIntyre & Craik, 1987), and young children with underdeveloped frontal lobes also have source memory difficulties (Cycowicz, Friedman, Snodgrass, & Duff, 2001). McIntyre and Craik (1987) suggested that a reduction in processing resources may underlie the deficiency in associating items with their context. In other words, the efficient incorporation of focal and contextual material may require the allocation of attentional resources, and these resources may be insufficient in populations with frontal impairments.

Specific role of frontal and temporal lobes in source memory. Early behavioral studies of amnesiacs, frontal lobe patients, and older adults have suggested that the frontal and temporal lobes may play dissociable roles in contributing respectively to source and item memory (e.g., Glisky, Polster, and Routhieaux, 1995; Janowsky et al., 1989; Schacter et al., 1984; Shimamura & Squire, 1987). For instance, Glisky et al. (1995) divided a sample of older adults into two groups based on their performance on a

task assessing frontal function (high-frontal, low-frontal). The high-frontal group performed significantly better when asked to identify which voice spoke a particular sentence (source memory), while their memory for the sentences themselves (item memory) did not differ between groups. The participants were also divided on a task assessing medial temporal lobe function (high-temporal, low-temporal), and the high-temporal group performed significantly better on the sentence memory task (item memory), while there were no group differences on the voice memory task (source memory).

More recent evidence has shown that these distinctions may oversimplify the functional divisions between the frontal and temporal lobes in memory. Several neuropsychological studies have shown that patients with temporal lobe lesions have deficits in remembering both the content and context of memories (Gold, Hopkins, & Squire, 2006; Kopelman, Stanhope, & Kingsley, 1997; Schwerdt & Dopkins, 2001). Neuroimaging research has also helped to clarify the role that the temporal lobes appear to play in source memory. In general, there are indications that the hippocampus is involved in the encoding process by binding the features of episodic memories together, and later recalling the association between item and context (Mitchell & Johnson, 2009).

Recent research has also brought clarification to the contributions of the frontal lobes during different stages of source memory performance. Overall, it appears that the frontal lobes are important in engaging a number of self-directed processes that promote the feature binding that takes place within the temporal lobes. During the encoding stage, the ventrolateral prefrontal cortex (VLPFC) is involved in controlling the selection of processing, so that features which are relevant to the individual are processed (Badre &

Wagner, 2007). The dorsolateral prefrontal cortex (DLPFC) is engaged when it is necessary to strategically organize and manipulate the processing of multiple features to create associations (Blumenfeld & Ranganath, 2007).

During the retrieval stage, the VLPFC is involved in activating and selecting material. The functioning of this brain region seems to be essential when relevant information does not automatically come to mind and a strategic search of memory must be initiated to retrieve the appropriate memory. Badre, Poldrack, Pare-Blagoev, Insler, and Wagner (2005) hypothesize that the left VLPFC is involved in two main functions: 1) a controlled retrieval process that activates goal-relevant information, accessible via the mesial temporal cortex, and 2) a post-retrieval selection process that engages and allows choices to be made between multiple representations that are activated. Furthermore, there is evidence that specific regions of the VLPFC are differentially engaged during source monitoring depending on whether the material is self-generated or perceptually derived (Mitchell et al., 2008). The DLPFC appears to be involved in online evaluation and monitoring of information that has already been retrieved (Petrides, 2002). Finally, the anterior cingulate cortex has been shown to identify conflict between activated representations (Botvinick, Cohen, & Carter, 2004).

Studies using fMRI have shown that there is more activation in the left lateral prefrontal cortex during source memory tasks than during recognition tasks (Dobbins & Han, 2006; Dudukovic & Wagner, 2007). On the other hand, there is more activation in the right prefrontal cortex for tasks that do not rely on the same level of recollection (e.g., recency discrimination tasks), where familiarity is adequate (Dobbins, Simons, & Schacter, 2004; Kensinger, Clarke, & Corkin, 2003).

In summary, the majority of evidence suggests that the frontal and temporal lobes work together during source-monitoring processes. Various components of source information are thought to be connected in an associative network regarding a particular event. Since attribution of source is a decision-making process, it involves a search of this associative network during retrieval. The level of engagement of strategic search and retrieval processes (associated with prefrontal activation) depends on the strength of the association between the item and its source (associated with activation of mesial temporal regions). Therefore, the frontal lobes would play a greater role in source memory processes during conditions where there is an ambiguous link between item and source information (Thaiss & Petrides, 2003). For patients with low frontal functioning, they should demonstrate greater impairments on these kinds of tasks. On tasks where there is a strong link between item and source information, retrieval of source information may be more reliant on the temporal lobes. Glisky, Rubin, & Davidson (2001) found that older adults with low frontal functioning did not independently initiate the processes needed to link item with source. However, when given a task that required them to think about how each item was integrated with its context, they were able to perform as well as other groups.

Generation Effects

Experiments of source memory often include information that is produced by the individual (e.g., answering questions), in addition to material that is externally presented (e.g., word lists). Therefore, it is important to understand differences in memory for these two classes of information. Numerous experiments have demonstrated the generation effect, which refers to greater memorability of material which subjects

produce themselves, compared to information which is externally presented (Hirshman & Bjork, 1988; Slamecka & Graf, 1978). This effect has been found with tests of free recall, cued recall, and recognition, and occurs with a variety of different kinds of tasks and materials (Mulligan, 2001). Bertsch, Pesta, Wiscott, and McDaniel (2007) conducted a meta-analysis on the generation effect and found that the effect size was .40 across 86 studies. The presumed reason for this consistent effect is that active generation engages deeper processing of the semantic aspects of the material, thereby enhancing memory (McDaniel, Waddill, & Einstein, 1988).

The effect of generation on source memory is not as clear and findings appear to be mixed. There is some evidence that the opposite pattern of performance occurs with source memory, such that generation can actually produce decrements in source memory (Jurica & Shimamura, 1999; Mulligan, 2004; Mulligan, Lozito, & Rosner, 2006; Rabinowitz, 1990). A potential interpretation is that the additional cognitive functions required to generate items could in turn detract from the ability to process contextual information. To the contrary, other studies have found that generation improves memory for contextual details (Marsh, Edelman, & Bower, 2001; Geghman & Multhaup, 2004).

Riefer, Chien, and Reimer (2007) provide an account to explain the wide range of findings in this area. The authors assert that the type of source-monitoring paradigm that is used may influence the direction of the results. They observed that the reality-monitoring paradigm is normally used in studies reporting a positive generation effect (i.e., better source memory for self-generated material). In the reality-monitoring paradigm, the focus of the source memory test is to distinguish which items were self-produced from items that were externally presented (internal-external discrimination).

For instance, Geghman and Multhaup (2004) asked subjects to read questions concerning topics of general knowledge. On some occasions, the answer was provided by a person viewed on a computer screen, representing the external source. For other questions, the participant was prompted to generate the answer themselves, representing the internal source. The source memory test required the subject to recall whether they had produced the answer themselves or whether the individual on the computer screen had provided the answer. Geghman and Multhaup (2004) reported that a positive generation effect occurred, meaning that subjects were better able to remember instances in which they had produced their own answers, as compared to instances in which the answer was provided on the computer.

In contrast, Riefer et al. (2007) observed that the external-external source-monitoring paradigm tends to be utilized in studies reporting a negative generation effect (i.e., impaired source memory for self-generated material). The external-external paradigm differs from the reality-monitoring paradigm in that subjects are not asked to explicitly recall whether they had previously generated a response, although generation is part of the task they must perform. During the encoding phase, half of the study items require participants to generate an answer, and the rest of the study items do not require a self-generated response. In addition, each study item is presented within a distinctive contextual modality and the context varies across items (generally contrasting colors, voices, or spatial locations). During the test phase, source memory is assessed by asking the subject to select the type of contextual stimuli that was previously associated with each item. The generation effect can be examined by separating the self-generated items

from the externally presented items and comparing source memory performance between these two conditions.

For example, Jurica and Shimamura (1999) created a source memory experiment that attempted to model a social conversation. For each item, study participants viewed pictures of different individuals on a computer screen. For half of the items, an individual would appear on the screen with a printed question associated with them, and the subject was instructed to provide their own answer (generate condition). The questions referred to topics of personal tastes and interests and were meant to simulate a social interaction. For the other half of the items, participants read statements presented by one of the individuals (read condition). The statements referred to the personal preferences and interests of the individual appearing on the computer screen. Participants were later asked to recall the topics of conversation (item memory) and then to recall which of the individuals had originally presented the information (source memory). Thus, source memory was tested by using externally presented sources of information (distinguishing between different kinds of facial stimuli). The generation effect was examined by comparing memory performance within the generate condition to memory performance within the read condition.

Jurica and Shimamura (1999) found a positive generation effect for item memory, and a negative generation effect for source memory. They offered the "trade-off hypothesis" as an explanation for this negative generation effect. This hypothesis posits that the same cognitive functions that enhance memory for generated items compete with and reduce the processing resources available for contextual information. One would

expect that the negative generation effect could be even greater in patients with reduced processing resources.

Source Memory in PD

While there is reason to anticipate that PD patients may have source-monitoring deficits based on their difficulties with other tasks that recruit the frontal lobes, very little research has systematically examined this topic. One study has shown evidence that PD patients exhibit a source memory impairment when choosing between two external sources (Drag, Bieliauskas, Kaszniak, Bohnen, & Glisky, 2009). Participants were presented with sentences recorded by two different voices (male and female), and the source memory task was to later remember which voice presented which sentence. The authors reported that PD patients were impaired on the source task compared to controls, but item recognition performance was spared.

An examination of mean scores from Drag et al. (2009) reveals that both groups performed close to ceiling on the item memory task (.95 within the PD group and .98 within the control group). Mean source memory performance was .69 for PD patients and .80 for controls. The data suggest that the item memory task selected for inclusion in this research was inherently less challenging than the source memory task. Thus, there are limitations to concluding that PD patients demonstrated a true impairment in source memory performance. It is difficult to discern whether the between-group difference occurred simply because the task parameters were more challenging for the source memory test, or because PD patients exhibit a specific source memory weakness.

Hsieh and Lee (1999) investigated source memory in PD by utilizing the source-monitoring framework of Johnson et al. (1993). The first experiment required the

subjects to complete an external-external source-monitoring task, in which they had to discriminate between two voices (male speaker or female speaker). The second experiment employed a reality-monitoring paradigm (internal-external discrimination), in which participants had to recall whether they answered a question themselves or whether the experimenter answered the question. In the third experiment, patients had to complete an internal-internal source monitoring task, in which they had to recall whether they answered a question aloud or whether they silently thought of the answer. Hsieh and Lee (1999) found that there was a significant difference between PD patients and controls on the source memory task with two internally-generated sources. In contrast, the difference between item memory scores of PD patients and controls was reported to be nonsignificant.

A review of the corrected hits from the third experiment by Hsieh and Lee (1999) revealed that PD subjects performed at the exact same level of mean accuracy on the item and source memory tasks (.71 on both tasks). While a statistically significant difference was found between the source memory performance of patients and controls, there was no evidence that PD patients were more challenged by the source memory task in comparison to their performance on the item memory task. Therefore, it is not possible to conclude that the PD source memory deficit is selective relative to item memory. Hsieh and Lee (1999) did not mention any attempts to equate the difficulty levels of the item and source memory tasks in the control group, which would have been beneficial in order to isolate a selective source memory deficit in the PD group.

The Influence of Generation on Source Memory in PD

Hsieh and Lee (1999) concluded that PD patients exhibited a deficit in distinguishing between two internally-generated sources of information, while there were no significant impairments in the other two source memory experiments (external-external and internal-external). The authors suggested that PD patients might have a source-monitoring deficit that surfaces when there are not enough salient perceptual cues to guide their source attribution decisions, such as was the case in the internal-internal experiment. This finding was somewhat contrary to the authors' original predictions, as they had hypothesized that deficits would be found in the external-external experiment and the internal-internal experiment where cues to be compared are more similar, but not in the internal-external experiment.

It is unclear why Hsieh and Lee (1999) only found the PD source-monitoring deficit in the experiment with two internally-generated sources. Drag et al. (2009) suggested that the design may have masked a source-monitoring deficit on the external-external experiment because PD patients benefited from the provision of extra perceptual cues. Hsieh and Lee (1999) asked patients to discriminate between a male and a female voice, but also provided them with pictures of the two speakers. In the internal-internal experiment, cognitive processes may have overlapped to a greater degree, eliciting fewer cues to monitor correct sources and thereby creating a more challenging source memory task. Hsieh & Lee (1999) provide an alternative interpretation, suggesting that the pattern of results could reflect a unique vulnerability that PD patients have on tasks in which they are required to produce their own response. They suggest that the neuropathology associated with PD may make generative tasks particularly challenging,

subsequently interfering with their ability to create a stored representation of source information.

This interpretation appears to be congruent with the theory that an underlying deficit of the SAS is likely to adversely impact other realms of cognitive function (Brown & Marsden, 1990; Taylor & Saint-Cyr, 1995). It is also consistent with prior findings suggesting that the SAS becomes overloaded in novel situations where PD patients must self-direct their cognitive activities (Brown & Marsden, 1988b; Werheid et al., 2007). Therefore, when PD patients have to produce their own response, this could overload the attentional resources of the SAS during the encoding process and consequently impair their ability to later recall source details.

In summary, the tradeoff hypothesis predicts that self-generation should enhance item memory but would subsequently leave less processing resources available to encode source information, resulting in a negative generation effect in healthy adults. Theories of cognitive dysfunction in PD lead to implications with respect to the impact of generation on source memory performance in PD patients. In particular, difficulty with independent response initiation and reduced processing resources of the SAS suggest that encoding source information would be markedly more difficult for PD patients when required to self-generate. It is conceivable that a negative generation effect would occur for PD patients that is more pronounced than the effect that has been shown to occur for healthy adults.

The Current Study

A primary aim of the current study was to determine if PD source memory deficits found in two prior studies could be replicated. Another goal was to improve

upon previous study designs by equating for item and source memory performance in control subjects as a method of exploring the selective nature of source memory impairments in PD. Uncovering possible dissociations in performance (e.g., intact item memory but impaired source memory) is important because it contributes to the development of descriptions and theories regarding the basis of cognitive dysfunction in PD. Finally, the approach of studying source memory in PD is worthwhile because it could eventually lead to new insights about how specific regions of the prefrontal cortex may be impacted by this disorder and how they interact with other brain regions.

The current project also examined the influence of the generation effect on item memory and source memory performance of PD patients and control subjects. First, the effect of generation on source memory performance of normal controls has not been well established, so the present study attempted to add to this literature. Furthermore, no studies appear to have yet explored the relation between generation and source memory performance in the PD population. In Experiment 2 of the Hsieh and Lee (1999) study, PD patients did demonstrate positive generation effects on item recognition memory; however, generation effects on source memory were not reported. The current study provided an opportunity to investigate the tradeoff hypothesis in a patient population, as most previous research has only examined this in non-clinical samples. The external-external source-monitoring paradigm was selected for use because it allowed for optimal conditions to study the tradeoff hypothesis. Finally, researching the generation effect is important because it provides information about encoding conditions which could potentially alter the memory performance of PD patients.

Hypotheses and Predictions

1.) From an analysis of item and source memory total scores, it was hypothesized that relative to controls, PD patients would exhibit deficits in source memory performance with intact item memory performance. In contrast to equivalent item memory performance across groups, it was predicted that the PD group would score significantly lower on the source memory test in comparison to controls. Drag et al. (2009) has previously demonstrated a similar pattern between PD patients and controls. To provide additional support for the specificity of decreased source memory performance in PD patients, item memory and source memory performance were equated in control participants so that differences in source memory between groups could not be attributed to differences in overall difficulty level between item and source memory tasks.

2.) It was hypothesized that a positive generation effect would be observed for both PD patients and controls on item memory performance. It was predicted that items in the generate condition would be remembered better than items in the read condition, regardless of group membership. This effect was reported in Experiment 2 of the Hsieh and Lee (1999) study, which showed that PD patients were able to perform as well as controls on an item memory task, and both groups performed better in the condition in which they had to generate their own responses to questions.

3.) It was hypothesized that a negative generation effect would be observed for both PD patients and controls on source memory performance. Specifically, it was predicted that a main effect of encoding condition would occur, with items in the generate condition remembered more poorly than items in the read condition. Jurica &

Shimamura (1999) demonstrated this effect in a similar type of experiment with college students. It was also expected that a main effect of group would be found (PD < controls), and that an ordinal interaction effect would occur. In other words, PD patients would perform worse in both encoding conditions, but would be particularly sensitive to impairment on the generate condition of the source task.

Method

Participants

The sample consisted of 50 individuals diagnosed with PD and 50 healthy control subjects matched by age, education, and gender. An a priori power analysis (G*Power 3; Faul, Erdfelder, Lang, & Buchner, 2007) was conducted to determine the number of participants in the sample required for adequate power. A medium effect size (d = .25) was assumed for this study. Power analysis revealed that a total sample size of 100 participants (50 per group) was required to yield a power level of .80 (α = .05).

The study was approved by the University of South Florida Institutional Review Board (see Appendix A). PD patients were recruited from the Department of Neurology at the University of South Florida and from support groups and seminars in the surrounding local area. Control subjects were recruited from continuing education courses for older adults at the Osher Lifelong Learning Center at the University of South Florida. PD patients and controls were also recruited from support groups affiliated with the American Parkinson's Disease Association in Tucson, Arizona. Data collected in Florida comprised 31% of the sample and data collected in Arizona comprised 69% of the sample. Individuals that qualified for the study were invited to participate either by their neurologist, the primary investigator, or the trained research assistants.

Medical records were available for approximately 28% of the PD sample. When possible, the primary investigator or a research assistant conducted a chart review to confirm that the diagnosis of PD was met and to identify whether the patient qualified

based on inclusion and exclusion criteria. When medical records were not available, this information was gathered by interviewing the patient or family members. The control subjects were screened based on self-report interview.

All participants included in the study were proficient in English and had intact vision and hearing. Only patients with idiopathic PD were selected, meaning that they demonstrated the classical motor symptoms of the disease and they had a positive response to dopamine replacement therapy. The control subjects were all in good general health as evidenced by maintaining functional independence.

Individuals living in nursing homes or with major medical conditions that could impact cognition were excluded. Any individuals who endorsed a history of alcohol or drug dependence were not eligible. Patients with poorly controlled diabetes were not included in the sample. Any individuals undergoing chemotherapy treatment at the time of evaluation were not invited to participate. Patients with a history of heart attack were excluded if there was evidence that the event impacted cognition. Subjects were excluded on the basis of a history of other neurological conditions, such as seizures or strokes. Any individuals that experienced head trauma with a loss of consciousness lasting more than 10 minutes were not eligible for participation. Patients with atypical Parkinsonism or young onset (defined as diagnosis of PD before age 40) were excluded. Those with a history of neurosurgery to alleviate PD symptoms were not included in the sample.

All subjects enrolled in the study were screened based on their scores on the Mini-Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975), with a cutoff of 24, to exclude any patients with possible dementia. Folstein et al. (1975) suggested that a score

of less than 24 on the MMSE indicates the presence of suspected dementia. Within the present sample, scores on the MMSE ranged from 25-30 (M = 28.95, SD = 1.31).

Individuals diagnosed with any psychiatric conditions other than depression were excluded. If they were diagnosed with a past history of depression, there must have been an indication (either through self-report or information provided in the chart) that they were not depressed at the time of evaluation. To evaluate current status, the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996) was administered for purposes of screening out individuals with high levels of self-reported symptoms of depression. Patients with a total score of greater than or equal to 18 on the BDI-II were excluded from participation in the present study. This cut-off has been suggested for identification of possible depression in mild to moderate PD patients (Leentjens, Verhey, Luijckx, & Troost, 2000; Silberman et al., 2006). Scores on the BDI-II ranged from 0 to 15 (M = 6.01, SD = 3.74). Internal consistency of the BDI-II was α = .69 for PD patients and α = .68 for controls. Potential subjects also completed the Apathy Evaluation Scale—Self-Rating (AES-S; Marin, 1991) as part of the screening process. It has been recommended that scores greater than or equal to 38 are representative of clinically significant elevations in apathy (Pluck & Brown, 2002; Rabkin et al., 2000). Therefore, patients that scored beyond this cutoff were excluded from the study. Scores from the present sample on the AES-S ranged from 18-37 (M = 25.73, SD = 5.16). Internal consistency of the AES-S was α = .79 for PD patients and α = .84 for controls.

To cover the normal age range of PD patients, only subjects over the age of 40 years old were included. The combined sample of patients and controls ranged in age from 49 to 93 years old (M = 69.39, SD = 7.84). The combined sample consisted of 50

(50%) males and 50 (50%) females, and years of education ranged from 11-22 years (M = 16.23, SD = 2.46). For the PD group, disease duration (from the time of diagnosis to the time of testing) ranged from less than 1 year to 25 years since diagnosis (M = 6.84, SD = 5.51). Age at diagnosis ranged from 42-86 years old (M = 62.02, SD = 9.75). Table 1 summarizes the descriptive statistics for the demographics of the sample and the scores on the screening measures.

Data collected from Florida and Arizona sites was inspected for differences in sample characteristics. There were no significant differences found between demographic information and screening score measures, although years of education approached significance, $t(98) = -1.88$, $p = .06$. The results suggested a trend toward more years of education attained by the Arizona participants (M = 16.54, SD = 2.41) compared to the Florida participants (M = 15.55, SD = 2.49).

Table 1

Descriptive Statistics for Demographic Information and Screening Measure Scores

			Range	
Variable	Mean	SD	Minimum	Maximum
Age[a]	69.39	7.84	49	93
Education[a]	16.23	2.46	11	22
Disease duration[b]	6.84	5.51	<1	25
Age at diagnosis[b]	62.02	9.75	42	86
MMSE[a]	28.95	1.31	25	30
BDI-II[a]	6.01	3.74	0	15
AES-S[a]	25.73	5.16	18	37

Note. MMSE maximum score = 30; Higher MMSE scores are associated with intact global cognitive functioning. BDI-II maximum score = 63; Higher BDI-II scores indicate more severe depressive symptoms. AES-S maximum score = 72; Higher AES-S scores represent greater elevations in apathy. [a]n = 100 (PD and Control groups combined). [b]n = 50 (PD group only).

Staging of disease for the PD group was classified by use of the Hoehn and Yahr scale (Hoehn & Yahr, 1967). For study inclusion, patients were required to fall within Stage I to Stage III, indicating that they have maintained functional independence. Twenty-three (46%) patients were classified in Stage I of the disease, meaning that motor symptoms were mild and unilateral. Twenty-three (46%) patients were classified in Stage II, meaning that symptoms were bilateral but posture was not yet affected. Four patients (8%) were classified in Stage III, meaning that balance and postural difficulties had begun but the patient remained functionally independent. There were no patients included from the most advanced disease stages (Stage IV and Stage V). Twenty-six patients (52%) reported that motor symptoms began on the left side of their body. Twenty-three patients (46%) reported that symptoms originated on the right side and one patient did not report this information. Table 2 displays a frequency distribution which compiles the demographic information of this sample.

Table 2

Frequency Distribution of Demographic Information

Variable		*F*	*p*
Gender[a]	Male	50	.50
	Female	50	.50
Stage of disease[b]	Stage I	23	.46
	Stage II	23	.46
	Stage III	4	.08
	Stage IV	--[c]	--
	Stage V	--	--
Side of onset[b,d]	Right	23	.46
	Left	26	.52

Note. [a]n = 100 (PD and control groups combined). [b]n = 50 (PD group only). [c]No subjects within the Stage IV and Stage V groups were included in the sample. [d]Side of onset data was not collected for one subject in the PD group.

Medications that subjects were taking were recorded at the time of testing, and medications that could be associated with changes in cognitive functioning were examined for group differences. The MMSE scores, item memory, and source memory total scores were included in the analyses examining the influence of medication on cognition. T-test analyses were conducted for each medication within patient and control groups. No significant cognitive differences were found to be associated with the use of levodopa, dopamine agonists, monoamine oxidase inhibitors, amantadine, quetiapine, antidepressants, benzodiazepines, or acetylcholinesterase inhibitors. Table 3 contains the cognitive performance data of PD patients based on medication use, and Table 4 summarizes this data for control subjects.

Procedures

Participants were assigned to the patient group on the basis of a diagnosis of PD. Control subjects were matched to each patient based on age (within $\pm$ 5 years), education (within $\pm$ 4 years), and gender. Subjects were brought to a quiet testing space and seated at a table with a laptop computer. Informed consent was obtained prior to beginning the experimental procedures and they were given the opportunity to ask questions before signing the consent form. Although subjects were pre-screened for eligibility, they also participated in a brief interview at the beginning of the study visit to confirm that they met inclusion and exclusion criteria. Demographic information was recorded on a cover sheet. The experimenter administered the MMSE to ensure that all participants met the basic cognitive requirements. The subjects were then instructed to complete paper and pencil versions of the self-report mood measures (BDI-II and AES-S). They were given as much time as they needed to complete the measures and the experimenter was

Table 3

Mean Cognitive Performance of PD Patients based on Medication Use

	MMSE		Item Memory Total		Source Memory Total	
Medication	User	Non-User	User	Non-User	User	Non-User
Levodopa						
M	28.65[a]	29.43[b]	73.09[a]	66.71[b]	62.12[a]	69.29[b]
SD	1.34	.98	21.73	21.56	22.41	20.90
Dopamine agonist						
M	28.89[c]	28.61[d]	72.52[c]	71.83[d]	64.67[c]	61.30[d]
SD	1.45	1.16	22.08	21.52	24.35	19.61
MAOI						
M	28.95[e]	28.61[f]	70.41[e]	73.61[f]	60.55[e]	65.14[f]
SD	1.17	1.42	24.90	18.98	22.50	22.05
Amantadine						
M	28.43[g]	28.81[h]	63.14[g]	73.67[h]	72.43[g]	61.60[h]
SD	.79	1.38	18.53	21.90	23.14	21.88
Quetiapine						
M	28.33[i]	28.79[j]	80.33[i]	71.68[j]	70.33[i]	62.66[j]
SD	2.08	1.28	21.13	21.75	17.21	22.49
AchEl						
M	29.25[k]	28.72[l]	66.50[k]	72.70[l]	62.50[k]	63.17[l]
SD	.96	1.34	39.23	20.06	21.79	22.41
Antidepressants						
M	28.29[m]	28.94[n]	74.36[m]	71.36[n]	63.43[m]	63.00[n]
SD	1.82	1.04	20.59	22.21	25.18	21.23
Benzodiazepines						
M	29.17[o]	28.70[p]	66.67[o]	72.95[p]	53.33[o]	64.45[p]
SD	.75	1.37	20.58	21.86	31.31	20.72

Note. MAOI = monoamine oxidase inhibitors; AChEl = acetylcholinesterase inhibitors.
[a]n = 43. [b]n = 7. [c]n = 27. [d]n = 23. [e]n = 22. [f]n = 28. [g]n = 7. [h]n = 43. [i]n = 3. [j]n = 47. [k]n = 4. [l]n = 46. [m]n = 14. [n]n = 36. [o]n = 6. [p]n = 44.

Table 4

Mean Cognitive Performance of Control Subjects based on Medication Use

	MMSE		Item Memory Total		Source Memory Total	
Medication	User	Non-User	User	Non-User	User	Non-User
Antidepressants						
M	29.00[a]	29.16[b]	73.86[a]	73.84[b]	76.86[a]	74.33[b]
SD	1.53	1.25	21.15	20.43	18.42	19.24
Benzodiazepines						
M	30.00[c]	29.10[d]	79.00[c]	73.63[d]	80.50[c]	74.44[d]
SD	.00	1.29	29.70	20.25	3.54	19.32

Note. [a]n = 7. [b]n = 43. [c]n = 2. [d]n = 48.

available to provide clarification. The experimenter scored the MMSE, BDI-II, and AES-S prior to proceeding. Based on scores from these measures, any individuals who did not meet the screening requirements were excluded from further participation. One control subject and eighteen patients were excluded from the study. The memory task was administered to qualifying participants on the laptop computer using Superlab 4.0 software (Abboud, Schultz, & Zeitlin, 2008). Four versions of the memory task were created to ensure randomization of item order presentation. Each PD patient and his or her matched control received the same version. After completion of the memory task, participants were debriefed and thanked for their participation. The entire study visit took approximately one hour and no follow-up visits were required.

Measures

Mini-Mental State Exam (MMSE). The MMSE (Folstein et al., 1975) is a brief screening measure that is used to evaluate global cognitive functioning. The patient is required to perform tasks that fall into 11 categories: orientation to time, orientation to place, registration, attention, recall, naming, repetition, comprehension, reading, writing,

and drawing. Patients can be classified into one of four categories of cognitive performance based on scores: normal, mild cognitive impairment, moderate cognitive impairment, and severe cognitive impairment. Research provides support for its ability to identify overall cognitive status. The average test-retest reliability (r = .82) was calculated based on test-retest reliability correlations from 25 samples described in a review by Tombaugh and McIntyre (1992). These authors reported that correlations of concurrent validity with other cognitive screening tests ranged from r = .70 to r = .90.

Beck Depression Inventory – II (BDI-II). The BDI-II (Beck et al., 1996) is a 21-item self-rating measure designed to assess the severity of depressive symptoms in accordance with the criteria outlined in the Diagnostic and Statistical Manual of Mental Disorders – 4th Edition (DSM-IV; American Psychiatric Association, 1994). This is a well-established scale that has been used previously with PD patients (Leentjens et al., 2000; Silberman et al., 2006) and has excellent reliability (r = .93; Beck et al, 1996) and validity (Beck et al, 1996; Dozois & Covin, 2004; Osman et al., 1997).

Apathy Evaluation Scale – Self-Rating (AES-S). The AES-S (Marin, 1991) is an 18-item self-report instrument that is used to assess for symptoms of apathy within behavioral, cognitive, and emotional spheres. This measure has been used in a number of clinical groups, including the PD population (Pluck & Brown, 2002; Rabkin et al., 2000), and has been found to have acceptable internal consistency (α = .86) and test-retest reliability (r = .76) as well as convergent and discriminant validity (Marin, Biedrzycki, & Firinciogullari, 1991).

Source memory task. The source memory task used in the present study was developed based on prior work by Mulligan et al. (2006). Extensive piloting was

conducted to adapt the experimental procedures for appropriate use with the PD population. Details of these piloting procedures are presented in Appendix B.

The memory task started with the study phase. Participants were told that a list of 12 rhyming pairs of words would appear serially on a computer screen. They were informed that on some trials, they would be presented with two rhyming words on the computer screen and that they should read both words and write the second word on their answer sheet (Read Condition). On the rest of the trials, they were told that they would see a word followed by the first letter of the second word (Generate Condition). Subjects were asked to read the first word, think of the rhyming word that started with the letter presented, and then record it on their answer sheet. Participants were informed that on some trials, the words would appear in green with a bold font style. On other trials, the words would appear in red with an italic font style. They were asked to try to remember the second word in each trial (i.e., the target word that they wrote down), and to try to remember the color and font combination of each word pair. Prior to beginning the study phase, participants completed a practice trial to ensure understanding of the instructions.

The study list was presented twice. Afterwards, a distractor task was presented and participants were asked to solve simple arithmetic problems for 3 minutes. Prior to the test phase, subjects were instructed that a list of words would appear on the computer screen, half of which they had seen before and half of which were new. First, they were asked to decide whether they had seen the word during the study phase (item memory test). If they indicated that the word was old, they were also required to select the correct color and font combination (source memory test). The test words were displayed on the computer screen in black Courier New font. Below each test word, examples of the color

and font combinations were included to serve as reminders. The red, italic font selection was referred to as "Choice 1", appearing on the lower left-hand side of the screen. The green, bold font selection was referred to as "Choice 2", appearing on the lower right-hand side of the screen. The experimenter emphasized that the color/font decision referred to the entire study stimuli that was shown during the study phase (consisting either of the cue-target or cue-target fragment). Participants verbalized their answer choice (new word, Choice 1, or Choice 2) and the experimenter pressed the corresponding button on the computer. The test item remained on the computer screen until the participant responded.

Results

Demographic information along with MMSE, BDI-II, and AES-S scores are shown for the PD group and control group in Table 5. T-test comparisons revealed that no significant differences were found between groups for age, $t(98) = -.67$, $p = .50$; education, $t(92) = .04$, $p = .97$; MMSE scores, $t(98) = -1.46$, $p = .15$; BDI scores, $t(98) = 1.42$, $p = .16$; or AES-S scores, $t(98) = 1.34$, $p = .18$. The control group consisted of 29 females and 21 males. The PD group was comprised of 21 females and 29 males. A chi square analysis revealed no significant differences in gender between the patient and control groups, $\chi^2 = 2.56$, $df = 1$, $p = .11$. To eliminate order effects, four versions of the study list presentation were administered. The four versions were evenly distributed across participants, as demonstrated by a nonsignificant result in a chi square analysis, $\chi^2 = .32$, $df = 3$, $p = .96$.

Table 5

Demographic Information and Screening Measure Scores Separated by Group

	Control		PD	
Variable	Mean	SD	Mean	SD
Age	69.92	7.40	68.86	8.30
Education	16.22	2.15	16.24	2.77
MMSE	29.14	1.28	28.76	1.32
BDI-II	5.48	3.84	6.54	3.59
AES-S	25.02	5.16	26.42	5.12

Note. MMSE maximum score = 30; Higher MMSE scores are associated with intact global cognitive functioning. BDI-II maximum score = 63; Higher BDI-II scores indicate more severe depressive symptoms. AES-S maximum score = 72; Higher AES-S scores represent greater elevations in apathy.

Data for Analysis

The variables included in the statistical analyses were calculated based on the proportion of items correct. To measure item memory, accuracy was assessed with corrected hit rates (hit rate minus false alarm rate). Source memory was measured with the identification of origin score (Johnson et al., 1993), defined as the proportion of items correctly recognized as old that were also attributed to the correct source. In order to examine the generation effect, proportion correct was calculated for items within the generate condition only, and for items within the read condition only. Therefore, the following variables were included in the statistical analyses and the abbreviated titles will be used for subsequent discussion: Item Total (overall item memory performance), Source Total (overall source memory performance), Item-Generate (item memory performance within the generate condition), Source-Generate (source memory performance within the generate condition), Item-Read (item memory performance within the read condition), and Source-Read (source memory performance within the read condition).

Assumptions

The assumption of sphericity was not evaluated because this assumption is always met in designs with only two levels of a repeated measures factor (Hinton, Brownlow, & McMurray, 2004). For all variables, the assumption of homogeneity was satisfied by Levene's test for equality of variances. The distribution of each variable was examined with the D'Agostino-Pearson omnibus test for normality (Moriarty, 2010). For the patient sample, the test revealed that the distribution of Item-Generate scores differed significantly from normality, $K^2 = 10.47$, $p = .005$. For the control sample, Item-

Generate scores, $K^2 = 6.39$, $p = .041$, and Source-Read scores, $K^2 = 15.31$, $p < .001$, both differed significantly from normality.

The data was also examined for skewness and kurtosis. Variables with z-scores greater than two were considered to be significantly skewed. Three variables within the patient sample (Item Total, Item-Generate, Item-Read) were found to be significantly skewed. Two variables within the control sample (Item-Generate, Source-Read) were significantly skewed. Significant kurtosis was found for one variable from the control sample (Source-Read).

An arcsine transformation was performed to correct for problems with normality. This transformation was selected because it is commonly used with proportional data. The arcsine transformation corrected the violations of the normality assumption, with the exception of the Source-Read variable, which remained skewed. The data were analyzed following the arcsine transformation and compared to the untransformed results. The outcome of the results was found to be the same regardless of whether the transformation was applied. Therefore, the results are reported below with the untransformed data.

Item and Source Memory Total Scores

Descriptive statistics for item memory and source memory total scores are presented in Table 6. An independent samples t-test was conducted to compare item memory performance of PD patients and controls, and there was no significant difference between the mean scores, $t(98) = -.39$, $p = .70$. An independent samples t-test was conducted to compare source memory performance of PD patients and controls. A significant difference was found between the mean scores, $t(98) = -2.80$, $p = .006$.

The item memory comparison is displayed in Figure 3 and the PD-specific source memory impairment is illustrated in Figure 4.

Table 6

Descriptive Statistics for Item Memory and Source Memory Total Scores

	Control			PD		
Memory Test	*M*	*SD*	*SE*	*M*	*SD*	*SE*
Item Total	.74	.20	.03	.72	.22	.03
Source Total	.75	.19	.03	.63	.22	.03

Note. Item Total = hit rate minus false alarm rate; Source Total = proportion of items correctly recognized as old that were attributed to the correct source.

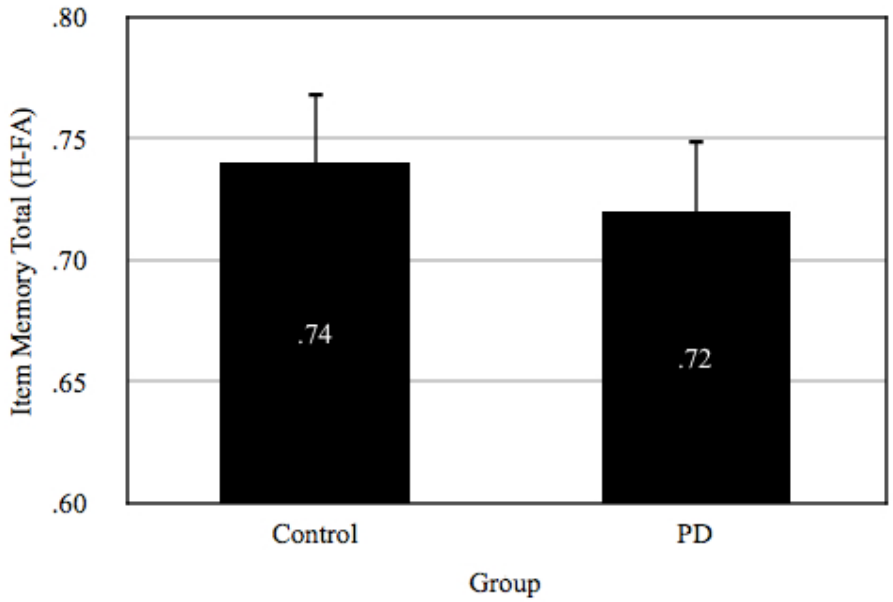

Figure 3. Mean item memory total scores (hit rate minus false alarm rate) as a function of group (Control, PD). Error bars represent one standard error above the mean.

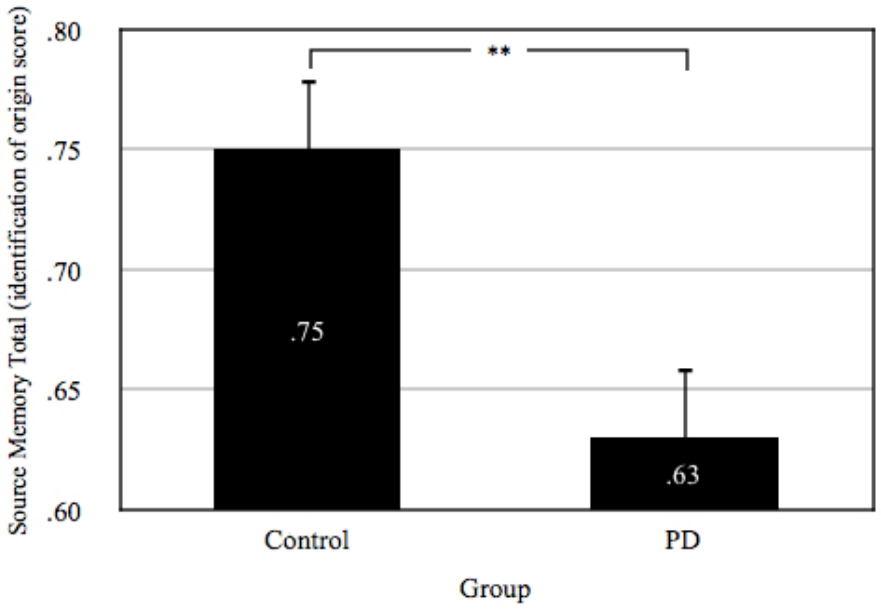

Figure 4. Mean source memory total scores (proportion of items correctly recognized as old that were attributed to the correct source) as a function of group (Control, PD). Error bars represent one standard error above the mean. Statistical significance is displayed: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Item Memory Analysis

Descriptive statistics for item memory scores separated by encoding condition are presented in Table 7. A mixed design analysis of variance with group (Control, PD) as the between-subjects factor and encoding condition (Item-Read, Item-Generate) as the within-subjects factor revealed that the main effect of encoding condition was significant, $F(1, 98) = 50.09$, $p < .001$, $\eta_p^2 = .34$. As predicted, a positive generation effect was observed for both groups on item memory performance (see Figure 5). Item memory performance did not differ significantly between the PD group and the control group, $F(1, 98) = .12$, $p = .73$, $\eta_p^2 = .001$. The interaction between encoding condition and group was not significant, $F(1, 98) = .02$, $p = .89$, $\eta_p^2 < .001$. Therefore, the only significant difference observed in item memory performance was between read and generate conditions with significantly more words recalled in the generate condition.

Table 7

Descriptive Statistics for Item Memory across Encoding Condition

	Control			PD		
Condition	*M*	*SD*	*SE*	*M*	*SD*	*SE*
Item-Read	.68	.28	.04	.69	.25	.04
Item-Generate	.83	.17	.02	.85	.17	.02

Note. Mean values represent hit rate minus false alarm rate.

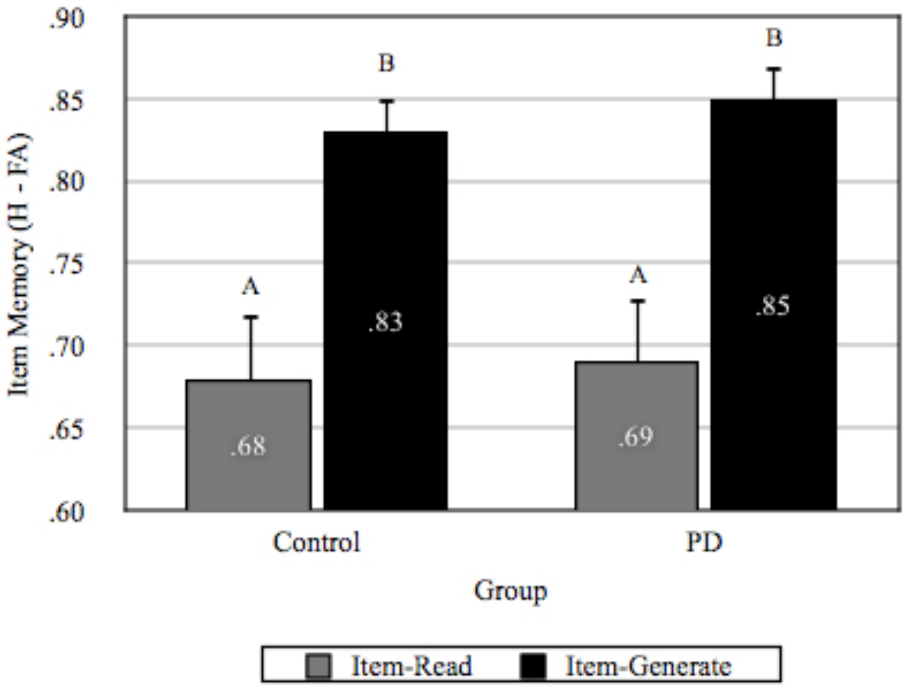

Figure 5. Mean item memory scores (hit rate minus false alarm rate) as a function of group (Control, PD) and encoding condition (Item-Read, Item-Generate). Error bars represent one standard error above the mean. Means are marked with letters to display the main effect of encoding condition. Means marked with the same letter are not significantly different.

Source Memory Analysis

A mixed design analysis of variance was conducted with group (Control, PD) as the between-subjects factor and encoding condition (Source-Read, Source-Generate) as

the within-subjects factor. Contrary to prior predictions, the main effect of encoding condition was not significant $F(1, 98) = .09$, $p = .77$, $\eta_p^2 = .001$. The predicted significant main effect of group, $F(1, 98) = 11.44$, $p = .001$, $\eta_p^2 = .104$, was qualified by a significant interaction between encoding condition and group, $F(1, 98) = 4.91$, $p < .029$, $\eta_p^2 = .048$.

Examination of the means (shown in Table 8) revealed that there was an 8.2-point gain in source memory performance for PD patients within the generate condition. For controls, there was a 6.2-point decrease in the generate condition. Simple effects comparisons demonstrated that the increase in patient performance was marginally significant ($p = .078$). The positive generation effect observed within the PD group was an unexpected finding. The decrease in the performance of controls revealed a nonsignificant trend in the predicted direction ($p = .18$). PD patients scored significantly lower on the source memory task in comparison to controls within the read condition only ($p < .001$). However, there was no significant difference across groups within the generate condition ($p = .16$). Figure 6 depicts this interaction and the associated simple effects comparisons.

Table 8

Descriptive Statistics for Source Memory across Encoding Condition

	Control			PD		
Condition	*M*	*SD*	*SE*	*M*	*SD*	*SE*
Source-Read	.79	.27	.04	.57	.30	.04
Source-Generate	.73	.24	.03	.66	.25	.03

Note. Mean values represent the identification of origin score (proportion of items correctly recognized as old that were attributed to the correct source).

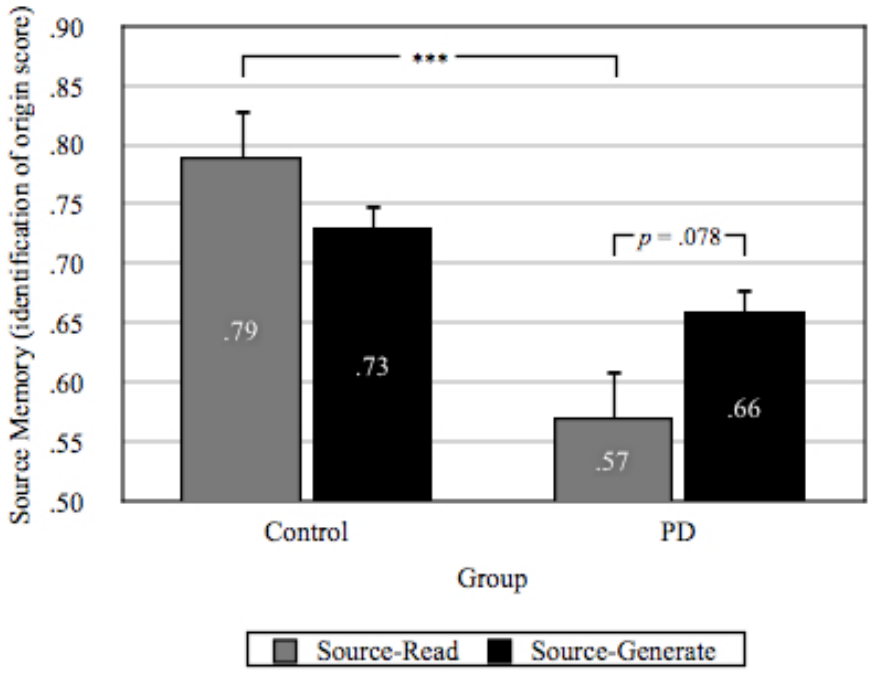

Figure 6. Mean source memory scores (proportion of items correctly recognized as old that were attributed to the correct source) as a function of group (Control, PD) and encoding condition (Source-Read, Source-Generate). Error bars represent one standard error above the mean. Statistical significance is displayed to show the comparisons that decompose the interaction effect: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Site Differences

The main analyses were conducted separately for data that was collected in Arizona and Florida. A comparison of group differences in source memory total scores for Florida participants was not significant, $t(29) = -1.66$, $p = .11$. The predicted pattern of performance was revealed for Arizona participants, $t(67) = -2.29$, $p = .02$, with source memory total scores higher in the control group ($M = .75$, $SD = .20$) than in the PD group ($M = .63$, $SD = .24$).

Discussion

The purpose of this project was to contribute to a limited body of literature that has investigated source memory performance in PD, and to examine the effect of generation on item memory and source memory in PD. As predicted, it was found that the PD group was impaired in source memory but not item memory. These results lend additional support to the existing evidence that deficits associated with prefrontal functioning are a prominent characteristic of the PD disease process.

As expected, both groups demonstrated improved item memory performance in the generate condition as compared to the read condition. However, the hypothesis that generation would hinder source memory performance, and that PD patients would display more susceptibility to this effect, was not supported. To the contrary, the PD group exhibited a marginally significant trend in the direction of improved source memory performance when they were required to generate a response. There is some evidence to suggest that tasks with a generative component may be related to increased activation of the frontal lobes, and this could have meaningful ramifications for individuals with compromised frontal function. Generative tasks may assist to activate frontal regions, thereby facilitating greater association of item features with contextual information. These findings could have promising implications for cognitive rehabilitation in PD, although this has not yet been directly explored.

Source Memory Deficits in PD

This appears to be the first study of its kind to provide confirmation of a selective source memory deficit in PD. PD subjects were found to have obtained significantly lower scores on the source memory test relative to control subjects, although there were no significant differences across groups on item memory performance. A distinguishing feature of this project was that the overall difficulty level of item and source memory performance was equated within the control sample during the piloting phase, thereby allowing more clear inferences to be drawn regarding group differences on source memory performance. In prior studies, there was no explicit mention of an attempt to equate item memory and source memory performance levels (Drag et al., 2009; Hsieh & Lee, 1999). It has been suggested that the frontal lobes may become engaged during source memory tasks primarily because of the difficult attributes of the task as opposed to reflecting a distinct aspect of memory processing (Shallice, 1982). Actually, source judgments generally are considered to be more challenging because they require retrieval of the linkage between an item and its context, not just a recollection of the item or source independently. Therefore, it seems feasible that source memory impairments could be accounted for by the simple fact that the source memory task was more difficult than the item memory task. By equating the overall difficulty level of the item and source memory tasks in controls, any differences in source memory performance in the PD group could more clearly be interpreted as due to the nature of the task itself rather than difficulty level.

In a study examining the source memory performance of older adults, Glisky et al. (2001) equated item and source memory performance by requiring subjects to

complete an extremely difficult item memory task involving voice discrimination. They divided groups into high and low frontal functioning based on a composite score of performance on several neuropsychological measures associated with frontal abilities. They found no difference between the high and low frontal functioning groups on item memory performance, and therefore concluded that the frontal lobes are not necessarily engaged based on task difficulty alone. In contrast, the older adults with below average frontal functioning showed impairments on the source memory task, suggesting that there is something distinct about the cognitive processes required for source memory as opposed to item memory.

Similar conclusions can be drawn from the present experiment. The item memory task was presumably quite challenging, as the mean corrected hit rate was .74 for controls. Due to the difficult nature of the item memory task, their mean source memory score (.75) was essentially equivalent. The words selected for study and test stimuli had high frequencies of occurrence in the English language (mean Kucera Francis frequency of 111). There is evidence that high frequency words are easier to recall but more difficult to correctly identify in recognition tasks (Yonelinas, 2002). Therefore, the high frequency of the selected words is likely to have increased the effort level required to perform the item recognition task, making the difficulty level comparable to the source memory task.

The current research provides a method of clearly isolating a source memory deficit in PD patients and implies that the impairment is not based solely on the difficulty of the source task. Rather, it seems likely that there is something unique about the nature of source memory processing which is selectively impaired in PD. More generally, these

findings support the idea that source memory is a dissociable element of memory functioning, as many prior studies outside the PD literature have already demonstrated (e.g., Brandt, Bylsma, Aylward, Rothlind, & Gow, 1995; Shimamura & Squire, 1991; Trott, Friedman, Ritter, Fabiani, & Snodgrass, 1999).

Generation Effects

Item memory. It was originally predicted that item memory would be enhanced for words that subjects had been asked to produce themselves, and this effect was observed for both PD patients and controls. The present study corroborates the previous finding of Hsieh and Lee (1999) demonstrating that PD patients exhibit a positive generation effect on an item recognition task. This effect seems to be consistent across different study designs. In the current experiment, the study list consisted of cue-target rhyme pairs that required the subject to either generate or read the target word. Hsieh and Lee (1999) used a task that required participants to discriminate between questions they answered themselves and questions that the experimenter had answered. In both studies, the generation effect was obtained in PD patients and controls with no differences across groups.

Tasks with a generation component may be particularly beneficial to various clinical populations with diminished cognitive resources. A positive generation effect has been demonstrated in individuals with Alzheimer's disease (Lipinska, Backman, Mantyla, & Viitanen, 1994; Multhaup & Balota, 1997), multiple sclerosis (Chiaravalloti & DeLuca, 2002; O'Brien, Chiaravalloti, Arango-Lasprilla, Lengenfelder, & DeLuca, 2007), traumatic brain injury (Goverover, 2010; Schefft, Dulay, & Fargo, 2008), mild cognitive impairment (Gonzalez-Nosti, Arango-Lasprilla, & Cuetos, 2010), and seizure

disorders (Schefft, Dulay, Fargo, Szaflarski, Yeh, & Privitera, 2008). There is also evidence that positive generation effects occur in patients in the early stages of frontal lobe dementia (Souliez, Pasquier, Lebert, Leconte, & Petit, 1996) and in patients diagnosed with frontal dementia and Parkinson-plus syndrome (Barrett, Crucian, Schwartz, & Heilman, 2000).

There have been numerous theoretical accounts that attempt to explain the underpinnings of the generation effect. Fiedler, Lachnit, Fay, and Krug (1992) discussed how many of these theories do not provide a sufficient explanation for a comprehensive account of the phenomenon. The authors utilize a revised methodology to discount many alternative explanations, and propose that the generation effect occurs due an increased engagement of additional cognitive resources. This stands in contrast to previous theories suggesting that a fixed amount of cognitive resources are utilized during generative tasks (e.g., Slamecka & Katsaiti, 1987).

In a meta-analytic review, Bertch et al. (2007) found that the generation effect yielded a larger effect size in older adults as compared to younger adults. The influence of task difficulty was also examined. On generation tasks that were considered to be effortful, larger effect sizes were noted for older adults compared to younger adults. On generation tasks that were judged to be less challenging, older adults still exhibited larger effect sizes as compared to younger adults, but the magnitude of the difference was smaller. The observation that older adults display greater generation benefit on more difficult tasks is unusual because the literature generally suggests that the performance of older adults declines on more effortful tasks (Zacks, Hasher, & Li, 2000). One potential interpretation of this unpredictable finding is that older adults have reduced processing

resources compared to younger adults, and therefore could receive a special benefit from generation tasks. This distinctive performance benefit could be explained by the theory that generation facilitates the recruitment of extra cognitive resources that would otherwise remain unactivated.

The normal aging process is associated with decreased frontal lobe volume (Coffey et al., 1992) and significantly lowered cerebral blood flow to frontal regions (Grady et al., 1995). In a dissertation study, Grix (1998) studied older and younger adults and compared performance on a passive processing task relative to a generative processing task. Although there was a significant difference in the performance between older and younger adults on the passive processing task, these age differences were eliminated on the generative processing task. The author suggests that the increased cognitive stimulation involved in generating is particularly beneficial for older adults, which is reflected in their substantially improved performance. Grix (1998) found positive correlations between tasks of frontal lobe function and performance on the generative processing tasks, but no significant correlations between frontal lobe tasks and passive processing tasks. Grix (1998) points to the possibility that the act of generating may be specifically related to increased activation of the frontal lobes.

Source memory. It was predicted that PD patients and control subjects would display a negative generation effect on the source memory task, but that this effect would be more pronounced within the PD group. This prediction was based on the tradeoff hypothesis, suggesting that generation tends to increase focus on the central aspects of the item while distracting from processing of the peripheral, contextual aspects of the

stimulus. Support for this hypothesis has been demonstrated in prior research utilizing external-external source memory paradigms with young, healthy adults.

Contrary to expectations, PD patients exhibited a marginally significant advantage in the generate condition of the source memory task. Older adults in the control sample of this study showed a suppression of the negative generation effect. Although group means fell within the expected direction, the difference in the means was nonsignificant. The lack of the predicted negative generation effect could be related to changes in frontal function that occur as part of the normal aging process, and to a more extreme extent in the PD disease process.

It has been well established that relative to younger adults, older adults are less effective in remembering contextual information (Spencer & Raz, 1995). Furthermore, Mitchell, Raye, Johnson, and Greene (2006) reported that older adults display less activity than younger adults in the left lateral prefrontal cortex while performing a source memory task. In the present experiment, the generative task may have activated regions of the prefrontal cortex which are not normally spontaneously engaged in older adults, thereby suppressing the expected negative generation effect.

For PD patients, the generative task in the current study may have actually provided a benefit to source memory performance. Prior fMRI evidence suggests that PD patients with cognitive impairments demonstrate underactivation in the VLPFC and DLPFC regions when performing a task of executive function (Lewis, Dove, Robbins, Barker, & Owen, 2003). Although there are no known imaging studies to have examined source memory performance in PD subjects, it seems likely that the PD source memory deficit could be related to this underactivation in the VLPFC and DLPFC regions. It is

possible that generating a response may have increased the engagement of the VLPFC and DLPFC, thus inducing elaborative encoding strategies to link item with context and facilitating source memory performance.

Recent research supports the assumption that the generation effect could recruit the engagement of frontal areas. Rosner, Elman, and Shimamura (2012) investigated the generation effect using fMRI analysis and found that the memory benefit was associated with activation of a broad network of brain regions from the prefrontal and posterior cortices. Within prefrontal regions, increased activation was noted in the left inferior frontal gyrus (a region of the VLPFC) and the middle frontal gyrus (a region of the DLPFC). It appears that the left inferior frontal gyrus plays an important role in source memory performance as well. Fan, Snodgrass, and Bilder (2003) found that activation of the left inferior frontal gyrus was related to successful encoding and retrieval during a source memory task. The left inferior frontal gyrus is considered to be an area that exerts cognitive control over memory processes when there is a need to select among competing possibilities (Badre & Wagner, 2007; Zhang, Mei Feng, Fox, Gao, & Tan, 2004). Based on converging results from neuroimaging data, it is plausible that underactivation of this brain region may contribute to source memory changes in PD and older adults, in addition to providing a potential neuroanatomical explanation for the generation effects observed in this study.

It has been proposed that the underlying basis of cognitive dysfunction in PD is a deficit of internal control for regulating attentional processes. (Brown & Marsden, 1988b; Werheid et al., 2007). The present findings suggest that generative tasks may not interfere with the weakened attentional control mechanisms in PD. The task of rhyme

completion used in this study was highly structured and there was only one possible response option. It seems that the incomplete cue-target rhyme pairs could have served to provide external cues for the PD group to facilitate elaborative encoding. This stands in contrast to the Brown and Marsden (1988b) task which provided no external support to determine when switching between task demands should occur. Therefore, highly structured generative tasks may not necessarily create a disruption in the ability of PD patients to recall contextual detail and could even enhance performance by activating areas of the brain involved in regulating internal control.

Future Directions

The adapted Mulligan et al. (2006) task employed in the current study appears to be a useful tool to evaluate item and source memory, while simultaneously assessing the effect of self-generation on performance. Preliminary inferences have been drawn regarding the contributions of the frontal lobes to source memory performance and generative tasks in PD. The above findings suggest that the adapted Mulligan et al. (2006) paradigm is sensitive to detecting the cognitive changes in PD, and may be a suitable methodology to apply to the investigation of other populations with memory loss, as well as normally aging individuals. Chan et al. (2008) emphasized the relevance of isolating specific component processes of frontal functioning in order to advance research in executive functioning.

This study is the first of its kind to demonstrate a PD item and source dissociation using a task that involves discrimination of perceptual features of linguistic stimuli. Hsieh and Lee (1999) and Drag et al. (2009) both used tasks that involved vocal discrimination. Cook (2006) proposed that there may be a general source memory factor

regardless of study stimuli, but also differences based on the unique characteristics of the stimuli. The methodological differences of source memory tasks across studies create a challenge when attempting to compare results. Cook (2006) utilized a repeated measures design and studied how younger and older adults performed on source discrimination tasks for voices, spatial location, and temporal material. A similar type of study may be helpful in determining if PD patients are particularly vulnerable to certain types of stimuli.

Prior research has suggested that providing explicit instructions to integrate item information with its context improves source memory and decreases the load on the frontal lobes (Glisky et al., 2001; Kuo & Van Petten, 2006). In the current experiment, subjects were given clear directions to attend to source information and to attempt to recall the link between each item and its context. Although the effect of different encoding instructions was not directly examined in this project, PD patients did not appear to benefit from having been provided with these instructions. An area of research to explore in the future would be to determine if orienting instructions could have an influence on how PD patients perform on tests of source memory. This could be used as a potential method of manipulating the level of frontal involvement and associated performance on tasks.

The conclusions that can be drawn about the effect of generation on source memory in PD are speculative at this point. The findings imply that generation may benefit source memory performance in individuals with PD, although these results were only approaching significance. Future replication of this trend is necessary to add confidence to the interpretation of the findings. In addition, altering study conditions to

potentially enhance the strength of the generation effect may add an interesting new perspective. Goverover, Chiaravalloti, and DeLuca (2008) hypothesized that task meaningfulness, familiarity, and complexity are likely to be important factors which influence the effectiveness of generative strategies. Buyer and Dominowski (1989) examined the effects of self-generation on university students. After a 1-week delay, the generation effect was only observed on the most challenging items. The authors theorized that the amount of cognitive effort enhanced the generation effect. If it is possible to enhance the strength of the generation effect with PD subjects, this may provide an approach to clarify patterns in source memory performance that occur across conditions and between groups.

Presently, there is little direct evidence to support the theory that generation tasks engage additional frontal regions in PD patients and healthy older adults. A limitation of the current experiment was that it did not include any measures of frontal functioning. It would be particularly worthwhile to pursue future neuroimaging research with PD patients that elucidates the role of the frontal lobes during generative tasks. Another relevant topic of study would be to determine whether the benefit of the generation effect varies depending on the severity of frontal dysfunction. Comparisons between healthy adults and clinical populations could also contribute to our understanding of the compensatory mechanisms of the brain.

Given the information that is currently available, it seems that generative strategies may have practical applications for PD patients. Self-generation could be used as a tool to activate more integrated processing that recruits frontal involvement, and the results suggest that both semantic and episodic memory may benefit from this strategy.

Some researchers have already attempted to incorporate generative types of tasks into memory intervention programs. It has been suggested that mnemonic training which is taught in standard memory intervention programs may be too complex for individuals with limited cognitive capabilities to successfully utilize (Yesavage, Sheikh, Friedman, & Tanke, 1990). Derwinger, Stigsdotter-Neely, Persson, Hill, and Backman (2003) evaluated the effectiveness of a standard mnemonic training program in comparison to self-generated memory strategy training in older adults. The results indicated that both groups showed equivalent improvements in comparison to a control group. Derwinger, Stigsdotter-Neely, and Backman (2005) performed follow-up with participants 8 months after completion of the intervention. In a condition where no support with task completion was provided, subjects in the self-generated strategy group maintained improvements while subjects in the mnemonic strategy condition experienced performance decline. This suggests that self-generated memory strategies may provide a lasting benefit to older adults.

This type of intervention might also be helpful for individuals with PD, although an adapted version of the intervention is recommended. Barrett et al. (2000) found that patients with Parkinson-plus syndrome and frontal lobe dementia recalled internally generated material significantly better when tested in a recognition format compared to a recall format. This suggests that when PD patients apply self-generated memory strategies, they are likely to work best in highly structured environments that also encourage recognition of memory events as opposed to recall. There is still much to be clarified with regard to the potential for PD cognitive rehabilitation. To date, only three studies were found to have conducted cognitive training with PD subjects, and all of

these have specifically emphasized executive functioning skills (Disbrow et al., 2012; Sammer, Reuter, Hullmann, Kaps, & Vaitl, 2006; Sinforiani, Banchieri, Zucchella, Pacchetti, & Sandrini, 2004).

Some studies have employed memory rehabilitation strategies based on self-generated learning and examined their effect on aspects of daily living. There is growing evidence that the generation effect could have real-world applications to functional activities in several patient populations. Goverover et al. (2008) concluded that learning tasks involving meal preparation and managing finances improved in patients with multiple sclerosis. Participants displayed memory improvements when they were asked to generate the items required to perform each step of the task. These improvements even lasted after a 1-week delay period. Basso, Lowery, Ghormley, Combs, and Johnson (2006) studied individuals diagnosed with multiple sclerosis who demonstrated moderate to severe memory impairment. Self-generation enhanced recognition and recall of names, appointments, and object locations. Goverover (2010) found that the generation effect appeared to be clinically meaningful for individuals with traumatic brain injury. Subjects improved on tasks of meal preparation and managing finances and it was found that the effects persisted after a week.

In summary, this study establishes the existence of a source memory deficit in PD patients, and provides initial evidence of the potential for generative techniques to improve item and source memory performance. Future research in this area could lead to new insights regarding brain function, and also lead to breakthroughs in the development of innovative cognitive-behavioral interventions to improve memory.

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Appendices

Appendix A: USF IRB Letter

DIVISION OF RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-5618

April 9, 2010

Lynn Oelke
Psychology
PCD 4118G

RE: **Expedited Approval** for Initial Review
IRB#: Pro00000384
Title: Souce Memory and Generation Effects in Parkinson's Disease

Dear Ms. Oelke,

On 4/8/2010 the Institutional Review Board (IRB) reviewed and **APPROVED** the above referenced protocol**.** Please note that your approval for this study will expire on 4/8/2011.

Approved Items:
Consent/Assent Document(s):

Adult Informed Consent.pdf	4/9/2010 3:43 PM	0.01

It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve only procedures listed in one or more of the categories outlined below. The IRB may review research through the expedited review procedure authorized by 45CFR46.110 and 21 CFR 56.110. The research proposed in this study is categorized under the following expedited review category:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Please note, the informed consent/assent documents are valid during the period indicated by the official, IRB-Approval stamp located on the form. Valid consent must be documented on a copy of the most recently IRB-approved consent form.

Your study qualifies for a waiver of the requirement for signed authorization as outlined in the HIPAA Privacy Rule regulations at 45 CFR 164.512(i) which states that an IRB may approve a waiver or alteration of the authorization requirement provided that the following criteria are met

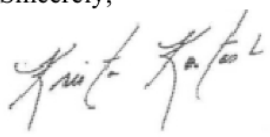
Appendix A: (Continued)

(1) the PHI use or disclosure involves no more than a minimal risk to the privacy of individuals; (2) the research could not practicably be conducted without the requested waiver or alteration; and (3) the research could not practicably be conducted without access to and use of the PHI.

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval by an amendment.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-9343.

Sincerely,



Krista Kutash, PhD, Chairperson
USF Institutional Review Board

Cc: Anna Davis, USF IRB Professional Staff

Appendix B: Piloting Procedures for the Source Memory Task

The items for the source memory task were derived from a series of experiments by Mulligan et al. (2006). These procedures allow for an examination of how generation exerts dissociative effects on item memory and source memory performance (i.e., positive generation effect for item memory and negative generation effect for source memory). Although the authors did not mention any intentional attempts to equate for task difficulty, an examination of the overall means revealed that performance on item memory and source memory tasks was relatively equivalent. The Mulligan et al. (2006) procedures were selected for use within the present study because this aspect was considered to be particularly important for making comparisons in performance between patient and control groups.

The Mulligan et al. (2006) experiments were originally conducted with college students. For purposes of this study, the experimental materials were modified to ensure that the task was appropriate for use with a patient population and for individuals over age 40. These adjustments were based on the results of pilot data collected from 60 subjects (42 controls and 18 PD patients). The study task was based on a combination of characteristics from Mulligan et al. (2006) Experiments 2A and 2B.

The Mulligan et al. (2006) Experiments 2A and 2B stimuli consisted of 48 cue-target rhyme pairs. The target words were four or five letters long with a mean Kucera-Francis (1967) frequency of 156. To examine the generation effect, encoding condition (Read, Generate) was manipulated within subjects. In the Read condition, the study stimulus consisted of both words presented in an intact form (e.g., sing-king). In the

Appendix B: (Continued)

generate condition, the study stimuli consisted of the first word and the first letter of the second word followed by a continuous underscore (e.g., sing-k___).

In Experiment 2A, the items varied by color. Half of the generate and read items appeared in red print while the remaining items appeared in green print. In Experiment 2B, the items varied by font. Half of the generate items appeared in the Jokerman font and the other half appeared in the Bauhaus 93 font. Experiments 2A and 2B were identical in all other aspects besides these differences in color and font.

Two additional rhyme pairs were placed at the beginning and end of the study lists to serve as primacy and recency buffers. The study word pairs were displayed for 7 seconds in the center of the computer screen, followed by a blank screen for 200 milliseconds. Four versions of the study list were created so that each target item appeared in each possible combination of encoding condition (Generate, Read) and source attribute (color in Experiment 2A; font in Experiment 2B). Each participant received one of the four versions of the study list. The study items were shown in random order and the presentation of encoding condition and source attributes were also randomly ordered.

The test list was introduced after a 3-minute delay. The test list consisted of the 48 target words intermixed with 48 new words, similar to the targets in length and frequency. Subjects were asked to identify which words they had seen previously in a yes-no recognition format (item memory test). For recognized words, they were then asked to identify which source attribute (color in Experiment 2A, font in Experiment 2B)

Appendix B: (Continued)

that the word was presented in during the study phase. This served as an index of source memory performance.

The pilot experiment for the current study was designed using Superlab 4.0 software (Abboud, Schultz, & Zeitlin, 2008) on a Macintosh computer. The experimental stimuli were created within the Macintosh version of Microsoft Word 2008 and imported into the Superlab experiment script. Initial piloting consisted of a replication of Experiment 2B procedures. The Jokerman font that was utilized by Mulligan et al. (2006) was not available within the Macintosh version of Microsoft Word 2008 and therefore was replaced with a similar font. Handwriting Dakota, size 72, and Bauhaus 93, size 64, were chosen for their distinctiveness from one another. Although the font sizes differed numerically, they appeared as equivalent sizes on the computer screen.

Based on the results from early pilot data, it was concluded that the study list should be shortened to adjust to an appropriate difficulty level for the age group of the sample. The study list was reduced to 12 cue-target rhyme pairs selected from the original Mulligan et al. (2006) stimuli. Twenty-four items were selected for the test list, and the targets and distractors in the shortened list were equated for word frequency with a mean Kucera-Francis frequency of 111 (Kucera & Francis, 1967). The data from seven additional pilot subjects revealed that scores on the source memory task remained below chance after implementing this change. The color and font cues, respectively from Experiments 2A and 2B, were combined in order to make the stimuli more salient. Both words in each trial (i.e., cue paired with target) always appeared in the same color and font. Green words always appeared in the Bauhaus 93 font and red words always

Appendix B: (Continued)

appeared in the Handwriting Dakota font. The primacy and recency buffers were removed and the study list was repeated three times in an attempt to improve performance. The time that each word pair remained on the computer screen was also increased to 13 seconds to allow PD patients extra time to adequately encode the stimuli. Pilot data from 12 subjects (8 PD and 4 controls) revealed that a ceiling effect occurred in the control group. Therefore, the study list was reduced to two presentations. Pilot data from 20 additional subjects (10 controls, 10 PD) suggested that optimal performance was achieved when the study list was presented twice. These 20 subjects were included in the final data analysis.

The above modifications in piloting yielded results that resembled the Mulligan et al. (2006) experiments. For the control group, item memory (M = .75, SD = .20) and source memory (M = .75, SD = .23) total scores were relatively equivalent. This suggested that the two tasks were equated on difficulty. For item memory performance, higher scores were observed in the generate condition (M = .85, SD = .14) as compared to the read condition (M = .67, SD = .28). The source memory data reflected lower scores in the generate condition (M = .72, SD = .27) as compared to the read condition (M = .83, SD = .25). Similar to the findings reported by Mulligan et al. (2006), these patterns were suggestive of a positive generation effect for item memory and a negative generation effect for source memory. Scores for the PD patients were above chance for item memory (M = .72, SD = .24) and source memory (M = .64, SD = .18) total scores, suggesting that the modifications were effective in eliminating potential floor effects.