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The Profile of Prospective Memory Impairment in Parkinson’s Disease

and Implications for Everyday Functioning

A dissertation submitted in partial satisfaction of the
requirements for the degree Doctor of Philosophy

in

Clinical Psychology

by

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2012
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Chair

University Of California, San Diego

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2012
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ABSTRACT OF THE DISSERTATION

The Profile of Prospective Memory Impairment in Parkinson’s Disease
and Implications for Everyday Functioning

by

Eva Pirogovsky

Doctor of Philosophy in Clinical Psychology

University of California, San Diego, 2012

San Diego State University, 2012

Professor Paul E. Gilbert, Chair

Prospective memory (ProM) is an aspect of episodic memory that involves remembering
to perform an intended action at some designated point in the future, and is critically
involved in everyday functioning. Studies suggest that ProM is dependent on the functional integrity of the frontal lobe system and associated executive functions, with time-based ProM relying more heavily on executive processes than event-based ProM. Although individuals with Parkinson’s disease (PD) demonstrate impairments in executive functions and strategic aspects of episodic memory, few studies have examined ProM in PD. The present study examined ProM and the relationship between ProM and everyday functioning in 33 PD patients and 26 demographically comparable adults. PD participants were disproportionately impaired in TB ProM (Cohen’s $d = 1.30$) compared to EB ProM ($d = 0.63$), committed an increased number of omission errors on TB trials, and were worse (at a trend level) than healthy older adults in retrospective memory for the contents of the intentions. TB ProM performance correlated with standardized measures of executive function, working memory, and retrospective episodic memory in PD. Taken together, these results suggest that PD participants are impaired in the executive stratégic and retrospective memory aspects of ProM. There were no significant differences between groups in strategic time monitoring or basic temporal perception, suggesting that TB ProM impairment in PD may not be related to declines in these cognitive processes. Alternatively, these findings may be related to methodological limitations of the tasks used to measure these processes in the present study. Within the PD sample, ProM deficits correlated with two performance-based measures of everyday functioning (financial capacity, medication management) and a self-report measure of medication management. Moreover, ProM impairment uniquely predicted declines on a performance-based measure of financial capacity, but not medication management, over and above other predictors of everyday functioning. Although future studies with larger
samples and longitudinal designs are warranted, these results suggest that ProM may provide unique information regarding everyday functioning skills. The present findings have implications for the assessment of ProM in clinical neuropsychological evaluations and for intervention strategies aimed at improving ProM dysfunction in individuals with PD.
I. INTRODUCTION

Clinical Features of Parkinson’s Disease

Idiopathic Parkinson’s disease (PD) is one of the most common neurological diseases among the older population. The disease typically begins after the age of 50, and prevalence increases from 0.5 to 1 percent among persons 65-69 years of age to 1 to 3 percent among persons 80 years and older (Tanner, Hubble, & Chan, 1997). PD is a movement disorder characterized by an insidious onset and gradually worsening symptoms. The cardinal motor symptoms include resting tremor, rigidity, bradykinesia, and postural instability. In addition, PD patients experience many other motor symptoms such as stooped posture, the freezing phenomenon, masked facies, and hypophonia (Fahn, 2003). While the motor symptoms define PD, it is now well understood that PD also causes cognitive and emotional disturbances. Depression is the most common mood disorder in PD, occurring in close to 50% of all patients (Slaughter, Slaughter, Nichols, Holmes, & Martens, 2001). In addition, PD patients may experience apathy and anxiety (Zgaljardic, Borod, Foldi, & Mattis, 2003). PD patients demonstrate subtle cognitive changes early in the course of the disease and a subset of patients develop dementia. Studies have estimated the prevalence of cognitive impairment in early PD patients without dementia to be between 19% and 30% (Aarsland, et al., 2004; Elgh et al., 2009; Muslimovic, Post, Speelman, & Schmand, 2005) and the prevalence of PD patients with dementia is estimated to be approximately 25% (Aarsland, Zaccai, & Brayne, 2005). The profile of cognitive impairments observed in PD will be described below in more detail.

Neuropathology of PD
Many of the motor, cognitive, and behavioral sequelae of PD are thought to result from disruption of multiple circuits linking the frontal cortex to the basal ganglia, referred to as frontostriatal circuits (Middleton & Strick, 2000; Owen, 2004; Zgaljardic, Borod, Foldi, & Mattis, 2003). Alexander and colleagues (1986) first described five frontostriatal circuits that follow a general pathway from the frontal lobes to the striatum, the striatum to the internal segment of the globus pallidus and substantia nigra pars reticulata, projections from these two structures to the thalamus, and the thalamus back to the frontal lobes. Within each circuit, there is a “direct” pathway that connects the striatum and basal ganglia output nuclei (internal globus pallidus and substantia nigra pars reticulata) an “indirect” pathway that projects from the striatum to the external globus pallidus and subthalamic nucleus before reaching the basal ganglia output nuclei. The five circuits share common structures and are parallel but are anatomically segregated. Although these circuits are closed loops, they do have open aspects that allow afferent and efferent projections with other regions that are functionally related to the circuit (Joel, 2001). The five circuits are named after the cortical regions they originate from: motor, oculomotor, dorsolateral prefrontal, lateral orbitofrontal, and anterior cingulate. The first two circuits mediate motor and oculomotor functions, and the last three are associated with cognition, behavior, and motivation (Cummings, 1993).

The major neuropathological feature of PD is the loss of dopaminergic neurons in the substantia nigra pars compacta, an area that directly innervates the striatum and modulates frontostriatal circuits. Depletion of dopamine content in the striatum consequently disrupts functioning in frontostriatal circuits, leading to the motor and cognitive symptoms of PD (DeLong, 2000). The clinical symptoms of PD do not arise
until approximately 50% of substantia nigra dopaminergic neurons and 80% of dopamine concentration in the striatum has been lost (Mardsen, 1990). Dopamine loss is more severe to the putamen, which is implicated in the motor deficits associated with PD. Dopamine depletion in the caudate nucleus, an area thought to be involved in the cognitive symptoms of PD, is more severe to the rostroventral region of head. Since this area of the caudate is connected to the dorsolateral regions of the frontal lobes, it has been suggested that cognitive functions subserved by the dorsolateral prefrontal circuit may be more affected in PD and earlier in the progression of the disease (Owen, 2004; Zgaljardic et al., 2003).

In addition to frontostriatal disruption via the nigrostriatal dopaminergic pathway, cognitive symptoms of PD may result from dysfunction in the mesocortical dopaminergic system (Pillon, Czernicki, Dubois, 2003), although this system is less severely affected in PD (Agid, Javoy-Agid, & Ruberg, 1987). Some of the cognitive deficits in PD may be associated with dysfunction in neurotransmitter systems outside of the dopaminergic system, including noradrenergic, cholinergic, and serotonergic systems (Cornford, Chang, & Miller, 1995). For example, reductions in cholinergic activity resulting from degeneration of the nucleus basalis of Meynert is thought to play a significant role in the development of dementia in PD (PDD). Another neuropathological hallmark of PD is the formation of Lewy bodies, which are intracytoplasmic neuronal inclusions, in the substantia nigra, locus ceruleus, nucleus basalis, dorsal vagal nucleus, and cortex (Braak et al., 2003; Hughes, Daniel, Kilford, & Lees, 1992; Jellinger, 1987).
**Neuropsychology of PD**

Circumscribed cognitive deficits are common in PD and found in the earliest stages of PD (Muslomovic et al., 2005; Owen, 2004; Zgaljardic et al., 2003). PD patients show a “subcortical” profile of cognitive impairment characterized by deficits in executive function, complex attention, visuospatial function, psychomotor slowing, as well as inefficient learning and memory. The following section will provide a brief review of the neuropsychological deficits in PD.

Executive functions are affected very early in the course of PD and may be an early sign of incident PDD (Woods & Tröster, 2003). Executive functioning refers to a group of higher-order cognitive abilities such as planning, inhibitory control, and cognitive flexibility that are critical for carrying out goal-directed behaviors and adapting to new situations (Lezak, 2004). Studies suggest that executive functions are particularly important for the ability to carry out complex activities of daily living (Morgan & Heaton, 2009). Executive functions depend on the functional integrity of the frontal lobes and frontostriatal circuits (Cummings, 1993; Lichter & Cummings, 2001). Evidence from behavioral (Lichter, 2001; Zgaljardic et al., 2006) and neuroimaging (Brück et al., 2001; Lewis et al., 2003; Dagher et al., 2001; Owen et al., 1995) studies suggests that many of the executive function deficits in PD may result from a disruption in frontostriatal circuitry, particularly the dorsolateral prefrontal circuit (Lewis et al., 2003; Owen, Sahakian, & Robbins, 1998; Owen, 2004; Zgaljardic et al., 2003; 2006). Patients with PD demonstrate a profile of executive dysfunction similar to those seen in patients with frontal lobe lesions, including complex attention (e.g., selective attention; Dujardin, Degreef, Rogelet, Defeubre, & Destee, 1999; Filoteo & Maddox, 1990; Filoteo, Maddox,
Ing, & Song, 2007), planning (Owen et al., 1995), working memory (e.g., Gabrieli, Singh, Stebbins, & Goetz, 1996; Lewis, Slabosz, Robbins, Barker, & Owen, 2005; Owen et al., 1997), verbal fluency (for meta-analysis, see Henry & Crawford, 2004), and cognitive set shifting (e.g., Gauntlett-Gilbert, Roberts, & Brow, 1999; Hsei, Lee, & Tai, 1995; Raskin, Borod, & Tweedy, 1992; Richards, Cote, & Stern, 1993).

Individuals with PD also demonstrate episodic memory deficits (e.g., Taylor, Saint-Cyr, & Lang, 1990; Massman et al., 1990; Whittington, Podd, & Kan, 2000). Although there can be heterogeneity in the memory performance of PD patients (Filoteo, Rilling, & Cole, 1997; Weintraub, Moberg, Culbertson, Duda, & Stern, 2004), the memory profile in general can be characterized by mild encoding and retrieval deficits, but relatively spared retention of information. Episodic memory deficits in PD are thought to be a result of frontostriatal dysfunction that leads to impairments in higher-level strategy or organization of information during encoding and retrieval (Higginson et al., 2003; Taylor et al., 1990). For example, PD patients demonstrate impairments in semantic clustering strategies during encoding of a list of words, but show intact serial clustering of the words (Buytenhuijs et al., 1994; Massman et al., 1990). This suggests that the use of internally generated strategies (i.e., semantic clustering) is impaired in PD, but less efficient, externally generated strategies (i.e., serial clustering) during encoding remains intact. It is widely believed that individuals with PD are impaired in free recall while recognition memory is normal or near normal, suggesting a “retrieval” deficit profile. However, a meta-analysis of recognition memory studies in PD found that both nondemented and demented patients show mild recognition memory impairment (Whittington et al., 2000). Furthermore, some recent studies have found a similar
magnitude of impairment in free recall and recognition memory in PD, specifically on
more complex verbal list learning tasks (Higginson, Wheelock, Carroll, & Sigvardt,
2005; Zizak et al., 2005). Recognition memory impairment in PD is characterized by
increased false-positive errors on yes-no recognition memory testing and this may be due
to difficulty inhibiting non-target words (Higginson et al., 2005). This pattern of false-
positive responding on recognition memory testing also is found in patients with frontal
lobe lesions (Alexander, Stuss, & Fansabedian 2003; Baldo, Delis, Kramer, &
Shimamura, 2002).

PD patients show deficits on memory tasks traditionally thought to be sensitive to
frontal lobe dysfunction, including source memory (Drag, Bieliauskas, Kaszniak,
Bohnen, & Glisky, 2009; Taylor et al., 1990), temporal order memory (Vriezen &
Moscovitch, 1990), conditional associative memory (Taylor et al., 1990), and
metamemory (Baran, Tekcan, Gürvit, & Boduroğlu, 2009; Ivory, Knight, Longmore, &
Caradoc-Davies, 1999), which is consistent with the notion that memory deficits in PD
are related to dysfunction in frontostriatal circuits. Furthermore, some studies suggest that
episodic memory deficits in PD are secondary to executive dysfunction (Bondi et al.,
1993; Higginson et al., 2003). For example, Higginson et al. (2003) found that
performance in working memory accounted for nearly 50% of free recall impairment in
PD patients. Finally, while episodic memory for novel information is impaired,
nondemented PD patients typically show intact remote memory (Fama et al., 2000;
Leplow et al., 1997; but see Ivory et al., 1999; Sagar, Cohen, Sullivan, Corkin, Growdon,
1988).
Along with deficits in explicit memory, PD patients have shown impairments in some forms of implicit (i.e., nondeclarative) memory, which is memory expressed in performance without conscious awareness (Schacter, 1987). Nondemented PD patients typically show preserved word stem priming, in which participants are shown a series of words and then shown the first few letters of each word (i.e., word stems) and asked to say the first word that comes to mind (Bondi & Kaszniak, 1991; Heindel, Salmon, Shults, Walicke, & Butters, 1989). Procedural memory may be defined as the ability to learn and retain motor or cognitive skills with repeated exposure to an activity (Salmon & Filoteo, 2007). PD patients are impaired in some procedural memory tasks, such as serial reaction time tasks (Ferraro, Balota, & Connor, 1993) and probabilistic classification tasks (Knowlton, Mangels, & Squire, 1996), but perform normally in other types of procedural memory (Bondi & Kasniak, 1991; Harrington, Haaland, Yeo, & Marder, 1990).

Performance on simple attention tasks, such as the digit span, is generally intact in nondemented PD. However, PD patients show impairments on more complex attentional tasks, such as selective attention (Dujardin, Degreé, Rögelet, Defebvre, & Destée, 1999; Filoteo & Maddox, 1990) and shifting attention (Downes et al., 1989).

Visuoperceptual and visuospatial deficits have been shown in PD, such as impairments in facial recognition, perception of line orientation, visuomotor construction, and memory for spatial location (Alegret, Pere, Junqué, Valdeoriola, & Tolosa, 2001; Levin et al., 1991; McKinlay, Grace, Dalryple-Alford, & Roger, 2009). Some researchers argue that executive function or motor impairments underlie visuospatial dysfunction in PD (Bondi, Kaszniak, Bayles, & Vance, 1993; Brown & Marsden, 1986). However, other studies have found impairments in visuoperceptual and spatial tasks when motor
demands were minimized (Levin et al., 1991) and when accounting for performance in executive function tests (McKinlay et al., 2009).

Individuals with PD show motor speech deficits termed hypokinetic dysarthria, which is characterized by hypophonia and dysprosody (Cummings, Darkins, Mendez, Hill, & Benson, 1988). Although PD patients do not exhibit frank aphasia, some studies report subtle linguistic impairments such as language comprehension and production (Murray, 2000). However, most studies have attributed any language deficits to cognitive impairments in other areas, such as attention, working memory, and information processing speed (Grossman, Lee, Morris, Stern, & Hurtig, 2002; Lee, Grossman, Morris, Stern, & Hurtig, 2003). PD patients also are impaired in verbal fluency tasks, in which one is required to generate words according to specific search conditions (e.g., a semantic category, beginning with a specific letter of the alphabet) within a time limit. A meta-analysis of verbal fluency studies found that PD patients were impaired in phonemic and semantic fluency, but were more impaired in semantic relative to phonemic fluency (Henry & Crawford, 2004).

Although many PD patients have cognitive dysfunction, some PD patients progress to develop cognitive deficits severe and extensive enough to qualify as dementia (Parkinson’s disease with dementia; PDD). A recent systematic review of prevalence studies suggested that 24 to 31% of PD patients have dementia (Aarsland et al., 2005). Although the neuropathological changes and cognitive profiles of individuals with PDD are heterogeneous (Janvin et al., 2006), the cognitive deficits in PDD are generally qualitatively similar but more severe than the cognitive deficits found in PD without dementia (Emre, 2003). At the group level PDD is characterized by a prominent
dysexecutive syndrome along with impaired attention, slowness of thought, visuospatial
dysfunction, and deficits in episodic memory (McPherson & Cummings, 2009).

Compared to patients with Alzheimer's disease, PDD patients show more severe
impairments in executive function and visuospatial processes, and less severe deficits in
learning and memory (Pillon, Dubois, Ploska, & Agid, 1991; Stern, Marder, Tang, &
Mayeux, 1993).

**Prospective Memory**

The majority of research examining episodic memory has focused on
retrospective memory, or memory for past events and experiences. Recently there has
been a growing interest in investigating prospective memory (ProM), an aspect of
episodic memory that involves remembering to perform an intended action at some
designated point in the future (McDaniel & Einstein, 2000), or “remembering to
remember.” ProM is thought to play a critical role in many everyday activities such as
remembering to take medications at the correct time or to mail bills on the way to work.

In the past there were debates regarding whether ProM was dissociable from
retrospective memory, or whether it was simply a special application of retrospective
memory (Crowder, 1996; Dalla Barbra, 1993; Ellis, 1996). However, the current
consensus is that retrospective memory is a necessary component of ProM, but that
additional cognitive processes are critical for ProM functioning. Retrospective memory is
involved in the retention of the action to be performed and retrieval cue (i.e., content on
the intention), and forgetting the content of the intention will result in ProM failure.

However, ProM and retrospective memory are thought to be singly dissociable, such that
ProM can be impaired in the context of relatively intact retrospective memory. Therefore, one may remember the intended action and retrieval cue, but fail to retrieve the intention at the appropriate moment. There is growing evidence to support the dissociation between ProM and retrospective memory (Maylor, Smith, Sala, & Logie, 2002; Salthouse, Berish, & Siedlecki, 2004; West & Craik, 2001; West & Krompinger, 2005). For example, studies have found that prospective memory can be impaired in participants who demonstrate normal performance on retrospective memory tests (i.e., free recall and recognition; Bisiacchi, 1996; Burgess, 2000; Burgess & Shallice, 1997; Cockburn, 1996). In addition, there is evidence from factor analytic studies showing the dissociability of ProM (Gupta et al., 2010; Maylor et al., 2002; Salthouse et al., 2004). For example, a recent study found that in a sample of HIV patients a confirmatory four-factor structural equation model in which ProM loaded on a unique factor (separate from standardized measures of retrospective memory, executive function, and motor skills) fit the data well. This model fit the data better than alternative models in which a single common factor was hypothesized to represent cognitive function as well as other competing models in which performance on ProM measures was hypothesized to be represented by other cognitive domains (Gupta et al., 2010). In addition, an evoked related potential (ERP) study that used prospective and retrospective memory tasks matched on task demands observed similar neural processes in both tasks, but found additional neural processes that were uniquely related to ProM (West & Krompinger, 2005). Thus, evidence suggests that ProM involves retrospective memory processes as well as additional processes that are unique to this type of memory.
Theoretical models generally divide ProM into several consecutive phases (Carey et al., 2006; Dobbs & Reeves, 1996; Ellis, 1996, Kliegal, Martin, McDaniel, & Einstein, 2002; Knight, 1998). The first phase, *intention formation*, involves the formation and encoding of an intention to perform some action paired with a cue that provides a context for retrieval. This stage requires knowledge about the most effective strategies for successful performance (i.e., metacognition). This phase also involves formation of the action plan, which requires planning and organizational strategies. During the second phase, referred to as *intention retention*, the intention and corresponding action is retained over a delay interval. The delay is filled with other activities (i.e., an ongoing foreground task) in order to prevent continuous rehearsal of the intention. This stage may require monitoring for the cue that indicates the appropriate moment to perform the intention. There is controversy in the ProM field regarding the processes underlying ProM monitoring, with some researchers arguing that relatively automatic processes are involved (Einstein & McDaniel, 1996) and others hypothesizing that strategic processes are involved (Shallice & Burgess, 1991; Smith, 2003). A more recent theory suggests that both automatic and strategic processes can be involved in ProM tasks depending on various characteristics of the task (Einstein & McDaniel, 2000). The third phase, *intention initiation*, involves detecting an appropriate cue, recognizing that it represents a cue for retrieval of an intention, and then searching retrospective memory for the content of the action that should be performed. The third phase is considered a central feature of ProM because it requires self-initiated retrieval (Craik, 1986), or the ability to independently detect a target cue and search retrospective memory for the intention without explicit prompting. This differs from traditional retrospective memory tasks, in
which there is explicit prompting to retrieve previously presented information, such as in traditional list learning and recall measures in which the experimenter directly cues the participant to recall previously presented material. The final stage, *intention execution*, requires the actual execution of the intended action according to the previously formed plan. This stage also involves output monitoring, or evaluating the accuracy or success of the performed intention.

Another way to understand ProM is by defining the parameters of tasks used to examine ProM (McDaniel & Einstein, 2007). First, ProM tasks include a delay interval between forming the intention and carrying it out (Ellis, 1996). Thus, ProM tests the ability to remember an intention at some point in the future. Second, ProM tasks are embedded in another ongoing activity (McDaniel & Einstein, 2007). The participant may monitor the environment for the appropriate circumstance to carry out an intention, but this occurs as a background activity. This is what distinguishes a ProM tasks from a test of vigilance (Dobbs & Reeves, 1996). Third, there is no explicit reminder to carry out the intended action at the appropriate moment. Therefore, unlike traditional retrospective memory tests where there is an explicit request to remember, ProM tasks require the participant to independently detect the appropriate cue and interrupt ongoing performance in order to carry out an intention (Knight, 1998). Lastly, the window for response initiation and execution is limited (McDaniel & Einstein, 2007). There is a window of opportunity to execute the ProM intention and not remembering the tasks within the window reflects a ProM failure.

*The Role of Frontal Lobes in ProM*
ProM is thought to rely on multiple executive processes dependent on the integrity of frontal lobes. For example, planning and organizational abilities are involved during the formation and encoding of a future intention. During the retention phase, working memory may be involved in maintaining the goals of the intention in mind while involved in the ongoing activity. Although ProM tasks can differ in the degree to which strategic processes are required (McDaniel & Einstein, 2000), the ability to detect retrieval cues may require strategic allocation of attention in order to monitor the environment for the cue. Once the cue is detected, one must self-initiate a strategic search through retrospective memory for the contents of the intention. Finally, ProM requires inhibition of ongoing activities and the ability to flexibly shift from the ongoing activity to the execution of the planned intention (Glisky, 1996; Knight, 1998; McFarland & Glisky, 2009). Since ProM involves multiple executive functions such as planning, working memory, monitoring, and cognitive flexibility, ProM tasks may be particularly sensitive to frontal lobe dysfunction.

Studies in various neurological populations generally support the role of frontal systems in ProM. For example, patients with frontal lobe lesions demonstrate impairment on ProM tasks or tasks that involve a ProM component (Burgess, Veitch, de Lacy Costello, & Shallice, 2000; Cockburn, 1996; Fortin, Godbout, & Braun, 2002; Shallice & Burgess, 1991a; Umeda, Kurosaki, Terasawa, Kato, & Miyahara, 2011). In addition, ProM deficits have been observed in HIV-1 infection (Carey et al., 2006), a disease that disrupts frontostriatal circuits. In this study, HIV patients demonstrated impaired performance on a ProM task but were able to remember the contents of the intentions in a subsequent recognition memory test in which demands on self-initiated retrieval were
minimized. The authors suggested that frontostriatal disruption in HIV results in impaired performance in the strategic or executive aspects of retrieving future intentions (Carey et al., 2006). Similar results have been found in patients with schizophrenia, with studies suggesting that ProM impairment in this group is consistent with frontostriatal loop disruption of the strategic aspects of ProM retrieval (Shum, Ungvari, Tang, & Leung, 2004; Twamley et al., 2008; Woods et al., 2007).

ProM deficits have been observed in healthy older adults, and this impairment has been attributed to age-related changes in the prefrontal cortex. Although some studies do not show age-related decline in ProM (Cherry & LeCompte, 1999; Einstein & McDaniel, 1996), multiple studies have reported significant differences between older and younger adults in ProM (Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Einstein, Smith, McDaniel, & Shaw, 1997; Maylor, 1996; Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997). These discrepancies are likely related to differences in the tasks used to measure ProM (Henry, Macleod, Phillips, Crawford, 2004). In addition, some studies have found relationships between ProM decline and executive functioning performance in older adults (McDaniel, Glisky, Rubin, Guynn, & Routhieaux; 1999; Martin, Kliegal, & McDaniel, 2003). Moreover, executive functioning has been found to account for a significant amount of variance in tests of ProM in older adults, even after controlling for the effects of performance on retrospective memory tests (Martin et al., 2003).

A few researchers have begun to use electrophysiological and neuroimaging techniques to examine the neural substrates of ProM. These studies provide further support for the role of the prefrontal cortex in ProM. Studies using both PET and fMRI have consistently observed activation in the rostral prefrontal cortex (area BA 10) during
ProM encoding and retrieval (Burgess, Gonen, & Volle, 2011; Burgess, Quayle, & Frith, 2001; Burgess et al., 2003; Okuda et al., 1998, 2007; Poppenk, Moscovitch, McIntosh, Ozcelik, & Craik, 2010; Simons, Scholvinck, Gilbert, & Frith, 2006; Volle, Gonen-Yaacovi, de Lacy Costello, Gilbert, & Burgess, 2011). For example, an fMRI study examined brain activity associated with the cue detection and intention retrieval (i.e., remembering the action to be performed) components of ProM by using tasks that differentially manipulated demands on these components (Simons et al., 2006). The study found a similar pattern of activation in the rostral prefrontal cortex in cue detection and intention retrieval conditions, suggesting that the rostral prefrontal cortex is of critical importance to ProM (Simons et al., 2006).

Although ProM depends on intact frontal lobe functioning, the integrity of other brain regions also are involved in ProM. Given the contribution of retrospective memory processes to ProM, it is not surprising that patients with medial temporal lobe lesions show impaired ProM (Adda, Castro, Alem-Mar e Silva, de Manreaza, & Kashiara, 2009) and neuroimaging studies observe medial temporal lobe activation in ProM tasks (Martin et al., 2007; Okuda et al., 1998; Poppenk et al., 2010). In summary, evidence suggests that ProM is dependent on some of the same neural processes involved in retrospective memory, but is more heavily dependent on frontal lobe systems and therefore is particularly sensitive to dysfunction in frontal systems.

*Time-Based versus Event-Based ProM*

Within the ProM literature, ProM tasks are divided based on the type of cue that represents the appropriate moment to perform an intended action (Einstein & McDaniel,
1690). In event-based (EB) tasks, the intended action must be performed when an external cue in the environment is present (e.g., seeing the grocery store reminds one to buy dinner on the way home from work). In time-based (TB) tasks, the cue for action is a specific time or amount of time (e.g., remembering to take medication at 2pm or every four hours) and is therefore considered an internal cue. According to the multi-process theory, the degree to which strategic monitoring and retrieval processes dependent on frontal systems are required in a ProM task will depend on characteristics of the target cue (McDaniel & Einstein, 2000). For example, ProM tasks with less salient cues are hypothesized to require greater levels of strategic attentional resources than tasks with more distinctive or focal cues. TB tasks involve cues that are less salient and may place greater demands on self-initiated monitoring and retrieval compared to typical EB tasks. EB tasks tend to rely on involuntarily and automatic processes that require less strategic processes then TB ProM, as EB cues are generally more salient external cues that signal the appropriate moment to retrieve the intention. Therefore, it is hypothesized that TB tasks place greater demands on strategic monitoring and retrieval processes linked to frontal lobe function. There is some support for this notion, including studies showing larger age-related differences in TB ProM relative to EB ProM (d’Ydewalle, Luwel, & Brunfant, 1999; Einstein et al., 1995; Jäger & Kliegel, 2008; Park et al., 1997, but see Henry et al., 2004) and relatively worse TB ProM in a few cases of individuals with frontal lobe damage (Cockburn, 1995, 1996).

As mentioned above, TB ProM may depend on the monitoring of passing time. In general, efficient monitoring requires a strategy that balances the cost of monitoring against the cost of having inaccurate information about the environment (Mäntylä &
Carelli, 2006). In terms of TB ProM, one must balance between performing the ongoing task and time monitoring (i.e., checking the time) in order to carry out an intention at the correct time. Studies of TB ProM measure time monitoring by assessing the frequency and pattern with which a participant checks the time on a clock that is placed behind him/her or presses a button on a computer screen to check the time. Studies show that healthy individuals use a strategic approach to monitor time in TB ProM tasks, such that there is an increase in the rate of clock checking as the target time to perform an action approaches (see Mäntylä & Carelli, 2006). This approach allows one to minimize interruptions to the ongoing task by allocating attention to time monitoring when the appropriate time to carry out the intention is nearing. Some studies have found that healthy older adults (Einstein et al., 1995; Park et al., 1997) and individuals with schizophrenia (Shum et al., 2004) monitor time less frequently in TB ProM tasks, particularly as the target time to execute the ProM intention nears. Furthermore, reduced clock checking is associated with worse TB ProM performance (Einstein et al., 1995; Shum et al., 2004). A recent study suggests that time monitoring during TB ProM tasks may be related to frontal lobe function (McFarland & Glisky, 2009). Older adults were classified as high versus low functioning in frontal lobe function and medial temporal lobe function based on a battery of neuropsychological tests. Older adults considered to have low frontal function produced significantly more errors on a TB ProM task relative to older adults with high frontal function. Moreover, older adults with low frontal function showed less frequent clock checking than high frontal functioning older adults, specifically in the minute preceding the target time on the ProM task. In addition, time
monitoring in the interval preceding the target time positively correlated with ProM performance in all older adults.

It has been proposed that time perception, or the subjective sense of passing time, may be involved in TB ProM (Block & Zakay, 2006). Temporal perception may play a role in the timely execution of an intended action, and may be associated with the frequency and pattern of reliance on external clock checking (i.e., time monitoring). To the author’s knowledge, only three studies to date have investigated the relationship between time perception and TB ProM (Mackinlay, Kliegal, & Mäntylä, 2009; McFarland & Glisky, 2009; Woods et al., 2009). None of these studies found a significant relationship between time perception (i.e., time estimation or production) and TB ProM in children ages 7-12 (Mackinlay, Kliegal, & Mäntylä, 2009), older adults (McFarland & Glisky, 2009), or individuals with HIV (Woods et al., 2009).

Ecological Validity of ProM

An increasingly common referral question for clinical neuropsychologists is regarding a patient’s everyday functioning, such as capacity to live independently, work, and manage finances (Chaytor & Scmitter-Edgecombe, 2003; Heaton & Morgan, 2010). Thus, an important goal of neuropsychological assessment is the ability to provide inferences about everyday functioning, in order to inform patients and others involved in their care about day-to-day abilities (Chaytor & Schmitter-Edgecombe, 2003). ProM may be particularly relevant, as it is believed to be critically involved in many aspects of everyday functioning. ProM failure can result in severe consequences, such as forgetting to take medications on time or forgetting to turn off the stove after cooking. Therefore,
intact ProM functioning may be necessary for maintaining functional independence. This is supported by studies that show ProM impairment is associated with instrumental activities of daily living (IADLs), which are higher-order functional abilities critical to independent living and include activities such as managing medications, balancing a checkbook, and preparing meals. For example, ProM dysfunction was found to be a unique predictor of IADL decline in HIV (Woods et al., 2008) and schizophrenia (Twamley et al., 2008), and is associated with IADL decline in patients with mild cognitive impairment (MCI, Schmitter-Edgecombe, Woo, & Greeley, 2009). A recent study showed that ProM was an independent predictor of unemployment in HIV (Woods et al., 2011). Thus, ProM may add unique information to the prediction of everyday abilities and therefore may be an important cognitive function to assess in clinical evaluations of neuropsychological function.

A specific area of IADLs that may be particularly dependent on ProM is medication adherence. Remembering to take a medication is commonly cited as an example of ProM and involves the phases of ProM discussed previously: 1) intention formation, forming an intention to take medication at a specific point in the future; 2) intention retention, maintaining the intention throughout the day while being absorbed in other daily tasks; 3) intention initiation, detecting a cue to take medication when it occurs (e.g., a specific time of day or after finishing dinner) and recalling the specific directions associated with the medication; and 4) intention execution, taking the medication as indicated (Woods et al., 2008). Although ProM is thought to be an important contributor to medication adherence, relatively few studies have examined this relationship (Contardo, Black, Beauvais, Dieckhaus, & Rosen, 2009; Hertzog, Park, Morell, &
Martin, 2000; Woods et al., 2008, 2009; Vedhara et al., 2004, review in Zogg, Woods, Sauceda, Wiebe, & Simoni, 2011). For example, TB ProM impairment was found to be a predictor of medication nonadherence measured with electronic medication monitoring, over and above other known predictors of adherence (e.g., retrospective episodic memory, depression) in a sample of HIV patients (Woods et al., 2009).

Another area of everyday functioning that may be impacted by ProM decline is health-related quality of life (HR-QoL), which is a multidimensional concept that involves the total impact of a disease on a person’s perceived life satisfaction or well-being (Den Oudsten, Van Heck, & De Vries, 2007). Measures of HR-QoL assess various domains of health such as physical, emotional, and social functioning from a patient's perspective. ProM impairment may result in declines in various aspects of HR-QoL; however, no study to the author’s knowledge has investigated the relationship between ProM and quality of life.

**Functional Decline in PD**

In PD, functional decline assessed with global measures of disability has been associated with various motor symptoms, non-motor symptoms, (e.g., depression, global cognitive dysfunction, hallucinations), and other factors such as disease severity, older age at onset, and delayed introduction of treatment with L-Dopa (Bouwens, Heugtne, & Verhey, 2009; Cahn et al, 1998; Liu et al., 1997; Marras, Rochon, & Lang, 2002; Sabbagh et al., 2005; Starkstein, Mayberg, Leiguard, Preziosi, & Robinson, 1992). Few studies have examined the relationship between specific cognitive domains and functional decline. Cahn and colleagues (1998) found executive function (i.e., cognitive
switching) was an independent predictor of IADL decline in PD, over and above simple motor function. On the other hand, motor function, but not executive function, was an independent predictor of declines in activities of daily living (ADLs) such as dressing, grooming, and toileting. Studies also have found relationships between everyday functioning and performance on measures of visual memory (Uc et al., 2005) and visuospatial function (Maeshima, Itakura, Nakagawa, Nakai, & Komai, 1997) in individuals with PD. In a study examining PDD patients, performance on tests of attention was a significant predictor of IADL decline (Bronnick et al., 2006).

Muslimovic, Post, Speelman, Schmand, & de Haan (2008) administered multiple cognitive and functional measures and found only a weak correlation between only one cognitive task (semantic fluency) and one of the functional tasks in a sample of PD patients. However, this study used functional measures that combined IADLs and ADLs into one global measure, which may have precluded detection of relationships between cognitive deficits and declines in IADLs.

PD patients show evidence of suboptimal medication adherence and this may result in poor health outcomes and impaired quality of life. Studies assessing medication adherence with electronic medication monitoring have found that 10-20% of PD patients show significant medication nonadherence, defined as >20% of total doses missed (Elm et al., 2007; Grosset, Bone, & Grosset, 2005; Grosset et al., 2009; Leopold, Polansky, & Hurka, 2004). Furthermore, many more PD patients do not take medications at the correct time (Grosset et al., 2005, 2009). Few studies have examined specific predictors of medication adherence in PD and have found that younger age, complex drug regimens, depression, longer disease duration, and lower quality of life are related to poorer
compliance (Grosset et al., 2005, 2009). In older adults with various medical conditions, it is recognized that many complex factors can influence medication adherence and cognitive impairment has been shown to be one of the critical factors (Bainbridge & Ruscin, 2009). In fact, “forgetting” is the most commonly cited reason for nonadherence in older adults (Schlenk, Dunbar-Jacob & Enbgr, 2004).

Studies have shown multiple predictors of HR-QoL in PD, such as severity of motor symptoms, age, and use of medication (Den Oudsten et al., 2007). Depression is one of the most consistent and strongest predictors of poorer HR-QoL in PD (Schrag, 2006); however, impaired cognitive function also is thought to play a role (Klepac, Trkulija, & Babic, 2008; Shrag, Jahanshahi, & Quinn, 2000). For example, Shrag et al. (2000) found that performance on a test of global cognitive function independently contributed to HR-QoL in PD. In another study, performance on tests of executive function, attention, retrospective episodic memory, and visuospatial function all were associated with HR-QoL in PD patients (Klepac et al., 2008). Additionally, a composite score based on these measures was an independent predictor of HR-QoL in PD patients, after controlling for significant contributors such as motor and psychiatric symptoms. However, Schieser, Han, Lessig, Song, Zizak, and Filoteo (2009) found that performance on cognitive tests failed to be a unique predictor of HR-QoL (HS) when mood and motor symptoms were statistically controlled. Interestingly, self-reported cognitive impairment (as measured with the cognitive items on the Geriatric Depression Scale, GDS) was the best unique predictor of HR-QoL in this sample (Schieser et al., 2009). The discrepancy between studies examining the relationship between cognition and IADL/QoL is likely due to differences in mode of functional assessments (e.g., self-report vs informant-
report), univariate versus multivariate statistical analyses, level of cognitive functioning of PD patients, and sensitivity of the neuropsychological tests administered.

*ProM in PD*

Given the disruption of frontostriatal circuits and resultant executive function and episodic memory deficits observed in PD, ProM impairment would be expected in this group. Compared with other cognitive domains such as retrospective memory, relatively few studies have investigated ProM functioning in PD. PD patients demonstrate impairments in EB ProM tasks (Altgassen, Zollig, Kopp, Mackinlay, & Kliegal, 2007; Foster, McDaniel, Repovis, & Hershey, 2009; Katai, Maruyama, Hashimoto, & Ikeda, 2003; Kliegal, Phillips, Lemke, & Kopp, 2005; Whittington, Podd, & Stewart-Williams, 2006). In general, these studies suggest that impaired EB ProM in PD is related to deficits in planning, self-initiated retrieval, and working memory (Altgassen et al., 2007; Katai et al., 2003; Kliegal et al., 2005). Some studies have shown impaired performance on ProM tasks despite intact retrospective memory for the contents of the intention (Foster et al., 2009; Katai et al., 2003; Kliegal et al., 2005), suggesting that ProM failures in PD may be due to difficulties with executive processes rather than to retrospective memory impairment. However, Costa, Peppe, Caltagirone, & Carlesimo (2008) found that individuals with PD were impaired at recalling the contents of more complex intentions (i.e., completing 3 unrelated actions) after failing to carry out the intention. A recent study (Foster et al., 2009) found that PD patients showed deficits when the ongoing activity of a ProM task did not focus attention on the retrieval cue. However, PD participants were not impaired when the ProM cue was focal to the ongoing task.
According to the multiprocess theory discussed above, the first condition presumably requires strategic monitoring and self-initiated retrieval, while the latter condition places less demand on these processes (McDaniel & Einstein, 2000). Overall, the data suggest that individuals with PD are particularly impaired on ProM tasks that place greater demands on executive processes such as monitoring, working memory, and self-initiated retrieval.

As discussed above, TB ProM tasks are thought to be more sensitive to frontal system dysfunction relative to EB ProM tasks. Therefore, PD patients would be expected to show greater impairment in TB ProM compared to EB ProM. Two studies have examined TB ProM in PD (Costa et al., 2009, Katai et al., 2003). Costa et al. (2009) found that PD participants were impaired on a TB task but not on an EB task, and there was a trend towards correlations between TB ProM and working memory/executive function measures. However, Katai et al. (2003) found opposite results, such that EB ProM was impaired, but TB ProM was intact in PD. This discrepancy may be related to psychometric differences between TB and EB tasks in these studies, such as task difficulty, salience of EB cues, as well as reliability and sensitivity of the measures. For example, Costa et al. (2009) used a more distinctive EB cue (i.e., timer ring), while Katai et al. (2003) used an EB cue that was less salient (i.e., a word embedded within a word categorization task) and may have placed greater demands on self-initiated executive processes. These studies also examined time monitoring (i.e. clock checking) and found inconsistent results. Katai et al. (2003) did not find any differences between PD participants and controls in frequency or pattern of clock checking on the TB task. However, Costa et al. (2009) found that PD patients checked the clock less frequently in
the five minutes preceding the target time and number of clock checks in the final 5 minutes was associated with the number of intentions recalled in both groups, suggesting a relationship between TB ProM impairment and difficulties implementing efficient time-monitoring strategies.

The frontal lobes (particularly the dorsolateral prefrontal cortex) and basal ganglia play a role in time perception (for review, see Rubia, 2006). In addition, altered time perception has been observed in individuals with PD, including abnormalities in time estimation, production, and reproduction (Jones, Malone, Dirnberger, Edwards, & Jahanshahi, 2008; Pastor, Artieda, Jaahanshahi, & Obeso, 1992, Smith, Harper, Gittings, & Abernethy, 2007). Therefore, it is possible that deficits in time perception play a role in impaired TB ProM in PD. However, no study to date has examined the relationship between time estimation/production and TB ProM in PD.

Finally, only one study has explored whether individuals with PD subjectively experience ProM difficulty in everyday life (Foster et al., 2009). Compared to healthy controls, PD patients reported more frequent everyday ProM failures than normal controls. Specifically, PD patients reported more failures in everyday ProM on self-cued tasks (e.g., “Do you forget to tell someone something you had meant to mention a few minutes ago?”) but not environment-cued tasks (e.g., “Do you fail to do something you were supposed to do a few minutes later even though it’s there in front of you?”), supporting the notion that ProM deficits in PD occur when higher levels of self-initiated monitoring are necessary. However, this study did not show a significant relationship between an objective ProM task and complaints (i.e., self-reported ProM) in their sample of PD patients (Foster et al., 2009). A lack of association between objective and self-
report measures in prospective memory, not to mention many aspects of cognition, is a common finding in the neuropsychological literature. This may be a result of many different factors, such as bias on self-report measures, metamemory deficits that lead to overestimation or underestimation of one’s memory abilities, and/or a lack of ecological validity of the specific experimental ProM tasks used.

Summary and Purpose of Study

ProM is an aspect of episodic memory that is particularly dependent on the functional integrity of the prefrontal cortex. Since PD involves frontostriatal disruption and consequently deficits on tasks that place great demands on these circuits, ProM impairment would be expected in this group. In fact, the few studies that have examined this hypothesis have found objective ProM deficits and more frequent self-reported ProM complaints in PD. While these studies have furthered our knowledge of ProM functioning in PD, the present study used a standardized measure to examine ProM in this group. Furthermore, there have been discrepancies among studies examining differences between TB and EB ProM. These discrepant findings may be related to the use of experimental paradigms with varying psychometric properties. The current study examined the profile of ProM dysfunction in PD using the Memory for Intentions Screening Test (MIST), a standardized test of ProM with known psychometric properties (Woods et al., 2008). Another advantage of the MIST is that it includes a naturalistic item that tests ProM over a 24-hour delay, which allows for the assessment of ProM in everyday life. Furthermore, the MIST includes an error scoring system that allows for an examination of the component processes underlying ProM impairment. For example, a
participant may not respond to a ProM cue (i.e., omission error) or respond to a cue at the wrong time (i.e., loss of time error), suggesting difficulty with detecting the ProM cue and/or self-initiated retrieval. On the other hand, one may be able to properly monitor and detect a target ProM cue, but not remember the contents of the action (i.e., loss of content error), which is more reflective of impaired retention of the ProM actions.

As discussed above, ProM is thought to be involved in the ability to engage in many everyday tasks and is therefore critical for functional independence. Although studies examining other neurological populations have found relationships between ProM and daily living skills, no study to our knowledge has investigated the functional correlates of ProM dysfunction in PD. Thus, the current study explored associations between self-reported and performance-based ProM and everyday functioning ability. Understanding the profile and functional consequences of ProM impairment in PD may have implications for formal assessment of ProM during clinical evaluations of neuropsychological function. Furthermore, such information may lead to the use of interventions aimed at teaching compensatory cognitive strategies for ProM dysfunction in order to improve everyday functioning and quality of life in individuals with PD.

Specific Aims of the Current Study

Aim 1: To examine the nature and extent of ProM impairment in PD.

Rationale:

The first aim was to use a well-validated, standardized ProM measure to assess the profile of ProM impairment in PD. In addition, the current study aimed to extend the literature on ProM in PD by investigating relationships between TB ProM, time
monitoring, and time perception in PD. Finally, the relationship between performance-based ProM and performance on traditional neuropsychological measures of executive function, attention/working memory, and retrospective episodic memory was explored.

Hypotheses:
1. Individuals with PD were hypothesized to show lower overall performance relative to healthy adults on a performance-based measure of ProM (i.e., MIST Summary Score).
2. Since TB cues are thought to place greater demands on frontostriatal circuits, it was hypothesized that individuals with PD would show a disproportionate impairment in TB relative to EB ProM. It was predicted that TB ProM deficits would be characterized by more errors reflecting deficits in the strategic aspects of ProM (e.g., omission errors, loss of time errors) relative to deficits in retention of the ProM intentions (e.g., loss of content errors).
3. Since strategic time monitoring was thought to be sensitive to frontal system dysfunction, it was hypothesized that PD patients would show poorer time monitoring (i.e., fewer clock checks in the minutes preceding TB trials) relative to healthy adults. Furthermore, it was hypothesized that reduced time monitoring would be associated with worse TB ProM performance in PD.
4. It was hypothesized that PD patients would be impaired in time perception (i.e., time estimation and production) relative to healthy adults. However, given that previous studies have not found a relationship between basic time perception and TB ProM in other populations, it was hypothesized that time perception would not be associated with TB ProM in individuals with PD.
5. Given findings from prior studies showing relationships between TB ProM and executive function, it was hypothesized that TB ProM performance would be associated with traditional measures of executive function and working memory in PD.

Aim 2: To investigate the association between ProM and everyday functioning in PD.

Rationale:

The second aim of this study was to examine the functional consequences of ProM dysfunction in PD using self-report and performance-based measures of IADLs and Hr-QoL. Since ProM is thought to be particularly important for medication adherence, the current study paid special attention to the relationship between ProM and self-reported and performance-based measures of medication management ability.

Hypotheses:

1. It was hypothesized that poorer performance on the ProM task and more frequent ProM complaints would be associated with self-reported IADL declines and lower scores on performance-based functional tasks in PD.

2. It was hypothesized that poorer performance on the ProM task and more frequent ProM complaints would be associated with poorer Hr-QoL in PD.
II. METHODS

Participants

All participants were provided an informed consent document approved by both San Diego State University and the University of California, San Diego. The study sample consisted of 33 PD patients (26 non-demented PD participants, 7 PD with dementia participants based on a formal diagnosis of dementia or scoring lower than 130 on the DRS) and 26 healthy adults. The patients with PD were recruited from the Parkinson’s Disease Research Subject Database of the San Diego VA Health Care System / University of California at San Diego. All PD patients were diagnosed by a board-certified neurologist who specializes in movement disorders. A diagnosis of PD was based on the presence of at least two of the following symptoms: (1) resting tremor, (2) rigidity, or (3) bradykinesia. Motor functioning was assessed by an experienced neurologist (and for a portion of the participants, the current author) using the modified Hoehn and Yahr’s (1967) rating scale. Hoehn & Yahr ratings were not available for 2 of the 33 participants. The average Hoehn & Yahr rating in the PD group was 2.6, ranging from 1 to 4 (see Table 1). The average disease duration in the PD group was 11.1 years, ranging from 2 to 33 years (see Table 1). All PD patients were on prescribed antiparkinsonian medications and were on their normal regimen of dopaminergic agents at the time of testing. No patients were on anticholinergic medications. Exclusion criteria for PD participants in the study included history of neurologic conditions other than PD, self-reported history of formal diagnosis of major depressive disorder prior to the diagnosis of PD, self-reported history of severe psychiatric disorders (e.g., bipolar disorder, schizophrenia) or substance abuse disorders.
The healthy adults were individuals who were taking part in a longitudinal study at SDSU. Exclusion criteria for healthy adult participants in the study included a history of neurologic conditions as well as self-reported history of formal diagnosis of psychiatric disorders (e.g., major depressive disorder, bipolar disorder, schizophrenia) or substance abuse disorders.

The PD group and healthy adults did not significantly differ in age, gender, education, or ethnicity (see Table 1). The Dementia Rating Scale (DRS; Mattis, 1976) was administered as a test of overall cognitive function and to screen for dementia. The PD group had significantly lower DRS scores than healthy adults (see Table 1). The range of DRS scores was from 136 to 144 in the healthy adults group, and from 119 to 144 in the PD group. Since depressive symptoms are common in PD patients and can have an impact on neuropsychological test performance and on self-reported measures of everyday function/QOL, the Geriatric Depression Scale (GDS; Yesavage et al., 1982) was administered as a measure of self-reported depressive symptoms. The PD group had significantly higher GDS scores than the healthy adults (see Table 1). The range of GDS scores was from 0 to 8 in the healthy adult group and 0 to 22 in the PD group.

Prospective Memory Measures

Performance-based ProM

The Memory for Intentions Screening Test (MIST) is a standardized ProM test that consists of eight different ProM trials assigned over a 30-minute period (Raskin, 2004). During the 30-minute period in which the ProM trials are assigned, participants are engaged in word search puzzles that serve as ongoing distracter tasks. A wall clock is
placed on the wall behind the participant so that they have to turn in order to check the
time on the clock during testing. If the participant was wearing a watch, they are asked to
take it off before test administration.

The test includes eight ProM trials balanced on the following characteristics: 1) TB cue (e.g., “In 15 minutes, tell me that it is time to take a break” or EB cue (e.g., “When I show you a post card, self-address it”); 2) 2-minute or 15-minute delay interval; and 3) verbal (e.g., “In 2 minutes, ask me what time this session ends”) or physical (e.g., “In 15 minutes, use that paper to write down the number of medication you are taking”) response modality. A detailed description of each ProM trial and these associated characteristics are displayed in the Appendix. In addition, the cognitive load (i.e., the total number of ProM intentions “online” at the time each intention should be recalled) is displayed in the Appendix. Each of the eight ProM trials is worth two points: one point for a correct response and one point for responding at the correct time (giving a response within 15% of the target time) or to the appropriate cue. For example, if a participant performs the wrong ProM task to an EB cue, they are given only one point for that trial because they responded to the correct cue but the response itself was incorrect. For another example, if a participant is 5 minutes late in performing a ProM task, then only one point is given for that trial because they performed the correct response at an incorrect time. A score of 0 is given if the participant does not perform the ProM task during the entire test or if they give an incorrect response at an incorrect time or to an inappropriate cue. The cue, delay, and response modality characteristics individually contribute 2 points toward a total of 6 points for each of the ProM trials. Thus, the overall
summary score for the MIST ranges from 0 to 48 (i.e., 6 points for each of the 8 ProM trials).

Immediately following the completion of the eight ProM trials, participants are given a multiple choice recognition memory test for the content of each of the ProM trials, with scores ranging from 0 to 8. A retrieval index also was calculated by subtracting free recall accuracy on the ProM trials (scores ranging from 0-8) from recognition memory accuracy (scores ranging from 0-8) and then summing the difference scores (as described in Carey et al., 2006). The retrieval index measures the number of intentions that are incorrectly recalled but correctly recognized and therefore higher scores on the retrieval index indicated greater impairments in retrieval. In addition, a 24-hour probe (range of scores = 0-2) was administered in which participants were instructed to leave a telephone message for the examiner the following day stating the number of hours they slept the night after the assessment. The purpose of this trial is to provide a more naturalistic assessment of ProM; therefore, participants were allowed to use any mnemonic strategy they choose (e.g., writing the phone number and assigned task in an organizer). However, participants were not explicitly instructed to use a mnemonic strategy on the 24-hour probe.

The MIST includes scoring criteria for specific error types on the ProM trials. A no response (NR) error was when the participant fails to make a response to a ProM cue and can be thought of as an error of omission. Task substitution (TS) was coded when a participant made an incorrect response to the appropriate cue. Three situations constitute a task substitution: 1) an action is substituted for a verbal response, or vice versa, 2) a response from an earlier trial is repeated, or 3) a novel response is performed. Loss of
content (LC) is coded when a participant recognizes the target cue at the appropriate moment (i.e., the correct time or event cue), but indicates that they do not remember the task that should be performed. Loss of time (LT) is coded when a participant performs the appropriate task, but not within 15% of the target time. Examining specific error types may help elucidate the component processes underlying ProM deficits in PD.

The following MIST variables were examined in the proposed study: 1) total summary score, 2) TB scale, 3) EB scale, 4) ongoing distracter task, 5) post-test recognition memory, 6) retrieval index, 7) 24-hour trial, and 8) the four aforementioned error types. Furthermore, time monitoring was assessed by recording the number of clock checks during testing. The total number of clock checks for the last 5 minutes of each of the 15-minute TB trials was used for analyses.

Studies generally support the psychometric properties of the MIST. There is evidence of internal consistency of the six subscales (Chronbach’s alpha = .89). The inter-rater reliability, split-half reliability, as well as inter-relationships between the MIST summary score, subscales, and error types are adequate (Woods, Moran, Dawson, Carey, & Grant, 2008). The MIST also shows evidence of convergent validity with other measures of ProM (i.e., the Rivermead Behavioral Memory Scale, correlation = .80, Raskin, 2004) and standardized measures of executive functioning, episodic memory, and working memory (Carey et al., 2006). Moreover, the MIST has been shown to discriminate between normal controls and individuals with HIV (Carey et al., 2006), schizophrenia (Woods et al., 2007b), and amnestic mild cognitive impairment (Karantzoulis, Troyer, & Rich, 2009). There is support for the predictive validity of the MIST, as it has been found to be a unique predictor (over and above other standardized
neuropsychological tests) of IADLs in HIV and schizophrenia (Twamley et al., 2008; Woods et al., 2008). Furthermore, recent studies have shown that performance on the MIST is an independent predictor of medication nonadherence in HIV (Woods et al., 2008, 2009).

Self-reported ProM

The Prospective and Retrospective Memory Questionnaire (PRMQ) is a 16-item questionnaire that measures self-reported prospective and retrospective memory failures that occur in everyday life (Smith, Della Sala, Logie, & Maylor, 2000). Eight of the questions ask about the frequency of retrospective memory failures (e.g., “Do you fail to recognize a place you have visited before?”) and the other eight pertain to prospective memory failures (e.g., “Do you forget to buy something you planned to buy, like a birthday card, even when you see the shop?”). The items are rated on a 5-point scale ranging from 1 (never) to 5 (very often). For each of the 16 items, the PRMQ also includes an item asking the participant to rate how frustrated they feel with the memory failures, with items rated on a 5-point scale ranging from 0 (not at all frustrating) to 5 (extremely frustrating). This scale serves as a measure of memory-related quality of life. The scores as well as the frustration ratings for the prospective and retrospective scales of the PRMQ range from 8 to 40, and the self-cued and environment-cued scores range from 4 to 20 within each memory scale. The PRMQ has been demonstrated to have adequate psychometric properties, including internal consistency (Cronbach’s alphas of the retrospective, prospective, and total scores were .80, .84, and .89, respectively), discriminative validity (Smith et al., 2000; Woods et al., 2007a), structural validity (i.e., separate factor structures for the retrospective and prospective scales, Crawford, Smith,
Maylor, Della Sala, & Logie, 2003), and ecological validity (i.e., using IADLS as an outcome measure, Woods et al., 2008)

*Everyday Functioning Measures*

Performance-based measures of everyday functioning

Medication Adherence. The two performance-based measures that were used in the present study were recommended for general use in a recent comprehensive review of performance-based measures (Moore et al., 2007). Medication management ability was examined using the Medication Management Ability Assessment (MMAA), a standardized performance-based measure that was originally validated in a large sample of older patients with schizophrenia (Patterson et al., 2002). The MMAA is a role-play task in which the examiner acts as the participant’s provider prescribing medication and the participant acts as the patient. The examiner presents a standardized description of the medication regimen for four mock medications. Participants are shown four plastic pill bottles with standardized labels stating the name of the medication, the frequency and amount of medication to be taken daily, as well as whether the medication should be taken with food or on an empty stomach. Following the description of the medication regimen, there is a 1 hour delay in which the medication bottles are set aside. After the delay, participants are given the four medication bottles and asked to walk through their day, saying when they would wake up, eat their meals, and take their medications, handing over the correct number of mock pills (beans) to the examiner. The participants are not given any information regarding the medication regimen during this part of the test, but are allowed to check the labels if they choose to. The test is discontinued at 15
minutes if the participant has not yet completed the daily prescription regimen. The total number of correct responses for all of the pills (scores ranging from 0-33) was used for analyses. The MMMA has shown excellent test-retest reliability (intra-class correlation coefficient = .96; Patterson et al., 2002). There is evidence for the predictive validity of the MMMA, as it has shown good agreement with prescription records (67%; Patterson et al., 2002). Additionally, Patterson et al. (2002) showed that the MMMA demonstrates evidence of concurrent validity, as it correlated with a multi-domain performance-based measure of functional living skills (Direct Assessment of Functional Status), a quality of life measure (Quality of Well-Being Scale), and a measure of global cognitive functioning (Mini-Mental State Exam; MMSE). Global cognitive functioning (MMSE, DRS) has been found to be the strongest predictor of performance on the MMMA (Patterson et al., 2002; Jeste et al., 2003).

Managing Finances. Ability to manage finances was evaluated using the Advanced Finances Test (Heaton et al., 2004), a standardized performance-based measure of financial capacity. In this test, participants are handed blank checks, a checkbook register, a check to deposit, three bills to pay, and a calculator. Participants are instructed to deposit the check, pay the bills, and calculate their checkbook balance. The participants also are instructed to pay as much of their credit card bill as possible but to leave $100 in their checking account. The total score on this measure is worth 0 to 13 points. The task is designed to take approximately 10 minutes and the current study imposed a 15-minute discontinue rule, to be consistent with the MMAA. Finally, the measure was modified to include a semi-naturalistic ProM test. At the end of the Advanced Finances test, the bills were placed in an envelope and the participant was
asked to “mail the bills” in an outbox near the door at the end of the testing session. The bills were kept on the side of the table and the examiner provided the cue “The testing session is now over” at the end of the evaluation. This ProM trial was worth two points: one point for responding at the end of the testing session and one point for actually mailing the bills in the outbox. Prior studies support the reliability (internal consistency; Chronbach’s alpha = .82) and discriminative validity (neuropsychologically impaired HIV patients showed worse performance compared to HIV patients with normal neuropsychological functioning). The Advanced Finances Test also relates to self-reported IADLS (Heaton et al., 2004).

**Self-report measures of everyday functioning**

IADLs. A modified version of the Lawton & Brody Activities of Daily Living (1969) measure was used to examine IADL decline (Heaton et al., 2004). The self-report measure includes ratings for current as well as best past level of functioning for a number of daily living skills. IADLS were defined as a subset of items involving areas of functioning that are less likely to reflect motor symptoms of PD. Thus, basic ADLs (e.g., bathing, dressing) were not used in the analysis. The IADL items that were used for analyses are as follows: 1) housekeeping; 2) finances; 3) groceries; 4) telephone use; 5) shopping; and 6) medication management. A total IADL decline score was calculated by subtracting past from current functioning and summing the difference scores on all of the IADL items (range of -18 to 0, with lower scores indicating greater severity of IADL decline; as described in Woods et al., 2008).

Medication adherence. Given the particular relevance of ProM in medication management ability, the proposed study also administered the Medication Management
Efficacy Scale (MMES) from the Beliefs Related to Medications Adherence (BERMA) questionnaire (McDonald-Miszczak, Maris, Fitzgibbon, & Ritchie, 2004). This 20-item self-report measures asks participants to rate medication management ability, including memory abilities related to medication management (e.g., “I am good at remembering to take my medications”), on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The total score for the MMES ranges from 20-100. The BERMA shows evidence of good internal consistency (Chronbach’s alpha = .91), split-half reliability (Spearman-Brown = .91) and construct validity (McDonald-Miszczak et al., 2004; Woods et al., 2008).

Hr-QoL Measure. The PD Questionnaire 39-item version (PDQ-39; Peto, Jenkinson, Fitzpatrick, & Greenhall, 1995) was administered to the PD patients. This self-report measure consists of 39 items on a five-point rating scale (never, occasionally, sometimes, often, or always). The test consists of eight subscales: mobility, activities of daily living, emotional well being, stigma, social support, cognitions, communication, and bodily discomfort. Each subscale is transformed into an index using a linear transformation to a 0-100 scale. A total score using the average of the eight subscales linearly transformed into a 0-100 scale was used for the analyses. Higher scores on the PDQ-39 reflect lower Hr-QoL. The PDQ-39 is a well-validated measure of Hr-QoL in PD, showing evidence of reliability and construct validity in multiple studies (for review, see Marinus, Ramaker, van Hilten, & Stigglebout, 2002).

It is important to note that some authors have argued that measures used to reflect Hr-QoL, including the PDQ-39, actually may be measuring perceived health status, or the impact of health on one’s ability to perform a variety of physical, emotional, and social
activities. However, Hr-QoL reflects perceived well-being or life satisfaction as a result of health status (Den Oudsten et al., 2007). If health status is being evaluated, we still believe that this is an important construct representing everyday functioning, and therefore may be affected by ProM dysfunction. However, in the present study the term Hr-QoL was used to describe this measure.

**Time Estimation and Time Production Measures**

Time estimation and time production was assessed using a paradigm originally developed by Mimura and colleagues (2000) and modified by Woods and colleagues (2009). During the time estimation task, participants are asked to subvocally count at a rate of one digit per second until the examiner stops the participant and asks how much time has passed. Time intervals of 15, 30, 45, and 90 seconds will be administered in a randomized order. The difference between the actual time that has passed and the participant’s response for each time interval was averaged to derive a mean time estimation score. The administration and scoring procedures for the time production test were analogous to the time estimation task except that the participant was given the target time and asked to state when that amount of time has passed.

**Other Neuropsychological and Emotional Functioning Measures**

Premorbid verbal intelligence was measured using the Reading subtest from the Wide Range Achievement Test – Fourth Edition (WRAT-4; Wilkinson & Robertson, 2006). In addition, the present study examined the relationship between ProM and traditional measures of executive function, learning and memory, and attention/working
memory. Executive function was examined with the following measures: inhibition and inhibition/switching conditions of the Color-Word Interference Test and letter, category, and category switching conditions of Verbal Fluency Test from the Delis-Kaplan Executive Function Scale D-KEFS (Delis, Kaplan, & Kramer, 2001); and perseverative errors and categories completed on the Wisconsin Card Sorting Test – 128 card version (WCST-128; Heaton, Chelune, Talley, Kay, & Curtiss, 1993). Episodic learning and memory were examined using total words recalled from trial 1 to 5, long delay free recall, and recognition discriminability on the California Verbal Learning Test – Second Edition (CVLT-II; Delis, Kramer, Kaplan, & Ober, 2000). Attention/working memory was examined using the Digit Span from the Wechsler Memory Scale - third edition (WMS-3; Wechsler, 1997).

Conceptually driven composite scores were computed for the learning/memory, working memory, and executive functioning domains to be used for regression analyses examining whether ProM predicts everyday functioning over and above other cognitive domains. The learning and memory cognitive domain included CVLT-II total words recalled from trial 1 to 5 and long delay free recall. The working memory domain included WMS-3 Digit Span backwards. The executive function domain included WCST categories, D-KEFS letter fluency, and the inhibition condition of the D-KEFS Color-Word Interference Test Inhibition. Z-scores were calculated for each of the measures within the groups separately. The z-scores for the tests within each domain were averaged to obtain a composite domain score.

Statistical Analyses
Data were checked for normality and appropriate non-parametric statistics were used for non-normally distributed data. If parametric approaches to testing the data were comparable to non-parametric statistics, then results from the parametric approach are described in the results section. Parametric correlational analyses (Pearson r) showed inconsistencies when compared with nonparamentric correlations (Spearman rank correlations), therefore the latter is presented throughout all analyses. A 2 x 2 repeated measures analysis of variance (ANOVA) with group (healthy adult, PD) as the between-group factor and cue type (EB, TB) as the within-group factor was used to analyze the data for a potential differential deficit in TB and EB. Although the MIST variables were non-normally distributed (based on Shapiro-Wilk test of normality, \( p < .05 \)), the results of the analysis did not change when testing the cue by group interaction using a non-parametric approach (i.e., calculating a difference score between time and event cue type for each group and then conducting a Mann-Whitney U test with difference score as the dependent variable and group as the between-group factor). Planned follow-up pair-wise comparisons of the MIST variables were conducted using Mann-Whitney U tests (one-way ANOVAs were inconsistent with nonparametric tests). A 2 x 2 repeated measures ANOVA with group (normal control, PD) as the between-group factor and memory type (prospective memory, retrospective memory) as the within-group factor was used to examine group differences in self-reported ProM. One-way ANOVAs were used to examine potential differences between groups in time monitoring, time estimation/production, and performance on neuropsychological measures. Time production and time monitoring variables were non-normally distributed, but results did not change when using a Mann-Whitney U test. Effect sizes for all of the group
comparisons were analyzed using the Cohen’s $d$ statistic. Spearman’s rank correlation coefficients were used to examine relationships between ProM and time monitoring, time estimation/production, and performance on standardized neuropsychological tests, in each group separately.

One-way ANOVAs were used to examine group differences on the functional measures (although some variables were non-normally distributed, results were comparable when using Mann-Whitney U tests). Spearman’s rank correlation coefficients were used to examine relationships between the ProM variables and each of the functional measures (i.e., self-reported IADL and medication management, performance-based measures of medication and financial management, Hr-QOL measure). An additional analysis was conducted to investigate whether ProM (i.e., MIST summary score) is predictive of everyday functioning, independent of other factors related to functional decline (e.g., mood, motor symptoms, performance on traditional neuropsychological measures). For each functional measure that showed a significant relationship with the MIST, the following analyses were conducted in the PD sample. First, correlational analyses were used to examine relationships between the functional measures and specific variables that have been associated with functional decline in previous studies in PD and other samples (e.g., depressive symptoms, demographic factors, standardized neuropsychological performance, severity of motor symptoms). This was followed by hypothesis-driven hierarchical regression analyses in order to examine whether ProM is a unique predictor of functional capacity, over and above that of other contributing factors. Given the relatively small sample size in the proposed study (and potential for insufficient power when including multiple predictor variables),
separate regression analyses were performed for each domain that may potentially contribute to everyday functioning, including 1) demographic, 2) depressive symptoms, 3) global cognitive decline, 4) neuropsychological functioning, and 5) disease characteristics. In the first step of each regression model, variables found to significantly correlate with the functional outcome measure were entered as predictor variables. The second step of each model included significant ProM variables. An alpha level of .05 was used for all analyses.

Parts of chapter II have been submitted for the following publication:


The dissertation author was the primary investigator and author of this paper.
III. RESULTS

Aim 1

Descriptive data on the MIST variables are provided in Table 2. A repeated measures ANOVA revealed significant main effects of cue type \( F(1, 57) = 17.47, p < .001 \) and group \( F(1, 57) = 15.87, p < .001 \), as well as a significant cue type x group interaction \( F(1, 57) = 5.50, p < .05 \). The PD group \( (M = 4.3, SE = 0.3) \) scored significantly lower than the healthy adults \( (M = 6.2, SE = 0.2) \) on the TB scale \( (p < .001) \), and this was associated with a large Cohen’s \( d \) \( (1.30) \). The PD group also scored significantly lower \( (M = 5.5, SE = 0.3) \) than the healthy adult group \( (M = 6.5, SE = 0.2) \) on the EB scale \( (p < .05) \) but the effect was smaller \( (d = 0.63) \). There were no statistically significant group differences on the ongoing distracter task \( (p > .07) \). The multiple choice recognition post-test was significant at a trend level \( (M = 7.3, SE = 0.2 \text{ in PD group, } M = 7.7, SE = 0.2 \text{ in healthy adult group} \ p = .06, d = 0.43) \). The PD group also showed significantly worse performance on the retrieval index \( (M = 3.7, SE = 0.3 \text{ in PD group, } M = 2.5, SE = 0.3 \text{ in healthy adult group, } p < .01, d = .81) \). A chi-square test of the semi-naturalistic 24-hour probe (trial completed versus not completed) showed no significant differences between groups \( (p > .07) \). Component process analyses of the MIST error types revealed that the PD group committed significantly more no response errors \( (M = 1.8, SE = 0.3 \text{ in PD group}; M = 0.42, SE = 0.14 \text{ in healthy adult group}; p < .01, d = 0.96) \) but did not significantly differ from healthy adults in other error types \( (ps > .07) \). An analysis examining MIST performance when excluding the 7 PDD patients revealed results that were generally consistent with the above findings. The only differences that
emerged were that there were no significant differences between the PD and healthy adult groups on the EB scale (with a substantially smaller effect size, $d = .17$) or recognition memory post-test ($d = .24$; $ps > .07$).

Post-hoc analyses were conducted to examine whether depressive symptoms, global cognitive decline, ceiling effects, or retrospective memory impairment confounded the PD effect on ProM performance. Since there were significant differences in DRS and GDS scores between groups, a 2 (group) x 2 (cue type) repeated measures ANOVA, with the addition of DRS and GDS as covariates, was conducted to examine whether global cognitive decline (DRS) or depressive symptoms (GDS) accounted for the group by cue type interaction. The addition of these covariates did not change the significant group x cue interaction ($p < .05$). Follow-up analyses also were conducted to examine whether ceiling effects on the EB scale were confounding the group x cue interaction. A chi-square test did not detect significant differences in the proportion of ceiling effects (8/8) on the EB scale between groups (19% in the healthy adult group, 12% in the PD sample, $p > .07$). In addition, a McNemar test did not detect significant differences in the proportion of ceiling effects between the EB scale (19%) and the TB scale (4%) in the healthy adult group ($p > .07$). Since post-test recognition memory performance was impaired at a trend level in PD, a follow-up analysis was conducted to examine whether recognition memory for the contents of ProM intentions accounted for the differences between groups in ProM. A regression with MIST summary score as the dependent variable and recognition memory post-test and group (PD, healthy adult) as the predictor variables revealed that the group predictor variable remained significant even when accounting for variance attributable to the post-test recognition memory task ($p < .01$).
A follow-up analysis was conducted to examine whether error types differed between the TB and EB scales. Error types were coded separately for the TB and EB scales and Mann-Whitney U tests were used to examine group differences on the error types. Analyses revealed significant differences between the PD ($M = 1.15, SE = 0.19$) and healthy adult ($M = 0.27, SE = 0.11$) group in no response errors on the TB scale ($p < .001, d = 1.05$). Groups did not differ on loss of time, loss of content, or task substitution errors on the TB scale ($ps > .07$). On the EB scale, the difference between PD participants ($M = 0.64, SE = 0.18$) and healthy adults ($M = 0.15, SE = 0.07$) in no response errors was at a trend level ($p = .07, d = 0.63$). There were no significant differences in no response, loss of time, or task substitution errors on the EB scale ($ps > .07$).

Descriptive data for the PRMQ are provided in Table 3. A repeated measures ANOVA examining PRMQ performance revealed a significant main effect of memory type [$F(1, 56) = 23.19, p < .001$]. There was no statistically significant main effect of group [$F(1, 56) = 1.36, p = .25$] or memory type x group interaction [$F(1, 56) = 2.57, p = .11$]. Given a prior study (Foster et al., 2009) that found significant differences between PD and healthy adults on the self-cued ProM items of the PRMQ, exploratory analyses of the self-cued and environment-cued scores within each memory scale were conducted. The analyses revealed a trend level difference between groups in self-cued ($p = .07, d = .50$) but not environment-cued prospective memory failures ($p > .07$). There were no significant differences between groups in self-cued or environment-cued retrospective memory failures ($ps > .07$). There were no significant differences between groups in ratings of frustration ratings in response to memory problems (frustration ratings). Self-reported ProM (PRMQ prospective memory total score) did not correlate with objective
ProM (MIST) in either of the groups (\( ps > .07 \)). Both self-reported ProM and retrospective memory significantly correlated with level of depression (GDS; \( \rho = .45, p = .01 \) for both correlations). Analyses examining PRMQ performance when excluding the 7 PDD participants were generally consistent with the above findings.

Descriptive data for time monitoring on the MIST is provided in Table 3 and correlations between the MIST TB Scale and time monitoring are displayed in Table 4. There were no significant differences between the PD and healthy adults in time monitoring (total number of clock checks for the last 5 minutes of each 15-minute ProM trial) for both of the 15-minute TB trials (\( ps > .07 \)). However, there were significant correlations between the MIST TB scale and total time monitoring for the each of the last 5-minute subperiods of the 15-minute TB trials in the PD group (\( \rho = .59 \) and \( .59, ps < .001 \)). There were no significant correlations between the TB scale and time monitoring in the healthy adults. A follow-up analysis of the time monitoring data was conducted to examine whether there were group differences in number of clock checks for each 1-minute interval in the last 5 minutes of each TB trial. For the first 15-minute TB trials, a 2 (PD, healthy adult) x 5 (1-minute intervals) repeated measures ANOVA found a significant main effect of time interval \( [F(4, 228) = 9.42, p < .001] \). There was no significant main effect of group \( [F(1, 57) = 0.40, p = .55] \) or group x time interval interaction \( [F(4, 228) = 0.34, p = .85] \). A 2 x 5 repeated measures ANOVA of the clock checking in the second 15-minute TB trial showed comparable results. Analyses examining time monitoring performance and correlations between time monitoring and MIST TB scale when excluding the 7 PDD participants were generally consistent with the above findings.
Descriptive data for time estimation and production on the MIST are provided in Table 3 and correlations between the MIST TB Scale and time estimation/production are displayed in Table 4. No statistically significant group differences were detected in time estimation or time production (ps > .07). However, there was a significant correlation between the TB scale and time estimation in the PD group ($\rho = .37$, $p < .05$). TB scale did not correlate with time production in the PD group. The TB scale did not correlate with time production or estimation in the healthy adults (ps > .07). Time estimation/production did not correlate with time monitoring in either of the groups (ps > .07). Analyses examining time estimation/production performance when excluding the 7 PDD participants were generally consistent with the above findings, except there was no significant correlation between TB scale and time estimation in the PD group when excluding the PDD participants.

Descriptive data for the formal neuropsychological measures are presented in Table 3, and relationships between MIST variables and neuropsychological measures are displayed in Table 4. The PD and healthy adult groups significantly differed on the Letter ($p < .01$) and Category Fluency ($p < .05$) subtests of the D-KEFS Verbal Fluency Test, as well as CVLT Total 1-5 and Long Delayed Free Recall ($ps < .05$). There were significant correlations between performance on the TB scale and CVLT indices, Verbal Fluency, WCST, and Digit Span backwards in the PD group ($ps < .05$). There were significant correlations between the MIST EB scale and CVLT Total 1-5 and Verbal Fluency in the PD group. In the healthy adult group, there were no significant correlations between the either of the ProM scales (EB and TB) and the neuropsychological measures ($ps > .07$). When excluding the PDD participants from analyses, the only significant difference
between the PD group and healthy adults on formal neuropsychological measures was on the Letter Fluency ($p < .05$). In the PD group excluding the PDD patients, there were correlations between the TB scale and CVLT indices (Long Delay Free Recall and Discrimination Index) as well as Digit Span Backwards. There were no other significant correlations between TB scale or EB scale and formal neuropsychological measures.

**Aim 2**

As shown in Table 5, one-way ANOVAs revealed significant (or trend level) differences between the PD group and healthy adults on all of the functional measures (MMAA, Advanced Finances, IADL scale, and MMES). Table 6 displays correlations between MIST and the everyday function measures in the PD group. There were significant correlations between the MIST summary score and MMAA ($\rho = .45$), Advanced Finances Task ($\rho = .58$), the semi-naturalistic ProM trial of the Advanced Finances Task ($\rho = .58$), and the MMES ($\rho = .37$). There were no correlations between the MIST summary score and the IADL task or PDQ-39 in the PD group. Correlations between functional measures and the individual EB and TB scales were generally comparable to correlations found between the MIST summary score and functional measures (except the correlations between EB scale and the MMAA and MMES were not significant, $ps > .07$). In healthy adults, the correlation between the MIST summary score and Advanced Finances Task was significant at a trend level ($\rho = .38$, $p = .05$). In addition, there was a significant correlation between the MIST TB scale and the Advanced Finances Task ($\rho = .49$, $p < .05$) and a significant correlation between the MIST EB scale and the MMAA ($\rho = .40$, $p < .05$) in the healthy adults. There were no
other significant correlations between the MIST and functional measures in the healthy adult group (ps > .07). When excluding the 7 PDD participants from the PD group, there was a significant correlation between the TB Scale and the MMAA ($\rho = .39$, $p < .05$) in the PD group. However, there were no other significant correlations between the MIST and functional outcome measures in the PD group in which the PDD participants were excluded.

Table 6 displays correlations between the PRMQ prospective scale and everyday function measures in the PD group. There were significant correlations between the PRMQ prospective scale and the IADL scale ($\rho = .64$), MMES ($\rho = .73$), PDQ-39 ($\rho = .66$), and the ProM trial of the Advanced Finances Task ($\rho = .42$). The correlations between the PRMQ and the MMAA as well as the Advanced Finances Task were not significant (ps > .07). In the healthy adult group, there were no significant correlations between the PRMQ prospective scale and the functional measures (ps > .07). When excluding the PDD participants, there was a significant correlation between the PRMQ and the IADL scale ($\rho = .61$, $p < .01$) and MMES ($\rho = .73$, $p < .001$) in the PD group. There were no other significant correlation between the PRMQ and functional outcome measures in the PD group excluding PDD participants.

Table 7 displays correlations between the functional measures and variables chosen on an a priori basis. Hierarchical regression analyses for each of the functional outcome measures that correlated with the MIST summary score (i.e., Advanced Finances Task, MMAA, and MMES) are displayed in Tables 8-10. Step 1 of each hierarchical regression analysis included significant correlates of the functional measure (see Table 7). In step 2, the MIST summary score was added to the model. As shown in
Table 8, a hierarchical regression analysis that included significant demographic variables (age and gender) in the first step accounted for a significant proportion of variance on the Advanced Finances Task \((p < .001)\). In the second step, MIST summary score significantly increased the prediction of Advanced Finances Task \((\Delta R^2 = 0.10, p < .01)\). Another hierarchical regression analysis found that GDS accounted for a significant proportion of variance in Advanced Finances \((p < .001)\), but addition of the MIST summary score significantly increased the prediction of Advanced Finances Task \((\Delta R^2 = 0.17, p < .01)\). Similarly, a hierarchical regression found that DRS accounted for a significant proportion of variance on the Advanced Finances Task \((p < .001)\) but the MIST summary score significantly increased the prediction of Advanced Finances Task \((\Delta R^2 = .10, p < .05)\). A hierarchical regression model found that learning/memory and working memory composite domains accounted for a significant amount of variance on the Advanced Finances Task \((p < .01)\) but the MIST summary score significantly increased the prediction of performance on the Advanced Finances Task \((\Delta R^2 = .19, p < .01)\). In addition, a hierarchical regression model found that disease duration and H&R ratings accounted for a significant proportion of variance on the Advanced Finances Task \((p < .01)\), but MIST summary score significantly increased the prediction of Advanced Finances \((\Delta R^2 = .19, p < .01)\). In hierarchical regression analyses predicting MMAA, the MIST summary score was not a significant predictor of MMAA when accounting for demographic variables, GDS, DRS, cognitive domains, or disease characteristics (Table 9). In the hierarchical regression predicting the MMES, PRMQ prospective memory scale was included in the model, as it significantly correlated with the MMES. The MIST summary score was not a significant predictor or MMES when accounting for GDS,
DRS, cognitive domains, or disease characteristics (Table 10). However, the PRMQ prospective scale significantly increased the prediction of MMES over and above GDS ($\Delta R^2 = .25$, $p < .001$), DRS ($\Delta R^2 = .45$, $p < .001$), executive functioning ($\Delta R^2 = .50$, $p < .001$), and disease characteristics ($\Delta R^2 = .34$, $p < .001$). Separate follow-up hierarchical regressions paralleling the regression analyses above with TB, EB, or no response errors predicting functional outcome were conducted. Results were generally comparable to hierarchical regressions with MIST summary score predicting functional outcome, except for one result (EB ProM did not remain significant in the hierarchical regression predicting Advanced Finances after controlling for DRS).

Parts of chapter II have been submitted for the following publication:


The dissertation author was the primary investigator and author of this paper.
IV. DISCUSSION

The first aim of the present study was to examine the profile of ProM in PD using a well-validated, standardized task. Two prior studies investigating TB ProM relative to EB ProM in PD have observed contrasting results (Costa et al., 2008; Katai et al., 2003); therefore, the current study aimed to investigate a potential differential deficit between TB ProM and EB ProM. Since TB ProM is thought to depend more heavily on executive processes than EB ProM, it was hypothesized that PD participants would show a disproportionate deficit in TB relative to EB ProM. The results revealed that PD participants were impaired in both TB and EB ProM. However, as predicted, there was a disproportionate deficit in TB ProM (Cohen’s $d = 1.30$) compared to EB ProM ($d = 0.63$). The results of the current study parallel the Costa et al. (2008) finding of a disproportionate impairment in TB ProM relative to EB ProM. Although Costa and colleagues did not find a statistical difference between PD patients and healthy adults in EB ProM, the effect sizes of the between group differences in EB ProM were similar between the current study ($d = .63$) and Costa et al. ($d = .54$). The present study is in direct contrast to the Katai et al. 2003 study, in which EB ProM but not TB ProM was impaired in PD. These mixed findings may be related to the use of experimental paradigms with varying psychometric properties. The findings in the current study add to the literature by demonstrating a differential deficit between TB ProM and EB ProM using a standardized task with psychometrically comparable TB and EB scales and evidence for reliability and validity (review in Raskin, 2009; Woods et al., 2008).
Since the PD group was significantly impaired relative to the healthy adult sample in global cognitive functioning (DRS) and depressive symptoms (GDS), ProM impairment could potentially be due to these differences. However, the disproportionate impairment between TB ProM and EB ProM (cue x group interaction) remained significant after accounting for the DRS and GDS scores, suggesting that this finding was not better accounted for by these factors. In addition, there were no significant differences between groups in the ongoing distracter task (i.e., word search puzzle), suggesting that deficits on the MIST in PD were not solely due to differences in allocation of resources to the ongoing task.

An examination of the errors underlying ProM impairment in PD revealed that deficits in both TB and EB ProM were driven by an increased rate of no response (i.e., omission) errors in the PD group relative to the healthy adults, but there were no significant differences in other error types (e.g., loss of content errors, which imply problems with retrospective memory for the content of the intention). This finding suggests that the ProM deficits in this group may have been related to difficulties with detection of the ProM cue and self-initiated retrieval of intentions dependent on executive processes. However, post-test recognition memory for the contents of the ProM intentions showed a trend level difference between groups \( (p = .06) \) with a medium effect size \( (d = 0.43) \), suggesting that PD participants also may have some difficulty with retrospective memory for the contents of ProM intentions. There were group differences in retrieval index, which measures the difference between free recall and recognition memory for each ProM trial. This finding suggests that PD participants’ performance improved when demands on self-initiated retrieval were
minimized. Although post-test recognition memory significantly predicted performance in ProM (MIST summary score), the PD effect on ProM performance remained significant when accounting for performance on the recognition memory task. These results suggest that ProM impairment in PD is not fully explained by deficits in the retrospective memory component of the ProM task. Costa et al. (2008) also found that PD patients were impaired in remembering the contents of actions in a ProM task, while others have found intact memory for the contents of the ProM intentions in PD (Katai et al., 2003; Kleigal et al., 2005). One potential explanation for the difference between studies may be related to the relative complexity of the contents of the ProM intentions. For example, in Katai et al. (2005), the retrospective memory demands of the ProM task were minimal, as participants were required to remember two target words. However, in Costa et al. (2009), the retrospective component was to recall 3 functionally unrelated actions, such as asking the examiner to turn off computer, writing their name on a paper, and replacing a telephone receiver, which required a greater memory load. Future studies should directly examine the impact of retrospective memory impairment on ProM deficits in PD. For example, in a sample of amnestic MCI patients, Costa et al. (2011) manipulated the retrospective memory load of a ProM task by varying the number of target words (1 versus 4 words) that were to be recalled. The study demonstrated that both amnestic MCI patients and healthy controls showed better ProM performance when the retrospective memory load was smaller. However, the superior performance in the smaller retrospective memory load condition was not greater in amnestic MCI patients compared to healthy controls. The authors concluded that retrospective memory
impairment was not fully accounting for ProM deficits in amnestic MCI, as ProM impairment was not disproportionately affected in aMCI by an increase in retrospective memory load.

The present study adds to a growing body of literature demonstrating ProM impairment in PD (review in Kliegal, Altgassen, Hering, & Rose, 2011). There is evidence from neuroimaging (review in Burgess et al., 2011) and behavioral (Burgess et al., 2000; Cockburn, 1996; Fortin et al., 2002; Shallice & Burgess, 1991a; Umeda et al., 2011) studies demonstrating the role of frontal systems in ProM, and studies have demonstrated frontal-striatal disruption and associated executive function and episodic memory impairments in PD. Thus, ProM deficits in PD may be related to frontal systems dysfunction. More specifically, the finding of disproportionate impairment in TB ProM in PD supports the hypothesis that TB ProM requires increased levels of executive control dependent on frontal systems relative to EB ProM. As mentioned previously, the multiprocess theory purports that the strategic monitoring and retrieval demands of a ProM task will depend on various characteristics of the target cue, with cues that are less salient or nonfocal placing greater demands on self-initiated processes linked to frontal systems (McDaniel & Einstein, 2000). According to this theory, TB ProM cues are generally less salient than EB ProM tasks with more salient external cues, and therefore are hypothesized to require increased levels of strategic processes associated with frontal systems. Although TB ProM cues may require higher levels of cognitive control than EB cues, PD patients still show impairment in EB tasks in which the target cues demand high levels of executive control. For example, Foster and colleagues (2009) found that PD patients were impaired on an EB ProM
task when the target cue was nonfocal (the ongoing task did not focus attention on the
target cue) and presumably required strategic attentional monitoring, but were
comparable to healthy adults when the target cue was focal (ongoing task encouraged
attention to the target cue) and placed less demands on strategic processes. This is in
accordance with the present finding of impairment on an EB ProM task with non-focal
cues (albeit less impairment than TB ProM) in our PD sample. An interesting avenue
of future research may be to measure differences in monitoring in TB ProM compared
to non-focal EB tasks, in order to examine whether TB tasks require even greater
demands on strategic monitoring compared to non-focal EB tasks. The multi-process
theory also purports that factors other than the target cue determine the strategic
demands of a ProM task; therefore, there are additional directions for research
examining the strategic aspects of ProM. For example, future studies in PD could
manipulate the amount of absorption or demand required in ongoing distracter tasks,
as it is hypothesized that more absorbing ongoing tasks leave fewer resources for
strategic monitoring and cue detection processes in ProM. The notion that PD patients
are impaired in ProM tasks that require self-initiated, strategic processes is generally
consistent with previous research in PD showing impairment in cognitive tasks that
depend on internally generated strategies. A number of studies have shown that PD
patients show specific difficulty in episodic memory (Buytenhuijs et al., 1994;
Massman et al, 1990; Taylor et al., 1990; Van Spaendonck et al., 1996) and executive
function (Brown & Mardsen, 1988; Hsieh et al., 1995) tasks when only internally
generated cues are available, and that performance improves with external (or explicit)
cues.
One possible explanation for the disproportionate impairment in TB ProM, associated with an increased rate of omission errors, is that TB ProM places greater demands on strategic time monitoring. PD patients may have difficulty maintaining balance between performance of the ongoing task (word search puzzle) and strategic time monitoring in order to perform the intended action on time. This hypothesis was tested in the current study by recording time monitoring, operationalized as the number of clock checks in the few minutes preceding the target time for retrieval during the ProM task. However, inconsistent with our hypothesis, time monitoring did not significantly differ between the PD and healthy adult groups. This finding is inconsistent with the study by Costa and colleagues (2009), in which PD participants monitored the time less frequently in the last few minutes preceding the target time than healthy adults. The study also reported that time monitoring in the minutes preceding the target time correlated with performance on the TB ProM task.

Relationships between reduced strategic time monitoring and impaired TB ProM also have been observed in healthy older adults and individuals with schizophrenia (Einstein et al., 1995; McFarland & Glisky, 2009; Shum et al., 2004). The lack of between group differences in time monitoring in the current study may be due to the design of the ProM task (MIST). Since the MIST was designed to be used as a clinical measure and was not originally developed to examine time monitoring, it may not be well suited for testing experimental hypotheses about time monitoring during task performance. For example, time monitoring on the MIST was measured by recording the amount of clock checks in the 15-minute TB trials, but there was a 2-minute TB trial embedded within the last few minutes of one of the 15-minute trials. Therefore, it is
unclear during some periods of time whether time monitoring was occurring in the last minutes of the 15-minute trial or was related to a separate 2-minute trial. Although there was a significant correlation between time monitoring and TB ProM in PD, this relationship was not observed in healthy adults. The lack of correlation in the healthy adult group may have been related to a more restricted range of scores on the TB scale in the healthy adults (range = 4-8).

Another potential underlying process responsible for the TB ProM deficits in PD is abnormalities in basic time perception. Accurate perception of temporal durations may play a role in both TB ProM and time monitoring. There is converging evidence for the role of dopamine and fronto-striatal circuits in time perception (review in Meck, 1996) and deficits have been reported on a variety of temporal perception tasks in PD patients (review in Meck & Benson, 2002), although there are inconsistent findings (e.g., Spencer & Ivry, 2005). However, inconsistent with prior studies showing deficits in temporal perception in PD, the current study did not find significant differences between the PD group and healthy adults in time estimation or production. These findings suggest that deficits in basic temporal perception, as measured in the current study, did not play a role in the TB ProM deficit observed in this group. The current findings may be related to the impact of dopaminergic medication on time perception. Prior research has shown that there is significant improvement in time perception in PD patients “on” versus “off” dopaminergic medication (Pastor et al., 1992), with time perception in PD patients “on” medication reaching levels comparable to controls in some studies (Lange, Tucha, Steup, Gsell, & Naumann, 1995; Malapani et al., 1998). Since PD patients in the present study were
tested “on” medication, this may explain the lack of differences between groups in
time perception. However, it is important to note that other investigators have shown
temporal perception deficits even in medicated PD patients (e.g., Smith, Harper,
Gittings, & Abernethy, 2007). In addition to differences in medication, the
inconsistencies in the literature examining time perception in PD also may be related
to methodological differences in the tasks, such as varying levels of motor functioning
involved in tasks, length of temporal intervals tested, and whether tasks involve
subvocal/vocal counting or use of a concurrent ongoing task that inhibits counting.
This latter point is particularly important, as TB ProM tasks require accurate time
estimation while being absorbed in some other ongoing task. Future studies may want
to explore the relationship between TB ProM and time perception with a timing task
that involves an ongoing activity. Although there was a significant correlation between
time estimation and TB ProM in PD, this relationship was not observed in healthy adults. As mentioned above, the lack of correlation in the healthy adult group may be related to a more restricted range of scores on the TB scale in the healthy adults.

As predicted, TB ProM correlated with measures of working memory (Digit
Span Backwards) and executive function (category fluency and category switching on
the verbal fluency measures and categories completed on the WCST) in the PD group.
In addition, TB ProM correlated with measures of episodic memory, including verbal
learning, delayed recall, and recognition memory on the CVLT. These correlations
provide evidence for the convergent validity of TB ProM as a cognitive domain
related to working memory, executive function, and retrospective episodic memory in
PD, and are consistent with the present findings of both prospective and (at a trend
level) retrospective components of ProM impairment in PD. However, measures of
divergent validity should be examined in order to further examine the construct
validity of TB ProM in PD. The cognitive correlates of EB ProM were generally
similar, except that EB ProM did not correlate with working memory and some
indices of episodic memory. Costa et al. (2008) observed similar correlations between
TB ProM and working memory/executive function, but did not find significant
correlations between TB ProM and other memory measures (i.e., a list learning test,
story memory, and visual memory test). In addition, Costa et al. (2008) did not find
correlations between EB ProM and any of the neuropsychological tasks administered
(working memory, retrospective episodic memory, executive function). The
discrepancies between the present study and the Costa et al. (2008) study may be
related to differences in the ProM tasks, neuropsychological measures, demographic
background (e.g., education) of study samples, and/or severity of cognitive decline of
participants (i.e., the current study included a subset of PDD patients, while the Costa
et al. study excluded dementia subjects). Future studies with larger sample sizes are
warranted to examine the relative contribution of different cognitive domains to TB
ProM, and may help to further elucidate processes underlying the TB ProM
impairment in PD. In addition, given prior confirmatory factor analytic studies
demonstrating that ProM is dissociable from other cognitive constructs in non-PD
samples (Gupta et al., 2010; Salthouse et al., 2004), future studies could use
confirmatory factor analyses to examine whether ProM is dissociable from other
cognitive functions (e.g., executive function, retrospective memory) in PD.
Furthermore, there may be executive/strategic processes, other than those studied in
the current study, involved in the TB ProM deficit in PD. For example, TB ProM impairment may be related to deficits in planning, which is involved in EB ProM decline in PD (Kliegal et al., 2005).

One issue in ProM studies, as well as other cognitive studies examining potential differential deficits, is differences in task difficulty between TB and EB ProM tasks. Ceiling effects in EB tasks are common, and may limit conclusions about differential deficits in TB versus EB ProM. Although the MIST TB and EB scales are psychometrically comparable on various task demands (e.g., scale, delay interval, response modality, ongoing task), it could be possible that ceiling effects on the EB scale confounded the finding of disproportionate impairment in TB relative to EB ProM. However, the proportion of participants that reached ceiling (8/8) on the EB scale did not significantly differ between groups (19% in the healthy adult group, 12% in the PD group). Although there was a large difference in the proportion of ceiling effects between the EB scale (19%) and TB scale (4%) in the healthy adult groups, this difference was not statistically significant. Furthermore, the few EB ceiling effects did not preclude the detection of differences between groups on the EB scale.

However, the possibility that the disproportionately worse performance in TB relative to EB ProM could be confounded by a ceiling effect in EB ProM cannot be ruled out in the present study.

In addition to examining ProM in a laboratory setting, the MIST also has a 24-hour item in which the participant is asked to call the experimenter the following day and state the number of hours they slept. This measure allows for a semi-naturalistic assessment of ProM in everyday life. Although PD patients were impaired on the
laboratory indices of the MIST (e.g., TB and EB scales), they performed comparably to healthy adults on the semi-naturalistic measure of ProM. The discrepancy between laboratory and semi-naturalistic ProM is a common finding in the ProM literature (e.g., Rendell & Thomson, 1999). This has been most extensively studied in healthy older adults, in which most studies find that older adults show deficits in laboratory ProM but outperform younger adults in naturalistic task, often referred to as the age-prospective memory paradox (Rendell & Thompson, 1999). In the present study, participants were allowed, but not explicitly instructed, to use any mnemonic strategy they chose (e.g., writing the phone number and assigned task in an organizer, reminder from caregiver). Therefore, the lack of differences between PD and healthy adult groups in the naturalistic ProM task may be related to the use of compensatory strategies in everyday life that cannot be used in the laboratory. In addition, the differences between naturalistic and laboratory ProM could be related to methodological differences between tasks. For example, the 24-hour item involves one trial, while the laboratory portion of the MIST involves multiple trials with varying levels of cognitive load, or number of ProM intentions held “online” at the time each intention should be recalled.

The current study also investigated everyday ProM complaints on a self-report measure. The results did not detect significant differences between the PD and healthy adult samples in self-reported ProM or retrospective memory complaints. Using the same self-report measure (PRMQ), Foster et al. (2009) examined differences between PD and healthy adults in self-cued (e.g., “Do you decide to do something in a few minutes’ time and then forget to do it?”) compared to environment-cued (e.g., “Do
you forget to buy something you planned to buy, even when seeing the shop”). According to the multiprocess theory, the authors hypothesized that PD patients would report more ProM failures in self-cued than environment-cued tasks, as self-cued tasks are thought to require greater levels of cognitive control than environment-cued tasks that have more salient external cues. As predicted, Foster and colleagues (2009) found significant differences between groups in self-cued ProM that were associated with a large effect size, $d = .89$, but there were no group differences in environment-cued ProM. The present study conducted an exploratory analysis examining self-cued compared to environment-cued items on the self-report ProM measure. Consistent with the study by Foster and colleagues, the results revealed that PD patients reported more self-cued ProM complaints (at a trend level, with a medium effect size, $d = .50$) than healthy adults, but there were no differences in environment-cued ProM complaints. Overall, these findings are consistent with the hypothesis that individuals with PD have particular difficulty with ProM tasks that have increased demands on executive control processes, such as TB ProM as well as EB ProM tasks with less distinctive or nonfocal cues.

A vital goal of clinical neuropsychology is to use neuropsychological assessment to predict everyday functioning (Morgan & Heaton, 2009). ProM is an area of cognition thought to be particularly relevant to this goal, as it is ubiquitous in everyday life. Although there is growing evidence of the relationship between ProM impairment and functional declines in various neurological populations (Contardo et al., 2009; Hertzog et al., 2000; Schmitter-Edgecombe et al., 2009; Twamley et al., 2008; Woods et al., 2008a, 2008b, 2009, 2011; Vedhara et al., 2004; Zogg et al., 2010,
2011), no study to our knowledge has investigated the functional consequences of ProM deficits in PD. Thus, the current study aimed to examine the relationships between ProM and everyday functioning in the PD sample. The current study used a multimodal approach to examine everyday functioning by using both self-report and performance-based measures of instrumental activities of daily living (IADLs) as well as a measure of healthy-related quality of life (Hr-QOL). The results revealed that deficits on the ProM task (the MIST summary score, as well as individual TB and EB scales) were related to poorer performance on the performance-based measure of financial capacity (Advanced Finances Task) in the PD sample. Moreover, while age, depressive symptoms, global cognitive decline, retrospective learning and memory, and severity of motor symptoms (Hoehn & Yahr ratings) were predictive of declines in financial capacity, overall ProM impairment (measured by MIST summary score) accounted for variance in financial capacity over and above these factors. The results were generally comparable when conducting separate regression analyses using MIST TB scale, EB scale, and omission errors to predict financial capacity. Therefore, the results suggest that ProM dysfunction uniquely adds to the prediction of declines in financial capacity. Although a prior study in a sample of schizophrenia patients examined relationships between ProM and a global performance-based measure of everyday functioning that included a financial management component (Twamley et al., 2008), this is the first study to our knowledge to specifically investigate the relationship between financial capacity and ProM in any population. ProM likely is involved in various aspects of managing finances, such as remembering to pay bills on time (TB ProM) or to stop at the bank on the way home from work (EB ProM). Future
studies may further examine the relationship between ProM and declines in financial capacity using other ecologically valid measures such as actual records of financial management (e.g., late payments, bounced checks) or virtual reality tasks that mimic online banking.

The present study also found that overall ProM impairment significantly correlated with a performance-based measure of medication management capacity (MMAA) and a self-reported medication management measure (MMES). Interestingly, performance on the TB scale, but not the EB scale, was related to both of the medication management measures. However, overall ProM impairment (MIST summary score) did not predict performance-based or self-reported medication management when controlling for other predictors of medication management, including demographic, psychiatric, cognitive, and disease characteristics. This finding did not change when using other MIST variables including TB scale, EB scale, and omission errors to predict medication management. These results are incongruent with the growing evidence for the relationship between ProM decline and medication adherence in non-PD samples (review in Zogg et al., in press). One potential explanation for the lack of unique association between ProM and medication management in the present study is the small sample size, which may have lead to low power to detect a significant effect in these regression analyses with multiple predictors. In addition, it is possible that the methods used to examine medication management did not accurately reflect actual medication adherence in the PD group, as this measure was not validated in a PD sample. For example, the medication management task involves a relatively minor motor component, as patients must take
small pills out of the bottle to hand to experimenter, which may have confounded the relationship between ProM and performance on this task. Finally, it is possible that ProM differentially predicts functional outcome (financial management versus medication management) in PD.

The present study found that performance on the ProM task did not correlate with self-reported IADLs. This could be related to methodological issues that result from self-report measures (e.g., self-report bias, discussed in more detail below). As discussed above, an alternative explanation is that ProM is related only to specific IADLs (e.g., financial capacity), but not other daily activities. Therefore, a global measure of IADL may not be sensitive to ProM decline in PD.

Interestingly, self-reported ProM complaints (PRMQ) significantly correlated with self-reported medication management, and were a unique predictor of self-reported medication management over and other predictors of medication management. Thus, only self-reported ProM complaints emerged as a unique predictor of (self-reported) medication management. It is possible that self-reported ProM represents a distinct aspect of ProM that is not reflected in performance-based measures of ProM and everyday function. For example, most performance-based measures of ProM and everyday function do not allow for the use of compensatory strategies that may be used in everyday life, while self-report measures ask the patient to report their ProM and everyday functioning abilities as they are in everyday life, including use of any compensatory strategies. However, this finding also could be due to other factors that limit the validity of self-report measures (as discussed in detail below).
In addition to examining the relationship between ProM and daily living skills, the current study explored the relationship between ProM impairment and health-related quality of life (Hr-QOL). Hr-QOL is another aspect of everyday functioning that may be affected by ProM decline; however, no study to our knowledge has examined the relationship between ProM and QOL/Hr-QOL in any population. The results of the study did not show a relationship between performance on the ProM task and Hr-QOL in the PD sample. As mentioned previously, widely used measures of Hr-QOL (e.g., PDQ-39) have been criticized for measuring health status (the impact of health on one’s ability to perform a variety of physical, emotional, and social activities), rather than Hr-QoL (perceived well-being or life satisfaction as a result of health status; Den Oudsten et al., 2007). Therefore, it is possible that another measure that better reflects well-being/life satisfaction may relate to ProM impairment in the PD group.

A finding that emerged from this study was that self-reported ProM complaints related to self-reported declines in everyday functioning (IADLs, medication management, Hr-QOL), but were not associated with performance-based measures of everyday function (medication management and financial capacity). In addition, self-reported ProM complaints were not related to laboratory ProM, as measured by the MIST. A lack of association between self-report measures and performance on objective neuropsychological testing is a common finding (Chaytor & Schmitter-Edgecombe, 2003), including discrepancies in self-reported versus laboratory ProM in various populations (e.g., Woods et al., 2007; Zeintl, Kliegel, Rast, & Zimprich, 2006). Studies in PD also have shown a divergence between self-report
and objective cognition (Marino et al., 2009; Sitek, Soltan, Wieczorek, Robowski, & Slawek, 2011), including a discrepancy between self-reported and laboratory ProM (Foster et al., 2009). Additionally, research suggests that there are inconsistencies between subjective ratings and performance-based measures of IADL function in PD (Shulman et al., 2006). Self-reported assessment of cognition and everyday functioning may be influenced by a number of confounding factors such as depression, cognitive impairment, social desirability bias, and metacognitive deficits, which may lead to overestimation or underestimation of ProM and functional abilities (Morgan & Heaton, 2009). For example, Marino and colleagues (2009) found that subjective ratings of cognition were more influenced by depressive symptoms than objective cognitive performance in a sample of PD patients. In the current study, depression significantly correlated with all of the self-report measures (ProM complaints, self-report of everyday functioning) in the PD sample (\(\rho\) ranging from .57 to .77). Given the limitations associated with self-report, these types of measures should be interpreted with caution. Furthermore, these findings emphasize the importance of including more objective measures of ProM (e.g., laboratory or semi-naturalistic measures) and everyday function (e.g., performance-based measures, molar outcomes, direct observation) in future studies examining functional consequences of ProM impairment.

Although performance-based measures are generally considered to be more representative of actual everyday functioning capacity, there also may be limitations associated these measures. The performance-based tasks used in the current study
were recommended in a comprehensive psychometric review of performance-based measures in a variety of populations (Moore et al., 2007); however, no studies to our knowledge have examined the reliability and validity of any performance-based measure of everyday function in a PD sample. Additionally, performance-based assessment is conducted in an artificial testing environment and therefore may not simulate the home environment or take into account the use of compensatory strategies (e.g., pill boxes, automatic online bill paying). Another related limitation of the present study is that other predictors of everyday function were not assessed, such as use of compensatory strategies, motivation (especially since apathy is common in PD), and environmental demands on the patient. In addition, the external validity of the present study was limited by the demographic characteristics of the PD and healthy adult samples, as most individuals were highly educated and Caucasian.

In summary, the present study contributes to the growing body of literature showing ProM impairment in PD by using a standardized measure of ProM with known psychometric properties. The results demonstrated that TB ProM was disproportionately impaired relative to EB ProM in PD, and PD patients committed an increased number of omission errors on TB trials relative to healthy adults. These results suggest that TB ProM impairment was related to difficulties with the strategic monitoring and self-initiated retrieval of intentions associated with frontal systems. In addition, there was a trend level difference between the PD and healthy adult group on the post-test recognition memory test, suggesting that PD patients also have difficulty with retrospective memory for the intentions. Consistent with these findings, TB ProM was associated with measures of executive function, working memory, and
retrospective episodic memory. The current study also found that ProM correlated with performance-based measures of everyday function (financial capacity, medication management) and a self-report measure of medication management. Moreover, ProM impairment uniquely predicted declines on a performance-based measure of financial capacity (but not medication management) over and above other predictors of everyday functioning. Findings from the current study provide preliminary evidence for the relationship between ProM impairment and declines in everyday functioning. Although future studies with larger samples and longitudinal designs are warranted, the results suggest that ProM may provide unique information regarding everyday functioning skills in PD. These findings have implications for the assessment of ProM in clinical neuropsychological evaluations as well as for the use of interventions for ProM dysfunction in order to improve everyday functioning and quality of life in individuals with PD. Studies in various populations have shown improvements in ProM using a variety of interventions (reviews in Raskin & Sohlberg, 2009, Zogg et al., 2011). The findings of the present study suggest that interventions that target the strategic monitoring and cue detection aspects of ProM may be particularly useful for individuals with PD. For example, self-regulatory strategies (e.g., helping patients redirect attention away from ongoing task to the ProM cue, such as in goal management training), increasing the distinctiveness of cues, or use of electronic devices that prompt the patient to execute intentions may help compensate for strategic monitoring and cue detection deficits (Zogg et al., 2011).
# V. APPENDIX

<table>
<thead>
<tr>
<th>Order of Presentation</th>
<th>The Memory for Intentions Screening Test (MIST) Instructions</th>
<th>Cue</th>
<th>Response Modality</th>
<th>Time Delay (Minutes)</th>
<th>Order of Execution</th>
<th>Cognitive Load</th>
</tr>
</thead>
</table>
| 1                     | “In 15 minutes, tell me it is time to take a break.”  
Recognition foils: “At any point during this test, were you supposed to: Tell the examiner to turn off the lights? Tell the examiner to leave the room?” | Time      | Verbal            | 15                   | 4                   | 4              |
| 3                     | “In 2 minutes, ask me what time this session ends today.”  
Recognition foils: “At any point during this test, were you supposed to: Ask what time the office closes? Ask for your medical records?” | Time      | Verbal            | 2                    | 1                   | 4              |
| 4                     | “When I show you a postcard, self-address it.”  
Recognition foils: “When you were handed a postcard, were you supposed to: Write today’s date? Write a note to the examiner?” | Event     | Action            | 15                   | 6                   | 2              |
| 5                     | “When I show you a Request for Records form, write your doctors’ names on it.”  
Recognition foils: “When the examiner handed you a Request for Records form, were you supposed to: Write your phone number? Fold the form?” | Event     | Action            | 2                    | 2                   | 4              |
| 6                     | “In 15 minutes, use that paper [examiner points to word search puzzle] to write the number of medications you are currently taking.”  
Recognition foils: “At any point during this test, were you supposed to: Write a list of your past hospitalizations? Write the number of children in your family?” | Time      | Action            | 15                   | 8                   | 1              |
| 7                     | “When I show you the tape recorder, tell me to rewind the tape.”  
Recognition foils: “When the examiner showed you a tape recorder, were you supposed to: Press the stop button? Tell the examiner to check the battery?” | Event     | Verbal            | 2                    | 3                   | 5              |
<table>
<thead>
<tr>
<th>Order of Presentation</th>
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<th>Delay (Minutes)</th>
<th>Order of Execution</th>
<th>Cognitive Load</th>
</tr>
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<tbody>
<tr>
<td>8</td>
<td>“In 2 minutes, please tell me two things you forgot to do this past week.” Recognition foils: “At any point during this test, were you supposed to: Tell the examiner 2 grocery items? Tell the examiner 2 things you have to do tonight?”</td>
<td>Time</td>
<td>Verbal</td>
<td>2</td>
<td>7</td>
<td>2</td>
<td></td>
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</table>
VI. TABLES

Table 1. Characteristics of healthy adults and Parkinson’s disease participants.

<table>
<thead>
<tr>
<th></th>
<th>HA</th>
<th>PD</th>
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<tbody>
<tr>
<td></td>
<td>(n = 26)</td>
<td>(n = 33)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>69.8 (1.3)</td>
<td>71.2 (1.4)</td>
</tr>
<tr>
<td>Education (years)</td>
<td>16.4 (0.5)</td>
<td>16.6 (0.4)</td>
</tr>
<tr>
<td>Gender (M/F)</td>
<td>17/9</td>
<td>24/9</td>
</tr>
<tr>
<td>Ethnicity (% Caucasian)</td>
<td>92%</td>
<td>100%</td>
</tr>
<tr>
<td>Geriatric Depression Scale</td>
<td>2.9 (0.4)</td>
<td>5.2 (0.9)*</td>
</tr>
<tr>
<td>Dementia Rating Scale</td>
<td>140.6 (0.5)</td>
<td>137.3 (1.2)*</td>
</tr>
<tr>
<td>WRAT-4 Reading</td>
<td>65.1 (0.8)</td>
<td>60.7 (3.2)</td>
</tr>
<tr>
<td>Disease Duration (years)</td>
<td>-</td>
<td>11.1 (1.1)</td>
</tr>
<tr>
<td>Hoehn &amp; Yahr</td>
<td>-</td>
<td>2.6 (0.1)</td>
</tr>
</tbody>
</table>

Note. Data represent means and standard errors. HA = Healthy Adults, PD = Parkinson’s disease patients. * \(p < .05\). WRAT-4 Reading = Reading subtest from the Wide Range Achievement Test – Fourth Edition.
Table 2. Performance-based ProM (MIST) in the healthy adult and Parkinson’s disease groups.

<table>
<thead>
<tr>
<th>MIST Variable</th>
<th>Healthy Adults</th>
<th>Parkinson’s Disease</th>
<th></th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>Mn</td>
<td>SE</td>
<td>Md (IQR)</td>
<td>%</td>
<td>Mn</td>
<td>SE</td>
<td>Md (IQR)</td>
<td>%</td>
<td>p</td>
<td>d</td>
</tr>
<tr>
<td>Summary score</td>
<td>38.3</td>
<td>1.0</td>
<td>39 (36, 42)</td>
<td>-</td>
<td>29.4</td>
<td>1.8</td>
<td>33.0 (23, 39)</td>
<td>-</td>
<td>&lt; .001</td>
<td>1.10</td>
</tr>
<tr>
<td>Time-based</td>
<td>6.2</td>
<td>0.2</td>
<td>6.5 (6, 7)</td>
<td>-</td>
<td>4.3</td>
<td>0.3</td>
<td>5.0 (3, 6)</td>
<td>-</td>
<td>&lt; .001</td>
<td>1.30</td>
</tr>
<tr>
<td>Event-based</td>
<td>6.5</td>
<td>0.2</td>
<td>7.0 (6, 7)</td>
<td>-</td>
<td>5.5</td>
<td>0.3</td>
<td>6.0 (4, 7)</td>
<td>-</td>
<td>&lt; .05</td>
<td>0.63</td>
</tr>
<tr>
<td>Recognition</td>
<td>7.7</td>
<td>0.2</td>
<td>8.0 (8, 8)</td>
<td>-</td>
<td>7.3</td>
<td>0.2</td>
<td>8.0 (7, 8)</td>
<td>-</td>
<td>.06</td>
<td>0.43</td>
</tr>
<tr>
<td>Retrieval Index</td>
<td>2.5</td>
<td>0.3</td>
<td>3.0 (1, 3)</td>
<td>-</td>
<td>3.7</td>
<td>0.3</td>
<td>4.0 (2, 5)</td>
<td>-</td>
<td>&lt; .01</td>
<td>0.81</td>
</tr>
<tr>
<td>Ongoing Task Errors</td>
<td>11.5</td>
<td>0.7</td>
<td>10.0 (8, 14)</td>
<td>-</td>
<td>9.2</td>
<td>0.7</td>
<td>9.0 (6, 13)</td>
<td>-</td>
<td>.11</td>
<td>0.58</td>
</tr>
<tr>
<td>No Response</td>
<td>0.4</td>
<td>0.1</td>
<td>0.0 (0, 1)</td>
<td>12</td>
<td>1.8</td>
<td>0.3</td>
<td>1.0 (0, 3)</td>
<td>36</td>
<td>&lt; .01</td>
<td>.96</td>
</tr>
<tr>
<td>Loss of Time</td>
<td>0.2</td>
<td>0.1</td>
<td>0.0 (0, 0)</td>
<td>9</td>
<td>0.2</td>
<td>0.1</td>
<td>0.0 (0, 0)</td>
<td>3</td>
<td>.68</td>
<td>0.10</td>
</tr>
<tr>
<td>Loss of Content</td>
<td>0.9</td>
<td>0.2</td>
<td>1.0 (0, 1)</td>
<td>32</td>
<td>1.1</td>
<td>0.2</td>
<td>1.0 (0, 2)</td>
<td>26</td>
<td>.83</td>
<td>0.18</td>
</tr>
<tr>
<td>Task Substitution</td>
<td>1.3</td>
<td>0.2</td>
<td>1.0 (0, 2)</td>
<td>47</td>
<td>1.3</td>
<td>0.2</td>
<td>1.0 (0, 2)</td>
<td>35</td>
<td>.80</td>
<td>0.03</td>
</tr>
<tr>
<td>24-Hour Probe</td>
<td>1.1</td>
<td>0.2</td>
<td>1.0 (0, 2)</td>
<td>46a</td>
<td>0.8</td>
<td>0.2</td>
<td>0.0 (0, 2)</td>
<td>33a</td>
<td>.58</td>
<td>0.32</td>
</tr>
</tbody>
</table>

Note. MIST = Memory for Intentions Screening Test. The data represent means (Mn), standard errors (SE), medians (Md), and interquartile ranges (IQR), and percentage of total errors. p-values based on Mann Whitney U tests. Recognition = multiple choice recognition memory post test. % = Percentage of total errors. *Proportion of participants who had a perfect score on the 24-hour probe. d = Cohen’s d effect size estimate.
Table 3. Self-reported memory and performance on neuropsychological tests, time monitoring and time perception measures in healthy adults and Parkinson’s disease participants.
<table>
<thead>
<tr>
<th></th>
<th>PD (n = 33)</th>
<th>HA (n = 26)</th>
<th>p</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRMQ</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prospective memory total score</td>
<td>20.6 (0.8)</td>
<td>18.6 (0.8)</td>
<td>.09</td>
<td>0.46</td>
</tr>
<tr>
<td>Self-cued scale</td>
<td>10.8 (0.5)</td>
<td>9.5 (0.5)</td>
<td>.07</td>
<td>0.50</td>
</tr>
<tr>
<td>Environmentally-cued scale</td>
<td>9.9 (0.4)</td>
<td>9.1 (0.4)</td>
<td>.14</td>
<td>0.38</td>
</tr>
<tr>
<td>Frustration rating</td>
<td>19.7 (1.1)</td>
<td>17.1 (1.3)</td>
<td>.12</td>
<td>0.42</td>
</tr>
<tr>
<td>Retrospective memory total score</td>
<td>17.7 (0.8)</td>
<td>17.2 (0.9)</td>
<td>.95</td>
<td>0.12</td>
</tr>
<tr>
<td>Self-cued scale</td>
<td>10.3 (0.5)</td>
<td>9.9 (0.6)</td>
<td>.61</td>
<td>0.16</td>
</tr>
<tr>
<td>Environmentally-cued scale</td>
<td>7.7 (0.3)</td>
<td>7.3 (0.4)</td>
<td>.47</td>
<td>0.20</td>
</tr>
<tr>
<td>Frustration rating</td>
<td>16.0 (0.8)</td>
<td>14.2 (0.8)</td>
<td>.13</td>
<td>0.41</td>
</tr>
<tr>
<td><strong>Neuropsychological Measures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CVLT-2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trials 1-5</td>
<td>41.3 (2.6)</td>
<td>50.0 (2.3)</td>
<td>&lt; .05</td>
<td>0.61</td>
</tr>
<tr>
<td>Long delay free recall</td>
<td>8.3 (0.7)</td>
<td>10.7 (0.7)</td>
<td>&lt; .05</td>
<td>0.63</td>
</tr>
<tr>
<td>Discrimination index</td>
<td>2.5 (0.2)</td>
<td>2.8 (0.2)</td>
<td>.13</td>
<td>0.42</td>
</tr>
<tr>
<td><strong>WCST</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perseverative errors</td>
<td>20.0 (3.0)</td>
<td>14.7 (3.2)</td>
<td>.27</td>
<td>0.29</td>
</tr>
<tr>
<td>Categories</td>
<td>4.4 (0.4)</td>
<td>5.3 (0.4)</td>
<td>.10</td>
<td>0.44</td>
</tr>
<tr>
<td><strong>CWIT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhibition</td>
<td>73.0 (5.4)</td>
<td>71.2 (3.6)</td>
<td>.78</td>
<td>0.08</td>
</tr>
<tr>
<td>Inhibition/Switching</td>
<td>88.4 (6.8)</td>
<td>75.8 (7.2)</td>
<td>.21</td>
<td>0.07</td>
</tr>
<tr>
<td><strong>Verbal Fluency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Letter Fluency</td>
<td>36.0 (2.3)</td>
<td>47.0 (2.6)</td>
<td>&lt; .01</td>
<td>0.80</td>
</tr>
<tr>
<td>Category Fluency</td>
<td>36.0 (2.3)</td>
<td>40.1 (2.0)</td>
<td>&lt; .05</td>
<td>0.88</td>
</tr>
<tr>
<td>Category Switching Fluency</td>
<td>12.3 (0.8)</td>
<td>13.4 (3.1)</td>
<td>.32</td>
<td>0.27</td>
</tr>
<tr>
<td>Category Switching Accuracy</td>
<td>11.0 (0.9)</td>
<td>11.6 (0.7)</td>
<td>.58</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>Digit Span</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward</td>
<td>10.9 (0.5)</td>
<td>11.3 (0.5)</td>
<td>.49</td>
<td>0.18</td>
</tr>
<tr>
<td>Backward</td>
<td>7.3 (0.4)</td>
<td>8.2 (0.5)</td>
<td>.12</td>
<td>0.42</td>
</tr>
<tr>
<td><strong>Time Monitoring</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 1</td>
<td>3.7 (0.6)</td>
<td>4.0 (0.5)</td>
<td>.76</td>
<td>0.08</td>
</tr>
<tr>
<td>Trial 2</td>
<td>4.6 (0.5)</td>
<td>5.5 (0.6)</td>
<td>.26</td>
<td>0.29</td>
</tr>
<tr>
<td><strong>Temporal Perception</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Estimation</td>
<td>9.3 (0.8)</td>
<td>9.7 (1.0)</td>
<td>.75</td>
<td>0.08</td>
</tr>
<tr>
<td>Time Production</td>
<td>10.7 (1.5)</td>
<td>13.0 (1.7)</td>
<td>.35</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Note. Data represent mean and standard error of raw scores. PD = Parkinson’s Disease group, HA = Healthy Adults. PRMQ = Prospective and Retrospective Memory Questionnaire. CVLT-2= California Verbal Learning Test – Second Edition, WCST = Wisconsin Card Sorting Test, CWIT = Color Word Interference Test. p-values based on one-way ANOVAs. d =Cohen’s d effect size estimate.
Table 4. Relationships between MIST variables and other neuropsychological measures, time monitoring, and time perception in the Parkinson’s disease group.

<table>
<thead>
<tr>
<th></th>
<th>MIST Time-Based Scale</th>
<th>MIST Event-Based Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CVLT-2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trials 1-5</td>
<td>0.53**</td>
<td>0.40*</td>
</tr>
<tr>
<td>Long Delay Free Recall</td>
<td>0.44*</td>
<td>0.33+</td>
</tr>
<tr>
<td>Discrimination Index</td>
<td>0.45*</td>
<td>0.15</td>
</tr>
<tr>
<td><strong>WCST</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perseverative Errors</td>
<td>0.33+</td>
<td>0.28</td>
</tr>
<tr>
<td>Categories</td>
<td>0.44*</td>
<td>0.35+</td>
</tr>
<tr>
<td><strong>CWIT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhibition</td>
<td>0.31</td>
<td>0.33+</td>
</tr>
<tr>
<td>Inhibition/Switching</td>
<td>0.22</td>
<td>0.32</td>
</tr>
<tr>
<td><strong>Verbal Fluency</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Letter Fluency</td>
<td>0.32+</td>
<td>0.35*</td>
</tr>
<tr>
<td>Category Fluency</td>
<td>0.48**</td>
<td>0.52**</td>
</tr>
<tr>
<td>Category Switching Fluency</td>
<td>0.47**</td>
<td>0.48**</td>
</tr>
<tr>
<td>Category Switching Accuracy</td>
<td>0.36+</td>
<td>0.42*</td>
</tr>
<tr>
<td><strong>Digit Span</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward</td>
<td>0.16</td>
<td>0.17</td>
</tr>
<tr>
<td>Backward</td>
<td>0.48**</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Time Monitoring</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 1</td>
<td>0.59***</td>
<td>-</td>
</tr>
<tr>
<td>Trial 2</td>
<td>0.59***</td>
<td>-</td>
</tr>
<tr>
<td><strong>Temporal Perception</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Estimation</td>
<td>0.37*</td>
<td>-</td>
</tr>
<tr>
<td>Time Production</td>
<td>0.12</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 5. Performance on everyday functioning measures in healthy adults and Parkinson’s disease participants.

<table>
<thead>
<tr>
<th></th>
<th>PD (n =33)</th>
<th>HA (n =26)</th>
<th>p</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Everyday Functioning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Performance-based Measures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMAA</td>
<td>28.4 (0.9)</td>
<td>31.0 (0.5)</td>
<td>&lt; .05</td>
<td>0.60</td>
</tr>
<tr>
<td>Advanced Finances Test Total</td>
<td>9.0 (0.7)</td>
<td>12.5 (0.5)</td>
<td>&lt; .001</td>
<td>1.03</td>
</tr>
<tr>
<td>Advanced Finances Test ProM</td>
<td>1.4 (0.9)</td>
<td>1.7 (0.1)</td>
<td>.23</td>
<td>0.42</td>
</tr>
<tr>
<td><strong>Self-report Measures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IADL</td>
<td>-2.4 (0.5)</td>
<td>-0.2 (0.1)</td>
<td>&lt; .001</td>
<td>1.21</td>
</tr>
<tr>
<td>MMES</td>
<td>70.0 (2.8)</td>
<td>82.1 (2.0)</td>
<td>&lt; .001</td>
<td>1.01</td>
</tr>
<tr>
<td>PDQ-39</td>
<td>22.6 (2.9)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 6. Relationships between ProM variables and everyday functioning measures in the Parkinson’s disease group.

<table>
<thead>
<tr>
<th>Everyday Functioning</th>
<th>MIST Summary Score</th>
<th>MIST Time-Based Scale</th>
<th>MIST Event-Based Scale</th>
<th>PRMQ ProM Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance-based Measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMAA</td>
<td>0.45*</td>
<td>0.46**</td>
<td>0.31</td>
<td>0.18</td>
</tr>
<tr>
<td>Advanced Finances Test Total</td>
<td>0.58***</td>
<td>0.56**</td>
<td>0.48**</td>
<td>0.27</td>
</tr>
<tr>
<td>Advanced Finances Test ProM</td>
<td>0.58***</td>
<td>0.52**</td>
<td>0.46**</td>
<td>0.42*</td>
</tr>
<tr>
<td>Self-report Measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IADL</td>
<td>0.26</td>
<td>0.21</td>
<td>0.21</td>
<td>0.64***</td>
</tr>
<tr>
<td>MMES</td>
<td>0.37*</td>
<td>0.41*</td>
<td>0.28</td>
<td>0.73***</td>
</tr>
<tr>
<td>PDQ-39</td>
<td>0.25</td>
<td>0.21</td>
<td>0.25</td>
<td>0.66***</td>
</tr>
</tbody>
</table>

Note: Data represent Spearman rho correlation coefficient (presented in absolute values). MMAA = Medication Management Ability Assessment. IADL = modified version of the Lawton & Brody Instrumental Activities of Daily Living Scale. MMES = Medication Management Efficacy Scale (MMES). PDQ-39 = PD Questionnaire 39-item version. PRMQ ProM total score = Prospective Retrospective Memory Questionnaire, prospective memory scale total score. * p < .05, ** p < .01, *** p < .001
Table 7. Relationships between everyday functioning measures and demographic, psychiatric, cognitive, and disease characteristics in the Parkinson’s disease group.

<table>
<thead>
<tr>
<th></th>
<th>MMAA</th>
<th>Advanced Finances</th>
<th>MMES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.57**</td>
<td>0.79***</td>
<td>0.33</td>
</tr>
<tr>
<td>Education</td>
<td>0.14</td>
<td>0.08</td>
<td>0.22</td>
</tr>
<tr>
<td>Gender</td>
<td>1.73***</td>
<td>1.65***</td>
<td>0.50a</td>
</tr>
<tr>
<td><strong>Psychiatric</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDS</td>
<td>0.50**</td>
<td>0.50**</td>
<td>0.62***</td>
</tr>
<tr>
<td><strong>Global Cognitive</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRS</td>
<td>0.52**</td>
<td>0.68***</td>
<td>0.44*</td>
</tr>
<tr>
<td><strong>Cognitive Domains</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Executive Function</td>
<td>0.44**</td>
<td>0.27</td>
<td>0.35*</td>
</tr>
<tr>
<td>Learning &amp; Memory</td>
<td>0.50**</td>
<td>0.57**</td>
<td>0.19</td>
</tr>
<tr>
<td>Working Memory</td>
<td>0.36*</td>
<td>0.46**</td>
<td>0.12</td>
</tr>
<tr>
<td><strong>Disease Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H&amp;R Rating</td>
<td>0.51**</td>
<td>0.62***</td>
<td>0.62***</td>
</tr>
<tr>
<td>Disease Duration (years)</td>
<td>0.42*</td>
<td>0.39*</td>
<td>0.36*</td>
</tr>
</tbody>
</table>

Note. Data represent Spearman’s rho correlation coefficient (presented in absolute values). MMES data represent Pearson r correlations (as this measure was normally distributed). *Value represents cohen’s d effect size and p value based on between group ANOVAs. MMAA = Medication Management Ability Assessment. MMES = Medication Management Efficacy Scale (MMES). GDS = Geriatric Depression Scale. DRS = Dementia Rating Scale. H&R = Hoehn & Yar. * p < .05, ** p < .01, ***p < .001.
Table 8. Predictors of performance on the Advanced Finances Task in Parkinson’s disease participants.

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SEB</th>
<th>β</th>
<th>R²</th>
<th>Δ R²</th>
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<tbody>
<tr>
<td><strong>Demographic</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-0.32</td>
<td>0.07</td>
<td>-0.64***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>1.44</td>
<td>1.40</td>
<td>0.16</td>
<td></td>
<td></td>
</tr>
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<td>Step 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-0.25</td>
<td>0.70</td>
<td>-0.50**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.79</td>
<td>1.23</td>
<td>0.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIST Summary Score</td>
<td>0.15</td>
<td>0.05</td>
<td>0.38**</td>
<td></td>
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Note. MIST = Memory for Intentions Screening Test. GDS = Geriatric Depression Scale. DRS = Dementia Rating Scale. H&R = Hoehn & Yahr Rating Scale. * p < .05, ** p < .01, ***p < .001
Table 9. Predictors of performance on the Medication Management Ability Assessment in Parkinson’s disease participants.

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Note. MIST = Memory for Intentions Screening Test. GDS = Geriatric Depression Scale. DRS = Dementia Rating Scale. H&R = Hoehn & Yahr Rating Scale. * $p < .05$, ** $p < .01$, ***$p < .001$
Table 10. Predictors of performance on the Medication Management Efficacy Scale in Parkinson’s disease participants.

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Note. MMES = Medication Management Efficacy Scale. MIST = Memory for Intentions Screening Test. GDS = Geriatric Depression Scale. DRS = Dementia Rating Scale. H&R = Hoehn & Yahr Rating Scale. * $p < .05$, ** $p < .01$, ***$p < .001$
VII. REFERENCES


