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The relationship between cognitive function and Activities of Daily Living

Pamela V. Lorenzo

LOMA LINDA UNIVERSITY
School of Behavioral Health
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The relationship between cognitive function and Activities of Daily Living

by

Pamela V. Lorenzo

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the requirements for the degree
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Each person whose signature appears below certifies that this dissertation in his/her opinion is adequate, in scope and quality, as a dissertation for the degree Doctor of Philosophy.

Chairperson

Grace J. Lee, Associate Professor of Psychology

Colleen A. Brenner, Associate Professor of Psychology

Elizabeth P. Cisneros, Clinical Neuropsychologist, Casa Colina Hospital and Centers for Healthcare

Caroline Schnakers, Assistant Director, Research Institute, Casa Colina Hospital and Centers for Healthcare

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ABBREVIATIONS

ADLs	Activities of Daily Living
BADLs	Basic Activities of Daily Living
IADLs	Instrumental Activities of Daily Living
FIM	Functional Independence Measure
MMSE	Mini Mental Status Examination
DSM-5	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
NCD	Neurocognitive Disorder
AD	Alzheimer’s Disease
MCI	Mild Cognitive Impairment
NIA-AA	National Institute on Aging and Alzheimer’s Association
VaD	Vascular Dementia
CVD	Cardiovascular Disease
VASCOG	Vascular Behavioral and Cognitive Disorders
ICF	International Classification of Functioning
FAM	Functional Assessment Measure
SEP	Senior Evaluation Program
PT	Physical Therapy
OT	Occupational Therapy
SLP	Speech Language Pathologist
WCST	Wisconsin Card Sorting Test
Cat #	Category Number

FMS	Failure to Maintain Set
TFC	Trials to First Category
CLR	Conceptual Level Response
COWAT	Controlled Oral Word Association Test
BNT	Boston Naming Test
BDAE-CI	Boston Diagnostic Aphasia Examination Complex Ideation
TMT	Trail Making Test
CVLT-II	California Verbal Learning Test, Second Edition
LDFR	Long Delay Free Recall
WMS-IV	Wechsler Memory Scale, Fourth Edition
LM	Logical Memory
VR	Visual Reproduction
GDS	Geriatric Depression Scale
EFA	Exploratory Factor Analysis
TFLS	Texas Functional Living Scale

ABSTRACT OF THE DISSERTATION

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Pamela V. Lorenzo

Doctor of Philosophy, Graduate Program in Clinical Psychology

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Dr. Grace J. Lee, Chairperson

Dementia is a cognitive disorder that can be caused by several underlying diseases, including Alzheimer's disease and vascular disease. Dementia is not only characterized by declines in cognition, but is also associated with declines in instrumental and basic activities of daily living (ADLs). Cognitive decline generally begins prior to any declines in ADLs, and as cognitive impairments progress, the ability to independently perform ADLs begins to decline as well. Accurate assessment of ADL functioning, though critical to the diagnosis of dementia, can be difficult with the use of self-report measures. One objective measure of ADLs is the Functional Independence Measure (FIM); however, as the FIM is often only administered in inpatient settings, neuropsychologists do not always have access to the FIM. The study examined the relationship between performance on neuropsychological measures and the FIM to assist in clinician's ability to predict declines in ADLs based on neuropsychological testing. Results indicated that the Mini-Mental State Examination (MMSE) was a significant predictor of the FIM Total, Psychosocial Adjustment, and Cognitive Functioning scores. Performances in the Memory domain also predicted FIM Cognitive Functioning scores. Performances on measures of Executive function did not predict scores on the FIM.

CHAPTER ONE

INTRODUCTION

Cognitive Function and Activities of Daily Living

Dementia is a cognitive disorder involving decline from a previously higher level of functioning, evidenced by impairment of memory and at least one other cognitive domain such that the individual's deficits interfere with his/her ability to carry out activities of daily living (ADLs; D'Onofrio et al., 2015; Internet Stroke Center, 1997). The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) defines Neurocognitive Disorder (NCD) as a disorder in which the primary symptom is impairment in cognitive function that represents an acquired deficit rather than a developmental problem (American Psychiatric Association, 2013; D'Onofrio et al., 2015). Two categories of NCD include Mild or Major NCD. Mild NCD is characterized by modest declines in one or more cognitive domains (complex attention, executive function, learning and memory, language, perceptual-motor or social cognition) without associated declines in everyday activities of daily living (ADLs), whereas Major NCD is characterized by declines in one or more cognitive domains that are severe enough to result in significant impairment of ADLs (American Psychiatric Association, 2013). Thus, dementia is now subsumed under the category of major NCD. Major NCD, or dementia, can be caused by a number of underlying conditions, which include but are not limited to Alzheimer's disease, vascular disease, Lewy body disease and frontotemporal degeneration.

The most prevalent cause of dementia is Alzheimer's disease, with vascular dementia being the second most common type. There are a number of factors that can increase or decrease one's risk for developing dementia. A host of medical, nutritional, and lifestyle risk factors can make an individual more susceptible to developing dementia. These risk factors increase as the life expectancy of the population increases (84.3 years of age for males and 86.6 years for females). Further, elderly who have memory impairment have a higher risk of progressing to dementia or Alzheimer's disease (AD). In the case of AD, cognitive decline typically begins several years before individuals develop dementia (Wilson, Segawa, Boyle, Anagnos, Hizel, & Bennett, 2012). Global cognitive function, which is a person's ability to use multiple areas of the brain in coordination to complete a task, begins to decline a mean of 7.5 years before the onset of dementia, and the rate of decline can begin to accelerate approximately 5.5 years later (Wilson et al., 2012). Therefore, early detection can help identify prodromal signs and symptoms prior to reaching the dementia stage and allow the individual to implement strategies to slow or prevent further decline.

Mild Cognitive Impairment

Mild cognitive impairment (MCI), which is subsumed under the DSM-5 category of Mild NCD, is conceptualized as the intermediate stage between the cognitive changes associated with normal aging and those characteristic of a dementia syndrome (Geda, 2012). Table 1 shows Mayo Clinic's diagnostic criteria for MCI (Albert et al., 2011; Geda, 2012; Petersen et al., 1999). The National Institute on Aging and Alzheimer's Association (NIA-AA) established updated criteria for the diagnosis of MCI, which included (a) concern regarding a change in cognition, (b) impairment in one or more cognitive domains, (c) preservation of independence in functional abilities, and (d) not demented (Albert et al., 2011). The prevalence of MCI in individuals 60 to 89 years old ranges from 3 to 22% per year. The incidence of MCI ranges from 1 to 6% per year, which is higher in men (7.24%) than women (5.73%; Geda, 2012). Additionally, the incidence of MCI in individuals with 12 years of education or less is two times higher than in people with more than 12 years of education. Some other risk factors for MCI include older age, lower Mini Mental State Examination (MMSE) score, and subjective memory impairment (Luck et al., 2010).

Table 1. Diagnostic Criteria for MCI

	NIA-AA MCI Criteria
1	Concern regarding a change in cognition
2	Impaired in one or more cognitive domains
3	Perseveration of independence in functional abilities
4	Not demented

*Albert et al., 2011

Individuals with MCI demonstrate cognitive impairment that is greater than what is expected for their age but do not exhibit any functional impairments in basic activities of daily living (ADLs), and/or significant impairments in instrumental activities of daily living (IADLs). However, they are at increased risk for further progressive decline in cognitive and functional impairments, with annual rates of conversion from MCI to dementia at 4.2% in the general population and 10% to 15% in high-risk clinical samples, such as individuals who were referred by a physician and/or a dementia clinic for cognitive symptoms (Petersen et al., 2009; Sachdev et al., 2012). Individuals diagnosed with MCI who demonstrate deficits in multiple domains have a higher risk of developing dementia (Sachdev et al., 2012). A proportion of individuals with MCI do not progress to dementia even after 10 years of follow up (Lopez-Anton et al., 2015; Mitchell & Shiri-Feshki, 2009). Various research has not yet identified one cause or treatment that prevents the progression to dementia, as MCI can be related to several different etiologies, not all of which are neurodegenerative. The management of cardiovascular risk factors (i.e., high blood pressure, high cholesterol, diabetes, etc.), depression, adverse drug effects, and staying active physically and mentally have been found to prevent progression to dementia in some cases (Campbell, Unerzagt, LaMantia, Khan, & Boustani, 2013). Thus, not all individuals with MCI share the same prognosis, and it is important to identify those who are at highest risk for progression and conversion to dementia.

Alzheimer's Disease

Alzheimer's disease (AD) is an irreversible, progressive brain disorder that results in gradual declines in an individual's memory and thinking skills and eventually one's ability to carry out simple tasks. AD is the most common cause of dementia in the elderly. It is ranked as the sixth leading cause of death in the United States (National Institute on Aging, 2016), and accounts for about 60% of all cases of dementia (D'Onofrio et al., 2015).

Prior to the manifestation of cognitive decline, individuals with AD begin to exhibit changes neuroanatomically over the course of several years. AD is caused by a buildup of amyloid plaques and neurofibrillary tangles which accumulate over time. Amyloid is a protein that develops within the brain that can divide improperly and aggregate together to create amyloid plaques outside of the cell, interfering with the neuron's ability to send messages to other neurons. Neurofibrillary tangles are hyperphosphorylated tau protein fibers that aggregate within the cell and interfere with the cell's functions. The buildup of these plaques and tangles eventually leads to neurodegeneration and brain atrophy, beginning predominantly in the medial temporal lobe and hippocampus, which is an area that is responsible for learning and memory (Petersen et al., 2014). Over time, the atrophy spreads to the neighboring areas (Figure 1). Due to the progression of atrophy, memory problems are the first sign of cognitive impairment as a result of AD pathology; however, there can be some variation in clinical presentations from person to person. Some may also show decline in non-memory aspects of cognition such as word-finding abilities, visual-spatial issues, and impaired reasoning or judgment (National Institute on Aging, 2016).

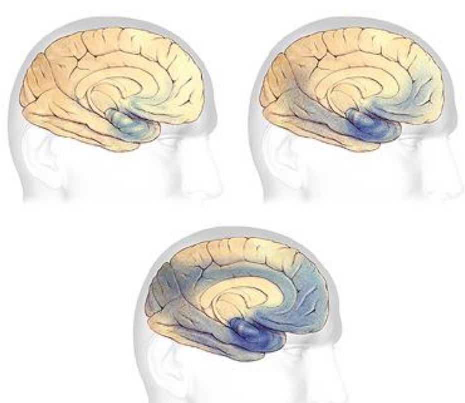

Figure 1. Progression of atrophy (Alzheimer's Association, 2011)

Vascular Dementia

Vascular Dementia (VaD) is the second-most common cause of dementia in the elderly after AD. VaD is defined as loss of cognitive function resulting from ischemic, hypoperfusive, or hemorrhagic brain lesions due to cerebrovascular disease (CVD) or cardiovascular pathology (Román, 2003; Tanaka, Kondo, Okamoto, & Hirai, 2003). CVD refers to a group of conditions that affect the blood supply to the brain, causing reduced or no blood flow to the affected areas. Sometimes changes in cognitive functioning can occur following strokes that block major brain blood vessels, or they can gradually worsen as the result of multiple minor strokes or other conditions that affect smaller blood vessels (Alzheimer's Association, 1980). VaD is estimated to be responsible for 20% of the 5.6 million cases of dementia in the United States (Román, 2003), with a higher prevalence in men than women in most age groups (Román et al., 1993).

VaD and AD share certain vascular risk factors such as hypertension (i.e., high blood pressure), peripheral arterial disease, some cardiovascular disorders, diabetes mellitus, and smoking history. However, the onset and progression of VaD is different from AD. The onset of VaD can be sudden (e.g., as in the case of a severe stroke), or in other cases gradual with a slow and stepwise progression, whereas the onset of AD is never sudden, but gradual and insidious. Further, memory is the primary area of impairment in AD, whereas VaD is primarily characterized by impairments in complex attention, speed of information processing, and executive ability (American Psychiatric Association, 2013).

The symptom profile of VaD is also highly variable, depending on the severity of the blood vessel damage and the area of the brain that is affected. Symptoms post-stroke include confusion, disorientation, trouble speaking and/or understanding speech, and vision loss. Additionally, the individual may have physical stroke symptoms such as sudden headache, difficulty walking, or numbness, or paralysis on one side of the face or the body (Alzheimer's Association, 1980). Alternatively, an individual may experience multiple small strokes that do not show distinct symptoms but may cause more gradual cognitive changes. These can include impaired planning and judgment, uncontrolled laughing and crying (pseudobulbar affect), declines in attention, impaired functioning in social situations, and difficulty finding the right words.

Table 2. Diagnostic Criteria for Vascular Dementia

		NINDS-AIREN Criteria
1	a	*Dementia*
	b	*Cerebrovascular Disease*
	c	*A relationship between the above two disorders*
2	a	Early presence of gait disturbance (small-step gait or marche a petits pas, or magnetic, apraxic-ataxic or parkinsonian gait)
	b	History of unsteadiness and frequent, unprovoked falls
	c	Early urinary frequency, urgency, and other urinary symptoms not explained by urologic disease
	d	Pseudobulbar palsy
	e	Personality and mood changes, abulia, depression, emotional incontinence, or other subcortical deficits including psychomotor retardation and abnormal executive function

According to the National Institute of Neurological Disorders and Stroke - Association Internationale pour la Recherche et I'Enseignement en Neurosciences (NINDS-AIREN) criteria, a diagnosis of VaD must establish the presence of dementia, cerebrovascular disease, and a relationship between the two disorders (See Table 3; Román et al., 1993). More recently revised criteria used to classify VaD is the Vascular Behavioral and Cognitive Disorders (VASCOG). The two primary aspects of diagnosing vascular cognitive disorders (VCD) are 1) verifying the presence of a cognitive disorder, and 2) confirming that vascular disease is the predominant pathology that accounts for the cognitive deficits (Sachdev et al., 2014).

Individuals diagnosed with MCI and/or mild NCD have a higher risk of progressing to dementia. In a clinical research setting, individuals with MCI have been shown to progress to dementia at a rate of 18% per year whereas another study demonstrated a conversion rate of 20% (Maioli et al., 2007; Pereira et al., 2017; Petersen et al., 2009; Sachdev et al., 2012). However, not all individuals with MCI progress to dementia; approximately 40 to 70% of individuals with amnestic MCI improve or stay stable at follow up (Lopez-Anton et al., 2015; Ravaglia et al., 2006). Various risk factors can further increase one's risk of conversion from MCI to dementia. When an individual progresses from MCI to dementia, they begin to demonstrate further declines in cognition, which in turn cause impairments in ADLs. In other words, an individual with MCI crosses over into dementia at the point when cognitive impairments become severe enough to cause deficits in ADL functioning. Therefore, the relationship between cognitive function and ADL functions warrants discussion.

Cognitive Function and ADLs

Activities of daily living (ADLs) can be divided into two categories. Basic ADLs refer to the individual's ability to manage basic physical needs in the areas of grooming/personal hygiene, dressing, toileting/continence, transferring/ambulating, and eating (Jekel et al., 2015; Mlinac & Feng, 2016). Instrumental activities of daily living (IADLs) refer to more complex tasks, encompassing the individual's ability to live independently in the community in terms of managing their own finances and medications, paying bills, driving, and remembering appointments (Jekel et al., 2015; Mlinac & Feng, 2016).

The ability to perform basic ADLs and IADLs is dependent upon cognitive (e.g., reasoning and planning), motor (e.g., balance and dexterity), and perceptual (including sensory) abilities (Mlinac & Feng, 2016). IADLs require more complex neuropsychological processing capacity than basic ADLs and are more prone to being adversely affected in earlier stages of cognitive decline (Jekel et al., 2015). IADLs often rely on the patient's memory and frontal or executive functioning (Ahn et al., 2009). Basic ADLs require different types of skills such as sequencing of action, conceptual knowledge, and manipulation. As such, research has shown that various cognitive functions, including attention, immediate memory, delayed memory, working memory, executive functioning, self-monitoring, attention, and visuospatial skills have been linked to different aspects of ADL functioning (Aretouli & Brandt, 2010; Farias et al., 2003; Hall, Vo, Johnson, Barber, & O'Bryant, 2011).

Attention

Many tasks require various aspects of attention, including sustained attention, divided attention, selective attention, concentration, and processing speed. Consistent with prior studies (Farias et al., 2006), Hall and others (2011) demonstrated a significant relationship between performance of ADLs and performance on neurocognitive tests. Specifically, it was found that attention was a more important predictor of ADLs in patients with Alzheimer's disease than executive functioning, visuospatial skills, and memory. A simple attention task was predictive of both ADL and IADL functioning among the total sample, while bathing, grooming, and feeding capacity was significantly predicted by a sustained and divided attention task (Hall et al., 2011). A study conducted by Bronnick and others (2006) similarly demonstrated that sustained attention was the strongest predictor of the individual's total ADL score. Carter, Oliveira, Duponte, and Lynch (1988) also observed that an auditory attention task was correlated with later ADL performance in individuals following a stroke.

Language

Language encompasses object naming, word finding, fluency grammar and syntax, and receptive language. Performance on language tasks has been shown to predict IADL functions, such as the ability to prepare meals in men and driving skills in women (Farias et al., 2006; Hall et al., 2011). Specifically, performance on tasks of phonemic fluency, naming, and receptive language predicted performance on physical activities and social orientation (i.e., socialization, reading, managing appointments, and keeping up on current events) of activities of daily living (Bronnick et al., 2006). However, Richardson, Nadler, and Malloy (1995) were unable to find a relationship between IADLs and phonemic fluency ability. In terms of basic ADLs, bathing, grooming, and feeding performance has also been found to be predicted by performance on a confrontational naming task (Hall et al., 2011).It is important that the individual is able to identify objects such as groceries needed to cook a meal. The ability to communicate and understand what is being communicated to them is also critical for both occupational and social functioning. Receptive language function (i.e., comprehension) is also important for managing medications and calendar appointments (Farias et al., 2006).

Perceptual-Motor Function

Perceptual-motor functioning is comprised of visual perception, visuospatial and visuoconstructional reasoning, and perceptual motor coordination. Research has demonstrated that visuospatial and visuoconstruction skills are correlated with the individual's ability to write a letter for mailing, counting money, write a check, and balance a checkbook (Farias et al., 2003). Maeshima and others (1997) demonstrated a significant correlation between constructional ability and mobility and social cognition scales on the FIM. Spatial orientation and visual processing are essential components for instrumental activities involved in money management and dialing a telephone (Richardson, Nadler, & Malloy, 1995). Schmitter-Edgecombe and Parsey (2014) observed the type of errors individuals diagnosed with MCI or dementia and healthy young and older adults made when they engage in everyday tasks in a naturalistic environment such as sweeping and dusting, medication dispenser, birthday card and check, watching a DVD, watering plants, cooking, dressing, and making a phone call. It was found that individuals with dementia had ended some tasks prematurely; alternative objects were used in order to complete tasks, irrelevant behaviors occurred or alternate task actions were completed such as dusting the kitchen instead of the living room (Schmitter-Edgecombe & Parsey, 2014).

Learning and Memory

Learning and memory encompasses encoding, free recall, cued recall, recognition memory, semantic and autobiographical long-term memory, and implicit learning. Learning and memory is important for completing tasks such as cooking, cleaning, remembering appointments and bills, and shopping. Aretouli and Brandt (2010) demonstrated that individuals with MCI had difficulties keeping appointments, remembering current events, and finding things at home. Schmitter-Edgecombe, McAlister, and Weakley (2012) showed that individuals 50 years and older with MCI performed more poorly than cognitively healthy controls on the naturalistic day out task that involved both retrospective memory (memory of people, words, and events encountered in the past) and prospective memory (ability to perform a planned action or recall a planned intention at some time in the future) (Overdorp et al., 2016; Schmitter-Edgecombe et al., 2012). Schmitter-Edgecombe and others (2012) demonstrated that retrospective memory was a predictor of the individual's ability to perform the day out task, whereas planning and prospective memory was not. Additionally, the ability to recall the locations of a series of objects was associated with immediate and delayed memory (Farias et al., 2003). Memory functioning (verbal or visual) has also been found to be related to issues of safety, and management of money and medications (Richardson et al., 1995).

Executive Function

Executive functioning tasks require planning, decision-making, working memory, inhibition, flexibility, and responding to feedback. These skills are essential in completing IADLs such as managing finances and medications, keeping track of appointments, and grocery shopping and cooking. Ahn and colleagues (2009) demonstrated that MCI patients with deficits in memory and executive functioning performed significantly poorer on IADLs than controls, on tasks such as the ability to use the telephone, prepare meals, take medication, manage belongings, keep appointments, talk about recent events, and perform leisure activities or hobbies. In another study, executive function, in particular, predicted both ADLs and IADLs in women and men (Hall et al., 2011). It was determined that executive functioning measures were significantly correlated with medication management, transportation, laundry, housekeeping, and food preparation for both men and women.

Cornelis and others (2018) demonstrated that executive function measures significantly contributed to the individual's basic (i.e. washing and dressing oneself) and instrumental (i.e., shopping and preparing meals) activities of daily living rating on the International Classification of Functioning (ICF), Disability and Health scoring system.

Functional Decline in MCI

Due to the severity of their cognitive impairments, patients with dementia experience declines in both instrumental and basic ADLs, leading to poorer quality of life, increased health care costs, increased risk of mortality, and institutionalization (Mlinac & Feng, 2016). It is assumed that an individual's ability to perform ADLs remains relatively unimpaired in the MCI stage (Perneczky et al., 2006). However, recent research has indicated that some degree of IADL impairment is often present in individuals with MCI (Ahn et al., 2009; Aretouli & Brandt, 2010; Farias et al., 2003;

Hall, Vo, Johnson, Barber, & O'Bryant, 2011; Mlinac & Feng, 2016; Overdorp, Kessels, Claassen, & Oosterman, 2016; Richardson, Nadler, & Malloy, 1995; Schmitter-Edgecombe et al., 2012). Although MCI patients can generally perform their social activities independently and maintain their occupations, there are subtle changes such as repeating minor mistakes at work, decreased efficiency, or slow performance (Ahn et al., 2009). Farias and colleagues (2006) also demonstrated that individuals with MCI (mean age 76.5 years with 13.8 years of education) displayed more functional problems relative to healthy elderly in everyday memory, language, visuospatial skills, planning, organization, and divided attention. Therefore, it is important to assess an individual's ability to complete both basic ADLs and IADLs in order to monitor progression of cognitive impairments and help identify when they may begin to need assistance in managing finances, medications, appointments, and/or cooking.

Assessment of ADLs

There is no "gold standard" for clinically assessing everyday functional status. Oftentimes, assessment involves use of self-report or informant-report measures. However, the ability of patients with MCI to adequately evaluate themselves on ADLs/IADLs is questionable, as they sometimes lack awareness of their own deficits and overestimate their functional capacity (Ahn et al., 2009; Jekel et al., 2015). Perneczky and others (2006) demonstrated that informants of MCI patients reported significantly more impairments on complex ADLs than those of unimpaired controls, suggesting that the patients themselves may under report and/or are inaccurate about their daily functioning. Therefore, the use of more objective, performance-based methods may be more accurate.

One method of evaluating ADLs is the use of the Functional Independence Measure (FIM) and Functional Assessment Measure (FAM). The FIM is a 30-item measure that assesses the areas of self-care (feeding, grooming, bathing, dressing, toileting, and swallowing), sphincter control (bladder and bowel), mobility (transferring from bed/chair/wheelchair to toilet, tub or shower, and car), locomotion (walking/wheelchair, stairs, and community access), communication (comprehension audio/visual items, expression verbal and nonverbal, reading, writing, and speech intelligibility), psychosocial adjustment (social interaction, emotional status, adjustment to limitations, employability), and cognitive function (problem solving, memory, orientation, attention, and safety judgment). The FIM also includes items from the FAM, which was added in 1992 as an extension that was created for patients with traumatic brain injury due to the prominence of communicative, cognitive, and behavioral disturbances (Hawley, Taylor, Hellawell, & Pentland, 1999). The FAM includes 12 items that assess cognitive, behavioral, communication, and psychosocial functioning. These include swallowing, car transfer, community access, reading, writing, speech intelligibility, emotional status, adjustment to limitations, employability, orientation, attention, and safety judgment (Gurka, Felmingham, Baguley, Schotte, Crooks, & Marosszeky, 1999; Hawley et al., 1999; McPherson, Berry, & Pentland, 1997).

Research has shown that there are correlations between neuropsychological assessment measures and IADL and basic ADL functioning; however, there has been limited research that observes the correlations between neuropsychological measures and the FIM+FAM specifically. Cullen and Weisz (2011) showed that there was a significant correlation between FIM scores and a wide variety of neuropsychological areas: mental speed/attention language comprehension and understanding, learning and memory, executive functioning and perceptual organization. McPherson, Berry, and Pentland (1997) demonstrated a significant relationship between the FIM and neuropsychological tests measuring comprehension, problem solving, and memory. Other research has demonstrated a significant relationship between the FIM and impairments in memory, concentration, and learning skills (Davidoff, Roth, & Richards, 1992). Tanaka and others (2013) indicated that the FIM cognitive score, in particular, which includes comprehension, expression, social interaction, problem solving, and memory subscales, was correlated with general cognitive function. In traumatic brain injury patients, adding a battery of neuropsychological tests with the FIM increased the power to predict readmission, handicap, functional outcome, supervision needs, employability, and return to driving over injury severity and early functional status alone (Cullen, Krakowski, & Taggart, 2014; Hanks et al., 2008). However, the FIM alone cannot be a substitute for a neuropsychology exam in predicting rehabilitation mobility outcome (Pavol et al. 2017).

The FIM+FAM is used to measure IADL and basic ADL functioning in inpatient settings and is typically administered by multiple professionals; therefore, it is a difficult measure to utilize in outpatient settings. Identifying the cognitive scores that are correlated with functional assessment could assist clinicians in making more accurate predictions regarding functional decline to promote earlier and more effective intervention (Aretouli & Brandt, 2010).

Purpose of the Study

The proposed study will examine the relationships between functional status, as measured by the FIM+FAM, and different aspects of cognitive function. In inpatient, hospital settings, functional impairment can be comprehensively assessed by occupational therapists, physical therapists, and speech and language therapists; however, in some outpatient facilities functional impairment is often assessed through a clinical interview with the patient and a family member, which can be unreliable. Using performance-based measures for functional impairment requires the clinician to obtain training on the measure, and requires additional time and resources in order to conduct these assessments. This study will help determine if there is a specific cognitive measure or group of measures, or a pattern in the neuropsychological profile that can predict global functional impairment, and specific areas of functional impairment.

Aims of the Current Study

Specific Aim 1

Examine the relationship between neuropsychological scores and the FIM Total, Communication, Psychosocial Adjustment and Cognitive Function score.

Hypothesis 1

The neuropsychological scores; more specifically the executive functioning scores (WCST and Trails B) will explain the variance in the FIM Total Score.

Hypothesis 2

The neuropsychological scores; more specifically the language scores (FAS, Animals, BNT and BDAE) will explain the variance in the FIM Communication score.

Hypothesis 3

It is predicted that the neuropsychological scores; more specifically the language (FAS, Animals, BNT and BDAE) and executive function scores (WCST and Trails B) will explain the variance for the FIM Psychosocial Adjustment score.

Hypothesis 4

The neuropsychological scores; more specifically the MMSE will explain the variance in the FIM Cognitive Function score.

Specific Aim 2

Examine the relationship between theory driven composite domain scores and the FIM Total, Communication, Psychosocial Adjustment, and Cognitive Function score.

Hypothesis 1

The Global and Attention/Executive domain scores will explain the variance in the FIM Total Score.

Hypothesis 2

The Language domain score will explain the variance in the FIM Communication score.

Hypothesis 3

The Global and Language domain scores will explain the variance for the FIM Psychosocial Adjustment score.

Hypothesis 4

The Global and Memory domain scores will explain the variance in the FIM Cognitive Function score.

Exploratory Aim 3

Examine the relationship between data-driven composite domain scores (defined by factor analysis of all neuropsychological test scores) and the FIM Total, Communication, Psychosocial Adjustment, and Cognitive Function score.

CHAPTER TWO

METHODS

Participants

Participants were recruited from Casa Colina Rehabilitation Hospital from the Senior Evaluation Program (SEP). SEP is a referral-based program offered at the outpatient clinic that the physician referred their patients, for a comprehensive examination. It includes an evaluation by Physical Therapy (PT), Occupational Therapy (OT), Speech and Language Therapy, and Neuropsychology as well as other necessary consultant services. The participants who were included in the study are individuals aged 50 or older who received this evaluation. Individuals were diagnosed by a licensed clinical psychologist, after a comprehensive neuropsychological evaluation and meeting criteria outlined in the ICD-10.

A power analysis conducted using G*Power 3.1 indicated that a sample of 91 participants were required to have sufficient power to detect a medium effect size (.35). Neuropsychological and medical records were obtained for 76 participants who were included in the study. The mean age of the participants was 79.86 (SD = 9.114). The majority of the sample was female (N = 51) and Caucasian (N = 59). The mean years of education was 12.85 (SD = 3.922).

Neuropsychological Assessment

Mental Status

The Mini-Mental Status Exam (MMSE) is a brief measure of gross cognitive functioning, which was first developed in 1975. It is used as a screening measure for dementia and cognitive impairments. Additionally, it is used to develop a probable diagnosis and track individuals who may be at risk for dementia (Gluhm, Goldstein, Loc, Colt, Van Liew, & Corey-Bloom, 2013). It takes five to ten minutes to administer. It assesses orientation, attention/registration, memory/recall, language, and praxis/construction. Scores less than 24 out of 30 possible points indicate cognitive impairment. The MMSE is reliable (Cronbach's $\alpha = 0.82$ and 0.84) and valid (87% sensitive and 82% specific) especially in a medical setting meaning that the measure measures cognitive impairments in respect to a diagnosis of dementia (Folstein, Folstein, & McHugh, 1975; Tombaugh, McDowell, Kristjansson, & Hubley, 1996).

Executive Functioning

Executive functioning is defined as control processes responsible for planning, assembling, coordinating, sequencing, and monitoring other cognitive operations (Salthouse, Atkinson, & Berish, 2003). It is related to higher-order cognitive processes that include initiation, planning, hypothesis generation, cognitive flexibility, decision-making, regulation, judgment, feedback utilization, and self-perception that help guide behavior (Salthouse, Atkinson, & Berish, 2003; Spreen & Strauss, 1998). It assesses the individual's novel problem solving, inhibition, abstract reasoning, and set-shifting abilities.

Measures that assess executive functioning include Wisconsin Card Sorting Test (WCST), Trail-Making Test Part B (Trails B), and Controlled Oral Word Association Test (COWAT). The WCST requires the individual to match cards with stimulus cards based on various characteristics and the provided feedback as to whether they are correct or incorrect. WCST assesses problem solving, memory, inhibition, and pattern recognition. The number of categories that the individual completes is recorded along with the number of trials to complete the first category. In addition to the number of categories completed the number of failed attempts to complete the category is assessed and the success of the measure (Failure to Maintain Set and Conceptual Level Responses). Perseverative errors are measured when the individual continues with a characteristic and is not responding to the feedback. The WCST has demonstrated reliability (Cronbach's α) ranging 0.60 to 0.85 with an average of 0.74 (Heaton, 2008). It was also determined that the WCST is a valid measure accounting 82.3% of the variance in test scores for normal adults (Bowden et al., 1998; Heaton, 2008; Strauss, Sherman, & Spreen, 2006).

The Trails B assesses set-shifting, visual scanning, and processing speed. The individual has to draw a line from 1 to A in ascending order, while shifting between number and letter, without lifting the pencil from the paper. The person is required to complete this task as quickly as they can without making mistakes.

The COWAT (FAS) assesses verbal production/output. FAS is a phonemic/letter fluency test that requires the individual to name as quickly as they can words that begin with a certain letter (i.e., F, A, and S) within a minute. FAS assesses a variety of frontal-based behaviors including set maintenance, set-shifting monitoring of responses to avoid repetitions, and generation of response alternative (Richardson, Nadler, & Malloy, 1995; Salthouse, Atkinson, & Berish, 2003).

Language

Language measures assess for an individuals fund of knowledge, and ability to communicate. These measures can tell the clinician if the individual has aphasia, which is an acquired disorder of verbal function involving difficulty with comprehension and/or formulation of language. Language measures include the COWAT, Boston Naming Test (BNT), and BDAE Complex Ideation (BDAE-CI). The BNT has high reliability (Cronbach's $\alpha > 0.95$) and highly correlated with other measures (ranging $r = 0.43$ to 0.86; Strauss, Sherman, & Spreen, 2006). The BDAE has high reliability on each subtest ranging from a Cronbach's α of 0.71 to 0.96 (Goodglass, Kaplan, & Barresi, 2000; Strauss, Sherman, & Spreen, 2006). The BDAE correlations between subtests are 0.60 or greater indicating good validity (Strauss, Sherman, & Spreen, 2006).

BNT is a test of confrontation naming or object naming. It is comprised of three scores; correct spontaneous responses, correct responses with or without semantic cue, and correct responses with or without phonemic cue.

The COWAT (or FAS, Animals) assesses verbal production/output. FAS assesses a variety of frontal-based behaviors including set maintenance, set-shifting, and generation of response alternative (Richardson, Nadler, & Malloy, 1995). Animals is a semantic/category fluency task in which the person is required to list off as many things that belong to that category within a minute. As people age with no clinical diagnosis of dementia, perform better on a task of semantic fluency than phonemic fluency. The COWAT has high reliability (Cronbach's $\alpha = 0.83$; average intercorrelation $R = .61$; Ruff, Light, & Parker, 1996).

BDAE-CI is a quick measure that assesses for aphasia or their ability to understand what the examiner is saying and their ability to communicate. It is comprised of a series of yes/no questions such as "will a cork sink in water," and the individual is read a short story and asked questions about the story.

Attention and Concentration/Processing Speed

Processing speed is the individual's ability to do a mental task or the speed in which they can understand and react to the information they receive either visually or verbally. The Trail Making Test Part A (Trails A) is a task that requires the individual to connect numbered bubbles from 1 to 25 as quickly as they can. Trails B is more complex and considered a task of executive function, as described above. The TMT has high reliability (Cronbach's $\alpha_{TMTA} = 0.89$; Cronbach's $\alpha_{TMTB} = 0.92$) and validity (correlated moderately $r = 0.31$; Reitan, R. M., 1986; Strauss, Sherman, & Spreen, 2006).

Memory

Memory is an individual's ability to encode the information, storage and retention of the information for long-term memory, and the ability to retrieve the information at a later time. Memory can be assessed through verbal and/or visual means.

Verbal

Verbal memory is when information presented in the form of a list of words or in a short story. Measures that assess verbal memory are California Verbal Learning Test, 2^{nd} Edition (CVLT-II), and Wechsler Memory Scale Fourth Edition Logical Memory (WMS-IV). The CVLT-II has been established as a reliable measure (Cronbach's α ranging from 0.80 to 0.96). The split-half reliability was very high (0.79). The CVLT-II is a valid measure with coefficients in the adequate to high range (0.70 to 0.89; Strauss, Sherman, & Spreen, 2006). The WMS-IV has established high reliability (Cronbach's α ranging from 0.74 to 0.96) and validity (RMSEA = 0.38 and 0.45; Wechsler, 2009).

The CVLT-II is a list-learning task and requires the individual to learn a list of 16 words. They are given 5 trials in order to learn the list of words (Trials 1-5). Then the person is asked to recall a second list of words (List B). The second list serves as a distractor for the individual. After a short delay, the patient is asked to recall the first list that was read to them several times and then is provided cues (Short Delay Free Recall and Short Delay Cued Recall). Then after a long delay, the patient is then asked to recall the list that was read to them several time and then provided cues (Long Delay Free Recall and Long Delay Cued Recall). Throughout the learning trials, short- and long-delayed recall, the number of times the individual says a word that is not on either list, intrusion, is counted. The individual is read a list of words and is asked to say yes or no if that word was from the first list that was read several times (Total Recognition Discriminability).

The WMS-IV Logical Memory test is a measure of story recall where the individual is read two short stories and asked to recall details from each story. After a 20 to 30 minute delay the individual is again asked to recall details from the short stories that were read earlier. A cue may be given to the patient if they are unable to recall the story. Afterwards, the individual is asked yes or no questions about the stories, which assesses their recognition of the stories.

Nonverbal

Nonverbal memory assesses the individual's ability to learn geometric figures and recall details after a delay. The WMS-IV Visual Reproduction requires the individual to look at 5 individual designs on a page for 10 seconds each and then draw the design from memory. After a 20 to 30 minute delay, the individual is asked to reproduce the designs from memory in any order. Then the individual is shown arrays of different designs and is asked to identify the original designs from among 6 choices.

Mood

The Geriatric Depression Scale (GDS) is a 30-item self-report measure used to identify depression. The individual answers "yes" or "no" questions, which is then added up to indicate "normal" (0-9 points), "mildly depressed" (10-19 points), or "severely depressed" (20-30 points). A number of studies have demonstrated that the GDS has good reliability (Cronbach's α ranging from 0.82 to 0.94) and validity (sensitivity 0.75; specificity 0.77; Kieffer & Reese, 2002; Strauss, Sherman, & Spreen, 2006; Wancata, Alexandrowicz, Marquart, Weiss, & Friedrich, 2006).

Standardization of Scores

All neuropsychological test scores were converted into the same measurable unit, z-scores, based on the sample means and standard deviations.

ADL and IADL Assessment

The National Task Force of rehabilitation research created the FIM in 1987 as a measure administered by therapists to assess the person's ADLs and IADLs. It consists of 18-items, each rated with a 7-point scale. The FAM was added to the FIM in 1992 due to prominent deficits in communication, cognition, and behavioral disturbance. The FAM consists of 12-items, which makes the entire measure 30-items total. It is a measure used in hospital or rehabilitation settings due to it measuring the patient's total functioning, tracking progress or lack thereof and correctly categorizing and quantifying dysfunction as discharge planning is done (Mortifee, Busser, & Anton, 1996). The patient is evaluated in the areas of Self-Care, Sphincter Control, Transfer, Locomotion, Communication, Psychosocial Adjustment, and Cognitive Function. It yields two scores - a Motor Score and a Cognitive Score. The Motor Score is comprised of Self-Care, Sphincter Control, Transfer, and Locomotion, whereas The Cognitive Score includes Communication, Psychosocial Adjustment, and Cognitive Function. The FIM has high reliability (Cronbach's $\alpha = 0.96$) and validity (sensitivity = 0.88; specificity = 0.65). An occupational therapist, physical therapist, and a speech and language therapist evaluate each of these areas.

Table 3. Functional Independence Measure with Functional Assessment Measure items*

	Categories	Individual Items
Motor Score	Self-Care	Feeding
		Grooming
		Bathing
		Dressing Upper Body
		Dressing Lower Body
		Toileting
		Swallowing*
	Sphincter Control	Bladder Management
		Bowel Management
	Transfer	Bed, Chair, Wheelchair
		Toilet
		Tub or Shower
		Car Transfer*
	Locomotion	Walking/Wheelchair
		Stairs
		Community Access*
Cognition Score	Communication	Comprehension-Audio/Visual
		Expression-Verbal/Non-verbal
		Reading*
		Writing*
		Speech Intelligibility
	Psychosocial Adjustment	Social Interaction
		Emotional Status*
		Adjustment to Limitations*
		Employability*
	Cognitive Function	Problem Solving
		Memory
		Orientation*
		Attention*
		Safety Judgment*

**** Items from the Functional Assessment Measure***

Each area is rated on a 1 to 7 point scale with 1 meaning the individual needs total assistance with tasks whereas 7 means they are completely independent. Self-Care encompasses the patient's ability to eat, groom, bathe, dress their upper body, dress their lower body, and toileting. Sphincter Control is divided into bladder and bowel management. Transfers refer to transferring from the bed, chair, wheelchair, the toilet, and the tub and/or shower. Locomotion is the individual's ability to walk or use their wheelchair, and ambulate up and down the stairs. Communication includes comprehension of what is being said or asked of the patient, and the patient's ability to express what they thinking and needs. Comprehension includes understanding either auditory or visual communication such as written, sign language, and/or gestures. Expression encompasses clear vocal and non-vocal expression of speech of intelligible speech or expression of language using written or a communication device. Additionally, reading, writing, and speech intelligibility. Psychosocial Adjustment, include social interaction, emotional status, adjustment to limitations, and employability. Social interaction includes skills related to getting along and participating with others in therapeutic and/or social situations. The last area, Cognitive Function encompasses problem solving, memory, orientation, attention, and safety judgment. Memory includes skills related to recognizing and remembering while performing daily activities in an institutional or community setting. Each item is added up (score of 1 to 7) in order to obtain a Total FIM Score. The Motor Score is the sum of all of the motor items and The Cognition Score is the sum of the cognition items.

The higher the FIM score the more independent the patient is whereas lower scores indicate that the patient needs assistance when ambulating, and conducting basic ADLs. The FIM Total, Psychosocial Adjustment, Communication, and Cognitive Function was observed due to these measuring instrumental ADLs, which declines with subtle cognitive declines whereas basic ADLs or the FIM Motor score declines with severe cognitive deficits. Previous research has demonstrated that individuals with MCI display difficulties with completing instrumental ADLs and rely on compensatory strategies in order to complete tasks.

Statistical Analysis

A series of multiple linear regressions will be conducted in order to determine whether there is a relationship between participants' neuropsychological test scores and the FIM scores; specifically the Total Score, and the total scores for the following sections of Communication, Psychosocial Adjustment, and Cognitive Function (dependent variable). These FIM scores are chosen due to their ability to map onto IADL tasks.

Neuropsychological test scores will be examined individually, and in combination as theory driven cognitive domains: Global cognition (MMSE), Language (Animals, BNT, and BDAE-CI), Memory (Logical Memory I and II, Visual Reproduction I and II, and CVLT Trials 1 to 5 and Long Delay Free Recall), and Attention/Executive (FAS, Trails A and B, WCST Category Number, Trials to First Category, Perseverative Errors, and Conceptual Level Response). Each domain score will be calculated as the average z-score of the component tests.

For exploratory aim 3, neuropsychological test scores will be composite scores based on components identified through an exploratory factor analysis (EFA) conducted on the neuropsychological measures. The following assumptions of a factor analysis are (1) all variables must be normally distributed, and (2) the relationship among all pairs of variables must be linear. Figure 2 demonstrates the proposed model. Any variables have a small sample size then a Bartlett sphericity test will be used. Four criteria were used to determine the appropriate number of components to retain: eigenvalue, variance, scree plat, and residuals. The domain scores will be calculated by averaging all of the z-scores of the measures that loaded/factored into that exact domain.

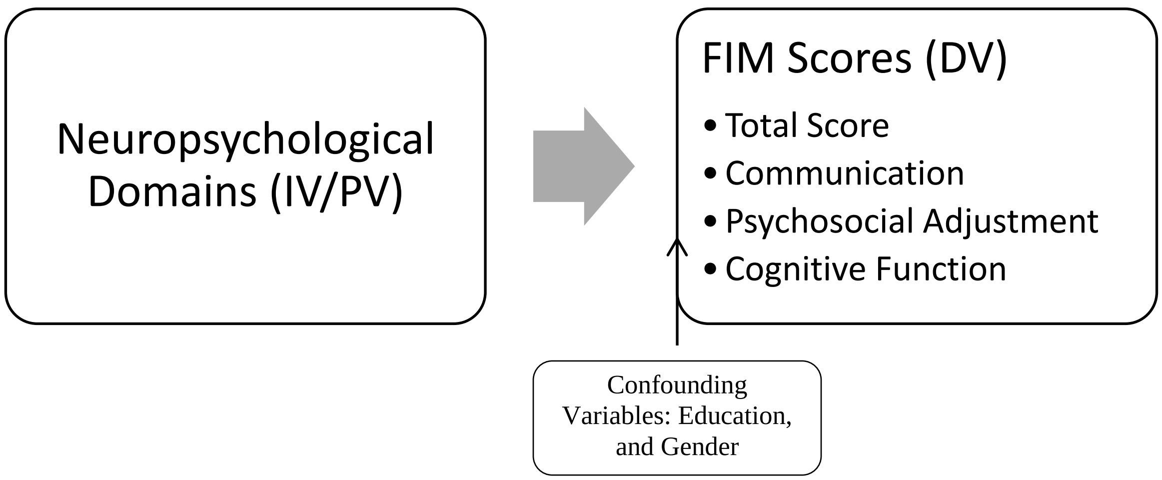

Figure 2. Multiple Regression Model

CHAPTER THREE

RESULTS

The mean age of the sample is 79.86 ± 9.114 years old. The mean level of education in years was 12.85 ± 3.922. The sample comprised of 51 females and 25 males. Table 4 shows the demographics of the sample. Table 5 shows the frequency, mean, and standard deviations of the neuropsychological measures.

Table 4. Demographics of the Sample

	N	M(SD)
Age	73	79.86(9.114)
Education	73	12.85(3.922)
Gender		
Male	25	
Female	51	
Ethnicity		
Caucasian	59	
Black/African American	5	
Asian	3	
Other	7	
Diagnosis		
Cognitively Normal	16	
MCI	10	
Dementia	28	
Other	22	

Table 5. Frequency and Descriptive for Independent Variables

		N	M(SD)
MMSE		71	22.83(5.96)
Trails			
	A	60	84.62(53.91)
	B	51	191.06(101.74)
BNT		64	42.28(14.54)
COWAT			
	FAS	67	27.16(12.21)
	Animals	67	3.09(2.99)
BDAE-CI		65	9.37(2.81)
WMS-IV			
	Logical Memory 1	60	20.42(10.48)
	Logical Memory 2	60	10.22(7.79)
	Visual Reproduction 1	59	21.17(9.09)
	Visual Reproduction 2	59	8.15(8.59)
CVLT-II			
	Learning Trial 1-5	59	27.20(12.64)
	Long Delay Free Recall	60	4.65(3.96)
WCST			
	Category Number	58	1.55(1.38)
	Trials to 1st Category	50	29.04(22.73)
	Conceptual Level Response	50	25.90(15.47)
	Perseverative Errors	50	16.16(9.61)
	Failure to Maintain Set	54	0.46(0.75)
GDS		62	10.68(6.96)
FIM Total		76	112.18(23.58)
FIM Communication		76	17.78(6.68)
FIM Psychosocial Adjustment		76	5.50(1.68)
FIM Cognitive Functioning		76	7.14(3.71)

Specific Aim 1

Analysis of the assumptions and multicollinearity revealed that there were high correlations between multiple neuropsychological measures (See Table 6). Multicollinearity can cause coefficient estimates to swing based on other variables in the model and reduces the precision of the estimated coefficients, which weakens the statistical power. Therefore, multiple linear regressions using the individual neuropsychological measures were not conducted. Further, due to our small sample size, we did not have sufficient power to run individual tests on each measure while correcting for multiple comparisons.

Table 6. Pearson Correlations between Independent Variables

	MMSE	Trails A	FAS	Animals	BNT	WMS LM1	WMS LM2	WMS LM Rec	CVLT T15	WMS VR1	WMVR2	WMS VR Rec	Trails B	WCST Cat #	WCST FMS	WCST TFC	WCST PE	WCST CLR	BDAE-CI	CVLT LDFR
MMSE	1	-.558	.506	-.164	.775	.653	.650	.556	.631	.784	.587	.588	-.544	.544	-.121	-.470	-.228	.499	.645	.511
Trails A	-.558	1	-.260	.273	-.503	-.361	-.333	-.349	-.460	-.481	-.338	-.412	.437	-.366	-.007	.366	.099	-.254	-.409	-.399
FAS	.506	-.260	1	-.190	.399	.383	.233	.174	.384	.448	.320	.303	-.288	.470	.257	-.359	-.308	.518	.414	.311
Animals	-.164	.273	-1.90	1	-.178	-.169	-.158	-.183	-.373	-.298	-.242	-.347	.238	-.203	.004	.117	-.023	-.217	-.295	-.306
BNT	.775	-.503	.399	-.178	1	.599	.615	.501	.650	.781	.579	.635	-.492	.421	-.112	-.441	-.250	.387	.717	.615
WMS LM1	.653	-.361	.383	-.169	.599	1	.879	.510	.735	.658	.608	.469	-.497	.451	-.183	-.308	-.265	.309	.575	.639
WMS LM2	.650	-.333	.233	-.158	.615	.876	1	.654	.737	.614	.572	.559	-.493	.436	-.206	-.376	-.240	.303	.495	.665
WMS LM Rec	.556	-.349	.174	-.183	.501	.510	.654	1	.579	.496	.571	.621	-.501	.462	-.179	-.362	-.160	.351	.331	.555
CVLT T15	.631	-.460	.384	-.373	.650	.735	.737	.579	1	.726	.638	.533	-.498	.368	-.158	-.306	-.273	.319	.563	.809
WMS VR1	.784	-.481	.448	-.298	.781	.658	.614	.496	.726	1	.701	.666	-.533	.390	-.103	-.364	-.251	.354	.683	.604
WMS VR2	.587	-.338	.320	-.242	.579	.608	.572	.571	.638	.701	1	.744	-.478	.439	-.172	-.396	-.319	.382	.453	.541
WMS VR Rec	.588	-.412	.303	-.347	.635	.469	.559	.621	.533	.666	.744	1	-.321	.383	-.008	-.365	-.250	.396	.437	.558
Trails B	-.544	.437	-.288	.238	-.492	-.497	-.493	-.501	-.498	-.533	-.478	-.321	1	-.526	.033	.517	.537	-.528	-.426	-.404
WCST Cat #	.544	-.366	.470	-.203	.421	.451	.436	.462	.368	.390	.439	.383	-.526	1	-.068	-.725	-.635	.908	.307	.271
WCST FMS	-.121	-.007	.257	.004	-.112	-.183	-.206	-.179	-.158	-.103	-.172	-.008	.033	-.068	1	.029	-.245	.188	-.256	.037
WCST TFC	-.470	.366	-.359	.117	-.441	-.308	-.376	-3.62	-.306	-.364	-.396	-.365	.517	-.725	.029	1	.547	-.748	-.382	-.292
WCST PE	-.228	.099	-.308	-.023	-.250	-.265	-.240	-.160	-.273	-.251	-.319	-.250	.537	-.635	-.245	.547	1	-.761	-.176	-.209
WCST CLR	.499	-.254	.518	-.217	.387	.309	.303	.351	.319	.354	.382	.396	-.528	.908	.188	-.748	-.761	1	.252	.251
BDAE-CI	.645	-.409	.414	-.295	.717	.575	.495	.331	.563	.683	.453	.437	-.426	.307	-.256	-.382	-.176	.252	1	.491
CVLT LDFR	.511	-.399	.311	-.306	.615	.639	.665	.555	.809	.604	.541	.558	-.404	.271	.037	-.292	-.209	.251	.491	1

Specific Aim 2

A series of multiple linear regressions were conducted to determine which cognitive domains (Global Score, Language Score, Memory Score, and Attention/Executive Score) were predictors of FIM Total, FIM Communication, FIM Psychosocial Adjustment, and FIM Cognitive Functioning while controlling for education and age. The Global Score was calculated by taking the z-score of the mini mental status exam (MMSE). The Language Score was calculated by averaging the z-scores for Animals, Boston Naming Test, and Boston Diagnostic Aphasia Examination Complex Ideation (BDAE-CI). The Memory Score was determined by averaging the z-scores of Logical Memory I and II, California Verbal Learning Test (CVLT) Trials 1 to 5 and Long Delay Free Recall, and Visual Reproduction I and II. The Frontal-Executive Function Score was calculated by averaging the z-scores of FAS, Trails A and B, and Wisconsin Card Sorting Test (WCST) Category Number, Trials to First Category, Perseverative Errors, and Conceptual Level Response. If there was any missing data for any of the participants, then the average of the available data was calculated. Pearson Correlations were calculated in order to determine if there was multicollinearity between the domain scores, which indicated that the Global Domain was highly correlated with the Language and Memory Domains (See Table 7).

Table 7. Pearson Correlations of Cognitive Domains

	Global	Language	Memory	Frontal-Executive Function
Global	1	.719	.690	.514
Language	.719	1	.552	.354
Memory	.690	.552	1	.572
Frontal-Executive Function	.514	.354	.572	1

Table 8. Cognitive Domain

Cognitive Domains	Neuropsychological Measure
Global	MMSE
Language	Animals BNT BDAE-CI
Memory	Logical Memory I & II CVLT Trials 1 to 5 CVLT Long Delay Free Recall Visual Reproduction I & II
Frontal-Executive Function	FAS Trails A & B WCST Category Number WCST Trials to First Category WCST Perseverative Errors WCST Conceptual Level Response

Additionally, the FIM Psychosocial Adjustment was transformed using a reflection and logarithm transformation in order to meet the assumptions of the analysis of normality due to a negative skew.

Regression results indicated the overall model did significantly predict FIM Psychosocial Adjustment (R^2= .45, R^2_{adj}=.39, $F_{(6,54)}$=7.33, p<.05). This model accounted for 39% of variance in the individual's FIM Psychosocial Adjustment score. A summary of the bivariate and partial correlation coefficients between each predictor and dependent variable are presented in Table 9 and indicates that only the Global domain significantly predicted the FIM Psychosocial Adjustment Score. The Global domain significantly predicted the FIM Psychosocial Adjustment Score even after a Bonferroni correction for multiple comparisons (p = .008).

Table 9. Multiple Linear Regression of Composite Scores on FIM Psychosocial Adjustment Score

	B	*β*	*t*	*p*	Bivariate *r*	Partial *r*
Global	-.145	.044	-3.262	.002	-.406	-.330
Language	.005	.047	.110	.912	.015	.011
Memory	-.028	.049	-.570	.571	-.077	-.058
Frontal-Executive Function	.073	.059	1.227	.225	.165	.124

Regression results indicated the overall model significantly predicted FIM Cognitive Function (R^2= .43, R^2_{adj}=.37, $F_{(6,54)}$=6.84, p<.05). This model accounted for 37% of variance in the individual's FIM Cognitive Function score. A summary of the bivariate and partial correlation coefficients between each predictor and dependent variable are presented in Table 10 and indicates that the Global and Memory domains significantly predicted the FIM Cognitive Score. A Bonferroni correction was calculated which indicated that the Global domain was no longer a significantly predictor of the FIM Cognitive Score (p = .152) after correcting for multiple comparisons, whereas the Memory domain remained significant (p = .044).

Table 10. Multiple Linear Regression of Composite Scores on FIM Cognitive Function Score

	B	*β*	*t*	*p*	Bivariate *r*	Partial *r*
Global	1.378	.374	2.128	.038	.278	.218
Language	-.586	-.127	-.848	.400	-.115	-.087
Memory	1.864	.405	2.619	.011	.336	.269
Frontal-Executive Function	-.287	-.046	-.333	.740	-.045	-.034

Regression results indicated the overall model also significantly predicted FIM Communication (R^2= .38, R^2_{adj}=.31, $F_{(6,54)}$=5.47, p<.05). This model accounted for 31% of variance in the individual's FIM Communication score. A summary of the bivariate and partial correlation coefficients between each predictor and dependent variable are presented in Table 11 and indicates that none of the four domains individually were significantly associated with the FIM Communication Score.

Table 11. Multiple Linear Regression of Composite Scores on FIM Communication Score

	B	*β*	*t*	*p*	Bivariate *r*	Partial *r*
Global	1.916	.296	1.610	.113	.214	.173
Language	1.870	.230	1.470	.147	.196	.158
Memory	.011	.001	.008	.993	.001	.001
Frontal-Executive Function	.786	.071	.496	.622	.067	.053

Regression results indicated the overall model significantly predicted FIM Total (R^2= .38, R^2_{adj}=.31, $F_{(6,54)}$=5.48, p<.05). This model accounted for 31% of variance in the individual's FIM Total score. A summary of the bivariate and partial correlation coefficients between each predictor and dependent variable are presented in Table 12 and indicates that the Global score significantly predicted the FIM Total Score. After applying a Bonferroni correction the Global domain was no longer significant (p = .084).

Table 12. Multiple Linear Regression of Composite Scores on FIM Total Score

	B	*β*	*t*	*p*	Bivariate *r*	Partial *r*
Global	10.226	.437	2.378	.021	.308	.255
Language	2.438	.083	.531	.598	.072	.057
Memory	-4.372	-.150	-.925	.359	-.125	-.099
Frontal-Executive Function	5.520	.138	.966	.339	.130	.104

A series of regressions were conducted on individuals diagnosed with MCI and dementia (Alzheimer's Disease, Vascular Dementia, Mixed/Unspecified Dementia, and Dementia due to Medical Condition). Regression results indicated the overall model did significantly predict FIM Psychosocial Adjustment (R^2= .37, R^2_{adj}=.28, $F_{(6,40)}$=3.98, p<.05). This model accounted for 28% of variance in the individual's FIM Psychosocial Adjustment score. A summary of the bivariate and partial correlation coefficients between each predictor and dependent variable are presented in Table 13 and indicates that only the Global domain significantly predicted the FIM Psychosocial Adjustment Score. A Bonferroni correction was calculated which indicated that the Global domain was not significant after correcting for multiple comparisons (p = .068).

Table 13. Multiple Linear Regression of Composite Scores on FIM Psychosocial Adjustment Score with MCI and Dementia Diagnosis

	B	*β*	*t*	*p*	Bivariate *r*	Partial *r*
Global	-.141	-.433	-2.481	.017	-.365	-.310
Language	.027	.061	.403	.689	.064	.050
Memory	-.069	-.197	-1.056	.297	-.165	-.132
Frontal-Executive Function	.089	.206	1.234	.225	.191	.154

Regression results indicated the overall model significantly predicted FIM Cognitive Function (R^2= .37, R^2_{adj}=.27, $F_{(6,40)}$=3.90, p<.05). This model accounted for

27% of variance in the individual's FIM Cognitive Function score. A summary of the bivariate and partial correlation coefficients between each predictor and dependent variable are presented in Table 14 and indicates that none of the four domains significantly predicted the FIM Cognitive Score.

Table 14. Multiple Linear Regression of Composite Scores on FIM Cognitive Function Score with MCI and Dementia Diagnosis

	B	*β*	*t*	*p*	Bivariate *r*	Partial *r*
Global	1.476	.309	1.764	.085	.269	.222
Language	.193	.030	.199	.843	.031	.025
Memory	1.502	.293	1.567	.125	.240	.197
Frontal-Executive Function	-.269	-.042	-.253	.802	-.040	-.032

Regression results indicated the overall model also significantly predicted FIM Communication (R^2= .27, R^2_{adj}=.16, $F_{(6,40)}$=2.48, p<.05). This model accounted for 16% of variance in the individual's FIM Communication score. A summary of the bivariate and partial correlation coefficients between each predictor and dependent variable are presented in Table 15 and indicates that none of the four domains individually were significantly associated with the FIM Communication Score.

Table 15. Multiple Linear Regression of Composite Scores on FIM Communication Score with MCI and Dementia Diagnosis

	B	*β*	*t*	*p*	Bivariate *r*	Partial *r*
Global	2.028	.252	1.338	.188	.207	.181
Language	.749	.069	.427	.672	.067	.058
Memory	.909	.105	.524	.603	.083	.071
Frontal-Executive Function	.448	.042	.232	.818	.037	.031

Regression results indicated the overall model significantly predicted FIM Total (R^2= .48, R^2_{adj}=.40, $F_{(6,40)}$=6.15, p<.05). This model accounted for 40% of variance in the individual's FIM Total score. A summary of the bivariate and partial correlation coefficients between each predictor and dependent variable are presented in Table 16 and indicates that the Global score significantly predicted the FIM Total Score. A Bonferroni correction was calculated which indicated that the Global domain did not remain significant after accounting for multiple comparisons (p = .132).

Table 16. Multiple Linear Regression of Composite Scores on FIM Total Score with MCI and Dementia Diagnosis

	B	*β*	*t*	*p*	Bivariate *r*	Partial *r*
Global	10.090	.352	2.215	.033	.331	.253
Language	8.820	.229	1.671	.102	.256	.191
Memory	-1.342	-.044	-.257	.798	-.041	-.029
Frontal-Executive Function	7.403	.194	1.275	.210	.198	.145

Exploratory Aim 3

Factor analysis was conducted to determine what, if any, underlying structure exists for the following measures: mini mental status exam (MMSE), Trails A and B, Boston Naming Test (BNT), Controlled Oral Word Association Test (COWAT), Boston Diagnostic Aphasia Examination (BDAE), Wechsler Memory Scale (WMS-IV) Logical Memory I and II, and Visual Reproduction I and II, California Verbal Learning Test (CVLT-II) Total Learning Trials 1-5 and Long Delay Free Recall, and Wisconsin Card Sorting Test (WCST) Category Number, Trials to 1st Category, Conceptual Level Response, and Perseverative Errors. A varimax rotation was utilized in order to minimize factor complexity. Four criteria were used to determine the appropriate number of components to retain (eigenvalue, variance, scree plat, and residuals), which resulted in two components. After the rotation, the first component accounted for 37.01%, the second for 23.23%. See Table 17 for the factor loadings for each of the scores.

Table 17. Component Loadings

	Loading
Component 1 (Memory, Language, Global)	
WMS Visual Reproduction 1	.865
BNT	.820
MMSE	.786
BDAE	.776
CVLT Long Delay Free Recall	.747
WMS-IV Logical Memory 1	.737
WMS Visual Reproduction 2	.664
Component 2 (Executive Function)	
WCST Perseverative Errors	.866
WCST Category Number	.854
WCST Trials to First Category	-.803
Trails B	.616

Component scores were calculated by averaging the z-scores of all of the measures that loaded onto the component, and a series of multiple linear regressions were conducted to determine which composite scores were predictors of FIM Total, FIM Communication, FIM Psychosocial Adjustment, and FIM Cognitive Functioning while controlling for education and age.

Regression results indicated the overall model significantly predicted FIM Total (R^2=.31, R^2_{adj}=.22, $F_{(4,29)}$=3.30, p<.05). This model accounted for 22% of variance in the individual's FIM Total score. A summary of the bivariate and partial correlation coefficients between each predictor and dependent variable are presented in Table 18 and indicates that Component 1 was approaching significance.

Table 18. Multiple Linear Regression of Factor Component Scores on FIM Total Score

	B	*β*	*t*	*p*	Bivariate *r*	Partial *r*
Component 1	9.536	.331	1.779	.086	.314	.274
Component 2	5.865	.125	.654	.518	.121	.101

Regression results indicated the overall model significantly predicted FIM Cognitive Functioning (R^2= .40, R^2_{adj}= .32, $F_{(4,29)}$= 4.89, p<.05). This model accounted for 32% of variance in the individual's FIM Cognitive Function score. A summary of the bivariate and partial correlation coefficients between each predictor and dependent variable are presented in Table 19 and indicates that only Component 1 significantly contributed to the model, even after applying a Bonferroni correction for multiple comparisons (p = .020).

Table 19. Multiple Linear Regression of Factor Component Scores on FIM Cognitive Function Score

	B	*β*	*t*	*p*	Bivariate *r*	Partial *r*
Component 1	2.368	.523	3.010	.005	.488	.432
Component 2	.962	.131	.732	.470	.135	.105

The regression results indicated the overall model significantly predicted FIM Communication (R^2= .29, R^2_{adj}=.19, $F_{(4,29)}$=2.93, p<.05). This model accounted for 19% of variance in the individual's FIM Communication score. A summary of the bivariate and partial correlation coefficients between each predictor and dependent variable are presented in Table 20 and indicates that Component 1 significantly contributed to the model. A Bonferroni correction was calculated which indicated that the Component 1 did not remain a significant predictor after accounting for multiple comparisons (p = .128).

Table 20. Multiple Linear Regression of Factor Component Scores on FIM Communication Score

	B	*β*	*t*	*p*	Bivariate *r*	Partial *r*
Component 1	3.408	.428	2.257	.032	.387	.354
Component 2	-.316	-.024	-.125	.901	-.023	-.020

The regression results indicated the overall model predicted FIM Psychosocial Adjustment (R^2=.29, R^2_{adj}=.19, $F_{(4,29)}$=2.94, p<.05). This model accounted for 19% of variance in the individual's FIM Psychosocial Adjustment score. A summary of the bivariate and partial correlation coefficients between each predictor and dependent variable are presented in Table 21 and indicates that Component 1 was approaching significance.

Table 21. Multiple Linear Regression of Factor Component Scores on FIM Psychosocial Adjustment Score

	B	*β*	*t*	*p*	Bivariate *r*	Partial *r*
Component 1	-.117	-.371	-1.960	.060	-.342	-.307
Component 2	.007	.013	.067	.947	.012	.010

A series of regressions were conducted on individuals diagnosed with MCI and dementia (Alzheimer's Disease, Vascular Dementia, Mixed/Unspecified Dementia, and Dementia due to Medical Condition). Regression results indicated the factor scores did not significantly predict FIM Psychosocial Adjustment (R^2= .29, R^2_{adj}=.17, $F_{(4,25)}$=2.50, p>.05) or FIM Communication (R^2= .26, R^2_{adj}=.14, $F_{(4,25)}$=2.20, p>.05), but did significantly predict FIM Cognitive Function (R^2= .35, R^2_{adj}=.25, $F_{(4,25)}$=3.42, p<.05) and FIM Total (R^2= .43, R^2_{adj}=.34, $F_{(4,25)}$=4.70, p<.05). This model accounted for 25% of variance in the individual's FIM Cognitive Function score. A summary of the bivariate and partial correlation coefficients between each predictor and dependent variable are presented in Table 22 and indicates that Component 1 significantly predicted the FIM Cognitive Score. A Bonferroni correction was calculated which indicated that the relationship was no longer significant after correcting for multiple comparisons (p = .176).

Table 22. Multiple Linear Regression of Factor Component Scores on FIM Cognitive Function Score with MCI and Dementia Diagnosis

	B	*β*	*t*	*p*	Bivariate *r*	Partial *r*
Component 1	2.284	.436	2.125	.044	.391	.342
Component 2	1.154	.161	.770	.448	.152	.124

The factor component scores accounted for 34% of variance in the individual's FIM Total score. A summary of the bivariate and partial correlation coefficients between each predictor and dependent variable are presented in Table 23 and indicates that the Component 1 score significantly predicted the FIM Total Score. A Bonferroni correction was calculated which indicated that the relationship between Component 1 and FIM Total Score was no longer significant after correcting for multiple comparisons (p = .104).

Table 23. Multiple Linear Regression of Factor Component Scores on FIM Total Score with MCI and Dementia Diagnosis

	B	*β*	*t*	*p*	Bivariate *r*	Partial *r*
Component 1	14.355	.457	2.371	.026	.428	.358
Component 2	3.834	.089	.454	.653	.091	.069

CHAPTER FOUR

DISSCUSION

The purpose of this study was to examine the relationship between cognitive functioning as measured by neuropsychological measures and activities of daily living. Individual's with subtle cognitive declines demonstrate difficulties completing IADLs. By determining a relationship between cognitive functioning and activities of daily living it will assist clinicians with determining if the individual has deficits in their ability to continue to live independently and make the necessary recommendations in order to maintain their safety. The first aim of this study was to determine whether individual neuropsychological measures predicted the individual's score for the FIM Total, Communication, Psychosocial Adjustment, and Cognitive Functioning. The analyses were not conducted due to the high degree of multicollinearity between neuropsychological measures.

The second aim of the study was to combine scores into 4 cognitive domains (Global, Language, Memory and Executive Function), and to determine which domain scores predicted the individual's score for the FIM Total, Communication, Psychosocial Adjustment, and Cognitive Functioning. Results demonstrated that the MMSE predicted the individual's performance on the FIM Psychosocial Adjustment, and Memory scores predicted the individual's performance on the FIM Cognitive Functioning. It should be noted that the Global domain was highly correlated with the Language and Memory domain, which may reduce the precision of the estimated correlation coefficients (Mertler and Vannatta, 2005). The Global domain or MMSE contains items that measure overall cognitive functioning which assesses language, visuospatial/perception, learning and memory, attention, and executive functioning.

The third aim of the study was to use factor analysis to combine scores into data-driven Composite scores. The factor analysis yielded two components. The first Component encompassed language, memory, and global cognitive functioning measures. Component 1 significantly predicted the FIM Cognitive Functioning scores. The second Component encompassed executive functioning measures, but did not significantly predict the individual's performance on the FIM.

The Global domain as measured by the MMSE assesses the individual's overall cognitive functioning, which encompasses assessing language, learning and memory, attention, visuospatial and perception, and executive functioning. Previous research has demonstrated that these measures have predicted the individual's performance of basic activities of daily living such as bathing, grooming, and feeding. Additionally, the MMSE has predicted the individual's performance of instrumental activities of daily living such as preparing meals, driving, managing medications and appointments, shopping, housekeeping, physical activities, and communication and discussion of current events. However, the MMSE has low sensitivity that indicates that the individual has to be severely impaired before scores on the MMSE begin to decline (Rajji et al., 2008). Therefore, when an individual displays low scores on the MMSE they display significant cognitive impairment and demonstrate significant impairments in ADLs.

The Memory domain predicted the individual's performance on the FIM Cognitive Function. The FIM Cognitive Function rates the individual's memory and ability to problem solve. Research has indicated that learning and memory abilities predict an individual’s ability to complete IADLs such as cooking, cleaning, shopping, remembering appointments and bills, finding things within the home, and current events. Thus, our findings are consistent with previous literature, which indicate that as an individual’s performance on memory measure decline they’re ability to complete IADLs.

Based on a factor analysis, a composite score combining tests of Language, Memory, and Global function predicted performance on the FIM Cognitive Function scores. The composite domain comprises measures that measure confrontational naming, auditory comprehension, and learning and memory of verbal and visual information, which have been shown to predict the individual’s ability to perform IADLs such as remembering appointments, managing medications and bills, cooking, cleaning, and conversing with others (Aretouli and Brandt; 2010; Bronnick et al., 2006; Farias et al., 2006; Hall et al., 2011; Overdorp et al., 2016; Richardson et al., 1995; Schmitter-Edgecombe et al., 2012). Similar to what was demonstrated previously with the Memory domain, as the individual’s performance on multiple measures of cognition declines their ability to perform ADLs declines.

It was hypothesized that frontal-executive function would predict performance on the FIM Total score, and that scores in the language domain would predict performance on the FIM Communication and Psychosocial Adjustment scores. Our findings did not support these hypotheses. Previous research observed performance across multiple domains of cognition, rather than any single domain, predicted the individual’s ability to perform ADLs and IADLs (Ahn et al., 2009; Cornelis et al., 2018; Hall et al., 2011). Thus, the ability to perform ADLs and IADLs may be dependent on their performance across multiple cognitive domains or measures rather than one. Additionally, the FIM is administered by multiple healthcare professionals, which is established based on a subjective rating and is not normed to other individuals of that age, gender, diagnosis, etc. The FIM scores are not always assigned through a consistent evaluation procedure and it may not accurately measure the individual's ability to complete ADLs and cognitive functioning. Individual's with modest declines in cognition with difficulty with completing ADLs or reliance on strategies; however, they may continue to be rated as independent in ADLs on the FIM. Therefore, it is important to conduct and/or include in an evaluation of the individual's ability to complete ADLs.

The neuropsychological evaluation is utilized in order to determine the individual's performance, strengths and weaknesses, and cognitive decline based on clinical interviews and neuropsychological measures. An individual's score on neuropsychological testing is compared among other's their age, ethnicity, level of education, and gender. As an individual's cognition declines so does their ability to perform ADLs. Individual's that display subtle cognitive declines may not demonstrate declines in ADLs as measured by the FIM. Previous research has indicated that individual's with subtle declines in cognition demonstrate difficulties with completing ADLs, more specifically instrumental ADLs. The neuropsychological evaluation is necessary and more accurate indication of the individual's cognitive functioning and depict their ability to live independently within the community. It gives the clinician an idea as to how the individual is functioning at home and then can make various recommendations for the individual in order to maintain safety and independence and/or advising a proxy or institutionalization.

Future Directions

Future research would be to further analyze neuropsychological measures with multiple activities of daily living measures. The ability to compare neuropsychological measures that assess ADLs such as the Texas Functional Living Scale (TFLS) with the FIM in order to determine if the measures assess ADLs and if the FIM is an accurate and valid measure. The TFLS is an ecologically valid, performance-based screening tool that helps identify the level of care an individual requires; therefore, comparing the FIM with an established measure will determine if the FIM indeed measures the individual's ability to complete ADLs. The combination of measures utilized by other medical professionals (i.e., physical and occupational therapist, speech therapists, and neuropsychologists) may better predict the individual's ability to perform daily tasks. Additionally, future research would ideally analyze a larger sample in order to improve the power and generalizability of findings, and analyze group differences.

Limitations

The study has some limitations being that the participants and their family members were not given self- and informant reports on basic ADLs and IADLs such as the Functional Activities Questionnaire (FAQ); therefore, there was not a comparison between self and informant reports with the FIM, and neuropsychological testing. Additionally, the neuropsychological evaluation did not contain measures that measure ADLs and IADLs directly such as the TFLS. Another limitation of the study was how the FIM was administered and scored. The FIM was administered by multiple professionals (i.e., physical and occupational therapist, and speech and language pathologists) and are given an abbreviated evaluation and assigned a score. The scores that are given by the professional are subjective and are not normed on a normative sample similar to the individual's demographics.

The study required 91 participants; however, the number of participants with valid FIM scores was 76, which reduced the power of the study. Additionally, not all of the individuals received the same neuropsychological battery and had missing data especially for the individuals who were further along in their dementia process and an abbreviated battery was administered. Individuals also had missing data in the medical record in regard to the PT, OT, and SLP evaluation.

Conclusion

The study identified that an individual's neuropsychological scores, particularly on the MMSE and memory tests, were predictive of their scores on the FIM, a measure of their ability to perform ADLs. Therefore, in settings where formal assessment of ADL functioning using the FIM are not possible, clinicians may be able to utilize results of neuropsychological testing to make inferences regarding an individual's ability to perform ADLs and make recommendations such as compensatory strategies, a proxy to oversee the individual, and/or 24-hour supervision, which are critical in helping to maintain the individual's independence as well as ensure their safety.

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