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Is episodic future thinking important for instrumental activities of daily living in neurological patients?

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IS EPISODIC FUTURE THINKING IMPORTANT FOR INSTRUMENTAL ACTIVITIES OF DAILY LIVING IN NEUROLOGICAL PATIENTS?

by

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CERTIFICATE OF APPROVAL

PH.D. THESIS

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ABSTRACT

Episodic future thinking is defined as the ability to mentally project oneself into the future into a specific time and place. Episodic future thinking has been explored extensively in neuroscience. However, it has not been determined whether the measurement of episodic future thinking might be valuable in a clinical neuropsychological setting. The current study examined the relationship between episodic future thinking and instrumental activities of daily living (IADLs), which is a domain of adaptive functioning frequently assessed by neuropsychologists to examine independent living potential including the ability to handle finances, prepare food, complete household duties, and manage medications. A secondary aim was to examine whether episodic future thinking is related to IADLs over and above standard measures of cognition.

61 older adults with heterogeneous neurological conditions and 41 healthy older adults completed a future thinking task (the adapted Autobiographical Interview), two measures of IADLs (an informant report measure called the Everyday Cognition Scale and a performance-based measure called the Independent Living Scales), and standard measures of memory and executive functioning.

Episodic future thinking was significantly associated with performance-based IADLs when accounting for age, education, gender, and depression ($r=.26$, $p=.010$). Episodic future thinking significantly predicted performance-based IADLs over and above executive functioning ($R^2=.025$, $p=.030$). Episodic future thinking was not predictive of performance-based IADLs over and above memory ($p=.157$). Episodic future thinking was not significantly associated with informant reported IADLs when accounting for age, education, gender, and depression ($p=.284$).

This study suggests that episodic future thinking is significantly associated with IADLs, beyond what can be accounted for by executive functioning. Episodic future thinking may

provide information about IADLs to clinical neuropsychologists so they can improve their recommendations for independent living.

PUBLIC ABSTRACT

Clinical neuropsychologists measure various domains of cognition to examine the relationship between the brain and behavior. One domain of cognition that has not been explored in clinical neuropsychology is future thinking. Future thinking involves mentally projecting oneself into the future. Patients with neurological conditions have trouble thinking in the future in a vivid way. The aim of the current study was to investigate whether the ability to mentally project oneself into the future was related to the ability the live independently in patients with neurological conditions. It seems intuitive that mentally placing oneself into a future scenario could aid in anticipating and overcoming obstacles during daily tasks, such as completing finances or taking medications appropriately, but this had not been studied. We found that the ability to think in the future was related to independent living in patients with neurological disease. Thus, performance on a future thinking task may give neuropsychologists valuable information about the level of care that is needed for a patient with neurological disease. It is important for clinical neuropsychologists to provide accurate and helpful information to patients and family members about whether they are capable of living independently or if they need additional supervision to be safe. Assessing the ability to think in the future may allow clinical neuropsychologists to improve their recommendations for independent living.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER

INTRODUCTION

Neuropsychological assessment is an area of psychology concerned with assessing behavioral effects of brain dysfunction. Cognitive functioning is measured to address the following aims: identify cognitive, behavioral, or mood dysfunction, assess changes in these areas over time, estimate the appropriate level of care, and identify suitable treatments (Hebben & Milberg, 2009; Lezak, Howieson, Bigler, & Tranel, 2012). However, improvements are needed in neuropsychological assessment to be able to understand patients' functioning in everyday life and recommend treatments to address these functional deficits (Larrabee, 2014; Ruff, 2003). Throughout the history of neuropsychology, novel measures have been developed to improve the information gained from our assessments so we can better address patient needs (Burgess et al., 2006).

A cognitive domain not included in clinical neuropsychological assessment is episodic future thinking. Episodic future thinking is a construct that has recently been studied in neuroscientific research. Episodic future thinking is defined as the ability to mentally project oneself into the future into a specific time and place (Atance & O'Neill, 2001). Others have defined the term as mental time travel (Wheeler, Stuss, & Tulving, 1997), prospection (Buckner & Carroll, 2007), and episodic simulation (Schacter & Addis, 2007).

The main episodic future thinking task (Addis, Wong, & Schacter, 2008) was adapted from the Autobiographical Interview (AI) (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002). In the adapted AI task (Addis et al., 2008), participants are asked to describe a specific future event that is novel and plausible in as much detail as possible. Episodic future thinking performance is measured based on the amount and type of details included in a future event description (Addis et al., 2008; Palombo, Keane, & Verfaellie, 2015). The central event described by the participant is scored based on the inclusion of internal details and semantic details. Internal details include details associated with a specific event, place, time, perceptions (sensory details including auditory, olfactory, tactile, taste, visual, or spatial-temporal details), or thoughts/emotion. Semantic details are general knowledge and facts, ongoing events, and extended states of being. The remaining details are categorized into an "other" category, including details that were unrelated to the main event described by the participant, repetitions and metacognitive statements. An example scored transcript from the current study is provided in Figure 1. Some previous research on episodic future thinking used to score the task by combining semantic and other details (Addis, Sacchetti, Ally, Budson, & Schacter, 2009; Irish, Addis, Hodges, & Piguet, 2012a; Irish, Hodges, & Piguet, 2013), but more recent research suggests that it is important to separately assess semantic details (Irish & Piguet, 2013).

Neuroscientific research has shown that there are various neurological populations with impairments in episodic future thinking. This research has also identified the core neural network and cognitive processes of episodic future thinking. Most critically, episodic future thinking has been connected to domains of adaptive functioning, which is a concept relevant to clinical neuropsychology. Previous research has found a relationship between measures considered standard to clinical neuropsychological assessment and functional abilities. However, these relationships vary across the literature and the standard assessments are only modestly related to functional status. Research is necessary to determine if episodic future thinking can be informative in a clinical neuropsychological setting.

It is easy to imagine that the ability to mentally project oneself into a future scenario could be valuable for optimal real-world functioning. Every day is filled with tasks that need to be completed. Mentally placing oneself into a vivid future scenario could potentially aid in the anticipation of obstacles and facilitate taking steps to overcome such obstacles. For example, imagine a healthy individual preparing for a job interview. When they mentally project themselves into that future scenario, they see the individuals present at the meeting, hear the interviewers asking various difficult questions, and perhaps even feel their arousal and anxiety. Their ability to engage in episodic future thinking may allow them to prepare and perform more effectively. One could imagine that if a person could not think ahead vividly they may not address potential obstacles as effectively. This may be especially relevant for an individual with a neurological condition such as mild cognitive impairment who is attempting to live independently. Imagine that this person has activities they need to complete, such as going to the grocery store, paying bills, and visiting a friend. Without being able to effectively engage in episodic future thinking, they may fail to perform such tasks or not complete them as successfully.

The connection between episodic future thinking and optimal daily functioning seems intuitive, but episodic future thinking has not been objectively measured with respect to functional abilities in patients with neurological conditions. Standard neuropsychological testing is not designed to measure episodic future thinking; moreover, this ability may be especially relevant for some of the typical neurological populations referred for neuropsychological assessment. Episodic future thinking may provide critical information about functional abilities that would be valuable in a clinical neuropsychological assessment setting.

The Origin of Episodic Future Thinking

To truly understand episodic future thinking, it is useful to explore its origin. The concept of episodic future thinking is deeply rooted in memory research. Memory researchers applied their understanding of memory to the ability to project oneself in the future. Tulving (1972, 1983, 2002) defined episodic memory as conscious recollection of subjective events tied to a specific time and place. Researchers have expanded this definition to state that episodic memory includes the retention of extensive sensory and perceptual details to allow re-experiencing of an event (Conway, Pleydell-Pearce, & Whitecross, 2001). Ingvar (1984) and Tulving (1985, 2002) first suggested the role of memory in thinking in the future. Tulving (1985, 2002) specified the importance of the episodic memory system for mental time travel into both the past and the future, which are necessary components to vividly experience a past or future event. Even though Tulving (1985, 2002) suggested that memory helps humans project into the past and future, memory researchers initially focused their efforts on thinking in the past. More recently, these researchers have applied these same concepts to the future. Memory research has influenced theoretical perspectives of episodic future thinking.

Researchers have conceptualized the underlying cognitive and neural processes involved in episodic future thinking (Hassabis & Maguire, 2007; Schacter & Addis, 2007). Schacter and Addis (2007) developed the constructive episodic simulation hypothesis, which states that episodic memory allows one to retrieve and recombine details into a future episodic simulation. Hassabis and Maguire (2007) developed the theory of scene construction which states that the ability to create a mental scene allows one to simulate the past and future. Even though neuroscience research has not explored the clinical utility of episodic future thinking, it has clarified that cognitive and neural processes of episodic future thinking.

Cognitive Processes of Episodic Future Thinking.

The following main cognitive processes have been proposed to be involved in episodic future thinking (Table 1): episodic memory, semantic memory, executive functioning, self-referential processing, and imagery (Addis & Schacter, 2012; Buckner, 2010; Buckner & Carroll, 2007; Hassabis & Maguire, 2007; Irish & Piguet, 2013; Klein, 2013; Schacter & Addis, 2007; Schacter, Addis, & Buckner, 2008; Szpunar, 2010). Literature from neuroimaging studies, behavioral studies, and studies that investigate neurological populations support each of these cognitive processes in episodic future thinking.

The first cognitive process involved in episodic future thinking is episodic memory. Findings supporting the vital role of episodic memory in episodic future thinking reveal neural activation in regions important for episodic memory (i.e., medial temporal lobe structures) during episodic future thinking tasks (Schacter & Addis, 2007). Patients who have damage to the medial temporal lobe also have deficits in episodic future thinking (Schacter & Addis, 2007). The second cognitive process involved in episodic future thinking is semantic memory. Patients with semantic dementia have deficits in episodic future thinking, and these deficits are associated with compromised regions of the temporal lobe important for semantic memory (Irish et al., 2012a).

The third cognitive process involved in episodic future thinking is executive functioning (Buckner & Carroll, 2007; Schacter & Addis, 2007). Patients with deficits in executive functioning (e.g., patients with Parkinson's disease) have deficits in episodic future thinking (de Vito et al., 2012). D'Argembeau, Ortoleva, Jumentier, and Van der Linden (2010) investigated a healthy adult population and found significant relationships between executive functioning and episodic future thinking. Another cognitive process important for episodic future thinking is self-referential thinking (Buckner & Carroll, 2007; Schacter & Addis, 2007). Though not directly investigated, some evidence suggests that patients who have deficits in self-referential processes (e.g., Korsakoff's syndrome) also have deficits in episodic future thinking (Talland, 1965). The last cognitive process involved in episodic future thinking is imagery. Imagery has been found to be involved in episodic future thinking, as individuals with better imagery abilities engage in episodic future thinking with more vivid details (D'Argembeau & Van der Linden, 2006). This finding is also reflected in neuroimaging data with activation in visual-spatial regions of the brain while participants engage in episodic future thinking (Buckner & Carroll, 2007; Schacter & Addis, 2007). Overall, these results help explain the cognitive mechanisms underlying deficits in episodic future thinking.

Core Neural Network of Episodic Future Thinking

Research has revealed a set of neural regions involved in episodic future thinking through structural and functioning imagining studies (Table 1) (Buckner & Carroll, 2007; Schacter & Addis, 2007; Schacter, Addis, & Buckner, 2007; Schacter et al., 2008; Schacter, Addis, et al., 2012; Szpunar, 2010; Verfaellie, Race, & Keane, 2012). The following regions have been identified as involved during episodic future thinking: the medial temporal lobe, the medial prefrontal cortex, the posterior cingulate cortex, the retrosplenial cortex, anterior and lateral temporal lobe, precuneus, and posterior parietal lobe. Another finding from neuroimaging studies was the significant overlap in neural regions involved in thinking in the past and the future. However, some evidence posits that regions of the core network are more active during future simulation since it is more cognitively demanding to imagine a novel event in the future when compared to simulating a past event (as reviewed by Schacter et al. (2008) and Schacter, Addis, et al. (2012)). This suggests that despite overlap, there may be elements of episodic future thinking that may be unique. Overall, the core neural network is supported by both functional neuroimaging and structural neuroimaging studies. The cognitive processes and core neural network of episodic future thinking is relevant to understanding the neurocognitive mechanisms underlying episodic future thinking deficits in neurological populations.

Episodic Future Thinking in Neurological Populations

Episodic future thinking impairments have been found in a wide array of neurological populations, as outlined in Table 2 (Irish & Piolino, 2016; Ward, 2016). Episodic future thinking has been found to be impaired in dementia, including patients with Alzheimer's disease (Addis et al., 2009; El Haj, Antoine, & Kapogiannis, 2015; Irish et al., 2012a; Irish, Addis, Hodges, & Piguet, 2012b; Irish et al., 2013), fronto-temporal dementia (Irish et al., 2013), Parkinson's disease (de Vito et al., 2012), semantic dementia (Irish et al., 2012a, 2012b; Viard et al., 2014), and mild cognitive impairment (Gamboz et al., 2010). Episodic future thinking is also impaired in patients with amnesia (Andelman, Hoofien, Goldberg, Aizenstein, & Neufeld, 2010; Hassabis, Kumaran, Vann, & Maguire, 2007; Klein, Loftus, & Kihlstrom, 2002; Kurczek et al., 2015; Race, Keane, & Verfaellie, 2011; Rosenbaum et al., 2005; Zeman, Beschin, Dewar, & Della Sala, 2013), left temporal resection (Manning, Denkova, & Unterberger, 2013), damage to the prefrontal cortex (Berryhill, Picasso, Arnold, Drowos, & Olson, 2010; Kurczek et al., 2015), damage to the posterior parietal cortex (Berryhill et al., 2010), damage to the thalamus (Weiler, Suchan, Koch, Schwarz, & Daum, 2011), multiple sclerosis (Ernst et al., 2014), transient global amnesia (Juskenaite et al., 2014), and traumatic brain injury (Rasmussen & Berntsen, 2014). Impairments in internal details are consistent across neurological populations. There is some variability in performance surrounding semantic details since some patients have deficits in semantic details, some patients perform similarly to healthy comparisons, and some patients provide more semantic details. Research has found that older adults provide less internal details in their future descriptions when compared to young adults (Addis, Musicaro, Pan, & Schacter, 2010; Addis et al., 2008; Cole, Morrison, & Conway, 2013; De Beni et al., 2013; Gaesser, Sacchetti, Addis, & Schacter, 2011; Gallo, Korthauer, McDonough, Teshale, & Johnson, 2011; Madore, Gaesser, & Schacter, 2014; Madore & Schacter, 2014; Rendell et al., 2012; Schacter, Gaesser, & Addis, 2012). Overall, episodic future thinking performance is impaired across neurological populations.

The Relationship between Episodic Future Thinking and Standard Measures of Cognition in Neuropsychological Assessment

Measuring episodic future thinking may have utility in a clinical neuropsychological setting. To be valuable in a clinical setting, episodic future thinking would need to capture a unique area of cognition not already included in clinical neuropsychological assessment. In a review, Ward (2016) examined the construct validity of episodic future thinking with the aim of determining whether episodic future thinking is a unique construct among standard measures of neuropsychological assessment and cognitive constructs that are studied in neuropsychology research. For the purposes of this study, it is important to consider the overlap between episodic future thinking and standard measures of neuropsychological assessment, such as memory and executive functioning. Memory and executive functioning are considered since they both are associated with functional abilities (Desai, Grossberg, & Sheth, 2004; Gold, 2012; Royall et al., 2007), and it is possible that episodic future thinking may also provide information about functional abilities in patients with neurological conditions.

As discussed by Ward (2016), episodic memory has been studied extensively with respect to episodic future thinking, especially internal details. Episodic memory is defined as memory of subjective events tied to a specific time and place (Tulving, 1972, 1983, 2002). Episodic future thinking and episodic memory are similar theoretically because they both require the mental construction of events tied to a specific time and place. Episodic memory is a standard task used in clinical neuropsychological assessment. The following tasks are verbal episodic memory tasks used in standard neuropsychological assessment: the Rey Auditory Verbal Learning Test (Rey, 1964), the California Verbal Learning Test (Delis, Kramer, Kaplan, & Ober, 2000), Verbal Paired Associates (Wechsler, Holdnack, & Drozdick, 2009) and Logical Memory (Wechsler et al., 2009). The following tasks are visual episodic memory assessments used in standard neuropsychological assessments: the Rey Complex Figure Test (Meyers & Meyers, 1996) and Designs from the Wechsler Memory Scale (Wechsler et al., 2009).

Ward (2016) reviewed the overlap between episodic memory tasks and episodic future thinking. The relationship between episodic memory performance and episodic future thinking performance was investigated in older adults (Addis et al., 2008; Cole et al., 2013), patients with Alzheimer's disease (El Haj et al., 2015; Irish et al., 2012a) and patients with frontotemporal dementia (Irish et al., 2013). Overall, the review found that there was a moderate, positive correlation between episodic future thinking and episodic memory, suggesting theoretical overlap between these two constructs. The review also examined performance on both episodic memory and episodic future thinking tasks in neurological populations (Ward, 2016). Most studies suggest that patients perform consistently across episodic memory tasks and episodic future thinking tasks in patients with Alzheimer's disease (Addis et al., 2009; El Haj et al., 2015; Irish et al., 2012a, 2012b; Irish et al., 2013), frontotemporal dementia (Irish et al., 2013), transient global amnesia (Juskenaite et al., 2014), amnesia (Kurczek et al., 2015; Race et al., 2011; Zeman et al., 2013), and in temporal resection (Manning et al., 2013). Overall, there was evidence of moderate convergence between episodic memory and episodic future thinking. Episodic future thinking and episodic memory may overlap substantially. This is important to consider if episodic future thinking is placed in a clinical setting with standard memory tasks. Episodic future thinking would need to provide unique information beyond episodic memory.

Less literature has considered the theoretical overlap between episodic future thinking and executive functioning. Executive functioning is defined cognitive tasks for goal-directed behavior and adaptation to environmental demands (Gurd, Kischka, & Marshall, 2010; Lezak et al., 2012; Tranel, Anderson, & Benton, 1994). Executive functioning includes cognitive abilities such as planning, decision-making, judgment, and self-perception (Tranel et al., 1994). Episodic future thinking may overlap with executive functioning since episodic future thinking has been shown to be involved with decision-making (Benoit, Gilbert, & Burgess, 2011; Lin & Epstein, 2014; Palombo et al., 2015; Peters & Büchel, 2010). Tranel and Lezak, et al. (2012) summarize various types of executive functioning assessments used in a clinical neuropsychology setting. Common executive functioning tasks include Trail Making Test (Reitan & Wolfson, 1985), Wisconsin Card Sorting Task (Berg, 1948; Grant & Berg, 1948), Tower Tests (Culbertson & Zillmer, 2004; Delis, Kaplan, & Kramer, 2001), Category Test (Halstead, 1947), Stroop Test (Golden & Freshwater, 2002), and Fluency Tests (Benton, Hamsher, & Sivan, 1994). Furthermore, questionnaires have been developed so informants can report on behavioral changes that may reflect executive dysfunction (Barrash, Anderson, Hathaway-Nepple, Jones, & Tranel, 1997).

Previous research has examined the relationship between episodic future thinking and executive functioning. Studies examined this relationship in healthy older adults (Addis et al., 2008; Cole et al., 2013; Irish et al., 2013), patients with Parkinson’s disease (de Vito et al., 2012), patients with frontotemporal dementia (Irish et al., 2013), and in patients with Alzheimer’s disease (Irish et al., 2013). Findings regarding the association between episodic future thinking and executive functioning are variable, from no relationship to a moderate relationship. These findings may be due to the wide range of executive functioning constructs measured by these studies. However, most studies found no significant association between episodic future thinking and executive functioning. When examining performance across neurological populations, there are variable findings with some patients having deficits in both episodic future thinking and executive functioning, and some patients only having a deficit in either episodic future thinking or executive functioning (de Vito et al., 2012; Irish et al., 2012b; Irish et al., 2013). Overall, it is possible that episodic future thinking and executive functioning do not substantially overlap. These findings suggest that episodic future thinking may capture a unique area of cognition in clinical neuropsychological assessment when compared to executive functioning.

As discussed by Ward (2016), before including episodic future thinking in a clinical setting, research needs to determine if episodic future thinking predicts functional abilities over and above standard areas of cognition. This is especially important to consider with respect to episodic memory and executive functioning since both these areas of cognition are related to functional abilities (Desai et al., 2004; Gold, 2012; Royall et al., 2007). Research on the incremental validity of episodic future thinking could help determine if this construct is worth measuring in a clinical neuropsychological setting (Ward, 2016).

The Relationship between Episodic Future Thinking and Adaptive Functioning

Episodic future thinking would be helpful in a clinical neuropsychological setting if it provides neuropsychologists with valuable information. As reviewed by Ward (2016), there is some evidence to suggest that episodic future thinking has predictive validity with respect to domains of adaptive functioning, including decision-making, goal processing, problem solving, and coping (Table 1) (Addis & Schacter, 2012; Atance & O'Neill, 2001; Boyer, 2008; Schacter, 2012; Schacter, Addis, et al., 2012; Szpunar, 2010).

The first subtype of adaptive functioning that is related to episodic future thinking is decision-making. Studies reveal that engagement in episodic future thinking results in reduced discounting of future rewards in comparison to immediate rewards in neurologically healthy participants (Benoit et al., 2011; Lin & Epstein, 2014; Palombo et al., 2015; Peters & Büchel, 2010). Palombo et al. (2015) showed that amnesic patients were unable to reduce temporal discounting after engaging in episodic future thinking due to their episodic future thinking deficits. However, research findings in amnesic patients are inconsistent, since other research has found patients with amnesia are able to reduce temporal discounting despite having episodic future thinking impairments (Kwan et al., 2012; Kwan et al., 2015; Kwan, Craver, Green, Myerson, & Rosenbaum, 2013). The second subtype of adaptive functioning that is related to episodic future thinking is goal-processing. For instance, when individuals mentally simulate attaining their goal in the future, their performance improves and they are more likely to accomplish their goal (Pham & Taylor, 1999; Taylor, Pham, Rivkin, & Armor, 1998).

The two last subtypes of adaptive functioning that are related to episodic future thinking are problem-solving and coping. Episodic future thinking has been found to be positively associated with problem-solving strategies (Madore & Schacter, 2014). Furthermore, research has suggested that episodic future thinking improves coping during problem solving through decreased worry and preparation (Brown, Macleod, Tata, & Goddard, 2002; Taylor et al., 1998; Taylor & Schneider, 1989).

Despite research examining the relationship between episodic future thinking and adaptive functioning, few studies have objectively measured episodic future thinking when investigating this relationship. Madore and Schacter (2014) and Palombo et al. (2015) objectively measured episodic future thinking and how it related to adaptive functioning. Madore and Schacter (2014) found that in older and young adults internal details were positively associated with problem solving, but semantic details were not significantly associated with problem solving. Palombo et al. (2015) found that a component of internal details (namely perceptual details) was associated with reduced delay discounting in healthy individuals. Based on these studies, internal details are associated with domains of adaptive functioning. Even though other studies exploring episodic future thinking and adaptive functioning did not use a formal episodic future thinking task, most conclude that prompting individuals to form internal details about the future improves adaptive functioning.

Overall, decision-making, goal processing, problem solving and coping are all relevant to recommendations given by clinical neuropsychologists. Episodic future thinking seems to be an important cognitive contributor to adaptive functioning, especially internal details. The evidence suggests that episodic future thinking may have some clinical utility. It is possible that episodic future thinking could improve upon neuropsychologists' abilities to predict functional abilities, since standard neuropsychological measures do not sufficiently predict everyday functioning (Mcalister, Schmitter-Edgecombe, & Lamb, 2016; Royall et al., 2007).

Adaptive Functioning in Clinical Neuropsychology

Neuropsychologists are interested in predicting patients' abilities to engage in adaptive behavior. Adaptive behavior is defined as "the collection of conceptual, social, and practical skills that have been learned and are performed by people in their everyday lives" (Schalock et al., 2010). In clinical neuropsychological literature, there are two domains of adaptive behavior: instrumental activities of daily living (IADLs) and basic activities of daily living (ADLs).

Basic ADLs are defined as activities that are necessary for self-care, including domains such as bathing, dressing, grooming, mobility, toileting, and feeding (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963). This domain is considered less complex than IADLs and more related to mobility than cognitive functioning. IADLs are abilities that allow one to adapt to the environment in order to live independently (Lawton & Brody, 1969) and include the following domains: handle finances, prepare food, clean, laundry, conversation, transportation, shopping, using the telephone, and accurate medication use. Patients who are neurologically compromised have impairment in their IADLs (Aretouli & Brandt, 2010; Hariz & Forsgren, 2011; Marshall et al., 2011; Mioshi et al., 2007; Pérès et al., 2006; Reppermund et al., 2013; Stephens et al., 2005). Measuring ADLs or IADLs can also be used to determine whether a person needs full time care in a nursing home (Andel, Hyer, & Slack, 2007; Black, Rabins, & German, 1999; Gaugler, Duval, Anderson, & Kane, 2007; Smith, O'brien, Ivnik, Kokmen, & Tangalos, 2001; Wattmo, Wallin, Londos, & Minthon, 2011). Furthermore, impairments in IADLs can occur early before diagnosis of dementia and IADL performance can help predict future decline (Pérès et al., 2008; Sikkes et al., 2011; Tabert et al., 2002).

Measurements have been developed to assess basic ADLs and IADLs. These measures have mainly been developed for older adults, patients with dementia, or patients with neurological conditions. Basic ADLs and IADLs can be measured in a self-report format, informant report format, or using a performance-based measure. Self-report tends to be challenging to give to patients with neurological deficits since they are not accurate reporters of their functioning and may lack insight (Carr, Gray, Baty, & Morris, 2000; Ecklund-Johnson & Torres, 2005; Roberts, Clare, & Woods, 2009; Vogel et al., 2004). Performance-based measures may be more accurate description of functional abilities, but they can be time consuming (Desai et al., 2004). Most informant report measures contain multiple choice questions arranged in a hierarchy ranging from no independence to fully independent. Other measures assess the change in IADLs over time. Information is collected from a close family member, friend, or from a caregiver. In a clinical setting, clinicians may fill out a measurement based on their knowledge of the patient. The main informant report IADL measure for patients with dementia is the Lawton Instrumental Activities of Daily Living Scale (Lawton & Brody, 1969). Several informant report measures of basic ADLs include the Barthel Activities of Daily Living Index (Mahoney & Barthel, 1965), Physical Self Maintenance Scale (Lawton & Brody, 1969), and the Katz Index of Activities of Daily Living (Katz et al., 1963). More recently, measures have been developed to capture changes in IADLs in older adults and patients with dementia, such as the Everyday Cognition Scale (Farias et al., 2008). While used less frequently, performance-based tasks measure performance of similar activities to the informant report measures. Examples of performance-based IADL measures include the Everyday Problems Test (Willis & Marsiske, 1993), Independent Living Scales (Loeb, 1996), Direct Assessment of Functional Abilities (Loewenstein et al., 1989), and the Observed Tasks of Daily Living (Diehl, Willis, & Schaie, 1995). The Katz Index of Activities of Daily Living can also be used as a performance-based measure of basic ADLs through observation of the patient (Katz et al., 1963). This study concentrates on IADLs since this domain is more sensitive to early decline and cognition rather than physical functioning.

Neuropsychologists assess various domains of cognitive functioning to understand the cognitive contributors to IADLs. Studies have examined various tasks used in clinical neuropsychological assessment with respect to IADLs, including general cognitive functioning, memory, executive functioning, processing speed, language, visuo-spatial functioning, attention, among others (Desai et al., 2004; Gold, 2012; Royall et al., 2007). Research has found that general cognitive functioning appears to be the strongest predictor of IADLs (Royall et al., 2007). When examining individual cognitive domains, executive functioning is the strongest predictor of IADLs within neuropsychological assessment, and memory has also been found to be a significant predictor of IADLs (Desai et al., 2004; Gold, 2012; Royall et al., 2007).

While a relationship has been found between standard measures of cognition and IADLs, research is variable in terms of significance of these relationships and magnitude of the effects. Royall et al. (2007) conducted a review and examined the association between cognition and functional outcomes across studies. They examined specific domains of cognition as well general cognitive measures. They found that the relationship between cognition and functional abilities was variable with the total variance explained ranging from 0% to 78%. They found that on average, the variance explained in functional abilities by cognition was modest at 21%. This finding suggests that the practical and statistical significance of these relationships varies across the literature. Mcalister et al. (2016) also examined this question by conducting a meta-analyses of the literature to study the relationship between cognition and functional status in patients with mild cognitive impairment. The study found that cognition explained 20% to 37% of the variance in functional status. The authors concluded that there is a large amount of variance that is left unexplained and improvements could be made in the ability to predict functional abilities. Overall, standard measures of cognition modestly predict functional abilities across the literature. Gold (2012) identified potential sources of variability in findings, such as the different measures used to assess IADLs (i.e., informant versus self-report versus performance-based measures), diversity of cognitive assessments within each domain, or the cognitive domains chosen to be included in prediction models. Another possible source of variability is the participants included in the study. Overall, found that regardless of the domain, cognition explains a modest amount of the variance in functional status. Thus, episodic future thinking may improve upon the connection between cognition and functional abilities in a clinical neuropsychological setting.

Gaps in the Literature Regarding the Clinical Utility of Episodic Future Thinking

Evidence suggests that episodic future thinking may provide information about adaptive functioning due to its connection to decision-making, goal-processing, problem-solving, and coping. Episodic future thinking could also be investigated with respect to IADLs. Episodic future thinking could improve recommendations given by clinical neuropsychologists for independent living.

A second area that has not been addressed is investigating the relationship between episodic future thinking and functional abilities among a heterogeneous neurological population. Episodic future thinking and its connection to adaptive functioning was only explored in healthy young adults, healthy older adults and patients with amnesia. To determine if episodic future thinking is useful in a clinical setting, a robust relationship between these two constructs must be established across populations. There is a limitation to this approach since the relationship could be impacted by the neurological populations included in the study. However, impairments in internal details are consistent across neurological populations based on previous literature. Furthermore, to be valuable in a clinical setting, episodic future thinking would need to provide information about functional abilities across neurological populations.

Another area of research that has not been addressed is the information that episodic future thinking provides to clinical neuropsychologists over and above constructs currently measured in a clinical neuropsychological setting. Improvement is needed in the prediction of functional abilities to allow neuropsychologists to give more accurate recommendations surrounding independent living. The relationship between standard neuropsychological assessments, such as memory and executive functioning, and functional abilities is modest. While standard neuropsychological measures only have a modest relationship with functional abilities, they are reliable and valid tasks and have normative data. Furthermore, standard neuropsychological tasks will continue to be included as part of the standard neuropsychological battery since they provide diagnostic specificity regarding neurological conditions and neural damage, adequately assess change over time, and help identify appropriate treatments or interventions. Clinical neuropsychologists have to be selective in terms of the tests they choose due to limited time available with each patient. Episodic future thinking could be valuable if it provides information about functional abilities over and above standard clinical neuropsychological tasks.

Summary

Episodic future thinking has been studied at some length from a cognitive neuroscience perspective. Within this research, a core neural network associated with episodic future thinking has been identified and various cognitive processes have been found to be involved in episodic future thinking. Research has also suggested a relationship between episodic future thinking and domains of adaptive functioning. While a relationship has been found between standard cognitive assessments and IADLs, data suggest that this association is modest. Clinical neuropsychologists rely on standard tests such as measures of memory and executive functioning to determine an individual's functional abilities. Neuropsychologists could make incorrect assumptions about real-world functional abilities when basing their judgment on standard cognitive assessments. Episodic future thinking may provide critical information to clinical neuropsychologists so they can improve their predictions about independent living. It is unclear if episodic future thinking has clinical utility that is not already provided from standard neuropsychological assessments. The current study can help determine if episodic future thinking provides information about functional abilities and if this information is unique from the information provided from standard neuropsychological assessments.

AIMS AND HYPOTHESES

The aims focus on older adult populations, defined as persons 55 years old or older. This is because functional deficits are common within an older adult neurological population, and can also be challenging for many healthy older adults. Functional deficits are much less relevant to a younger adult population. Exploring predictors of IADLs within older adults is important and highly relevant to a clinical neuropsychological setting. The relationship between episodic future thinking and IADLs was examined in a heterogeneous neurological population since a robust relationship between these two constructs must be established to determine if episodic future thinking is useful in a clinical setting. The prediction of IADLs from episodic future thinking was examined in both a heterogeneous neurological population and healthy older adults to allow for more variability in measures of interest, including episodic future thinking, domains of cognitive functioning, and IADLs. Furthermore, episodic future thinking has been examined in healthy older adults and a range of neurological conditions, and previous research suggests the relationship between episodic future thinking and functional abilities is relevant for both healthy older adults and patients with neurological conditions (Benoit et al., 2011; Lin & Epstein, 2014; Liu, Feng, Chen, & Li, 2013; Madore & Schacter, 2014; Palombo et al., 2015; Peters & Büchel, 2010; Taylor et al., 1998; Taylor & Schneider, 1989).

Aim One

To examine episodic future thinking in an older adult heterogeneous neurological population, and compare this population to an age-matched sample of healthy older adults. Episodic future thinking performance, as measured by the adapted Autobiographical Interview (AI), was compared between an older adult heterogeneous neurological population and healthy older adults. There were two specific hypotheses under this Aim, as follows.

Hypothesis 1a: It was hypothesized that older adult patients with neurological disease would have impaired episodic future thinking performance when compared to healthy older adults, as indicated by fewer mean number of internal details in the AI performance. This hypothesis would be supported if significantly fewer mean number of internal details were included in episodic future thinking descriptions by the older adult heterogeneous neurological population when compared to healthy older adults. This hypothesis would be falsified if there was no significant difference in internal details between the older adult neurological population and healthy older adults or if healthy older adults provided fewer internal details than the older adult neurological population.

Hypothesis 1b: It was hypothesized that older adult patients with neurological disease would not differ significantly from healthy older adult comparisons on semantic details in their AI performance. This hypothesis would be supported if there was not a significant difference between semantic details included in episodic future thinking descriptions by the older adult neurological population when compared to healthy older adults. This hypothesis would be falsified if the two groups differed significantly in semantic details in their AI performance.

Aim Two

To investigate the relationship between episodic future thinking and instrumental activities of daily living in an older adult heterogeneous neurological population and healthy older adults. Episodic future thinking was measured using the mean proportion of internal details using the adapted AI task. IADLs were measured by 1) an informant report questionnaire called the Everyday Cognition Scale, and 2) a performance-based measure called the Independent Living Scales.

It was hypothesized that there would be a significant, positive relationship between episodic future thinking performance (as measured by internal details on the AI) and IADLs. This hypothesis would be supported if there was a significant, positive relationship between internal details and IADLs in a sample that included both an older adult heterogeneous neurological population and healthy older adults. This hypothesis would be falsified if there was no significant relationship or a negative relationship between internal details and IADLs in the sample.

Exploratory Aim

To investigate the relationship between episodic future thinking and instrumental activities of daily living over and above standard neuropsychological assessments in an older adult heterogeneous neurological population and healthy older adults. Episodic future thinking and IADLs were measured as specified in Aim #2. Standard neuropsychological assessments included memory and executive functioning. For each of these domains, a composite variable was created, based on various specific measures (described in detail in the Methods section).

It was hypothesized that episodic future thinking (as measured by internal details) would have a significant, positive relationship with IADLs in an older adult heterogeneous neurological population and healthy older adults, over and above what was accounted for by episodic memory. It was hypothesized that episodic future thinking (as measured by internal details) would have a significant, positive relationship with IADLs in an older adult heterogeneous neurological population and healthy older adults over and above what was accounted for by executive functioning. These hypotheses would be supported if a significant, positive relationship was found between episodic future thinking and IADLs after accounting for standard neuropsychological measures of memory and executive functioning. These hypotheses would be falsified if a significant, positive relationship was not found between episodic future thinking and IADLs after accounting for the standard neuropsychological measures.

METHODS

Participants

There were 107 participants in this study. All participants were age 55 or older. 65 older adult patients with neurological disease and 42 healthy older adult participants were enrolled in this study. The specific neurological diagnoses were provided in the neuropsychological report from the Benton Neuropsychology Clinic. All work was conducted with the formal approval of the University of Iowa Institutional Review Board. Exclusion criteria are outlined in Table 3 for both healthy older adult and patients with neurological disease. Exclusion criteria consisted of the following: intellectual disability, history of a learning disability, a neurodevelopmental disorder, any psychiatric condition (besides a current diagnosis of major depression or anxiety that is treated and stable), a history of being an inpatient for drug or alcohol abuse, impaired and uncorrected vision or hearing, severe dementia as indicated by an MMSE score < 10 (Perneczky et al., 2006), being involved in litigation, and age less than 55. This MMSE cutoff was chosen since patients with severe dementia would have significant difficulty engaging in the research tasks and previous studies in patients with dementia included patients with MMSE scores in the mild to moderate impairment range (MMSE scores between 10 and 25) which allowed them to capture deficits in functional abilities (Bucks, Ashworth, Wilcock, & Siegfried, 1996; Mathuranath, George, Cherian, Mathew, & Sarma, 2005; Mioshi et al., 2007; Norton, Malloy, & Salloway, 2002; Wlodarczyk, Brodaty, & Hawthorne, 2004; Zanetti, Geroldi, Frisoni, Bianchetti, & Trabucchi, 1999). Regarding healthy older adults, the same overall exclusion criteria applied, with the addition of a history of a neurological condition. Eligibility was determined through patient and caregiver interviews and review of the medical record. The Mini Mental Status Exam (MMSE) was administered in person during data collection.

The older adult patients with neurological disease were recruited through the Benton Neuropsychology Clinic in the University of Iowa Hospitals and Clinics. Recruitment of neurological patients from the Benton Neuropsychology Clinic were completed by the following steps. First, patient files from the Benton Clinic were reviewed to identify eligible participants. Patients who were eligible were mailed information about the study and were provided the opportunity to decline participation by mailing back a decline form. Patients who did not decline participation within two weeks were called and recruited for the study. If they were interested in the study, screening questions (based on exclusion criteria outlined in Table 3 besides the MMSE) were administered via telephone to verify that the participants were eligible. If they agreed to participate, they were invited to the lab to complete the study.

Patient files were examined from patients seen in the Benton Neuropsychology Clinic from September 2015 through August 2016. A total of 817 patients were seen during this period of time. 240 of these patients met inclusion criteria for the research study as identified through chart review (29.4% of the patients seen in the Benton Clinic). 105 participants were not interested in participating and 72 patients did not return calls. A total of 65 patients with neurological conditions were tested in the study (8.0% of patients seen in the Benton Clinic). This information was outlined in Table 4.

The healthy older adult participants were recruited through the Cognitive Neuroscience Registry for Normative Data and mass emails at the University of Iowa. Older adults in the registry were recruited via telephone to participate in the research study. If the individual was interested in the study, screening questions were administered. Individuals who expressed interest in the study in response to the mass email were contacted and the same screening questions were administered. Screening questions were administered via telephone based on the exclusion criteria outlined in Table 3 (besides the MMSE).

78 participants either responded with interest to mass emails or were contacted through the older adult registry. 5 participants declined participation and 31 participants did not return calls. A total of 42 older adult comparison participants were tested in the study (53.8% of the 78 participants). This information was outlined in Table 4.

Patients and healthy older adults were paid $12.50 an hour to complete the study. The two groups were matched on mean age and education. All participants gave written consent to the research study. A standardized assessment (DeRenzo, Conley, & Love, 1998) was used to determine whether patients with neurological conditions could consent to the study. If patients with neurological conditions could not consent, their caregivers provided informed consent and the participants provided assent.

There were five participants that were initially enrolled in the study that had to be excluded. One participant did not complete the visit and four participants did not report an ineligible past history during the initial screening (one patient had a history of inpatient psychiatry admission due to alcohol use, one participant had macular degeneration which interfered with the ability to complete cognitive tasks, and two participants had bipolar disorder). The final sample included 61 patients with a neurological condition and 41 healthy older adults. The neurological diagnoses were based on the diagnoses provided in the neuropsychological reports.

Measures

Demographics and mood. Patients or their caregivers filled out a demographics questionnaire. The Beck Depression Inventory Second Edition (Beck, Steer, & Brown, 1996) was administered as a measure of depression. The Beck Depression Inventory can be categorized into the following: minimal depression (0-13), mild depression (14-19), moderate depression (20-28), and severe depression (29-63). The Beck Anxiety Inventory (Beck & Steer, 1993) was administered as a measure of anxiety. The Beck Anxiety Inventory can be categorized into the following: minimal anxiety (0-7), mild anxiety (8-15), moderate anxiety (16-25), and severe anxiety (26-63).

Minimal Mental State Exam (MMSE). The MMSE is a standardized assessment to measure global cognitive functioning (Folstein, Folstein, & McHugh, 1975). An MMSE score of less than 26 indicates cognitive impairment (Perneczky et al., 2006). The MMSE can be categorized into the following cutoff scores: mild (21-25), moderate (11-20), and severe cognitive impairment (0-10) (Perneczky et al., 2006). Patients with severe cognitive impairment based on the MMSE were excluded from the study.

Adapted Autobiographical Interview. The episodic future thinking task (Addis et al., 2008) was adapted Autobiographical Interview (AI) (Levine et al., 2002) to measure thinking in the future. In the adapted AI task, participants were instructed to describe five specific events in as much detail as possible in response to verbal cues. Participants were asked to respond with an event that could occur three to five months from the current date. They were given three minutes to describe each event once they had chosen an event. Participants were required to provide a novel event that could reasonably occur and that did not last longer than one day. Participants were not required to include the verbal cue in their description. The following verbal cues were used: going to a sporting event, being visited by someone, going on a vacation, giving assistance to someone, and making a large purchase. These verbal cues have been used in previous studies on autobiographical memory (Levine et al., 2002). Prompts would be provided if the participant was silent for 30 seconds or if the participant provided an off-topic or vague response. This task took about around 30 minutes to 60 minutes to administer. Instructions for this task are provided in Figure 2.

The results of the adapted AI task were scored by the scoring method proposed by Palombo et al. (2015), which was slightly modified from Addis et al. (2008) and Levine et al. (2002). In this scoring method, a central event is chosen based on the most fundamental event described. Within the central event, internal and semantic details are identified. Internal details signify episodic details. As mentioned previously, internal details were categorized into the following: event, place, time, perceptual, or thought/emotion. Semantic details are general knowledge and facts, ongoing events, and extended states of being. Semantic details were categorized into general semantic, semantic autobiographical, semantic time, and semantic place details. The remaining details were in a category called "other" which included details that were unrelated to the main event described by the participant, repetitions and metacognitive statements. Internal details and semantic details were scored based on the mean number of details. To account for the length of future descriptions, the proportion of internal to total details was also calculated (Cole et al., 2013; Kurczek et al., 2015; Sheldon, McAndrews, & Moscovitch, 2011). A scored transcript from the current study is provided in Figure 1. Two raters coded episodic future thinking performance from a random subset of participants (10 healthy older adults and 12 patients with neurological disease) to establish inter-rater reliability. An intraclass correlation found that the two raters scored the transcripts in a reliable manner (Cronbach's alpha: internal details=.92, semantic details=.84).

Instrumental activities of daily living. Two measures were used to examine IADLs: an informant report IADL measure and a performance-based IADL measure. The informant report measure used in this study was The Everyday Cognition scale (Figure 3) (Farias et al., 2008). The Everyday Cognition Scale was developed to assess functional abilities of older adults through mild to moderate dementia. The informant rates the patient's ability to perform everyday tasks now as compared to the patient's ability to complete the tasks 10 years ago. The measure contains 39 items. The Everyday Cognition Scale was scored based on the average overall rating with a maximum score of 4. The informant ranks the individual from 1-4, with 1 as better or no change as compared to 10 years earlier, 2 for questionable/occasionally worse, 3 for consistently a little worse, 4 for consistently much worse. An overall score is provided and there also scores for the following domains: everyday memory, everyday language, everyday visuospatial functioning, everyday planning, everyday organization, and everyday divided attention. The overall score was the score used for the Everyday Cognition Scale in this study. Previous research has found evidence of adequate test-retest reliability, concurrent validity, and external validity (Farias et al., 2008). The Everyday Cognition Scale had sufficient internal consistency in this sample as indicated by a Cronbach's alpha of .82.

The eligibility criterion for the informant was that they must have known the participant for at least 10 years. The informant filled out the questionnaire in person or through the mail. The informant filled out the following information: their relationship with the participant, how long they have known the participant, whether they live with the patient, how many days a week on average they spend time with the participant, how many hours a week on average they spend time with the participant, their age, their education, and their gender. The Everyday Cognition Scale was referred to as informant reported IADLs throughout the rest of the paper.

The performance-based measure of IADLs used in this study was The Independent Living Scales (ILS) (Loeb, 1996). The scale assesses the following domains: Memory/orientation, managing money, managing home and transportation, health and safety, and social adjustment. The ILS was examined using the total score. The maximum total score on the ILS is 140. The ILS contains questions that require participants to complete a certain act to get a correct answer or questions that require a certain verbal response. The ILS takes around 45 minutes to administer. Normative data is provided in the ILS manual. The ILS has data on the performance of the following populations: Adults with mental retardation, traumatic brain injury, dementia, chronic psychiatric disturbance, major depression, and schizophrenia. Evidence suggests the ILS has adequate internal consistency, interrater reliability, test re-test reliability, content validity, concurrent validity, criterion validity, and construct validity (Loeb, 1996). The ILS had sufficient internal consistency in this sample as indicated by a Cronbach's alpha of .95. The ILS was referred to as performance-based IADLs throughout the rest of the paper.

Neuropsychological assessment. Two domains of neuropsychological functioning were investigated, namely, episodic memory and executive functioning. The following memory measures were administered: Rey Auditory Verbal Learning Test (AVLT) (Rey, 1964), Benton

Visual Retention Test (BVRT) (Sivan, 1992) and the Logical Memory II (Delayed Recall) Test from the Wechsler Memory Scale Third Edition (Wechsler, 1997). A composite memory score was made from the RAVLT Long Delay Recall and Logical Memory II Delayed Recall. BVRT was not included in the memory composite score since it did not have a delay component. These measures were chosen since various verbal and visual memory tasks have been significantly associated with IADLs (Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000; Gold, 2012; Royall et al., 2007). A composite executive functioning score was created based on the following measures: Trail-making B minus A (time in seconds) (Reitan & Wolfson, 1985), Controlled Oral Word Association test (Benton et al., 1994), and the Color Word condition of the Stroop Color and Word Task (Golden & Freshwater, 2002). These measures were chosen since they have been significantly associated with IADLs (Cahn-Weiner et al., 2000). To create composite scores, z scores were calculated based on the raw memory and executive functioning tests from the entire sample. Then the z scores were averaged for each domain to create make a composite memory score and composite executive score. Previous research has found that these neuropsychological measures map onto the latent constructs of memory (Smith et al., 1992; Smith, Ivnik, Malec, & Tangalos, 1993) and executive functioning (Greenaway, Smith, Tangalos, Geda, & Ivnik, 2009; Hayden et al., 2011).

Retrospective neuropsychological data from the Benton Neuropsychological Laboratory were used if the patients were assessed within 6 months of the research study. Most of the neuropsychological data were collected for the neuropsychological populations since the AVLT, Logical Memory Test, Benton Visual Retention Test, COWA, Trails B-A, and Stroop are commonly administered within the Benton Neuropsychology Clinic. If these measures were not included in the Benton Neuropsychology Clinic, they were collected in the context of this research project. The neuropsychological data were collected for the healthy older adult comparisons within the context of the current study.

Statistical Approach and Data Analysis

Demographics and cognition: Demographic and cognitive variables were compared between individuals with and without neurological disease. T-tests were used for continuous variables that were normally distributed and Mann-Whitney U tests were used for continuous variables that were not normally distributed (e.g., depression, anxiety, and MMSE). A chi-square test was used to compare gender between groups.

Aim One. Episodic future thinking internal details and semantic details were compared for the older adult neurological group and healthy comparisons using a 2 (Detail: Internal vs. semantic) by 2 (Group: Neurological vs. healthy older adults) mixed factorial ANCOVA. Detail was included as a within-subjects factor and group was included as a between-subjects factor. Since participants were matched on age and education, these variables were not included as covariates. Gender and depression were used as covariates if they significantly correlated with episodic future thinking. Internal and semantic details were examined using the mean number of details.

Aim Two. Episodic future thinking internal details were examined in relation to the IADLs by conducting partial correlations in the older adult heterogeneous neurological population and healthy older adults. All participants were included in this analysis to examine a wide range of performance on episodic future thinking and IADL tasks. Age and education were selected as a priori covariates due to their relationship with IADLs. Gender and depression were included as covariates in both models if they were significantly associated with performance-based or informant reported IADLs. Episodic future thinking was examined using the mean proportion of internal to total details to account for the length of descriptions. Internal details were explored since previous research has found them to be associated with adaptive functioning (Madore & Schacter, 2014; Palombo et al., 2015), and there was a restricted range of semantic details in our study.

Separate partial correlations were conducted for the informant reported IADL measure and the performance-based measure of IADL. Since the informant report measure of IADLs was positively skewed (most informants reported minimal IADL difficulties (mean=1.7, SD=0.7)), a rank-order partial correlation was used to examine the relationship between episodic future thinking and informant reported IADLs. A total of two partial correlations were conducted. The analyses were corrected for multiple comparisons using Holm's sequential Bonferroni procedure.

Exploratory aim. A hierarchical multiple regression was used to determine if episodic future thinking was associated with IADLs while accounting for a domain of clinical neuropsychological assessment. Similar to aim 2, all participants were included in this analysis so a wide range of performance on episodic future thinking and IADL tasks could be examined. Age and education were selected as a priori covariates due to their relationship with IADLs. Gender and depression were included as covariates in both models if they were significantly associated with performance-based or informant reported IADLs. Episodic future thinking was examined using the mean proportion of internal to total details to account for the length of descriptions. The two cognitive domains of interest were episodic memory and executive functioning. Separate models were run for the episodic memory and executive functioning, as well as the informant reported IADL measure and the performance-based measure of IADL. A total of four hierarchical regression models were conducted. Since the residuals were positively skewed for the informant reported IADL measure, a logarithmic transformation was used. The analyses were corrected for multiple comparisons using Holm's sequential Bonferroni procedure.

In the analyses for the exploratory analyses and for aim 2, I chose not to take group into account. I predicted that there would be a relationship between episodic future thinking and functional abilities in patients with a wide spectrum of cognitive functioning. I did not predict that there would a difference in the relationship based on group. Previous research has shown a relationship between episodic future thinking and adaptive functioning in both healthy and neurological patients (Benoit et al., 2011; Lin & Epstein, 2014; Palombo et al., 2015; Peters & Büchel, 2010). Thus, I chose to approach cognitive and IADL abilities as a continuum between healthy and neurological patients. This was supported further by the data in Figure 5.

Power analyses for study aims. Power analyses were completed for both aim 1 and aim 2 to determine the number of participants needed to detect a significant effect within the analyses. Since aim 2 provides the higher number of participants needed, the number of participants that were included in the overall study exceeded the number required from the aim 2 power analysis.

Aim 1: Previous research has found a moderate effect size of d=.62 when comparing episodic future thinking performance between an older adult neurological population and healthy comparison (de Vito et al., 2012). Assuming a moderate effect and 80% power, 12 participants would be required in each group.

Aim 2: A power analysis was conducted for aim 2 to detect a moderate effect between episodic future thinking and IADLs in an older adult heterogeneous neurological population and healthy older adults. In previous research, a moderate effect size of r=.46 was found when examining the relationship between episodic future thinking and adaptive functioning ((Madore

& Schacter, 2014). Assuming a moderate effect and 80% power, 54 participants would be required.

Exploratory aim. A power analysis was conducted for the exploratory aim to detect a small effect between episodic future thinking and IADLs over and above standard neuropsychological assessment in an older adult heterogeneous neurological population and healthy older adults. Although a moderate relationship (r=.46; Madore and Schacter (2014)) was found between episodic future thinking and adaptive functioning in previous research, this study did not examine the relationship over and above standard neuropsychological measures. Due to the potential overlap in the predictors, a small effect was estimated. Assuming a small effect and 80% power, 395 participants would be required. This analysis is underpowered and as a result it is an exploratory aim. Since 395 participants would not be a feasible number to test in this study, the highest amount of participants that was feasible to test was included in the study, which was at least 100 participants. If significant results were not found, it was likely due to an underpowered analysis or due to episodic future thinking having no effect or a very small effect over and above neuropsychological assessments.

RESULTS

Participant Characteristics

Patients with a neurological condition had an average age of 69.1 and their average years of education was 15.5. The patients with a neurological condition had 37.7 percent females. Their mean MMSE score was 26.0, and they reported a mean BDI score of 7.7 and mean BAI score of 5.6. Patients with a neurological conditions performed in the average range on executive functioning tests (Stroop Color Word mean scaled score = 8.7; Trails A mean scaled score = 9.6;

Trails B mean scaled score = 9.6; COWAT mean scaled score = 9.6) and in the average range on memory tests (AVLT mean scaled score = 8.7; logical memory II test mean scaled score = 9.3).

Older adult comparison subjects had an average age of 69.6 and their average years of education was 16.1. Regarding gender, they had 56.1 percent female. Their mean MMSE score was 28.0 and they reported a mean BDI score of 4.9 and a mean BAI score of 2.8. Older adult comparisons performed overall in the average range on executive functioning tasks (Stroop Color Word mean scaled score = 11.8; Trails A mean scaled score=11.7, Trails B mean scaled score=12.6; COWAT mean scaled score = 12.0). They performed in the average range on the AVLT (mean scaled score = 12.0) and in the high average range on the logical memory II test (13.2).

Differences between Older Adults Patients with Neurological Disease and Healthy Older Adults in Demographic Variables and Cognition

Demographic and cognitive performances are presented in Table 5. Individuals with a neurological condition performed significantly lower on the MMSE (p = .002), and they reported significantly higher depression (p = .006) and anxiety (p = .002). There were no significant differences in age and education. There was a numerical difference between groups based on gender ratios (37.7 % female in patients with neurological disease and 56.1% female in healthy older adults). This numerical difference was due to the available individuals able to participate in the study. However, there was not a statistically significant difference between groups based on gender (p = .067).

Individuals with a neurological condition performed significantly worse on the standard memory tasks, including AVLT long delay recall (p < .001) and the Logical Memory II subtest (p < .001). Individuals with a neurological condition performed significantly worse on executive functioning tasks, including the Stroop Color Word Task ($p < .001$), COWA ($p < .001$), and Trails B minus A ($p < .001$). Individuals with a neurological condition performed worse on the performance-based measure of IADLs ($p < .001$). Individuals with a neurological condition were rated by an informant as having significantly more difficulty on IADLs ($p < .001$), with an 87% response rate from informants. Table 6 illustrates the demographic and cognitive performances within each neurological population tested. Table 6 was provided to gain a better understanding of the types of neuropsychological deficits within each neurological population which could influence performance on IADLs.

Differences between Older Adults Patients with Neurological Disease and Healthy Older Adults in Episodic Future Thinking Performance

Episodic future thinking internal details and semantic details were compared for the older adult neurological group and healthy comparisons using a mixed factorial ANCOVA (Figure 4). Gender was included as a covariate since it was significantly associated with episodic future thinking performance. There was no statistically significant interaction between detail (internal vs. semantic) and group (neurological vs. healthy older adults) ($p = .265$). There was not a main effect of group suggesting that participants with neurological conditions provided a similar amount of overall details in their future descriptions as healthy older adults ($p = .085$). There was a main effect of detail, $F(1,99) = 235.884$, p=<.001, partial $\eta^2 = .704$, suggesting that overall (including both groups) participants reported more internal details (mean=26.8, S.D.=10.8) were reported than semantic details (mean=4.3, S.D.=2.9).

Follow-up paired-samples t-tests were run to determine if differences in episodic future thinking performance (average internal and semantic details) between healthy older adults and patients with neurological conditions emerged when two groups were matched on age, education, and gender. Participants were matched on age and education if they were within 2 years of each other regarding age or education. 24 healthy older adults and 24 patients with a neurological condition were able to be matched for these analyses. Using the paired-samples t-tests, no differences were found between healthy older adults and patients with neurological conditions on internal details (p = .094) and semantic details (p = .468)

Relationship between Episodic Future Thinking and Instrumental Activities of Daily Living

Partial correlations were conducted to explore the relationship between the mean proportion of internal details and IADLs. The relationships were examined in all participants from both groups. Gender and depression were found to be significantly associated with IADLs. Age, education, gender, and depression were included as covariates. There was a small, positive relationship between the mean proportion of internal details and performance-based IADLs while controlling for age, education, gender, and depression (r = .26, p = .010, Table 7, Figure 5). The relationship between the mean proportion of internal details and informant reported IADLs while controlling for age, education, gender, and depression was not significant (p = .284, Table 7, Figure 6).

Relationship between Episodic Future Thinking and Instrumental Activities of Daily Living Over and Above Standard Measures of Cognition

Hierarchical multiple regression models were used to investigate the relationship between episodic future thinking and IADLs over and above standard neuropsychological assessments. The two domains investigated were memory and executive functioning. Four hierarchical regression models were conducted to account for each domain of cognition (e.g., memory and executive functioning) and the two IADL measures (e.g, performance-based and informant reported). Overall, age, education, gender, and depression were included as covariates. The models were run in all participants from both groups.

I examined the relationship between the mean proportion of internal details and IADLs over and above executive functioning. The performance-based IADL model was significant with age, education, gender, and depression entered into the first block, $F(4,96) = 7.775$, $p < .001$. In the second block, the addition of executive functioning to the prediction of performance-based IADLs led to a statistically significant increase in R^2 of .251, $F(1, 95) = 47.281$, $p < .001$. The addition of the mean proportion of internal details to the prediction of performance-based IADLs led to a statistically significant increase in R^2 of .025, $F(1, 94) = 4.866$, $p = .030$ (see Table 8). The informant reported IADL model was significant with age, education, gender, and depression entered into the first block, $F(4,83) = 3.523$, $p = .010$. In the second block, the addition of executive functioning to the prediction of informant reported IADLs led to a statistically significant increase in R^2 of .130, $F(1,82) = 14.644$, $p < .001$. The addition of the mean proportion of internal details to the prediction of informant reported IADLs did not lead to a statistically significant increase in R^2 ($p = .186$) (see Table 9).

I examined the relationship between the mean proportion of internal details and IADLs over and above memory. The performance-based IADL model was significant with age, education, gender, and depression entered into the first block, $F(4, 95) = 8.506$, $p < .001$. In the second block, the addition of memory to the prediction of performance-based IADLs led to a statistically significant increase in R^2 of .146, $F(1, 94) = 23.188$, $p < .001$. In the third block, the addition of the mean proportion of internal details to the prediction of performance-based IADLs did not lead to a statistically significant increase in R^2 ($p = .157$) (see Table 10). The informant reported IADL model was significant with age, education, gender, and depression entered into the first block, $F(4, 83) = 3.523$, $p = .010$. In the second block, the addition of memory to the prediction of informant reported IADLs led to a statistically significant increase of R^2 of .260, $F(1, 82) = 35.768$, $p < .001$. In the third block, the addition of the mean proportion of internal details did not lead to a statistically significant increase in R^2 ($p = .882$) (see Table 11).

DISCUSSION

The present study examined episodic future thinking in an older adult heterogeneous neurological population and healthy older adults. Episodic future thinking performance was compared between the older adult heterogeneous neurological population and healthy older adults. I also examined the relationship between episodic future thinking and IADLs in an older adult heterogeneous neurological population and healthy older adults. I included two measures of IADLs: performance-based IADLs and informant reported IADLs. Both IADL measures were impaired in the heterogeneous neurological population when compared to healthy older adults, which is consistent with previous literature (Aretouli & Brandt, 2010; Hariz & Forsgren, 2011; Marshall et al., 2011; Mioshi et al., 2007; Pérès et al., 2006; Reppermund et al., 2013; Stephens et al., 2005). Further, I investigated the relationship between episodic future thinking and IADLs over and above two domains of cognition, namely memory and executive functioning. These two constructs are commonly measured in clinical neuropsychological assessment and have been shown to be related to IADLs (Desai et al., 2004; Gold, 2012; Royall et al., 2007). This is the first study to directly examine whether episodic future thinking could provide useful information about functional abilities. This research question is especially relevant for a clinical neuropsychological setting.

Episodic Future Thinking Performance in Neurological Patients and Healthy Older Adults

Specific to aim 1, no differences were found in episodic future thinking performance (internal and semantic details) between the older adult heterogeneous neurological population and healthy older adults. This finding does not support the hypothesis that patients with neurological disease would have impaired internal details when compared to healthy older adults. While I tested neurological populations with a wide range of cognitive functioning (MMSE range = (16, 30)), the average MMSE performance in neurological participants was in the mild range (mean=25.92) (Perneczky et al., 2006). Therefore, the mild cognitive deficits in the current sample could have resulted in the lack of significant difference between the older adult heterogenous neurological group and the healthy older adults in episodic future thinking performance. Additionally, episodic future thinking performance has not been assessed in some of these populations, particularly in patients with normal pressure hydrocephalus, vascular dementia, and epilepsy. As a result, it is unclear what to expect with regard to their future thinking performance.

The hypothesis regarding semantic details was supported since patients with neurological disease did not differ significantly from healthy older adult comparisons. This finding supports previous literature suggesting variability in performance across neurological conditions regarding semantic details. Previous literature suggests that some patients with neurological conditions have no impairment in semantic details (Irish et al., 2013; Race et al., 2011), some have impairments in semantic details (Irish et al., 2013), and some report more semantic details than healthy older adults (de Vito et al., 2012; Gamboz et al., 2010).

The Relationship between Episodic Future Thinking and Functional Abilities

For aim 2, I found a significant relationship between episodic future thinking and performance-based IADLs. This supports previous literature suggesting a relationship between episodic future thinking and adaptive functioning, including decision-making, goal processing, coping, and problem-solving (Benoit et al., 2011; Lin & Epstein, 2014; Liu et al., 2013; Madore & Schacter, 2014; Palombo et al., 2015; Peters & Büchel, 2010; Taylor et al., 1998; Taylor & Schneider, 1989). This finding supports our hypothesis that episodic future thinking could be relevant to IADLs. Based on our findings, episodic future thinking may be a domain of cognition that aids individuals in anticipating the steps necessary to successfully complete IADLs, such as handling finances or completing errands. Episodic future thinking may help individuals adjust their plans appropriately if challenges arise when completing IADLs. Episodic future thinking may be a domain of cognition that clinical neuropsychologists should attend to when thinking about areas of cognition that may influence a patient's ability to successfully complete daily tasks.

While I found a significant relationship between episodic future thinking and performance-based IADLs, episodic future thinking did not significantly predict informant reported IADLs. There are several possible explanations for the non-significant relationship between episodic future thinking and informant reported IADLs. The first potential explanation is that the two IADL measures captured different constructs. However, this does not seem to be a sufficient explanation since informant reported IADL difficulties were associated with lower scores on the performance-based IADL measure ($r = -.48$, $p < .001$).

Another explanation is due to the limitations of informant-report measures. Previous research suggests that informant report measures of IADLs do not adequately capture IADL difficulties. Loewenstein et al. (2001) investigated functional abilities in patients with Alzheimer's disease through objective measures of functional abilities and informant report measures of functional abilities. They found that caregivers overestimated patients' abilities to engage in real-world tasks. They also found that higher MMSE scores in the patients with Alzheimer's disease was associated with caregivers' overestimation of functional abilities. They concluded that caregivers overestimated functional abilities in patients with mild cognitive difficulties. As a result, caregivers may think that patients with mild cognitive difficulties can successfully complete daily tasks when in fact they may be unable to complete these tasks. Similar results were found by Okonkwo et al. (2008) in patients with mild cognitive impairment. Okonkwo et al. (2008) investigated informant reports of financial abilities of patients with mild cognitive impairment. Patients with mild cognitive impairment also completed an objective measure of financial abilities. One main finding of the study was that informants overestimated the patients' abilities to complete financial tasks. They concluded that informants may have difficulty accurately assessing financial abilities in patients with mild cognitive impairment. Overall, research suggests that caregivers may not accurately report on the functional capacities of patients with mild cognitive deficits. Informant inaccuracy may have contributed to the limited variability in informant reported IADLs in this study as well.

Informant reports may also be influenced by caregiver burden. Literature suggests that caregiver burden may limit the accuracy of informant reports by caregivers. Neumann, Araki, and Gutterman (2000) conducted a review of the literature on informant reports for individuals older than 60 years. They found that a higher amount of responsibilities and stress reported by caregivers was associated with a negative evaluation of patients' health and well-being. Persson, Brækhus, Selbæk, Kirkevold, and Engedal (2015) examined the relationship between caregiver burden and informant report of IADLs by caregivers of patients with mild cognitive impairment and dementia. Findings showed that caregiver burden biased their informant reports of IADLs. Zanetti et al. (1999) examined personal characteristics of caregivers and how they impacted the relationship between caregivers' report of activities of daily living and the patient's objective performance on activities of daily living. Zanetti et al. (1999) found that the time demands associated with being a caregiver resulted in higher discrepancies between caregivers' reports of activities of daily living and patient objective performance on activities of daily living.

Depression has also been identified as influential to the accuracy of informant reports. Argüelles, Loewenstein, Eisdorfer, and Argüelles (2001) investigated depression in caregivers of patients with Alzheimer's disease and its effect on informant reports of activities of daily living. Patients with Alzheimer's disease completed a performance-based activities of daily living task. The findings showed that depression in caregivers was associated with errors when estimating the functional performance of patients with Alzheimer's disease. Jorm et al. (1994) examined informant reports of a community sample of healthy older adults and found that the informant reports were significantly associated with informants' self-reported depression. Based on the literature, the accuracy of informant reports may be compromised due to the difficulty in assessing mild functional impairment, caregiver burden and mood. As a result, episodic future thinking could have been related to performance-based IADLs but not informant reported IADLs since informants may have not accurately estimated functional abilities in this study. Future research could incorporate a measure of IADLs that better captures subtle IADL difficulties and account for factors that are known to influence informant ratings.

An additional explanation of the lack of the significant relationship between episodic future thinking and informant reported IADLs is that episodic future thinking may be more capable of predicting IADL performance in a controlled testing environment rather than in the unstructured real world. The performance-based measure of IADLs was conducted in a controlled testing environment, while the informant reported IADLs were based on observations of participants' functioning in the real world. The ability for episodic future thinking to predict performance-based but not informant-based measures may undermine the ecological validity of episodic future thinking. Ecological validity, defined as the extent to which neuropsychological performance reflects real-world functioning, is a common problem in neuropsychological assessment (Chaytor & Schmitter-Edgecombe, 2003). Neuropsychologists make recommendations about a patient's ability to live independently, drive, and handle finances, among many other tasks, and the accuracy of these recommendations greatly impact a patient's quality of life. Future research should examine the ecological validity of episodic future thinking by utilizing an IADL task that reflects real-world functioning.

To further explore the relationship between episodic future thinking and real-world functioning, future research could utilize naturalistic tasks designed to measure IADLs typical of the real-world environment (Robertson & Schmitter-Edgecombe, 2016; Schmitter–Edgecombe, McAlister, & Weakley, 2012). This research could help determine if episodic future thinking has sufficient ecological validity. As explained in Robertson and Schmitter-Edgecombe (2016), within clinical neuropsychological assessment clinicians and researchers have attempted to predict functional abilities with cognitive tasks, performance based tasks within a laboratory setting, self-report measures, and informant-report measures. However, self-report and informant-reports have notable limitations, such as being influenced by mood and insight. Some research suggests that cognition and performance-based measures of IADLs modestly predict real-world functional abilities. Tasks that mimic naturalistic settings have been developed to better capture real-world functional abilities and improve upon the ecological validity of neuropsychological assessment. Robertson and Schmitter-Edgecombe (2016) reviewed naturalistic tasks performed in realistic environments, such as settings that mimic vocational, kitchen, store, hospital, and home environments. While these tasks have limitations (such as limited research, high cost, the unknown applicability of the setting to each individual patient), there is evidence to suggest these tasks have better ecological validity than other IADL tasks. Investigating the relationship between episodic future thinking and naturalistic tasks could help clarify the ecological validity of episodic future thinking.

Incremental Validity of Episodic Future Thinking with Respect to Instrumental Activities of Daily Living

Specific to aim 3, I found a significant relationship between episodic future thinking and performance-based IADLS over and above executive functioning. This finding has important implications for the potential utility of episodic future thinking in a clinical setting. Executive functioning tasks have the strongest relationship to IADLs among clinical neuropsychological assessments (Gold, 2012). Currently, neuropsychologists rely on executive functioning tasks to understand functional limitations in patients with neurological conditions. My findings suggest that episodic future thinking provides information about daily functioning abilities beyond standard executive functioning tasks. It is possible that assessing episodic future thinking could allow neuropsychologists to make more accurate predictions about patients' abilities and lead to improved recommendations regarding treatment planning.

I also examined the relationship between episodic future thinking and performance-based IADLs over and above episodic memory. I found that episodic future thinking did not significantly predict performance-based IADLs when accounting for episodic memory. This finding suggests that episodic future thinking may provide similar information as episodic memory abilities when considering their relationship to IADLs. Given that episodic memory measures are a staple in neuropsychological practice (Marshall & Gurd, 2012), this finding challenges the notion of incorporating episodic future thinking into the clinical neuropsychological setting. As discussed in Ward (2016), there are advantages to measuring episodic memory. Reliable valid measures of episodic memory, such as the AVLT (Rey, 1964) and the Wechsler Memory Scale (Wechsler, 1997), are used extensively and can be efficiently administered and scored, unlike currently available episodic future thinking measures. Episodic memory tasks also have extensive normative data. Incorporating an episodic future thinking measure into the clinic does present with substantial obstacles (Ward, 2016). The current episodic future thinking task takes up to an hour to administer. Furthermore, episodic future thinking tasks take a long time to score since details have to be coded within each episodic future thinking description. If episodic future thinking does not provide unique information to neuropsychologists, it may not be a construct worth measuring. Future research is needed to determine whether measuring episodic future thinking within a clinical setting provides enough valuable information to be justified. This finding also suggests that future research consider memory when determining the clinical utility of future thinking, since these constructs may capture similar elements when predicting IADLs.

There are potential explanations for the non-significant finding regarding the relationship between episodic future thinking and performance-based IADLs over and above memory. Previous research has found that episodic future thinking is closely related to episodic memory (Schacter & Addis, 2007) and previous work has speculated about the potential overlap between episodic future thinking and clinical measures of episodic memory (Ward, 2016). It is possible that the overlap of episodic future thinking and episodic memory resulted in a null finding. However, episodic future thinking and memory were only moderately correlated ($r=.36$, $p<.001$). Another possibility for the null finding is due to insufficient power to examine this research question. Future studies could examine this question with a larger sample.

Limitations

There are several limitations in my study. One limitation is that the sample was all Caucasian, which may limit the generalizability of the results to different racial and ethnic groups. Also, as discussed previously, I chose to explore the relationship between episodic future thinking and functional abilities over and above standard measures of cognition as an exploratory aim. Future research could examine this research question with a larger sample size. Individuals were not asked why they chose not to participate in the study. As a result, I do not have a thorough understanding the reasons why they chose not to participate and how they may have differed from participants who did participate.

Another limitation to this study is that I examined a heterogeneous neurological population and it is possible that the relationship between episodic future thinking and IADLs differs by neurological population. Previous research has only examined the relationship between episodic future thinking and adaptive functioning within healthy adults, healthy older adults, and amnesic patients (Benoit et al., 2011; Lin & Epstein, 2014; Liu et al., 2013; Madore & Schacter, 2014; Palombo et al., 2015; Peters & Büchel, 2010; Taylor et al., 1998; Taylor & Schneider, 1989). I would speculate that episodic future thinking is the mechanism by which memory is related to functional abilities. This is supported by research that has found a relationship between memory and episodic future thinking (Addis et al., 2008; Cole et al., 2013; El Haj et al., 2015; Irish et al., 2012a; Irish et al., 2013), and a relationship between memory and IADLs (Desai et al., 2004; Gold, 2012; Royall et al., 2007). If this is the case, the relationship between episodic future thinking and functional abilities may be most relevant for amnesic populations. However, in previous research on amnesic patients, the findings are variable regarding the relationship between episodic future thinking and adaptive functioning (Kwan et al., 2012; Kwan et al., 2015; Kwan et al., 2013; Palombo et al., 2015). Future research could examine the relationship between episodic future thinking and functional abilities in individual neurological populations to aid in understanding if this relationship is more relevant for certain neurological populations. Another limitation is that the informant-based measure was skewed, since most informants reported minimal difficulties. Future research should use a measure of IADLs that better captures more complex adaptive behaviors.

We identified our comparison group as "healthy elderly" This term is used commonly in episodic future thinking research for older adult comparison groups that were screened for neurological conditions (Addis et al., 2009; Cole et al., 2013; Gamboz et al., 2010; Viard et al., 2014). However, our comparison participants were only screened verbally over the phone and it is possible that they had undiagnosed or subclinical neurological impairment. A limitation of our study is that we do collect data to confirm that the healthy older adults were truly neurologically healthy.

Future Research

Overall, the findings suggest that episodic future thinking significantly predicts performance-based IADLs. Moreover, episodic future thinking significantly predicts performance-based IADLs when accounting for executive functioning. While these findings provide some justification for incorporating episodic future thinking into a clinical neuropsychological setting, there are areas that need to be investigated before a future thinking measure could be considered useful to clinical neuropsychology.

Episodic future thinking measure. First, improvements are needed in the measurement of episodic future thinking. The current measure takes up to an hour to administer and extensive time to transcribe and score. The measurement, as is, would not plausibly fit into the time available in a clinical setting. Neuropsychologists have limited time to properly assess many different domains of cognition, emotion, and personality through interviews and objective testing. Afterwards, the test results must be scored efficiently. Spending hours assessing one domain of cognition would not be useful. If future research determines that episodic future thinking is worth including in clinical neuropsychological assessment, an episodic future thinking measure with more efficient administration and scoring would need to be developed. For example, to speed up the transcribing process, voice recognition software could be used and a detailed scoring manual could also be developed so clinicians can have a reference to quickly examine future thinking performance (Ward, 2016).

It is also worth considering whether we are adequately capturing the construct of episodic future thinking. It is possible that the current episodic future thinking task is not truly capturing the construct of episodic future thinking. For example, participants may be describing an event from the past while using future tense. While episodic future thinking is an elusive construct, future research could attempt to carefully evaluate how researchers can assess episodic future thinking in a more valid way.

The content validity of episodic future thinking. When developing a future thinking task, future research should examine the content validity of episodic future thinking. Based on a previous review (Ward, 2016), it is unclear what content is most important to measure in an episodic future thinking task. The adapted AI task is the main episodic future thinking task used in the literature and is the task used in this study. Though widely used, the adapted AI task is not administered in a similar fashion in every study and is still evolving. For example, the task varies on how many future events are described, how far the event is described in the future, and the words or phrases used to help participants think of future events. Furthermore, in recent studies the scoring of the adapted AI task has been modified to examine semantic details separately (Palombo et al., 2015). Previously, semantic details were put into a category named "external details," along with repetitions, events described that were not related to the central event, and meta-cognitive details (Addis et al., 2008).

In addition, there are several other tasks of episodic future thinking in the literature, such as the scene construction task (Hassabis et al., 2007), the Lived Future Questionnaire (Klein et al., 2002), the Known Future Questionnaire (Klein et al., 2002), and the Future Thinking Task (MacLeod & Byrne, 1996; Moore, MacLeod, Barnes, & Langdon, 2006). The scene construction task is similar to the adapted AI task, but it only measures episodic details (Hassabis et al., 2007). The Lived Future Questionnaire and the Known Future Questionnaire measure personal and non-personal events respectively, and they are scored by the plausibility of the described future event (Klein et al., 2002). The Future Thinking Task measures the amount of future events that can be produced in a short period of time (MacLeod & Byrne, 1996; Moore et al., 2006). Research within neurological conditions has mainly used the adapted AI task since episodic details and semantic details have been shown to be useful elements to measure within episodic future thinking. While progress has been made in understanding the content validity of episodic future thinking, future research could continue to clarify the content that is helpful to capture in an episodic future thinking task.

Language and episodic future thinking. Future research could consider the contribution of language to episodic future thinking performance. The only aspect of language that has been addressed in previous literature is the length of episodic future thinking descriptions. To verify that differences between healthy and neurological populations were not due to the length of descriptions, researchers have used various approaches to control for the length of descriptions. The main approaches that have been used are controlling for word count, controlling for fluency, or calculating episodic future thinking performance using the proportion of details. Additionally, previous studies have concentrated on populations that do not have language impairments.

If an episodic future thinking task was incorporated in a clinical neuropsychological setting, it would be important to have a more thorough understanding of how language influences episodic future thinking performance. Future research could examine different aspects of language in relation to episodic future thinking performance, such as examining neuropsychological tasks that measure naming, paraphasic errors, articulation, word finding, and comprehension. For example, if an individual has naming deficits, they may not include as many internal details in their future description since objects and people would be counted as internal details. It is also important to consider language aptitude, such as vocabulary, grammar, and sentence composition. Individuals who are verbally apt may perform better on episodic future thinking tasks. One clinical measure that includes subtests of language aptitude is the Wechsler Individual Achievement Test. Overall, various aspects of language abilities beyond fluency likely impact episodic future thinking performance. Future research could also examine whether episodic future thinking predicts functional abilities over and above language, since previous research has shown that verbal abilities are associated with functional abilities (Royall et al., 2007).

It is also possible that a limitation of episodic future thinking tasks is that they require verbal responses, since individuals may be able to engage in episodic future thinking despite language impairments. However, at this time we are not able to measure episodic future thinking without requiring a verbal response. Studies investigating aphasic populations have speculated that these patients are able to retain non-verbal representations of autobiographical memory (Greenberg & Rubin, 2003), which may apply to episodic future thinking as well. Future research could consider ways to measure episodic future thinking without requiring a verbal response.

Incremental validity of episodic future thinking over and above prospective memory and autobiographical memory. The relationship between episodic future thinking and IADLs was examined in this study over and above both episodic memory and executive functioning. Future research could consider the incremental validity of episodic future thinking with respect to IADLs over and above other domains of memory (Ward, 2016). Two domains of cognition that research has found to be related to episodic future thinking include autobiographical memory and prospective memory (Ward, 2016). Autobiographical memory is defined as memory of personal experiences (Brewer, 1986; Conway et al., 2001; Conway & Rubin, 1993). Ward (2016) conducted a review and found that autobiographical memory was strongly related to episodic future thinking (Addis et al., 2010; Addis et al., 2009; Addis et al., 2008; El Haj et al., 2015; Ernst et al., 2014; Gamboz et al., 2010; Irish et al., 2013; Race et al., 2011). Prospective memory is defined as remembering to carry out actions at a certain point in the future (McDaniel & Einstein, 2007). While less research has examined the relationship between episodic future thinking and prospective memory, there is some evidence that prospective memory and episodic future thinking are related (Addis et al., 2009; Altgassen et al., 2015;

Neroni, Gamboz, & Brandimonte, 2014; Terrett et al., 2016; Ward, 2016). However, autobiographical memory tasks and prospective memory tasks are not currently included in clinical neuropsychological assessment because they have similar limitations as episodic future thinking tasks (Ward, 2016). Both autobiographical memory tasks and prospective memory tasks are time intensive to administer and score. Autobiographical memory tasks are difficult to standardize and they may not have sufficient validity when relying on informant reports (Lezak et al., 2012). Improvement in the reliability and validity of prospective memory tasks is also needed (Fish, Wilson, & Manly, 2010; Lezak et al., 2012; McDaniel & Einstein, 2007; Phillips, Henry, & Martin, 2008).

While there are practical obstacles that need to be addressed with prospective memory and autobiographical memory tasks, it is possible that measuring autobiographical memory or prospective memory could also provide useful information about functional abilities. Minimal research suggests that prospective memory is associated with IADLs (Woods, Weinborn, Velnoweth, Rooney, & Bucks, 2012), and autobiographical memory may contribute to functional abilities (Bluck, 2003). Future research could examine whether autobiographical memory or prospective memory are associated with IADLs. Future research could also examine if episodic future thinking provides information about IADLs over and above both prospective memory and autobiographical memory. It is possible that measuring autobiographical memory or prospective memory could provide more information about functional abilities than standard neuropsychological assessments. The most clinically useful task could be incorporated into a clinical setting. This research may help determine if episodic future thinking should be measured in clinical neuropsychological assessment.

The relationship between episodic future thinking and other domains of adaptive functioning. I found that there was a relationship between episodic future thinking and IADLs. Future research could examine the relationship between episodic future thinking and specific domains of IADLs, such as medication use, financial decision-making, and navigation abilities. The current study examined overall functional abilities which included many different functional tasks, so it was unclear from the findings whether episodic future thinking is associated with certain functional tasks more than others.

It may also be important to consider other domains of adaptive functioning, such as problem solving and social functioning. It is important to consider the incremental validity of episodic future thinking over and above memory since various domains of memory are associated with problem solving and social functioning (Ward, 2016). Research has found that autobiographical memory is related to problem solving across many populations including healthy older adults, psychiatric populations, patients with amnesia, and patients with Asperger syndrome (Beaman, Pushkar, Etezadi, Bye, & Conway, 2007; Evans, Williams, O'loughlin, & Howells, 1992; Goddard, Dritschel, & Burton, 1996, 1997; Goddard, Howlin, Dritschel, & Patel, 2007; Maurex et al., 2010; Pollock & Williams, 2001; Raes et al., 2005; Sheldon et al., 2011; Sheldon et al., 2015; Sutherland & Bryant, 2008). Episodic memory has also been found to influence problem solving abilities (Burton, Strauss, Hultsch, & Hunter, 2006; Vandermorris, Sheldon, Winocur, & Moscovitch, 2013). As discussed previously, episodic future thinking has been shown to be related to problem-solving (Madore & Schacter, 2014). Future research could examine the relationship between episodic future thinking and problem-solving over and above autobiographical memory and episodic memory.

It is also relevant to explore the incremental validity of episodic future thinking with respect to social functioning since various domains of memory have been associated with social functioning. Episodic memory has been shown to be related to social functioning across various populations (Bielak, Gerstorf, Anstey, & Luszcz, 2014; Gaesser & Schacter, 2014; McClure et al., 2007; Tan, Hultsch, & Strauss, 2009). In a sample of patients with schizophrenia, prospective memory was shown to be related to social functioning (Guaiana, Tyson, & Mortimer, 2004). Research also suggests that episodic future thinking is also relevant for social functioning (Gaesser & Schacter, 2014). Future research could determine if episodic future thinking provides additional information about social functioning than episodic memory and prospective memory. Overall, measuring whether episodic future thinking is useful over and above both prospective memory and autobiographical memory could help identify which task is most useful in a clinical setting. This research could also clarify the information that could be gained from the measurement of episodic future thinking.

The relationship between semantic details and instrumental activities of daily living. The current study examined internal details since this is the episodic future thinking domain that is most commonly compromised in neurological populations (Addis et al., 2009; Gamboz et al., 2010; Irish et al., 2012a, 2012b; Irish et al., 2013; Kurczek et al., 2015; Race et al., 2011; Rasmussen & Berntsen, 2014) and is related to adaptive functioning (Madore & Schacter, 2014; Palombo et al., 2015). The relationship between semantic details and functional abilities was not examined in this study. There was limited variability in semantic details in this sample which restricted my ability to examine the relationship between semantic details and IADLs. Future work could examine the relationship between semantic details and IADLs since they may be an essential part of episodic future thinking performance (Irish & Piguet, 2013). Currently, it is unclear if semantic details are relevant to functional abilities.

Episodic future thinking intervention. Future research could examine an episodic future thinking intervention to see if this intervention helps patients with neurological conditions complete daily activities. The aim of neuropsychological rehabilitation is to allow people to 'achieve or maintain optimal level of physical, psychological, and social functioning in the context of specific impairments arising from illness or injury' (Bahar-Fuchs, Clare, & Woods, 2013; McLellan, 1991). An episodic future thinking intervention may allow individuals to achieve optimal functioning since my findings show that episodic future thinking is associated with functional abilities. The goal of an episodic future thinking intervention would be to help individuals mentally project themselves into the future in a vivid way to aid in successful completion of daily activities. An episodic future thinking intervention could use similar techniques as memory interventions used in neuropsychological rehabilitation that allow patients to compensate for their memory deficits (Clare & Woods, 2004; De Vreese, Neri, Fioravanti, Belloi, & Zanetti, 2001; Ptak, Van der Linden, & Schnider, 2010). For example, visual aids could be used to help the patient visualize a vivid future scenario. Patients could also be guided through a future scenario with prompts provided from a psychologist to help patients come up with vivid details. An episodic future thinking intervention could impact the functional abilities in a variety of neurological populations due to their impairments in episodic future thinking (Addis et al., 2009; Berryhill et al., 2010; El Haj et al., 2015; Gamboz et al., 2010; Hassabis et al., 2007; Irish et al., 2012a, 2012b; Irish et al., 2013; Kurczek et al., 2015; Race et al., 2011; Rasmussen & Berntsen, 2014; Viard et al., 2014; Zeman et al., 2013). Future research could help determine if incorporating an episodic future thinking intervention in neuropsychological rehabilitation would be worthwhile.

The relevance of episodic future thinking for neurologically healthy individuals. In this study, the relationship between episodic future thinking and functional abilities was examined in patients with neurological conditions. However, it is also possible that episodic future thinking is a concept that is also relevant for healthy individuals in the real world. As mentioned previously, there is literature to suggest that episodic future thinking is related to different types of adaptive functioning, such as decision-making, coping, problem-solving, and goal processing in healthy individuals (Benoit et al., 2011; Lin & Epstein, 2014; Liu et al., 2013; Peters & Büchel, 2010; Taylor et al., 1998; Taylor & Schneider, 1989). However, no research has examined the relationship between episodic future thinking and real-world functional abilities in healthy individuals. It is possible that episodic future thinking could be relevant to real-world activities such as having a successful career or having financial stability. Future research could consider the benefit of engaging in future thinking in healthy individuals.

Maladaptive consequences of episodic future thinking. The current article presented results that suggest that episodic future thinking may be a helpful skill in healthy older adults and patients with neurological conditions. It is possible that there are also downsides to engaging in future thinking. No study has objectively explored the maladaptive consequences of episodic future thinking. However, there is literature to suggest that engaging in mind wandering may not be beneficial. Mind wandering is defined as thinking in the past or the future (Killingsworth & Gilbert, 2010). Killingsworth and Gilbert (2010) conducted a study to explore the emotional consequences of mind wandering. Their study involved contacting participants while they engaged in daily activities. They developed an iPhone application that prompted participants to report on their thoughts, feelings, and actions during their daily activities. They found that mind wandering is a frequent activity that occurred in 47% of their sample. They found that mind wandering was associated with less happiness. They concluded that mind wandering may also negatively influence one's emotional experience.

Additionally, mindfulness interventions have been developed to help individuals actively attend to the present moment (Baer, 2003). Engaging in mindfulness has been shown to reduce anxiety and depression (Hofmann, Sawyer, Witt, & Oh, 2010). These studies suggest that being in the present moment is more emotionally beneficial than thinking in the future. While these studies provide some evidence that future thinking could have negative emotional consequences, they focus on the frequency of mind wandering rather than the ability to vividly think in the future. Future research could objectively measure future thinking to understand if there are maladaptive consequences to the ability to vividly think in the future.

Conclusion

In conclusion, episodic future thinking may be a domain of cognition that provides valuable information about everyday functioning in patients with neurological disease and healthy older adults. While episodic future thinking has been explored mainly in neuroscientific research, more recently it has been identified as a construct that may be useful and worth including in clinical neuropsychological assessment (Irish & Piolino, 2016; Ward, 2016). Neuropsychologists make critical judgments about patients' functional abilities, such as their ability to take medications, drive, handle finances, and live independently. Neuropsychologists commonly rely on tests that were developed in the infancy of the field of neuropsychology. While these tests may provide adequate information, we must not become complacent in our test selection and development. By improving cognitive testing, neuropsychologists can make more accurate predictions to aid in treatment planning. It is our responsibility as neuropsychology researchers to create assessments that are objective, reliable, valid, and have clinical utility. While this is a challenge, it has important implications for neuropsychologists' ability to provide useful information to patients, their caretakers, and their healthcare providers.

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Table 1: Overview of Research on Episodic Future Thinking

Domains of research on episodic future thinking	Findings from each domain
Regions of the core neural network of episodic future thinking	Medial temporal lobe Medial prefrontal cortex Retrosplenial cortex Posterior parietal cortex Anterior and lateral temporal cortex Cingulate cortex Precuneus
Cognitive processes involved in episodic future thinking	Episodic memory Semantic memory Executive functioning Self-referential processing Imagery
Domains of adaptive functioning related to episodic future thinking	Decision-making Problem-solving Goal-processing Coping

Table 2: Episodic Future Thinking Performance in Neurological Populations

Neurological population	Study
Alzheimer's disease	Addis et al. (2009)
	El Haj et al. (2015)
	Irish et al. (2012a, 2012b)
	Irish et al. (2013)
Semantic dementia	Irish et al. (2012a, 2012b)
	Viard et al. (2014)
Mild cognitive impairment	Gamboz et al. (2010)
Amnesia	Andelman et al. (2010)
	Hassabis et al. (2007)
	Klein et al. (2002)-
	Manning et al. (2013)
	Race et al. (2011)
	Rosenbaum et al. (2005)
	Squire et al. (2010)
	Zeman et al. (2013)
Fronto-temporal dementia	Irish et al. (2013)
Parkinson's disease	de Vito et al. (2012)
Frontal lobe damage	Berryhill et al. (2010)
Parietal lobe damage	Berryhill et al. (2010)
Thalamic damage	Weiler et al. (2011)
Multiple sclerosis	Ernst et al. (2014)
Transient global amnesia	Juskenaite et al. (2014)
Traumatic brain injury	Rasmussen and Berntsen (2014)

Table 3: Exclusion Criteria

Exclusion criteria for neurological patients	*Exclusion criteria for healthy older adults*
• Intellectual disability • History of a learning disability • A neurodevelopmental disorder • Any psychiatric condition (besides a current diagnosis of major depression or anxiety that is treated and stable) • Current alcohol or drug abuse • A history of being an inpatient for drug or alcohol abuse • Impaired and uncorrected vision or hearing • Severe dementia as indicated by a Mini Mental State Exam score <10 • Age of less than 55 • Being involved in litigation.	• History of a neurological condition • Intellectual disability • History of a learning disability • A neurodevelopmental disorder • Any psychiatric condition (besides a current diagnosis of major depression or anxiety that is treated and stable) • Current alcohol or drug abuse • A history of being an inpatient for drug or alcohol abuse • Impaired and uncorrected vision or hearing • Severe dementia as indicated by a Mini Mental State Exam score is <10 • Age of less than 55 • Being involved in litigation.

Table 4: Recruitment Information

Patients with Neurological Conditions	Healthy Older Adults
Patient files were examined from patients seen in the Benton Neuropsychology Clinic from September 2015 through August 2016. A total of 817 patients were seen during this period of time. ↓ 240 patients of these patients met inclusion criteria for the research study as identified through chart review (29.4% of the patients seen in the Benton Clinic). ↓ 105 participants were not interested in participating and 72 patients did not return calls. A total of 65 patients with neurological conditions were tested in the study (8.0% of patients seen in the Benton Clinic).	78 participants either responded with interest to mass emails or were contacted through the older adult registry. ↓ 5 participants declined participation and 31 participants did not return calls. A total of 42 older adult comparison participants were tested in the study (53.8% of the 78 participants).

Table 5: Demographic, Cognitive and Functional Variables

	All Participants n=102		Neurological Disease n=61		Healthy Older Adults n=41			
Demographic and Clinical Variables	**Mean (SD)**	**(n) %**	**Mean (SD)**	**(n) %**	**Mean (SD)**	**(n) %**	**P**	**Effect size**
Age	69.3 (8.5)		69.1 (7.7)		69.6 (9.8)		0.786	0.06
Sex (n/% female)		46 (45.1)		23 (37.7)		23 (56.1)	0.067	
Education	15.7 (3.0)		15.5 (3.3)		16.1 (2.7)		0.395	0.20
Mini Mental State Exam (MMSE)	26.8 (3.2)		26.0 (3.6)		28.0 (2.2)		0.002	0.67
Depression (BDI)	6.6 (6.5)		7.7 (6.4)		4.9 (6.2)		0.006	0.44
Anxiety (BAI)	4.5 (5.2)		5.6 (6.0)		2.8 (3.2)		0.002	0.58
Neuropsychological Tests								
AVLT Long Delay Recall (Raw score)	7.3 (3.8)		5.8 (3.7)		9.6 (2.5)		<0.001	1.20
Logical Memory II (Raw score)	20.2 (9.8)		16.4 (9.8)		26.2 (6.0)		<0.001	1.21
Composite Memory Score (Z score)	0.01 (0.90)		-0.39 (0.90)		0.60 (0.49)		<0.001	1.37
Stroop Color Word Condition (Raw score)	31.8 (11.5)		27.9 (11.4)		37.5 (9.2)		<0.001	0.93
Trails B minus A (Raw score)	53.0 (38.0)		66.6 (42.1)		35.6 (22.3)		<0.001	0.92
COWA (Raw score)	38.2 (13.3)		34.5 (12.8)		43.8 (12.1)		<0.001	0.75
Composite Executive Functioning Score (Z score)	-0.03 (0.82)		-0.35 (0.79)		0.45 (0.59)		<0.001	1.22
Episodic Future Thinking								
Internal Details (Mean Raw Score)	26.8 (10.8)		25.2 (11.9)		29.2 (8.7)		.149	0.38
Proportion of Internal Details (Mean)	0.68 (0.12)		0.66 (0.13)		0.70 (0.11)		*	0.33
Semantic Details (Mean Raw Score)	4.3 (2.9)		3.9 (2.5)		5.0 (3.2)		.110	0.38
Proportion of Semantic Details (Mean)	0.10 (0.06)		0.10 (0.05)		0.11 (0.06)		*	0.18
Instrumental Activities of Daily Living								
Independent Living Scales (Total Raw Score)	124.8 (12.4)		121.3 (14.2)		129.9 (6.5)		<0.001	0.8
Everyday Cognition Scale (Mean Total Raw Score)	1.7 (0.7)		2.0 (0.8)		1.3 (0.3)		<0.001	1.3

Note. *The proportion of internal and semantic details were not compared statistically since these variables were used in the partial correlation and regression analyses to account for length of future thinking description. Groups in Table 5 were compared using t-tests or Mann-Whitney U tests for all variables except episodic future thinking variables. Episodic future thinking variables were compared using ANCOVA. The range of possible scores on the Independent Living Scales is 0-140. The range of possible scores on the Everyday Cognition Scale is 14. AVLT=Auditory Verbal Learning Test. COWA=Controlled Oral Word Association test.

Table 6: Demographic, Cognitive, and Functional Variables by Neurological Population

	Parkinson's Disease n=16	Mild Cognitive Impairment n=15	Stroke n=12	Traumatic Brain Injury n-4
<u>Demographic and Clinical Variables</u>	**<u>Mean (SD)</u>**	**<u>Mean (SD)</u>**	**<u>Mean (SD)</u>**	**<u>Mean (SD)</u>**
Age	69.3 (5.1)	71.9 (7.9)	63.7 (5.9)	68.3 (10.8)
Sex (n/% female)*	6 (37.5)	5 (33.3)	6 (50.0)	1 (25%)
Education	15.4 (3.1)	14.9 (3.0)	15.4 (2.4)	16.3 (4.3)
Mini Mental State Exam (MMSE)	25.7 (4.4)	26.7 (3.6)	26.3 (3.1)	26.5 (3.0)
Depression (BDI)	7.5 (6.6)	7.8 (4.8)	4.9 (4.9)	6.0 (4.3)
Anxiety (BAI)	5.9 (4.4)	4.6 (6.5)	2.3 (2.1)	8.8 (9.2)
<u>Neuropsychological Test</u>				
AVLT Long Delay (Raw)	6.5 (4.4)	4.2 (3.0)	8.0 (2.7)	5.8 (3.9)
Logical Memory II (Raw)	16.4 (11.4)	13.9 (9.5)	20.3 (6.9)	17.0 (7.3)
Composite Memory Score (Z score)	-0.30 (1.03)	-0.73 (0.77)	0.09 (0.62)	-0.37 (0.86)
Stroop Color Word (Raw)	24.9 (12.0)	27.9 (10.9)	34.9 (9.9)	23.8 (9.7)
Trails B minus A (Raw)	86.1 (44.9)	76.0 (51.2)	38.1 (20.7)	107.3 (17.2)
COWA (Raw)	39.0 (13.1)	35.5 (12.1)	36.3 (12.9)	33.0 (2.9)
Composite Executive Functioning Score (Z score)	-.47 (0.82)	-0.36 (0.83)	0.17 (0.70)	-0.74 (0.4)
<u>Episodic Future Thinking</u>				
Internal Details (Mean Raw Score)	21.3 (7.1)	25.2 (12.3)	30.0 (11.9)	21.7 (5.9)
Proportion of Internal Details (Mean)	0.64 (0.15)	0.64 (0.12)	0.67 (0.11)	0.68 (0.02)
Semantic Details (Mean Raw Score)	3.8 (2.5)	3.9 (2.2)	4.1 (2.7)	3.4 (1.8)
Proportion of Semantic Details (Mean)	0.25 (0.13)	0.10 (0.04)	0.09 (0.04)	0.10 (0.03)
<u>Instrumental Activities of Daily Living</u>				
Independent Living Scales (Total Raw Score)	121.3 (14.5)	122.5 (11.8)	128.3 (5.6)	118.8 (13.5)
Everyday Cognition Scale (Mean Total Raw Score)	2.1 (0.8)	2.0 (0.6)	1.4 (0.4)	1.9 (1.5)

Note. *Sex is a dichotomous variable so the data is presented as number female and percent female. AVLT=Auditory Verbal Learning Test. COWA=Controlled Oral Word Association test.

Table 6 – continued

	Normal Pressure Hydrocephalus n=3	Tumor with Resection n=2	Mixed Dementia n=1	Lewy Body Dementia n=1
Demographic and Clinical Variables	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Age	67.7 (2.9)	62.5 (5.0)	81.0 (0.0)	78.0 (0,0)
Sex (n(% female))*	1 (33.3%)	1 (50.0)	1 (100.0)	1 (100.0)
Education	16.0 (2.0)	15.0 (1.4)	16.0 (0.0)	20.0 (0.0)
Mini Mental State Exam (MMSE)	27.0 (2.6)	26.5 (2.1)	25.0 (0.0)	30.0 (0.0)
Depression (BDI)	8.3 (5.1)	11.5 (13.4)	21.0 (0.0)	4.0 (0.0)
Anxiety (BAI)	5.0 (1.0)	7.5 (7.8)	14.0 (0.0)	4.0 (0.0)
Neuropsychological Test Performance				
AVLT Long Delay (Raw)	3.0 (1.7)	7.5 (0.7)	4.0 (0.0)	7.0 (0.0)
Logical Memory II (Raw)	16.3 (5.5)	32.5 (5.0)	15.0 (0.0)	16.0 (0.0)
Composite Memory Score (Z score)	-0.77 (0.15)	0.65 (0.35)	-0.71 (0.0)	-0.26 (0.00)
Stroop Color Word (Raw)	30.0 (13.5)	22.0 (1.4)	20.0 (0.0)	44.0 (0.0)
Trails B minus A (Raw)	59.7 (23.8)	53.0 (17.0)	**	10.0 (0.0)
COWA (Raw)	23.0 (5.0)	22.0 (5.7)	39.0 (0.0)	46.0 (0.0)
Composite Executive Functioning Score (Z score)	-0.49 (0.47)	-0.70 (0.33)	-0.48 (0.0)	0.93 (0.00)
Episodic Future Thinking				
Internal Details (Mean Raw Score)	35.8 (25.9)	28.5 (6.6)	28.2 (0.0)	25.8 (0.0)
Proportion of Internal Details (Mean)	0.56 (0.14)	0.78 (0.07)	0.78 (0.00)	0.82 (0.00)
Semantic Details (Mean Raw Score)	6.8 (2.9)	3.7 (0.4)	0.40 (0.0)	2.2 (0.0)
Proportion of Semantic Details (Mean)	0.13 (0.05)	0.09 (0.01)	0.01 (0.00)	0.07 (0.00)
Instrumental Activities of Daily Living				
Independent Living Scales (Total Raw Score)	123.7 (8.5)	120.0 (0.0)	93.0 (0.0)	134.0 (0.0)
Everyday Cognition Scale (Mean Total Raw Score)	1.9 (0.9)	2.3 (1.5)	2.3 (0.0)	2.2 (0.0)

Note. *Sex is a dichotomous variable so the data is presented as number female and percent female. **These participants discontinued on Trails B and as a result they do not have a Trail B minus A score. Their composite executive functioning score was created based on the remaining executive functioning tasks. AVLT=Auditory Verbal Learning Test. COWA=Controlled Oral Word Association test.

Table 6 – continued

	BvFTD n=1	Alzheimer's Disease n=1	Vascular Dementia n=1	PPA n=1
Demographic and Clinical Variables	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Age	64.0 (0.0)	90.0 (0.0)	79.0 (0.0)	70.0 (0.0)
Sex (n(% female))*	1 (100.0)	1 (100.0)	1 (100.0)	1 (100.0)
Education	28.0 (0.0)	12.0 (0.0)	16.0 (0.0)	12.0 (0.0)
Mini Mental State Exam (MMSE)	19.0 (0.0)	22.0 (0.0)	24.0 (0.0)	24.0 (0.0)
Depression (BDI)	3.0 (0.0)	0.0 (0.0)	8.0 (0.0)	29.0 (0.0)
Anxiety (BAI)	3.0 (0.0)	3.0 (0.0)	5.0 (0.0)	17.0 (0.0)
Neuropsychological Test Performance				
AVLT Long Delay (Raw)	1.0 (0.0)	0.0 (0.0)	4.0 (0.0)	2.0 (0.0)
Logical Memory II (Raw)	0.0 (0.0)	2.0 (0.0)	8.0 (0.0)	7.0 (0.0)
Composite Memory Score (Z score)	-1.9 (0.0)	-1.90 (0.0)	-1.1 (0.0)	-1.4 (0.0)
Stroop Color Word (Raw)	19.0 (0.0)	21.0 (0.0)	14.0 (0.0)	29.0 (0.0)
Trails B minus A (Raw)	86.0 (0.0)	**	**	64.0 (0.0)
COWA (Raw)	24.0 (0.0)	6.0 (0.0)	22.0 (0.0)	9.0 (0.0)
Composite Executive Functioning Score (Z score)	-1.02 (0.0)	-1.68 (0.0)	-1.38 (0.0)	-.91 (0.0)
Episodic Future Thinking				
Internal Details (Mean Raw Score)	13.6 (0.0)	13.0 (0.0)	29.6 (0.0)	20.0 (0.0)
Proportion of Internal Details (Mean)	0.71 (0.00)	0.45 (0.00)	0.57 (0.57)	0.80 (0.00)
Semantic Details (Mean Raw Score)	0.4 (0.0)	6.6 (0.0)	8.8 (0.0)	3.0 (0.0)
Proportion of Semantic Details (Mean)	0.02 (0.00)	0.21 (0.00)	0.17 (0.00)	0.10 (0.00)
Instrumental Activities of Daily Living				
Independent Living Scales (Total Raw Score)	63.0 (0.0)	116.0 (0.0)	112.0 (0.0)	105.0 (0.0)
Everyday Cognition Scale (Mean Total Raw Score)	3.0 (0.0)	3.6 (0.0)	1.9 (0.0)	2.8 (0.0)

Note. *Sex is a dichotomous variable so the data is presented as number female and percent female. **These participants discontinued on Trails B and as a result they do not have a Trail B minus A score. Their composite executive functioning score was created based on the remaining executive functioning tasks. AVLT=Auditory Verbal Learning Test. COWA=Controlled Oral Word Association test. BvFTD = Behavioral variant frontotemporal dementia. PPA = Primary progressive aphasia.

Table 6 – continued

	Multiple Sclerosis n-1	Epilepsy with Resection n=1	Normal Pressure Hydrocephalus and Lewy Body Dementia n=1
Demographic and Clinical Variables	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Age	61.0 (0.0)	63.0 (0.0)	75.0 (0.0)
Sex (n (% female))*	1 (100.0)	1 (100.0)	1 (100.0)
Education	14.0 (0.0)	20.0 (0.0)	12.0 (0.0)
Mini Mental State Exam (MMSE)	28.0 (0.0)	28.0 (0.0)	21.0 (0.0)
Depression (BDI)	13.0 (0.0)	11.0 (0.0)	15.0 (0.0)
Anxiety (BAI)	13.0 (0.0)	2.0 (0.0)	26.0 (0.0)
Neuropsychological Test Performance	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
AVLT Long Delay (Raw)	9.0 (0.0)	14.0 (0.0)	4.0 (0.0)
Logical Memory II (Raw)	29.0 (0.0)	24.0 (0.0)	3.0 (0.0)
Composite Memory Score (Z score)	0.67 (0.0)	1.1 (0.0)	-1.3 (0.0)
Stroop Color Word (Raw)	23.0 (0.0)	50.0 (0.0)	14.0 (0.0)
Trails B minus A (Raw)	21.0 (0.0)	56.0 (0.0)	**
COWA (Raw)	36.0 (0.0)	51.0 (0.0)	31.0 (0.0)
Composite Executive Functioning Score (Z score)	-0.03 (0.0)	0.82 (0.0)	-1.04 (0.0)
Episodic Future Thinking			
Internal Details (Mean Raw Score)	52.8 (0.0)	18.0 (0.0)	4.4 (0.0)
Proportion of Internal Details (Mean)	0.80 (0.00)	0.97 (0.00)	0.58 (0.00)
Semantic Details (Mean Raw Score)	6.6 (0.0)	0.60 (0.0)	0.80 (0.0)
Proportion of Semantic Details (Mean)	0.09 (0.00)	0.01 (0.00)	0.13 (0.00)
Instrumental Activities of Daily Living			
Independent Living Scales (Total Raw Score)	133.0 (0.0)	132.0 (0.0)	107.0 (0.0)
Everyday Cognition Scale (Mean Total Raw Score)	1.8 (0.0)	***	2.8 (0.0)

Note. *Sex is a dichotomous variable so the data is presented as number female and percent female. **These participants discontinued on Trails B and as a result they do not have a Trail B minus A score. Their composite executive functioning score was created based on the remaining executive functioning tasks. ***This participant did not have an informant report. AVLT=Auditory Verbal Learning Test. COWA=Controlled Oral Word Association test.

Table 7: Partial correlations between episodic future thinking and IADLs in patients with neurological disease and healthy older adults

Episodic Future Thinking Variable	**Independent Living Scales**		**Everyday Cognition Scale**	
	r	**p**	**r**	**P**
Mean Proportion of Internal Details	.261	.010	-.118	.284

Note. The relationship between the mean proportion of internal details and the Independent Living Scales was examined using a partial correlation. The relationship between the mean proportion of internal details and the Everyday Cognition Scale was examined using a spearman partial correlation. Both analyses controlled for age, education, gender, and depression. The Independent Living Scales was examined using the total raw score. The Everyday Cognition Scale was examined using the mean total raw score.

Table 8: Hierarchical Multiple Regression Model: Prediction of Performance-based IADLs (ILS) from Episodic Future Thinking over and above Executive Functioning in Patients with Neurological Disease and healthy older adults

	IADLs (ILS)								
	Model 1			Model 2			Model 3		
Variable	B	β	p	B	β	p	B	β	p
Constant	127.984		<.001***	121.038		<.001***	108.916		<.001***
Age	-0.270	-.214	.023*	0.059	.047	.584	0.090	.072	.397
Education	1.078	.278	.003*	0.092	.024	.780	0.095	.025	.768
Gender	5.786	.268	.006*	4.604	.213	.008**	4.272	.198	.013*
Depression	-.511	-.306	.001**	-0.473	-.283	<.001***	-0.524	-.314	<.001***
Executive Functioning				7.995	.604	<.001***	7.339	.554	<.001***
Mean Proportion of Internal Details							15.368	.174	.030*
F	7.775		<.001***	18.675		<.001***	17.007		<.001***
R^2	.245			.496			.490		
ΔF	7.775		<.001***	47.281		<.001***	4.866		.030*

ΔR^2	.245	.251	.025

Note. *p<.05, **p<.01, ***p<.001

Table 9: Hierarchical Multiple Regression Model: Prediction of Informant-reported IADLs (Everyday Cognition Scale) from Episodic Future Thinking over and above Executive Functioning in Patients with Neurological Disease and healthy older adults

	IADLs (ILS)								
	Model 1			Model 2			Model 3		
Variable	B	β	p	B	β	p	B	β	p
Constant	-0.013		.937	0.106		.485	.135		.403
Age	0.004	.210	.053	0.000	-.024	.823	-.001	-.033	.763
Education	-0.007	-.117	.274	0.005	.077	.460	.005	.081	.440
Gender	-0.012	-.036	.748	0.000	-.001	.993	.003	.009	.929
Depression	0.007	.288	.008**	0.007	.280	.004**	.007	.278	.005**
Executive Functioning				-0.100	-.505	<.001***	-.097	-.490	<.001***
Mean Proportion of Internal Details							-.001	-.056	.581
F	3.523		<.001***	7.841		<.001***	6.530		<.001***
R^2	.145			.323			.326		
ΔF	3.523		<.001***	21.613		<.001***	.308		.581

ΔR^2	.145	.178	.003

Note. *p<.05, **p<.01, ***p<.001

Table 10: Hierarchical Multiple Regression Model: Prediction of Performance-based IADLs (ILS) from Episodic Future Thinking over and above Memory in Patients with Neurological Disease and healthy older adults

	IADLs (ILS)								
	Model 1			Model 2			Model 3		
Variable	B	β	p	B	β	p	B	β	p
Constant	131.860		<.001***	126.675		<.001***	118.548		<.001***
Age	-0.245	-.217	.020*	-0.120	-.106	.219	-0.095	-.084	.337
Education	0.797	.228	.015*	0.593	.170	.046*	0.576	.165	.052
Gender	4.819	.248	.010*	2.166	.112	.219	2.186	.113	.213
Depression	-.559	-.374	<.001***	-0.444	-.297	.001**	-0.484	-.324	<.001***
Memory				4.713	.429	<.001***	4.265	.388	<.001***
Mean Proportion of Internal Details							10.186	.126	.157
F	8.506		<.001***	13.032		<.001***	11.320		<.001***
R^2	.264			.409			.422		
ΔF	8.506		<.001***	23.188		<.001***	2.040		.157
ΔR^2	.264			.146			.013		

Note. *p<.05, **p<.01, ***p<.001

Table 11: Hierarchical Multiple Regression Model: Prediction of Informant-reported (Everyday Cognition Scale) from Episodic Future Thinking over and above Memory in Patients with Neurological Disease and healthy older adults

	IADLs (ILS)								
	Model 1			Model 2			Model 3		
Variable	B	β	p	B	β	p	B	β	p
Constant	-.013		.937	0.096		.498	0.125		.406
Age	0.004	.210	.053	0.001	.053	.574	0.001	.040	.676
Education	-0.007	-.117	.274	-0.002	-.030	.739	-0.001	-.022	.810
Gender	-0.012	-.036	.748	0.056	.170	.091	0.058	.176	.082
Depression	0.007	.288	.008**	0.005	.183	.047*	0.005	.183	.048*
Memory				-0.109	-.583	<.001***	-0.106	-.571	<.001***
Mean Proportion of Internal Details							-0.001	-.055	.562
F	3.523		.010*	11.153		<.001***	9.276		<.001***
R^2	.145			.405			.407		
ΔF	3.523		.010*	35.768		<.001***	.340		.562
ΔR^2	.145			.260			.002		

Note. *p<.05, **p<.01, ***p<.001

Figure 1: Episodic Future Thinking Transcript: Scored Transcript from a Healthy Older Adult

(It would probably be in the late fall **(ed-t))**. My son's birthday is on November 13th **(sem-A)),** (so we could celebrate **(ed)).** The Hawkeyes have better records in wresting **(sem-G)),** but I like going to basketball games **(th/em)).** (I would go in the stadium **(ed-pl))** (and find my seat **(ed))**. (I would probably get a hotdog **(ed))** (and a drink **(ed))** (and hunker to watch the Hawkeyes **(ed))** (play basketball **(ed))**. (And uh on good plays I would react happily **(th/em))** (and on bad plays I would be sad **(th/em))**. (Um the game itself is about 2 hours long **(ed-t))** (and at the end of that time I would go back to home **(ed-pl))** (or go to a hotel **(mc))**. (After that **(ed))** (I would go to a bar **(ed-pl))** (and have a drink **(ed))**. (I would try to hook up with my friends **(ed))** (and try to dissect the game **(ed))**. (And see if we won **(ed))** (we would be happy **(th/em))** (and if we lost **(mc))** (we would try to figure out what went wrongs **(mc))**. (And I would try to find something to eat **(ed))** (and go back to my hotel room **(ed-pl))** (- assuming it is not in Iowa City **(mc))**.

Note. Internal details signify episodic details. Internal details were categorized into the following: event (ed)), place (ed-pl)), time (ed-t)), perceptual (per)), or thought/emotion (th/em)). Semantic details are general knowledge and facts, ongoing events, and extended states of being. Semantic details were categorized into general semantic (sem-G)), semantic autobiographical (sem-A)), semantic time (sem-T)), and semantic place details (sem-P)). The remaining details were in a category called "other" which included details that were unrelated to the main event described by the participant (ex)), repetitions (rep)) and metacognitive statements (mc)).

Figure 2: Episodic Future Thinking Task Description Adapted AI task Instructions

"I am going to ask you to tell me about future events that could occur three to five months from today. I will ask you to describe events that are from a specific time and place from a first person perspective. For example, describing a 3 week event is not sufficient. However, a specific incident that will happen on one day would be good. Don't provide an event you complete every day or every week, but rather provide a new event. I want you to provide as much detail as you can about the future event. I will provide you with a verbal cue. You do not have to use the cue word in your description. Our interest is not so much in which events you choose, but rather how you describe them. Be sure to only choose events that you feel comfortable discussing in detail. Tell me about a future event that could happen in the next three to five months."

Figure 3: Everyday Cognition Scale

Patient's Name ______________________ Today's Date _______________

Everyday Cognition– Informant/Caregiver Form

Directions: Please rate the patient's ability to perform certain everyday tasks **NOW**, as compared to his/her ability to do these same tasks 10 years ago. In other words, try to remember how he/she was doing 10 years ago and indicate any change you have seen. Rate the amount of change on a five-point scale ranging from: 1) no change or actually performs better than 10 years ago, 2) occasionally performs the task worse but not all of the time, 3) consistently performs the task a little worse than 10 years ago, 4) performs the task much worse than 10 years ago, or 5) don't know. Circle the number that fits your response.

Compared to 10 years ago, has there been any change in…	*Better or no change*	*Questionable /occasionally worse*	*Consistently a little worse*	*Consistently much Worse*	*Don't know*
Memory					
1. Remembering a few shopping items without a list.	1	2	3	4	9
2. Remembering things that happened recently (such as recent outings, events in the news).	1	2	3	4	9
3. Recalling conversations a few days later.	1	2	3	4	9
4. Remembering where she/he has placed objects.	1	2	3	4	9
5. Repeating stories and/or questions.	1	2	3	4	9
6. Remembering the current date or day of the week.	1	2	3	4	9
7. Remembering he/she has already told someone something.	1	2	3	4	9
8. Remembering appointments, meetings, or engagements.	1	2	3	4	9

Figure 3: Everyday Cognition Scale (continued)

Compared to 10 years ago, has there been any change in…	*Better or no change*	*Questionable or occasional problems*	*Consistently a little worse*	*Consistently much Worse*	*Don't know*
Language					
1. Forgetting the names of objects.	1	2	3	4	9
2. Verbally giving instructions to others.	1	2	3	4	9
3. Finding the right words to use in a conversation.	1	2	3	4	9
4. Communicating thoughts in a conversation.	1	2	3	4	9
5. Following a story in a book or on TV.	1	2	3	4	9
6. Understanding the point of what other people are trying to say.	1	2	3	4	9
7. Remembering the meaning of common words.	1	2	3	4	9
8. Describing a program he/she has watched on TV.	1	2	3	4	9
9. Understanding spoken directions or instructions.	**1**	***2***	3	4	9
Visual-spatial and Perceptual Abilities					
1. Following a map to find a new location.	1	2	3	4	9
2. Reading a map and helping with directions when someone else is driving.	1	2	3	4	9
3. Finding one's car in a parking lot.	1	2	3	4	9
4. Finding the way back to a meeting spot in the mall or other location.	1	2	3	4	9
5. Finding his/her way around a familiar neighborhood.	1	2	3	4	9
6. Finding his/her way around a familiar store.	1	2	3	4	9
7. Finding his/her way around a house visited many times.	1	2	3	4	9

Figure 3: Everyday Cognition Scale (continued)

Compared to 10 years ago, has there been any change in…	*Better or no change*	*Questionable or occasional problems*	*Consistently a little worse*	*Consistently much Worse*	*Don't know*
Executive Functioning: Planning					
1. Planning the sequence of stops on a shopping trip.	1	2	3	4	9
2. The ability to anticipate weather changes and plan accordingly (i.e. bring a coat or umbrella).	1	2	3	4	9
3. Developing a schedule in advance of anticipated events.	1	*2*	3	*4*	*9*
4. Thinking things through before acting.	1	2	3	4	9
5. Thinking ahead.	1	2	3	4	9
Executive Functioning: Organization					
1. Keeping living and work space organized.	1	2	3	4	9
2. Balancing the checkbook without error.	1	2	3	4	9
3. Keeping financial records organized.	1	2	3	4	9
4. Prioritizing tasks by importance.	1	2	3	4	9
5. Keeping mail and papers organized.	1	2	3	4	9
6. Using an organized strategy to manage a medication schedule involving multiple medications.	1	2	3	4	9
Executive Functioning: Divided Attention					
1. The ability to do two things at once.	1	2	3	4	9
2. Returning to a task after being interrupted.	1	2	3	4	9
3. The ability to concentrate on a task without being distracted by external things in the environment.	1	2	3	4	9
4. Cooking or working and talking at the same time.	1	2	3	4	9

Figure 4: Episodic Future Thinking Performance in Patients with Neurological Disease and Healthy Older Adults

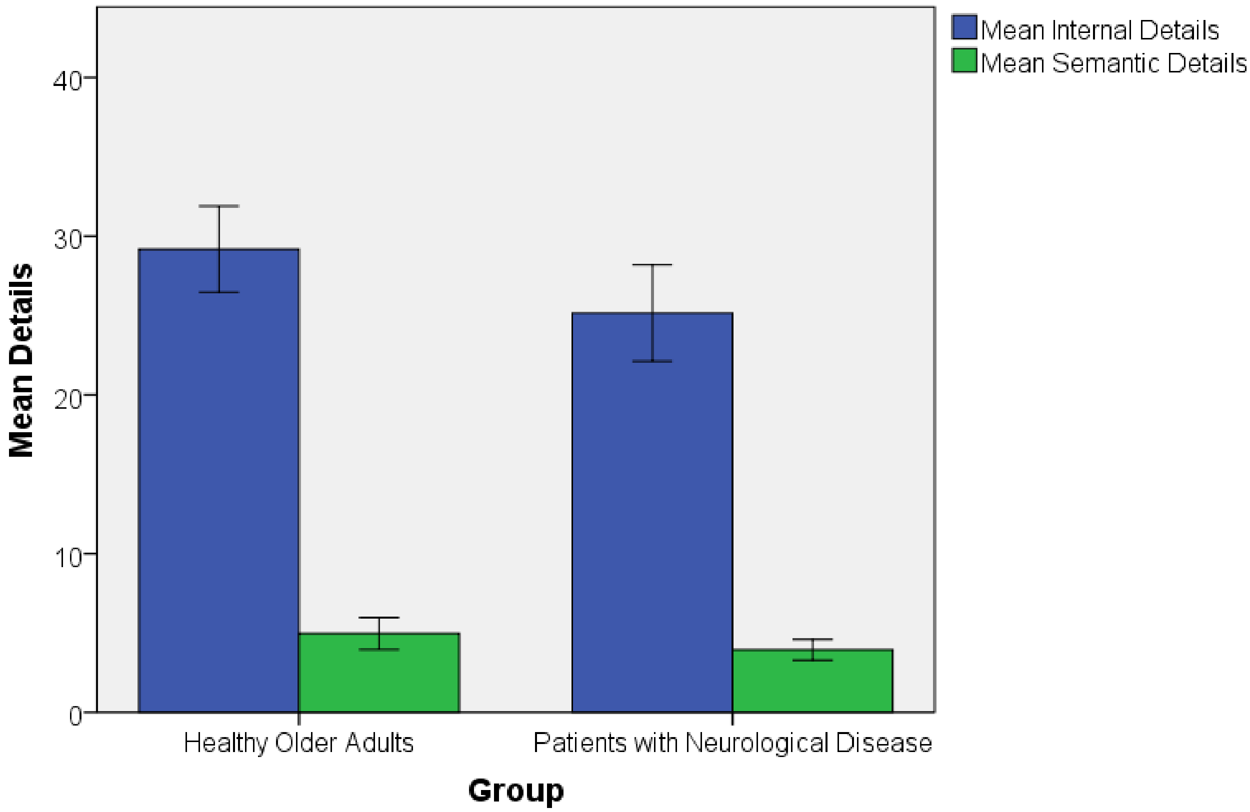

Figure 5: The Association between Episodic Future Thinking and Performance Based IADLs

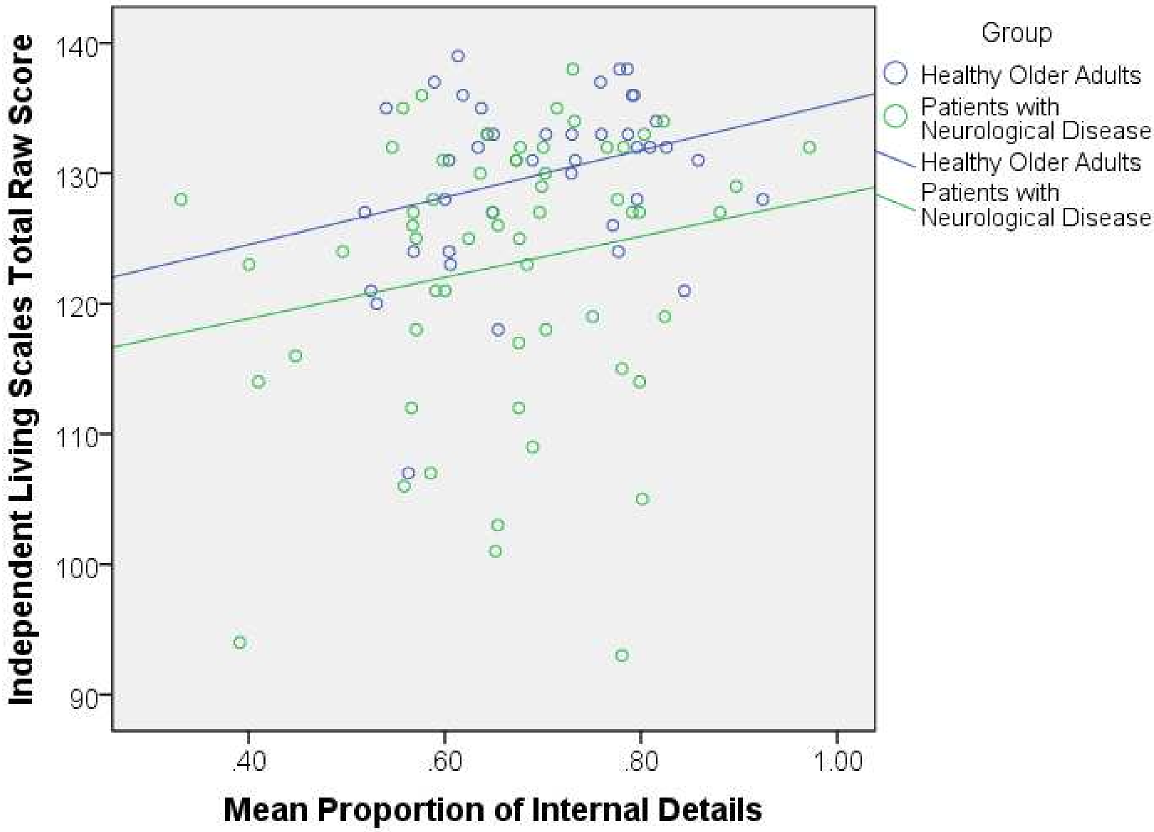

Figure 6: The Association between Episodic Future Thinking and Informant Reported IADLs