Functional Abilities and Mild Cognitive Impairment: Investigation Using the Modified Scales of Independent Behavior-Revised

By

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B.Sc., University of Victoria, 2002
M.Sc., University of Victoria, 2004

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Supervisory Committee

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Abstract

The purpose of the present investigation is to add to existing research on functional ability as it relates to the diagnosis of mild cognitive impairment (MCI) by modifying a report-based measure, the Scales of Independent Behavior-Revised (SIB-R), to use in an elderly population. Self- and informant-reports (e.g. spouse) of participants' functional status were obtained on the modified SIB-R (mSIB-R) from a sample of community-dwelling, non-demented older adults, ranging in age from 66 to 92. Participants also completed various measures of motor skills, cognitive functioning and a performance-based measure of functional ability. The mSIB-R demonstrated sound psychometric properties as a comprehensive measure of functional ability in this population, but the nature of functional ability measured is impacted by the mode of report (self, other). Higher cognitive functioning is associated with functional independence; however, the functional ability-cognition relationship differed depending on the mode of report and the aspect of functional ability examined. When baseline mSIB-R and an index of one-year functional decline were used in longitudinal analysis, both baseline and decline scores

were useful in predicting cognitive status in three years. However, baseline functional ability did not provide additive information over and above cognitive measures in this regard. Similarly, both baseline and decline scores did not predict changes in cognitive status over three years. Using attrition as the outcome measure, functional ability and cognitive measures both predicted attrition from the study three years later. These results suggest that functional disability is observed among community-dwellers with varying degrees of cognitive impairment, but the inclusion of functional disability in the diagnostic criteria of MCI do not appear to improve the prediction of long term cognitive status changes. Moreover, characteristics of individuals who drop out of studies differed from those who remained, suggesting that attrition effects need to be considered in longitudinal studies.

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CHAPTER I

General Introduction

As life expectancy continues to increase, there is growing need to improve the quality of life of an expanding group in society. In order to delay the onset of diseases commonly associated with late life, an important focus of research on older adults has been on methods to identify diseases before they emerge at a clinically significant level. Of all diseases associated with old age, dementia appears to be most debilitating and costly to the healthcare system (Ostbye & Crosse, 1994). As such, recent studies aim to identify prodromal conditions of this disease, so that interventions may be implemented at an early stage. One such condition is Mild Cognitive Impairment (MCI; Petersen et al., 1998). Although not a formal clinical diagnosis, studies have revealed a high rate of conversion from MCI to a dementing disorder, particularly Alzheimer's disease (Petersen et al., 1999). The diagnostic criteria of MCI are currently controversial. In particular, some authors argue that instrumental activities of daily living should be intact for those exhibiting MCI (Petersen et al., 1999), whereas others provide evidence to the contrary (Griffith et al., 2003; Perneczky et al., 2006). In order to improve the diagnostic clarity of MCI with regard to functional abilities, a number of factors must be considered (e.g. Royall et al., 2007). The measures used to evaluate functional status must demonstrate good psychometric properties. As well, knowledge of the cognitive correlates of functional abilities may increase our understanding of the association between specific functional tasks and cognitive impairments that may be indicative of a disease process. Despite various methods (e.g. cognitive screening, neuropsychological assessment, functional assessment) to identify individuals who later develop cognitive impairment, it is unclear which method provides the most predictive utility for MCI classification. First we highlight the relevant literature on MCI and functional status. Then, three studies that address the limitations of current research are presented.

Continuum of impairment: normal aging, MCI, dementia

Research on changes in cognitive function as a result of the aging process has been a topic of interest in the literature for many years. Some older adults maintain their cognitive abilities well into the ninth decade of their lives (Formiga, Ferrer, Perez-Castejon, Olmedo, & Pujol, 2007), whereas others experience changes in cognitive functioning that may indicate a more serious pathology. A variety of different terms (e.g., benign senescent forgetfulness, age-associated memory impairment, age-associated cognitive decline, cognitive impairment no dementia, mild cognitive impairment) have been used to describe these changes, with the earlier terms (e.g., benign senescent forgetfulness, age-associated memory impairment, age-associated cognitive decline) identifying normal declines and recent terms (e.g., cognitive impairment, no dementia; mild cognitive impairment) indicating a disease process (Smith & Bondi, 2008).

In order to differentiate neurological conditions from normal aging, an understanding of the continuum from the normal end of the declining cognition spectrum to a dementing disease on the other end is helpful. The first concept of cognitive decline in aging was identified by Kral (1962) as "benign senescent forgetfulness." This term centered on age-related memory changes that are not part of a disease process. Subsequent researchers followed his conceptualization and provided specific criteria for what they termed "age-associated memory impairment" (AAMI; Crook et al., 1986). According to this scheme, older adults with AAMI experienced a gradual decline in memory function that, at the point of measurement, is 1 SD below the memory function of young adults. These criteria were, however, criticized because of a lack predictive validity. Life-long poor performers would also fulfill the criteria despite the lack of decline. Later, decline based on age standardization in any one of multiple cognitive domains (including memory and learning, attention and concentration, thinking, language, and visuospatial functioning) was included in the concept of "age-associated cognitive decline" (AACD; Levy, 1994). Again, AACD is thought to be the result of normal aging.

In order to characterize the intermediary between normal aging and dementia, the Canadian Study of Health and Aging used the term, "cognitive impairment, no dementia" (CIND; Ebly, Hogan, & Parhad, 1995). CIND is a broad condition sub-typed by the likely cause of cognitive impairments (e.g., delirium, chronic alcohol and drug use, mental retardation, psychiatric condition, AAMI) and is based solely on a single exclusion criterion (i.e., no dementia). Past studies have provided evidence that patients with the circumscribed memory subtype of CIND have a higher risk for progression to a dementia syndrome (Tuokko et al., 2003). As this is an inclusive term for a variety of cognitive disturbances that may or may not be associated with early disease, the prognosis of individuals labeled as CIND is hard to determine. In recent years, the term "mild cognitive impairment" (MCI) has been used to refer to cognitive decline in older adults that is related to a disease pathology and excludes individuals with significant depression, delirium, mental retardation or other psychiatric disorders (Petersen, 2001). This impairment, as defined by Petersen and his colleagues at the Mayo Clinic, most resembles the circumscribed memory subtype of CIND. With the exception of MCI, most of these concepts appeared to measure normal aging and do not imply an underlying pathological condition. MCI is therefore the focus here.

The characterization of MCI has evolved over the years. Petersen (2001) described three theoretical groups, with a focus mainly on memory impairment. These included a group of individuals with primarily memory impairment known as amnestic MCI. A second group of individuals has comparable impairment in multiple cognitive domains, labeled multiple-domain MCI. The final group, known as single non-memory-domain MCI involves impairment in a single non-memory cognitive domain. According to Petersen (2001), those with amnestic MCI are at the highest risk for progression to a neurodegenerative disorder such as Alzheimer's disease (AD), whereas multiple-domain MCI as well as single non-memory-domain MCI commonly progress to both degenerative and vascular dementias.

Controversies have arisen following the initial description of MCI. Some argue that the MCI criteria should include subjective and objective signs of memory impairment (Petersen et al., 2001), whereas others argue for the inclusion of only objective impairment in one or more cognitive domains (Ritchie et al., 2001). The predictive validity of either set of criteria for dementia has been disappointing (Hong et al., 2003). In 2003, the First Key Symposium (Winblad et al., 2004) was held to discuss current perspectives in MCI. The international work group integrated both clinical and epidemiological information on MCI and identified areas for future research. Recommendations for MCI general criteria included (a) objective impairment in cognitive function but not sufficient to meet criteria for a dementia syndrome, and (b) cognitive decline as reported by the patient and/or a proxy. More importantly, they recommended a new criterion that was not included in the initial Petersen (2001) criteria; that is, there must be (c) evidence of cognitive *decline* (based on serial examination) on objective tests. Finally, the workgroup allowed for minimal impairment of complex activities of daily living (ADL) but with preserved basic ADL (Winblad et al., 2004). The specific measures to be used as well as the definition of impairment for each criterion were left to the discretion of clinicians and researchers. Unfortunately, the lack of consensus with regard to the specific composition of each criterion has complicated comparisons of subsequent studies.

As a result, the criteria for MCI continue to require fine-tuning, particularly with respect to functional status. Even though current criteria specify that the diagnosis of MCI must not include deficits in basic activities of daily living, some have argued that the predictive validity of MCI may be improved by the inclusion of decline in instrumental ADLs (e.g. Nygard, 2003; Ritchie et al., 2001; Winblad et al., 2004). In fact, Perneczky and colleagues (2006) reported that among patients with MCI, there is impairment in ADLs that require memory or complex reasoning, whereas ADLs that are more basic in nature remain intact (as measured by the Alzheimer's Disease Cooperative Study scale for ADL in MCI; ADCS-MCI-ADL). Therefore, research is needed on the nature and extent of IADL deficits that are associated with MCI. The literature is unclear, however, as to the optimal methods to be used to measure functional abilities.

Components of functional abilities: ADLS & IADLS

Functional ability, as conceptually defined by Lawton (1991), is "the quality of overt behavior as evaluated by social-normative and subjective criteria." Reuben and colleagues (1993) operationalized functional ability as "a person's ability to perform tasks and fulfill social roles associated with daily living across a broad range of complexity" (Reuben, Wieland, & Rubenstein, 1993). Both of these definitions suggest that functional ability can be observed and evaluated by outsiders as well as the behaving person.

Functional ability is a multidimensional construct (Marsiske & Willis, 1995), and is commonly thought to comprise two hierarchically related levels: basic ADL and instrumental activities of daily living (IADL). At the lower level, ADLs are basic self-care activities necessary for functional independence such as bathing, dressing, and toileting, and are commonly associated with cognitive abilities of lower complexity (Katz, 1983). At this simple level, successful functioning involves only tasks related to different systems within the person and less so to an interaction with systems in the environment. In the absence of physical limitations, dependency in ADLs is a diagnostic criterion for dementia, at least according to the DSM-IV (APA, 1994).

By contrast, IADLs are complex activities performed by individuals in their everyday lives. Katz (1983) defined IADLs as the adaptive tasks that a person is required to perform in order to cope with the environment, such as financial management, house-keeping, use of transportation, medication management, and meal preparation. The concept of IADL was introduced to acknowledge that individuals are required to perform beyond basic self-care skills in order to function independently (Lawton & Brody, 1969). Thus, at this complex level, successful functioning involves an integration of different systems of the person and the environment (Lawton, 1983). Among community-dwelling samples, functional dependence has been associated with cognitive impairments (Covinsky, Eng, Lui, Sands, & Yaffe, 2003; Landi et al., 2001). Therefore, it is no surprise that IADLs tend to diminish first in the context of central nervous system degeneration (Loewenstein & Mogosky, 1999; Njegovan, Man-Son-Hing, Mitchell, & Molnar, 2001). For an individual to be fully independent, both ADLs and IADLs are required activities.

The fact that IADLs require higher-order cognitive functions that are most sensitive to changes in the integrity of the central nervous system suggests that impairments in IADLs may be good indicators of MCI. Indeed, some authors suggest that the diagnosis of MCI should include changes in IADL (e.g. Peres et al., 2008; Winblad et al., 2004). Peres and colleagues (2008), for example, suggested that early deficits in everyday functioning add prognostic value for risk of dementia that may not be captured by neuropsychological tests alone. Thus, for the purpose this research, IADLs are of particular focus.

CHAPTER II

Conceptual Issues

Functional ability assessment methods

Currently, functional ability can be evaluated using a variety of methods and instruments. These include clinician-rated scales (e.g. Mahony & Barthel's Barthel Index, 1965; Granger's Functional Independence Measure, 1993), performance-based measures (e.g. Loewenstein et al.'s Direct Assessment of Functional Skills, 1989; Fisher's Assessment of Motor and Process Skills, 1999; Willis & Marsiske's Everyday Problems Test, 1993), and self/informant-based questionnaires (e.g. Katz et al.'s Index of Activities of Daily Living, 1963; Lawton & Brody's IADL, 1969). Although useful, all these approaches have their limitations and have all been criticized. For example, clinician-rated measures are inconvenient because they may require extensive training and experience in their use. Performance-based measures are typically expensive and time-consuming to administer (Myers, Holliday, Harvey, & Hutchinson, 1993). Self/informant based measures, on the other hand, have been criticized as being too brief and susceptible to the informant's subjective bias (Angel & Frisco, 2001; DeBettignies, Mahurin, & Pirozzolo, 1993; Lawton, 1988; Loewenstein & Mogosky, 1999; Ready, Ott, & Grace, 2004), although they may be a good compromise between time and cost. In fact, despite concerns about self/informant report approaches, there is evidence to suggest that they may provide adequate assessment of functional independence, at least under some circumstances (Myers et al., 1993; Sager, Dunham, Schwantes, & Mecum, 1992). For instance, Myers and colleagues (1993) found that self-reports correlated highly with performance-based measures, suggesting that performance-based measures are not superior to self-reports as previously believed. Further, performance-based measures index functional status at a single time point, and may not represent a change that is of clinical concern. Informant/self-reports, with its *intraindividual* marker of change, thus, may provide a better estimate of clinically relevant functional ability (Morris & Storandt, 2006). Finally, Loewenstein and Mogosky (1999) reported four advantages of report-based measures, particularly among community-dwelling older adults: (1) quick and easy to administer and score, (2) familiar informants are able to report on functional behaviors observed daily in the natural environment, (3) self and informant observations provide stable estimates of functional ability over time that are less likely influenced by fluctuations present at a single time point, and (4) the ability to utilize real world contextual cues to perform functional tasks are taken into account in report-based measures.

Although report-based measures are useful, the mode of report (self, other) needs to be considered when interpreting results using this functional ability measurement method. The informant may provide a different account of the patients' functional abilities than the patients themselves. This may reflect, in part, the fact that some individuals (e.g. those with dementia) may lack the insight necessary to report their functional status accurately (e.g. Nygard, 2003). Informants, however, may also be susceptible to bias, perhaps due to factors such as caregiver stress and depression (Jorm et al., 1994; Kiyak, Teri, & Borson, 1994) or the different values patients and informants place on the activities in question (Fricke & Unsworth, 2001). Although not an evaluation of functional independence per se, a study that compared self and informant reports on the quality of life of individuals with mild cognitive impairment (MCI) or Alzheimer's disease (AD) reported results that suggest a discrepancy in the mode of report that is dependent on the severity of patient's cognitive dysfunction. The researchers found that informants tended to rate individuals with MCI as having a higher quality of life than individuals with AD. In contrast, there was no difference among those classified as MCI and AD in their self-reports (Ready et al., 2004). Mode of reporting on the Lawton and Brody's (1969) IADL scale was examined by Bertrand and colleagues (Bertrand, Willis, & Sayer, 2001). In their sample of patients with mild to moderate dementia of the Alzheimer's type, they found differences between self- and informant-report on the IADL over a period of 18 months. Self-reports formed a linear pattern of decline, whereas informant-reports showed a curvilinear pattern of decline. These studies suggest that informant and self reports provide different information and that mode of report needs to be taken into consideration when interpreting results regarding functional status.

Many self/informant measures of functional status have been developed to assess the capacity of the frail elderly or patients with dementia (e.g., Katz et al.'s Index of Activities of Daily Living, 1963; Lawton & Brody's IADL, 1969). These measures are often restricted in the kinds of activities they examine. For example, Katz and colleagues' Index of Activities of Daily Living (1963) examined only basic self-care activities such as bathing and toileting. Likewise, the commonly used IADL scale developed by Lawton and Brody (1969) takes about 10 minutes to complete and consists of only 8 items, tapping competencies in 8 domains (e.g. telephone usage, meal preparation, financial management). Comprehensive report-based measures of functional independence that include the full range of functional abilities from simple to complex activities sensitive to mild changes seen in the community-dwelling, non-demented elderly population are scarce. Accordingly, the first aim of this dissertation is to modify an existing self/informant report of functional ability (the Scales of Independent Behavior-Revised; Bruininks, Woodcock, Weatherman, & Hill, 1996) that may be used to monitor functional changes in this population.

Functional ability and cognitive functioning

Factors found to be related to functional ability include demographic variables such as age, gender, and education (Bell-McGinty, Podell, Franzen, Baird, & Williams, 2002; Grigsby, Kaye, Baxter, Shetterly, & Hamman, 1998; Tuokko, Morris, & Ebert, 2005), depression (Bennett et al., 2006; Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000), chronic diseases (Black & Rush, 2002; Plehn, Marcopulos, & McLain, 2004; Wang, van Belle, Kukull, & Larson, 2002), and motor skills (Bennett et al., 2006; Judge et al. 1996; Wang et al., 2002; Wood, Edwards, Clay, Wadley, Roenker, & Ball, 2005). The literature suggests that poor motor skills, old age, female sex, low education, depressed mood, and an increased number of chronic diseases are associated with functional dependence (Bennett et al., 2006; Tuokko et al., 2005; Wang et al. 2002). In fact, even after accounting for demographic variables, the number of chronic illnesses and motor function retain their association with functional ability. Specifically, chronic illnesses such as diabetes mellitus, hypertension, coronary heart disease, cardiovascular disease and osteoporosis are associated with more difficulty in ADLs and IADLs among non-demented, community-dwelling older adults (Wang et al., 2002). Slow gait, weak hand grip, poor balance, and increased chair rise time were also associated with greater IADL dependence in a meta-analysis of multiple samples of community-dwelling, non-demented older adults (Judge, Schechtman, & Cress, 1996). Not surprisingly, gait speed is associated with the shopping activity (Bennett et al., 2006). Therefore, in order to study the cognitive contributions to functional abilities, these factors (i.e. demographic variables, chronic illness, and motor skills) must be taken into account.

As expected, even after taking the abovementioned factors into account, the literature shows clear evidence that higher cognitive functioning is associated with functional independence (Burton, Strauss, Hultsch, & Hunter, 2006; Cahn-Weiner et al., 2000; Grigsby et al., 1998; Landi et al., 2001; McGuire, Ford, & Ajani, 2006; Perneczky et al, 2006; Plehn et al., 2004; Tuokko et al., 2005; van Hooren et al., 2005; Warren, Grek, Conn, & Herrmann, 1989; Tam, Chiu, Chiu, & Lui, 2007). A strong understanding of the association between cognitive and functional ability is important because poor functional skills signal poor cognitive ability that may be prodromal to a dementia syndrome (Burton et al., 2006; Tam et al., 2007). In fact, some researchers have recommended that further objective investigation is warranted once there is self or informant evidence of functional decline among older adults suspected of mild cognitive impairment (Winblad et al., 2004). In support of this proposal, Njegovan and colleagues (2001) found a dose-response relationship between varying levels of global cognitive dysfunction and functional loss. In their sample of community-dwelling older adults, IADL loss was associated with Modified Mini-Mental State Examination scores (3MS; a measure of global cognitive functioning) of over 75; those with 3MS scores between 70-75 demonstrated a combination of IADL and ADL loss; and ADL loss was related to 3MS scores of less than 70. Their results suggest that poorer global cognitive functioning is associated with more basic aspects of everyday tasks. As such, both ADL and IADL items should be included in a single measure to tap a wider range of tasks for the purpose of examining the cognitive-functional ability relationship, particularly when studying individuals with varying degrees of cognitive impairment.

In addition to finding that global cognitive functioning is related to everyday functioning, investigating the contribution of specific cognitive domains to functional status provides a clearer picture of the cognitive-functional ability association. Understanding the specific cognitive aspects of functional tasks may alert us to subtle cognitive changes when functional decline is observed. For instance, Burton and colleagues (2006) found that overall cognitive decline as well as specific cognitive variables (i.e. fluid ability, episodic memory, crystallized ability) accounted for close to a quarter of the variance on a performance-based measure of everyday problem solving (i.e. the Everyday Problem Test; EPT; Willis & Marsiske, 1993) in a community-dwelling, non-demented sample once demographic and health variables were accounted for. In their investigation with specific cognitive predictors, Wood and colleagues (2005) found that cognitive speed accounted for the most variance on performance-based measures of functional ability in a sample of community-dwelling, non-demented adults. Similarly, psychomotor speed was found to be related to impairment on informant-rated measures of everyday activities (i.e. showering, transportation, shopping, meal preparation, housework, medical management) in a sample of community-dwellers with mild cognitive impairment (MCI; Tuokko et al., 2005).

Executive function also appears to demonstrate a robust relationship with IADLs (Bell-McGinty et al, 2002; Bennett et al., 2006; Burton et al. 2006; Perneczky et al., 2006; Plehn et al., 2004; van Hooren et al., 2005). For example, Cahn-Weiner and colleagues (2000) reported that executive dysfunction explained the largest proportion of variance

(14%) on a performance-based measure of functional status even after taking other cognitive domains into consideration. Similarly, executive function predicted self-reported IADL performance in a sample of non-demented, older adults (Bennett et al., 2006), although the association depended in part on the type of everyday activities examined. Moreover, when specific elements of executive function (e.g., working memory, generation, inhibition, planning, and sequencing) were evaluated among community-dwelling elderly with documented history of cardiovascular disease, it was found that inhibitory control (as measured by the DKEFS Color-Word Interference Test) was most important to performance of everyday tasks such as shopping, laundry, use of transportation, and managing finances, as reported by informants (Jefferson, Paul, Ozonoff, & Cohen, 2006). The latter study, however, examined only aspects of executive function; inclusion of other cognitive domains may present a different picture. The relationship between the memory domain and everyday activity is less certain. Some studies suggest that memory is associated with IADL (Burton et al., 2006; Perneczky et al., 2006; Tuokko et al., 2005), whereas others do not (Brennan, Horowitz, & Su, 2005; Cahn-Weiner et al., 2000; Plehn et al., 2004).

The inconsistent results for the memory-functional ability association may be due to methodological differences, specifically in how functional status was evaluated. When informant report of functional status was evaluated, Tuokko and colleagues (2005) found poor memory and visuospatial ability to be associated with IADL impairments. Another study that used informant report also suggested that memory and executive functioning are related to baseline functional impairment (Cahn-Weiner et al., 2007). By contrast, memory did not predict IADL functioning in another study when self-ratings were used

(Plehn et al., 2004). Similar discrepancies have been reported by Farias and colleagues (2005), who noted that diagnostic groups (normal, MCI, dementia) could not be differentiated when self-reports of functional status were used, whereas all groups differed on informant reports. Accordingly, mode of report (self, informant) appears to influence findings on the relationship between cognitive functioning and functional status. The nature of the differences is unknown, although researchers have suggested that some individuals (e.g. those with dementia or MCI) may lack the insight, which is linked to executive function, necessary to assess their abilities accurately (Nygard, 2003; Vogel et al., 2004). Interestingly, some studies suggest that individuals with dementia tend to underreport functional impairments whereas those with MCI or the cognitively intact are more likely to rate themselves as having more functional impairments than do their informants (Farias et al., 2005).

Only a few studies have examined the cognitive correlates of self and informant reports of functional status (Bennett et al., 2006; Farias et al, 2005 Wood et al., 2005). Unfortunately, two of these studies used measures (e.g. Kilsyth Disability Rating Scale; Akhtar et al., 1973) that tapped a restricted range of functional ability (e.g. cooking, shopping, housework, reading, hobbies, and socializing), which may not be sensitive enough to detect mild impairments. Further, the cognitive predictors of various everyday activities have not been thoroughly documented, and past studies have focused on a limited number of specific cognitive domains and a restricted sample. For instance, one study suggested that individuals are more likely to be rated by informants as impaired on functional tasks that are heavily dependent on memory ability and high-level executive functions (Farias et al., 2006). However, the sample was drawn from individuals attending a memory disorders clinic, and the participants may have been at a different stage of cognitive decline compared to individuals sampled from the community. Thus, the authors cautioned that the results may not generalize to community-based MCI samples (c.f. Palmer, Fratiglioni, & Winblad, 2003). Also, few have investigated the relative contribution of each cognitive domain to specific functional tasks within a single study. Cahn-Weiner and colleagues (2007) found both memory and executive function to be associated with functional impairment; however, they stated that other cognitive domains should be included to identify the cognitive domain most associated with specific areas of functional decline. Therefore, additional studies that examine the cognitive correlates of informant vs. self reports of specific functional tasks, and their utility in community-based MCI samples are warranted.

Prediction of dementia and MCI by functional ability

If functional ability is related to cognitive functioning, would early functional deficits be useful to identify older adults at risk of cognition-based pathologies such as dementia? The literature suggests that poor baseline functional status is related to future diagnosis of dementia (Peres et al., 2008; Touchon & Ritchie, 1999). In a community sample of high risk older adults (i.e. those who were reported by proxies to have experienced cognitive decline), deficits in ADLs were observed about two years prior to a diagnosis of dementia (Touchon & Ritchie, 1999). In fact, among community-dwelling older adults, poor IADL performance was observed as early as 10 years before the development of dementia (Peres et al., 2008). These studies suggest that early functional deficits among those later diagnosed with dementia are limited to IADLs, but as the disease evolve, deficits gradually include ADLs.

Given a high rate of conversion from MCI to dementia, it is likely that those with poorer IADLs are more likely to demonstrate cognitive deficits consistent with a diagnosis of MCI than those with higher IADL abilities. Indeed, Burton and colleagues (2006) reported that older adults with multiple cognitive impairments showed poorer baseline IADL abilities than those who are cognitively intact. Over a 3-year period, Wadley and colleagues (2007) reported that a steeper decline in IADL performance was observed among older adults with psychometrically defined MCI than those with intact cognitive functioning. Purser and colleagues (Purser, Fillenbaum, Pieper, & Wallace, 2005) also suggested a link between functional changes and MCI. They reported on the 10-year trajectories of functional disabilities in a community-dwelling sample of older adults living in rural areas. Using very gross criteria for MCI (i.e. recalling fewer than 4 words on a 20-item immediate word recall test), they found that the disability trajectory of individuals with MCI but without IADL dependencies most resembles those without cognitive impairment; on the other hand, individuals with MCI and IADL deficits showed a rate of change that was very similar to individuals who have severe cognitive impairment but who have not yet fulfilled criteria for dementia. Moreover, they found that the more severe the cognitive status at baseline, the more likely it was for functional disabilities to progress at a faster rate. As such, they concluded that limitations in IADLs seen in MCI may represent an intermediary between normal aging and ADL-based dementia diagnoses.

Thus, the evidence suggests that functional status may help predict dementia and even MCI status; however, this may be dependent on mode of report. For instance, Touchon and Ritchie (1999) found that ADL deficits were seen by informants up to two years before dementia diagnosis. Peres and colleagues (2008) found that clinician-rated IADL abilities were observed 10 years before a diagnosis of dementia. Wadley and colleagues (2007), on the other hand, indicated that self-reported functional status is a valuable source of information for older adults with MCI among those who experienced functional decline over a 3-year period. However, a study that investigated mode of report in a single sample found that self-report of functional status (mainly ADLs) was not predictive of Alzheimer's disease (AD), whereas informant report was predictive of AD, among outpatients presented at memory disorder clinics at two-year follow up (Tabert et al., 2002). Given the lack of clarity in the potential of self or informant-based rating of functional status to estimate clinically relevant functional ability, a comparison of these two modes of report is therefore of interest.

Of note, some studies report that a large proportion of older adults remain stable in their functional abilities over a period of time (Corey-Bloom et al., 1996; Formiga et al., 2007). Although a small proportion appears to decline, there was also a subset of older adults whose functional capacity improved during follow up measurement (Hebert, Brayne, & Spiegelhalter, 1997; Hebert, Brayne, & Spiegelhalter, 1999). It is, therefore, necessary to differentiate the chronic poor functional performers from those who are truly experiencing functional decline.

Prediction of dementia and MCI by cognitive measures

There is strong evidence that cognitive impairment, as measured by standard neuropsychological measures, is present many years prior to a diagnosis of dementia (e.g., Arnaiz & Almkvist, 2003; Backman, Berger, Laukka, & Small, 2005). In a meta-analysis of cognitive impairment in preclinical AD, it was concluded that global cognitive ability, episodic memory, perceptual speed, and executive functioning showed large effects of impairment years before a clinical diagnosis of dementia was made (Backman et al., 2005). Although Backman and colleagues (2005) argued that decline in cognition a few years prior to the diagnosis of cognitive impairment appeared to be nonspecific, one recent study (Mickes et al., 2007) reported that measures of episodic memory (Free and cued recall on the CVLT) and semantic knowledge (Category fluency and Boston Naming test) appeared to be more impaired than measures of executive functions (Letter Fluency, TMT, and WCST). This study used a sample of participants from an ongoing longitudinal study who were cognitively intact, but who were diagnosed with preclinical AD 2 or 3 years later (Mickes et al., 2007). However, shortcomings of the study may lessen the impact of the conclusions drawn: the study had a small sample size and domain-ambiguous measures were used to represent specific cognitive domains

A number of issues may limit generalizability of the meta-analysis as well as other studies on the association between baseline cognitive functioning and future cognitive impairment. Methodological differences may obscure interpretation. These include the type of sample (population-based vs. sample of convenience), time interval of follow-up studies, task ambiguity of neuropsychological measures used to represent specific cognitive domains, and the type of cognitive domains examined in the model. Regardless, Arnaiz and Almkvist (2003) recommended that a battery of neuropsychological tests that examines multiple cognitive domains, including episodic memory, visuospatial function, attention and executive functions, should be used to provide information for screening and diagnosis of MCI and early AD.

Combining functional status and cognitive status to predict dementia

In order to investigate the baseline differences in both functional and cognitive measures among older adults who developed AD at a later time, Bidzan and Bidzan (2002) undertook a study that involved yearly examination of nursing home residents over a 5-year period. They compared cognitive measures (MMSE and Alzheimer's Disease Assessment Scale – Cognitive; ADAS-Cog) and functional scales (IADL and Physical Self Maintenance Scale; PSMS) among two groups of residents: one group that developed AD within the 5-year period, and a second group that remained without AD. At baseline measurement, the groups differed on all measures except the PSMS, suggesting that poor performance on global cognitive functioning and complex functional tasks was present a few years prior to AD diagnosis.

The answer to the question of whether cognitive or functional measures were most useful for the prediction of dementia was provided by Kuchibhatla and Fillenbaum (2003) in their investigation of dementia over a 10-year period. Using backward stepwise logistic regression that included age, chronic health conditions, ADL, IADL and cognitive status as predictors, they found that functional status (specifically IADL) generated an adjusted Odds Ratio (OR) of 1.23, and cognitive status generated an adjusted OR of 8.96, based on which they suggested that cognitive status is the single most important predictor of dementia. However, in this study, cognitive status was based on a dichotomous classification of cognitive impairment using a measure of global cognitive function (the SPMSQ); the utility of domain-specific cognitive predictors of dementia is unknown.

Prediction of attrition

Longitudinal studies involve repeated measurement of each individual. In aging studies particularly, elderly participants may refuse to participate in follow-up studies for many reasons, including death. Past studies suggested that individuals who attrite do not drop out of longitudinal studies at random (e.g. Feng, Silverstein, Giarrusso, McArdle, & Bengtson, 2006; Holstein, Avlund, Due, Martinussen, & Keiding, 2006; Ritchie & Toukko, 2007; Sliwinski, Hofero, Hall, Bushke, & Lipton, 2003). "Refusal" in follow-up studies has been found to affect the findings observed in the remaining sample. For example, incidence rates for cognitive impairment among older adults increased substantially when the rates were corrected for attrition due to death using previous cognitive and health status (Caracciolo, Palmer, Monastero, Winblad, Backman, & Fratiglioni, 2008). As such, reasons for "refusal" have been the focus in several studies.

It has been suggested that individuals experience an abrupt "terminal decline" a few years prior to death (e.g. Kleemeier, 1962; Small, Fratiglioni, von Strauss, & Bäckman, 2003). The sudden and sharp decline prior to death may have prevented older adults from participating in follow-up studies. Recent modeling using memory change as the outcome measure, however, suggests some differences between time to death and time to drop out. Although time to drop out and time to death represent related effects, time to drop out may explain more effects of memory change in the elderly than time to death (Sliwinski et al., 2003). The authors speculated that the lower impact of the time to death analysis may be the result of medical intervention that has artificially prolonged life.

Another study investigated the differences in estimated growth-decline trajectories when attrition due to death and nonresponse were compared (Feng et al., 2006). The authors found that estimates of self-reported functional health (as assessed on

4 ADL/IADL items) over time were biased by attrition due to death, whereas nonresponse did not seriously bias estimates of the same. Contrary to findings by Sliwinski and colleagues (2003), the authors concluded that using baseline data from eligible dropouts (i.e., those who did not exit the study because of death) to estimate growth trajectories will generate results that are very similar to those with more complete data.

Other studies found that those who attrite represent a section of the sample experiencing declining health status (e.g. Holstein et al., 2006; Powell et al., 1990). Moreover, regardless of the reason for attrition, those who attrite exhibit poor cognitive functioning at baseline (e.g., Holstein et al., 2006; Ritchie & Tuokko, 2007). For example, Ritchie and Tuokko (2007) found that WMS Information and WAIS-R Digit symbol subtests were predictive of attrition due to death within a 10-year period, over and beyond age. However, when cognitive status at baseline was taken into consideration, none of the neuropsychological tests predicted attrition status. A number of reasons may have contributed to their non-significant results. First, participants with missing neuropsychological data, those who voluntarily dropped out, or for whom vital stats were unconfirmed, were omitted from the analyses. The reason for the missing data is unclear, and this omitted subset may have included those who are cognitively impaired. Moreover, their classification of cognitive impairment included individuals with diverse etiology, including delirium, substance abuse, mental retardation, depression, age-associated memory decline, and diseased states. Analysis of a more homogenous set of cognitively impaired sample may yield different results, especially if an eventual outcome of dementia before death is of interest. Finally, their results were based on bonferroni corrections that, while protecting against type 1 error, may have inadvertently increased type 2 error rates.

Thus, the sample in longitudinal studies likely comprises the elites of the population. This lends support to the suggestion that any significant results obtained from those who remain in the study and are classified MCI (i.e. a restricted sample) may well generate results that represent a degree of impairment that is less pronounced than what the actual disease progression may appear in the general population. Attrition effects should, therefore, be considered when interpreting results of longitudinal studies, especially with an older population. To our knowledge, a thorough investigation of the functional ability of those lost to follow-up has not been investigated and is therefore a focus of this dissertation.

Summary

Taken together, current research with regards to MCI and functional capacity are limited in a number of ways. First, a comprehensive measure of functional ability that taps into both ADLs and IADLs, and is sensitive to mild functional deficits is currently unavailable to monitor functional changes related to MCI. Second, because of convenience, most MCI studies utilize self-report measures of functional ability, but the impact of mode of report on prediction of MCI using functional measures has not been investigated. Third, the cognitive correlates of specific functional abilities remain unclear. Fourth, many studies have focused on predicting dementia status using functional ability; yet, despite the link between MCI and dementia, only a few studies (e.g., Wadley et al., 2007; Purser et al., 2005) have investigated the ability of functional status to predict future MCI status. Past studies also have not rigorously compared the predictive utility of functional measures to that of a battery of standard cognitive tests for MCI, even though both methods have shown promise in separate, partial models. Moreover, whether functional status provides information regarding changes in cognitive status is unknown. In fact, more evidence is needed to determine if the inclusion of functional abilities to the criteria of MCI can improve the stability of the groupings over time. It is also unknown if poor baseline functional abilities are a risk factor for MCI, or if the risk is a result of functional decline, representing a subset of those with "pre-MCI" (Morris & Storandt, 2006; Storandt, Grant, Miller, & Morris, 2006). Therefore, in addition to comparing functional and cognitive measures, it is important to examine the utility of baseline performance as well as functional decline to predict future cognitive status (intact vs. MCI). Finally, despite evidence of attrition effects in longitudinal studies, the comparative utility of functional and cognitive measures in predicting attrition is also unknown.

Introducing the modified Scales of Independent Behavior-Revised (mSIB-R)

The Scales of Independent Behavior-Revised (SIB-R; Bruininks, Woodcock, Weatherman, & Hill, 1996) holds promise as a comprehensive measure of evaluating functional abilities. It was initially developed for use in children and later revised to cover the lifespan. It is a report-based measure that examines a wide range of behaviors that are required for independent living, including basic self-care and instrumental activities of daily living. It consists of 14 subscales organized into four adaptive behavior clusters (Table 1).

The SIB-R is relatively new and only one validation study, focusing on children and young adults with mental retardation, is available in a peer-reviewed publication

(McIntyre, 2002). Similarly, normative data published in the test manual focus mainly on children (ages 3 months to 12 years, N = 1,428). Information on the elderly is scarce; only 71 participants were included in the normative sample aged 60 – 90 years.

Table 1. Structure of the original SIB-R.

Adaptive behavior clusters	**Subscales**
Motor skills	Gross motor
	Fine Motor
Social Interaction & Communication skills	Language comprehension
	Language expression
	Social interaction
Personal living skills	Domestic skills
	Personal self-care
	Dressing
	Toileting
	Eating & Meal preparation
Community living skills	Time & punctuality
	Money & Value
	Work skills
	Home/community orientation

CHAPTER III

Research Questions and Hypotheses

Study 1: Psychometric properties of the mSIB-R

1. Does the mSIB-R show adequate internal consistency and one-year test-retest reliability?

Given good psychometric properties on the original SIB-R, it is hypothesized that the mSIB-R will show good internal consistency and one-year test-retest reliability among the community-dwelling, non-demented elderly population.

2. What is the construct validity of the mSIB-R i.e., factor structure, relation with an established measure, the Lawton and Brody (1969) IADL questionnaire, and the ability to distinguish cognitive status groups?

It is hypothesized that the mSIB-R taps into multiple aspects of functional ability, but shows convergence with the established IADL measure. It is also hypothesized that, because of the comprehensive nature of the mSIB-R, it can distinguish among the cognitive groups, particularly the multiple domain impairment group.

3. Are self and informant-based reports of functional ability as measured by the mSIB-R different?

Past studies indicated that self and informant reports of functional ability among dementia patients (e.g., Bertrand et al., 2001) were different. It is hypothesized that self and informant-based reports will glean different information about functional ability among older adults with varying degrees of cognitive impairment.

Study 2: Cognitive correlates of functional ability

1. What are the associations between cognitive variables and different aspects of functional ability as measured by mSIB-R informant- and self-reports?

It is hypothesized that poor cognitive functioning is associated with functional dependence, and that different cognitive variables are associated with specific factors of functional ability, given the multidimensional nature of functional ability (Marsiske & Willis, 1995) as measured by the mSIB-R.

2. How do informant- and self-reports of functional ability hold up in predicting cognitive status when compared to a performance-based measure of everyday function, the Everyday Problems Test?

It is hypothesized that there will be an improved classification rate for cognitive status when the mSIB-R is included in the prediction model.

Study 3: Prediction of longitudinal outcome

1. Of the available methods (report-based measure of functional ability & standard cognitive measures), which method demonstrates the best utility for predicting cognitive status over a 3 year period?

It is hypothesized that cognitive variables are stronger predictors of MCI status, given the psychometrically and cognitively defined nature of our MCI groups, than measures of functional ability.

2. Can baseline functional and/or neuropsychological functioning be used to predict attrition?

It is hypothesized that measures of functional abilities, particularly the mSIB-R factor scores and an index of functional decline, are stronger predictors of attrition than cognitive variables, because changes in functional ability are likely more obvious to the individuals than subtle cognitive changes.

CHAPTER IV

General Methodology

Participants

Participants were drawn from year 3 of the Project MIND because the modified Scales of Independent Behavior-Revised (mSIB-R) was implemented in year 3. For the purpose of this dissertation, participants were 258 community-dwelling adults living in Victoria, BC, ranging in age from 66 to 92 years ($M = 75.66$, $SD = 5.72$), with a mean of 15.20 ($SD = 3.09$) years of education. Eighty of the participants were males. Participants were recruited through advertisements in the local media (newspaper and radio) requesting healthy community-dwelling volunteers who were concerned about their cognitive functioning. All participants were Caucasian. Exclusionary criteria included a diagnosis of dementia by a physician or a Mini Mental Status Examination (MMSE; Folstein, Folstein, & McHugh, 1975) less than or equal to 24, a history of significant head injury (defined as loss of consciousness for more than 5 minutes), other neurological or major medical illnesses (e.g., Parkinson's disease, heart disease, cancer), severe sensory impairment (e.g., difficulty reading newspaper-size print, difficulty hearing a normal conversation), drug or alcohol abuse, current psychiatric diagnoses, psychotropic drug use, and lack of fluency in English. On average, the participants reported having few chronic illnesses ($M = .5$, $SD = .79$).

Participants identified an individual (e.g. spouse, friend, sibling, adult child) familiar with them to provide ratings of their daily functioning. A total of 226 informants took part in the study. Three of the informants who obtained an MMSE (Folstein et al., 1975) score of less than or equal to 24 were removed from further analysis. The remaining informants' general cognitive ability as measured by the MMSE (Folstein et al., 1975) ranged from 25 to 30, with a mean of 28.82 (*SD* = 1.20). Most of the informants either lived with the participant or saw the participant almost daily. On average, informants reported knowing the participants for about 20 years. Age of the informants ranged from 29 to 90, with a mean age of 66.60 years (*SD* = 13.13) and 15.33 years of education (*SD* = 3.12).

Measures

The original Scales of Independent Behavior-Revised (SIB-R) is a comprehensive measure of adaptive and maladaptive behaviors, with reference groups ranging from infant-toddler to older adults. The items in each subscale are ranked in order of task complexity, with instructions to start at a specific item relevant to the age of the examinee. In order to modify the SIB-R for use specifically in the non-demented, community living, elderly population, items considered irrelevant and potentially disrespectful to this population were identified and removed. As such, most of the items removed were low ranking, and this resulted in a modified version consisting of 13 areas (as opposed to 14 in the original), with the Toileting subscale completely removed. At a minimum, each scale contained at least five items.

The WAIS-R Digit Symbol Substitution subtest (WAIS-R; Wechsler, 1981) is a measure of processing speed. The number of symbols correctly copied by participants beneath a series of digits according to a key displaying the digit and symbol pairs is recorded. Participants are given a maximum of 90 seconds to complete the task. The possible scores range from 0 to 93, with higher scores representing better performance.

The Letter Series (Thurstone, 1962) task is a measure of inductive reasoning where participants complete series of letters (e.g. a b c a b d a b e a b) by selecting the letter that comes next in the series from a choice of 5 letters. Participants were given 4 sample items prior to the test trial in which they were given 6 minutes to complete 20 letter series. The series range in length from 6 to 15 letters. One point is awarded for each correct item to a maximum possible score of 20.

The Word Recall (Hultsch, Hertzog, & Dixon, 1990) task is a measure of immediate free word recall. Participants were given a list of 30 English nouns to study for 2 minutes on the Word Recall task. The list contained 6 words from each of 5 taxonomic categories presented in unblocked order. After the study list was removed, participants were given 5 minutes to write down as many words as they could recall. One point was awarded for each correct word to a maximum possible score of 30, with higher scores representing better performance. Duplicates and incorrect words were not scored.

The Controlled Association (Ekstrom, French, Harman, & Dermen, 1976) task is based on the total number of acceptable words provided by participants that are the same or similar in meaning to some target words within 6 minutes. Participants were first given a sample word (i.e. "weak) for practice. They were then given 4 words ("clear", "dark", "strong", and "wild") during the test trial.

The Vocabulary Survey (Ekstrom, 1976) is a measure of vocabulary. Participants completed a 36 item multiple choice in which they selected, from 5 options, one word with the same or nearly the same meaning for each item. The time limit for the task was 10 minutes and the maximum possible score was 36.

CHAPTER V

Study 1: Psychometric investigation of the modified Scales of Independent Behavior-Revised

Introduction

Functional ability has been shown to be a multifaceted concept (Marsiske & Willis, 1995). Unfortunately, most of the report-based measures commonly used (e.g., Lawton & Brody's IADL, 1969) are brief and tap only into limited aspects of functional ability. Therefore, most measures have not been useful to identify subtle functional difficulties among community-dwelling, elderly individuals who are at the beginning stages of dementing disorders. A measure of functional ability that is comprehensive yet relatively quick to administer to both informants and patients is needed to monitor changes in functional status among these individuals who present with varying degrees of cognitive impairment. This first study (Tan, Hultsch, Hunter, & Strauss, in press) examines the psychometric findings of a modified SIB-R (mSIB-R) in a community-dwelling, non-demented elderly sample. There are three goals: to examine (1) its internal consistency and one-year test-retest reliability, (2) its construct validity by examining its factor structure, its relation with an established measure, the Lawton and Brody (1969) IADL questionnaire, and its ability to distinguish cognitive status groups, and (3) to compare self and informant-based reports.

Method

Cognitive status groups

The participants were divided into five cognitive status groups based on the consensus classification of MCI reported by Winblad et al. (2004). A psychometric rather than a clinical definition of MCI was used. Data were drawn from the archives of the Victoria Longitudinal Study (Dixon & de Frias, 2004) to establish norms based on participants recruited from the same population as the present sample. Data were available on five cognitive measures (perceptual speed – WAIS-R Digit Symbol Substitution, Wechsler, 1981; inductive reasoning - Letter Series, Thurstone, 1962; episodic memory – immediate free word recall, Hultsch, Hertzog, & Dixon, 1990; verbal fluency - Controlled Associations, Ekstrom, French, Harman, & Dermen, 1976; and vocabulary - Extended Range Vocabulary, Ekstrom et al., 1976) from 445 adults aged 65 to 94 years[1]. Although published norms are available for most of these measures, they derive from a variety of different samples with varying demographic characteristics. The use of local norms from a separate sample drawn from the same population is preferred given the close demographic match to the current sample and the ability to make more accurate comparisons across tasks. Participants who performed below (1 *SD* or more) their age- and education-matched peers on the memory test were classified as a Memory single group (n = 10). Those who scored more than 1.0 *SD* below the normative group on the memory measure <u>and</u> one or more of the other cognitive tests were classified as Memory multiple (n = 14). The Non-memory single group (n = 66) scored more than 1.0 *SD* below their peers on one of the four non-memory cognitive tasks. Participants in the Non-memory multiple group (n = 41) scored more than 1.0 *SD* below the normative group on two or more of the non-memory cognitive tests. The remaining participants were in the Intact group. Table 2 presents the participants' demographic information as a

[1] Data on all 445 participants were available for the measures of perceptual speed, reasoning, verbal fluency, and vocabulary, but, due to implementation of a counterbalancing procedure, information on the episodic memory task was only available for 194 of the 445 participants of the normative sample.

function of cognitive status group. The groups did not differ in terms of age, $F(4, 252) = 2.115, p > .05$, or number of years of education, $F(4, 252) = 2.183, p > .05$.

Table 2. Demographic information of participants as a function of cognitive status group.

Cognitive status	*N*	Mean Age (*SD*)	Mean years of education (*SD*)
Intact	122	73.21 (5.43)	15.50 (3.11)
Memory single	10	70.20 (3.68)	14.50 (4.38)
Memory multiple	14	75.29 (7.75)	14.29 (3.32)
Non-memory single	66	73.58 (5.87)	15.62 (2.67)
Non-memory multiple	41	75.15 (5.60)	14.17 (3.15)

Statistical Analysis

An exploratory factor analysis (i.e. Principle Components Analysis (PCA)) was first conducted on the subscales of the mSIB-R to verify its construct validity. Profile analysis was then performed to determine the utility of the mSIB-R factors in distinguishing between the psychometrically-defined MCI groups. Profile analysis is a multivariate analysis of variance that is used to determine whether groups have different patterns of profiles on a set of measures (Tabachnick & Fidell, 2001). There are three major tests in profile analysis. The *parallelism* test is similar to the test of interaction in univariate analysis of variance (ANOVA). This test evaluates whether the groups differ with regard to ratings of particular mSIB-R factors. The *levels* test evaluates the same hypothesis as the between-subject main effect in ANOVA where the question regarding overall group differences is answered. We expected the psychometrically-defined MCI groups to differ in mSIB-R ratings when mSIB-R scores were collapsed across factors. In cases where the levels test generated a significant difference among groups, post-hoc tests using Tukey's HSD were conducted to examine the group differences (e.g. of all psychometrically-defined MCI groups, MCI memory multiple group may be rated the lowest). Finally, the test of profile *flatness* evaluates the same hypothesis as the within-subject main effect in repeated-measures ANOVA. Specifically, the *flatness* test addresses whether all the dependent variables elicit similar average responses, in that ratings were collapsed across psychometrically-defined MCI groups and the mSIB-R factors were compared. The *flatness* hypothesis is typically evaluated when the profiles are parallel. All analyses were done using SPSS 12.0 for Windows.

Results

Reliability. Analysis of the internal consistency of the mSIB-R revealed a Cronbach's alpha of .92 for self report and .95 for informant report. A total of 210 individuals (target participants with informants) were reassessed about one year later. Test-retest reliability was high for both the self report ($r = .80$) and the informant report ($r = .84$).

Validity. Because the factors were expected to be highly correlated, a PCA with oblimin rotation was performed on the mSIB-R separately for self and informant reports. Table 3 and Table 4 present the results for the PCA.

Using eigenvalue greater than 1 as criterion, both modes of report generated three factors: social/cognitive engagement, basic living skills, and physical/environmental engagement. The factors accounted for a total of about 63% of the variance on self-report, and about 69% of the variance on informant report.

Differences in the factor structures between self and informant reports emerged when the composition of the factors was examined, suggesting that somewhat disparate information about the target participants was obtained from the two modes of report. As the items on the mSIB-R were factorially complex (i.e. some items loaded across all factors), further analysis was done using the factor scores. Additionally, separate analysis was conducted for each mode of report because differences in factor compositions do not allow for direct comparisons.

Table 3. Principal component analysis of the Self report.

	Social/Cognitive Engagement	Basic Living Skills	Physical/Environmental Engagement
Gross Motor	-.176	.126	**.825**
Fine Motor	.113	.142	**.664**
Social Interaction	**.608**	-.145	**.305**
Language Comprehension	**.723**	-.213	.206
Language Expression	**.463**	**-.353**	**.569**
Eating & Meal	.108	**.600**	**.338**
Dressing	**.640**	**.336**	.013
Personal Self-Care	.291	**.656**	.093
Domestic Skills	.000	**.424**	**.675**
Time & Punctuality	**.697**	.122	-.133
Money & Value	**.782**	.099	-.137
Work Skills	**.627**	.065	**.326**
Home/Community	.218	-.199	**.741**

Table 4. Principal component analysis of the Informant report.

	Social/Cognitive Engagement	Basic Living Skills	Physical/Environmental Engagement
Gross Motor	.193	-.015	**.831**
Fine Motor	.225	**.356**	**.460**
Social Interaction	**.898**	.036	-.114
Language Comprehension	**.845**	.117	-.038
Language Expression	**.880**	-.053	.131
Eating & Meal Preparation	.260	**.655**	-.025
Dressing	.111	**.757**	-.109
Personal Self-Care	-.227	**.816**	.221
Domestic Skills	.054	**.628**	**.414**
Time & Punctuality	.203	**.594**	-.265
Money & Value	**.399**	**.433**	-.004
Work Skills	**.543**	.164	**.381**
Home/Community	**.693**	.009	.332

Correlating the mSIB-R factors with Lawton and Brody's (1969) IADL measure revealed a large correlation coefficient for the physical/environmental engagement factor on the self reports ($r = -.531$) and a very large correlation coefficient for the basic living skills factor on the informant reports ($r = -.746$). Correlations of the Lawton and Brody IADL measure with other factors were moderate, ranging from -.326 to -.462, as presented in Table 5. The negative correlations resulted from differences in the direction of item scoring between the two scales: high scores on the mSIB-R represent good functional status, whereas high scores on Lawton and Brody's IADL measure represent poor functional status.

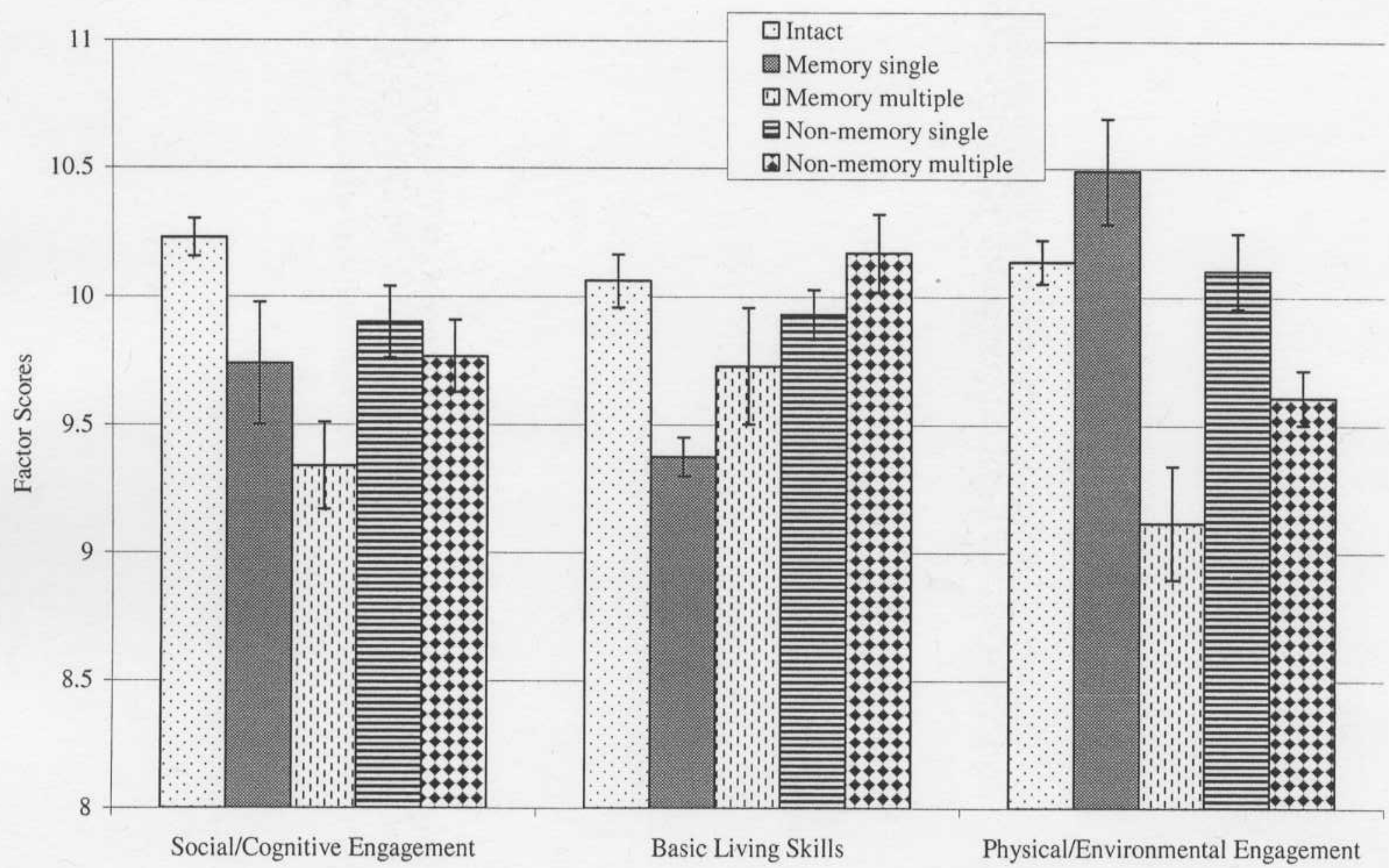
Table 5. Correlation of the mSIB-R factors and Lawton and Brody's (1969) IADL.

	1.	2.	3.	4.
Self				
1. Social/Cognitive Engagement	-			
2. Basic Living Skills	.168**	-		
3. Physical/Environmental Engagement	.420**	.147*	-	
4. Lawton & Brody IADL	-.326**	-.404**	-.531**	-
Informant				
1. Social/Cognitive Engagement	-			
2. Basic Living Skills	.534**	-		
3. Physical/Environmental Engagement	.271**	.254**	-	
4. Lawton & Brody IADL	-.462**	-.746**	-.363**	-

In order to determine the utility of the mSIB-R factors in distinguishing between the five groups, a separate profile analysis was performed on the self and informant reports. For the self report measure, as presented in Figure 1, using Wilks' criterion, the profile deviated significantly from parallelism, $F(8, 494) = 3.132$, $p<.01$, partial $\eta^2 = .048$, indicating that self ratings of the various psychometrically-defined MCI groups differed depending on the mSIB-R factors. To evaluate deviation from parallelism of the profile, the data were split by factors and analyzed using Tukey's HSD. The Intact group (M = 10.228, SD = .088) rated themselves higher than the Memory multiple group (M = 9.340, SD = .261) in the social/cognitive engagement factor. For the physical/environmental engagement factor, the Intact group (M = 10.137, SD = .087) rated themselves higher than the Memory multiple (M = 9.118, SD = .257) and the Non-memory multiple group (M = 9.609, SD = .150). The Memory single group (M = 10.491, SD = .304) rated themselves higher than the Memory multiple group, and the Non-memory single group (M = 10.102, SD = .118) rated themselves higher than the Memory multiple group. There were no differences among the subgroup ratings in the basic living skills factor.

The levels test revealed a significant difference among the psychometrically-defined MCI groups, $F(4, 248) = 4.636$, $p<.01$, partial $\eta^2 = .070$. To this end, the differences among the psychometrically-defined MCI groups collapsed across factors were evaluated. The post-hoc test showed that the Intact group ($M = 10.142$, $SD = .062$) rated themselves higher than the Memory multiple group ($M = 9.396$, $SD = .183$). The Non-memory single group rated themselves higher than the Memory multiple group ($M = 9.979$, $SD = .084$). Regardless of the type of skills examined, participants with multi-domain impairment, including memory, rated themselves the lowest.

Figure 1. Factor scores of self ratings on the mSIB-R as a function of psychometrically-defined MCI group.

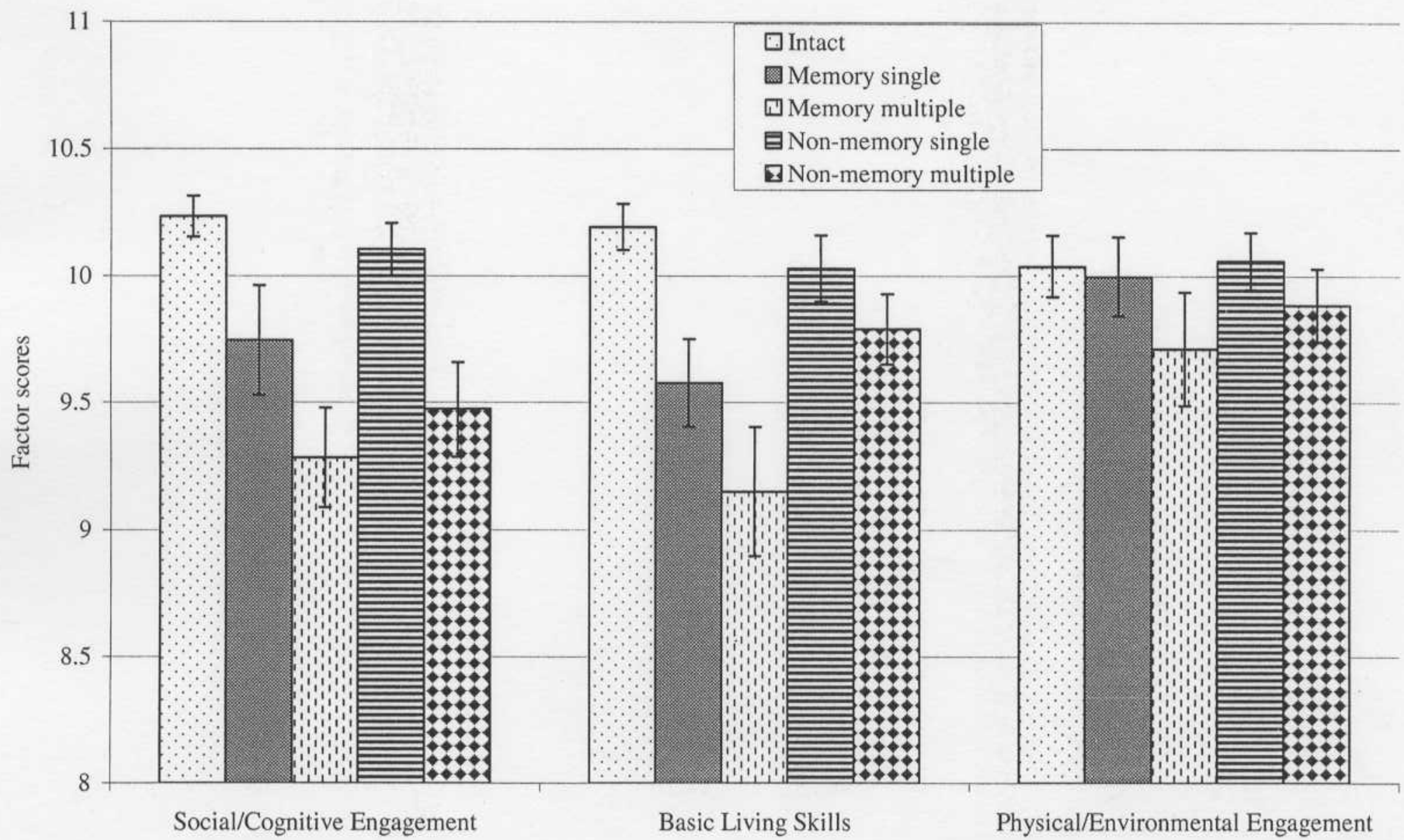


On the informant report, as shown on Figure 2, the profile did not deviate significantly from parallelism, $F(8, 442) = 1.668$, $p > .05$, partial $\eta^2 = .029$, suggesting that informant ratings of the various psychometrically-defined MCI groups did not differ as a function of the mSIB-R factors. When averaged over groups, the factors did not deviate significantly from flatness, $F(1.907, 23.430) = 1.747$, $p > .05$, partial $\eta^2 = .008$. None of the three factor subtotals was particularly lower than the other.

The levels test generated a significant difference among the psychometrically-defined MCI groups, $F(4, 222) = 5.149$, $p < .001$, partial $\eta^2 = .085$. Post-hoc test conducted on the psychometrically-defined MCI groups collapsed across mSIB-R factors revealed that the Intact group ($M = 10.155$, $SD = .071$) were rated higher than the Memory multiple ($M = 9.386$, $SD = .210$) and Non-memory multiple groups ($M = 9.717$, $SD = .117$). The Non-memory single group ($M = 10.065$, $SD = .093$) was rated higher than the Memory multiple group. Overall, although informants rated the participants with multi-domain impairment the lowest, ratings were not dependent on the type of skill.

In summary, participants with multiple cognitive impairments rated themselves the lowest but this tended to occur more for skills relying on physical and social engagement than for basic living skills. Informants, on the other hand, rated the participants with different degrees of psychometrically-defined MCI in the same manner without regard for the type of task. Those with multi-domain impairments were rated the lowest.

Figure 2. Factor scores of informant ratings on the mSIB-R as a function of psychometrically-defined MCI group.



Self-Informant discrepancies

A one-way Analysis of Variance with the mSIB-R total scores as the dependent variable and mode of report (Self, Informant) as the independent variable revealed a significant difference between Self (M =197.87, SD = 12.688) and Informant (M = 193.79, SD = 18.881) reports, $F(1, 479) = 7.86$, $p < .01$, $\eta^2 = .016$. Self ratings were higher than Informant ratings. The discrepancy between informant and self ratings was examined further by comparing the number of cases with abnormally large discrepancy scores in the various psychometrically-defined MCI groups as compared to the Intact group (Table 6). The cut-off score used to identify cases with an abnormal discrepancy was determined by using discrepancy scores larger than 1.5 standard deviations from the mean score of the Intact group. In general, looking at the percentage of cases relative to the original number of cases in each psychometrically-defined MCI group, the Memory multiple and Non-memory multiple groups had more cases (%) with very discrepant ratings than the other groups (%). In a large proportion of these cases, participants rated themselves higher than did the informants.

Table 6. Number of cases with discrepancy scores (Informant-Self) larger than 1.5 standard deviation from the mean as a function of psychometrically-defined MCI group.

MCI group (n^2)	Number of cases (%)		
	Self > Informant	Self < Informant	Total
Intact (106)	7 (6.6)	7 (6.6)	14 (13.2)
Memory Single (9)	1 (11.1)	0 (0.0)	1 (11.11)
Memory Multiple (12)	4 (33.3)	1 (8.3)	5 (41.1)
Non-memory Single (61)	6 (9.8)	7 (11.5)	13 (21.3)
Non-memory Multiple (39)	9 (23.1)	3 (7.7)	12 (30.8)

[2] The number of participants in the MCI groups for the discrepancy analysis does not correspond to the numbers in the original MCI groups because some informants declined participation in the study.

Discussion

The current study evaluated the psychometric properties of a modified version of the SIB-R in a community-dwelling, non-demented sample of older adults. The mSIB-R was found to have excellent internal consistency. Similarly, both the self and informant reports generated good test-retest reliabilities at a one-year interval. The mSIB-R demonstrated convergent validity, as seen by its relatively high correlation with Lawton and Brody's (1969) IADL measure. In addition, the mSIB-R differentiated among groups of participants with varying degrees of psychometrically-defined MCI. Self ratings of physical/social/cognitive engagement appear sensitive to the extent of cognitive impairment: those showing more extensive impairment (impairment in multiple domains) reported more higher-order functional impairment. Taken together, results suggest that the mSIB-R provides a reliable and valid assessment of functional status in a community-living, non-demented elderly population to some extent.

The mSIB-R appears as factorially complex, tapping at least three separable dimensions: basic living skills, social/cognitive engagement and physical/environmental engagement. The mSIB-R appears to not only assess physical/personal care issues tapped by the Lawton and Brody IADL but it also appears to tap more higher-order social interaction/cognitive skills. It should be noted that the factor composition on the self report was somewhat different from the informant report. For example, language expression was factorially complex and therefore loaded across all factors in the self-report, suggesting that the participants presented with a "global," integrated sense of their language ability. Informants, to the contrary, had a more "categorical" view of the participants, at least with regard to this domain.

The mSIB-R was able to distinguish between groups of mildly impaired elderly adults. However, the pattern of discrimination differed somewhat depending on the mode of report. Those with multiple areas of impairment rated themselves as having significant difficulties in terms of their environmental engagement, be it physical or social/cognitive. By contrast, informant ratings of participants with multiple impairments suggested problems across the board, be it basic skills or higher order functions. Regardless of mode of report, however, those with multiple areas of cognitive impairment appear to be functioning less well in their daily life compared to those with impairment in no or a single domain. The presence/absence of memory impairment seemed to play little part in determining ratings on functional independence.

When the discrepancy scores of informant and self-reports were examined in our study, individuals with multiple cognitive impairments appeared to have an inflated sense of efficacy on everyday activities compared to informants' views of the participants, a finding also reported by others (Albert, Michaels, & Padilla, 1999; Tabert et al., 2002; Ready et al., 2004). Although our results suggest that self ratings on the mSIB-R appear to better distinguish between groups of individuals with varying degrees of psychometrically-defined MCI, particularly on tasks related to physical/environmental engagement, whether the participants or informants were more accurate assessors of the participant's everyday functioning is unknown. However, our finding that disagreement between self and informant ratings were most pronounced in those with multi-domain impairment is similar to results reported by Albert and colleagues (1999). They found that the concordance between self and informant reports was low among those with questionable dementia.

Several limitations need to be acknowledged. First, the number of people with a single memory deficit or multiple deficits including memory was small compared to the other psychometrically-defined MCI subgroups. Because of the unequal sample sizes, the comparison between the psychometrically-defined MCI subgroups may not yield results that are reflective of the actual phenomenon. Further, as our sample is very bright and highly educated, the findings may not generalize to groups with lower abilities and little education. According to Katz's (1983) definition, IADLs are culturally and environmentally determined; therefore, the utility of the mSIB-R may be restricted in a different population or setting. It is also important to note that the four-factor structure outlined in the SIB-R manual was not replicated in this study. This likely reflects the fact that we modified the scales and focused on a sample of older adults; however, replication in another sample would be needed to confirm the structure of the mSIB-R.

With regard to future research, it would be important to examine the cognitive correlates of the mSIB-R in order to have a better appreciation of the relationship between cognition and functional ability. In addition, it would be useful to compare the clinical utility of the mSIB-R (a self/informant-based report) against a performance-based measure such as the Everyday Problems Test (Willis & Marsiske, 1993) in order to determine if they provide similar information regarding older adults' functional abilities.

Determination of functional status has relevance for both diagnosis and treatment. The current study suggests that the mSIB-R provides sound psychometric properties as a measure of functional status in a community-dwelling, non-demented elderly population.

Study 2: Cognitive correlates of the modified Scales of Independent Behavior-Revised

Introduction

Findings from the first study suggest that the modified Scales of Independent Behavior-Revised (mSIB-R) provides sound psychometric properties as a measure of functional ability among community-dwelling older adults; therefore, the mSIB-R may be useful to address gaps in the literature regarding the association between cognitive function and functional ability. First, the association between cognition and functional ability appears to differ across studies (e.g., Cahn-Weiner et al., 2007; Farias et al., 2005; Tuokko et al., 2005). These differences appear to be due to the use of different measurement methods such as self/informant-report and performance-based measures, and existing literature that examined the methodological difference used measures that tapped a restricted range of functional abilities that may not be sensitive to detect mild impairments (e.g., Bennett et al., 2006; Farias et al., 2005; Wood et al., 2005). Second, past studies examined partial models that included only a few cognitive domains or restricted samples (e.g., Cahn-Weiner et al., 2007; Farias et al., 2006) and may not be representative of community-based samples. Given these limitations in the literature, the purpose of the second study (Tan et al., 2009) was to examine the associations between cognitive function and specific factors on an informant/self-report measure of functional status, the modified Scales of Independent Behavior-Revised (mSIB-R), in a sample of community-dwelling, non-demented elderly. Although performance-based measures such as the EPT are reportedly better than report-based measures in differentiating among older adults with varying degrees of cognitive impairment (Marsiske & Willis, 1995), report-based measures may be a good compromise between time and cost (Royall et al., 2007). The use of the mSIB-R addresses the shortcoming of previous studies in that it covers a wide range of everyday activities (e.g. basic living skills, physical/environmental engagement skills, social/cognitive engagement skills). Moreover, the mSIB-R appears to be reliable and sensitive to mild cognitive impairments (Tan et al., in press). A wide array of cognitive domains, including motor functioning, speed of processing, executive functioning, episodic memory, verbal ability as well as general cognitive status, was also evaluated.

The study focuses on two general questions: (1) What are the associations between cognitive variables and different aspects of functional ability as measured by informant- and self-reports? (2) How do informant- and self-reports of functional ability hold up in predicting cognitive status when compared to a performance-based measure of everyday function, the EPT? Poor cognitive functioning is expected to be associated with functional dependence, and different cognitive variables should be associated with specific factors of functional ability. As well, an improved classification rate for cognitive status when the mSIB-R was included in the prediction model is also expected.

Method

Cognitive status groups. The participants were divided into two cognitive status groups, using a psychometric rather than a clinical definition of MCI, similar to the method as described in the first study. As the literature suggests that even healthy individuals obtain some low scores when given numerous neuropsychological tests (e.g., Heaton, 1991), participants who performed below (1 *SD* or more) their age- and education-matched peers on two or more of the cognitive reference measures were classified as MCI. The remaining participants were placed in the Intact group. Table 7 presents the participants' demographic information as a function of psychometrically-defined MCI group. The groups differed in terms of age, $F(1, 248) = 5.208$, $p < .05$, and number of years of education, $F(1, 248) = 7.693$, $p < .01$. Table 8 presents the means and standard deviation of the participants' performance on the motor and cognitive measures.

Table 7. Participants' demographic information as a function of psychometrically-defined MCI group.

Demographics	Intact	MCI
Age, mean ± SD	75.20 ± 5.55	77.18 ± 6.14
Education, years, mean ± SD	15.50 ± 3.04	14.20 ± 3.17
Gender, male/female, n	55/139	22/33
Number of chronic illnesses, mean ± SD	.46 ± .74	.55 ± .92

Table 8. Participants' mean and standard deviation scores on motor and cognitive variables.

	M	SD
Dominant hand grip, kg	30.04	10.535
Non-dominant hand grip, kg	28.51	10.500
Dominant finger tapping time, sec	3.9140	1.08782
Non-dominant finger tapping time, sec	3.7819	.98028
Timed turn, sec	2.1500	.78619
Timed walk, sec	5.8874	1.75713
Total MMSE score	28.67	1.429
Speed of processing	.0000	.86195
Executive functioning	.0075	.90335
Episodic Memory	.0030	.87215
Verbal ability	.0000	.86557

Measures

Everyday Problems Test. The Everyday Problems Test (EPT; Willis & Marsiske, 1993) is a paper and pencil measure of functional ability that requires participants to solve problems associated with daily living. The domains measured are consistent with those investigated in Lawton and Brody's (1969) Instrumental Activities of Daily Living: medication use, meal preparation, telephone use, shopping, financial management, household management and transportation. Participants are provided with 21 printed stimulus materials (e.g., medication label, pay phone information) and asked to solve two practical problems pertaining to each stimulus. The original EPT consists of 42 items; however, for the purposes of the present study, items # 10 (Medicare Benefits Payment Schedule) and 12 (Stain Removal Directions) were omitted because a significant minority of participants disputed interpretation of elements of the problems. Consequently, possible scores ranged from 0 to 40, with higher scores indicating better performance.

Willis and Marsiske (1994) reported a one-year Spearman-Brown test-retest reliability of .91 for the total score. The internal consistency (Cronbach's alpha) for the EPT for year 1 of the current study was .88. With respect to validity, the EPT has been found to correlate significantly ($r = .67$) with direct observation of older adults' performance of everyday tasks involving medications, meal preparation, and phone usage. Correlations with older adults' self-reports ($r = .23$) and dementia patients' self-reports ($r = .36$) of IADL functioning, although lower, were also significant.

Motor variables. Psychomotor functioning of participants was measured on four motor tasks including finger tapping, hand grip strength, timed walk, and timed turn. The finger tapping task was administered on a laptop computer. Participants were instructed to respond as quickly as possible by pressing the "Left" key with their left hand. A letter "L" appeared on the screen with each tap. During the practice trial, participants were asked to continue tapping until they completed a row of 24 taps. Immediately following the practice run, participants completed the test trial that consisted of two rows of 48 taps. The procedure was repeated using the right hand with the "Right" key. The latencies between the taps were recorded and used for analysis.

The hand grip strength task was measured using a single reading for each hand from a dynamometer. The grip strength in kilograms was recorded. The timed walk task, a measure of gait, required participants to walk a distance of 10ft, turn around, and return to the starting point as quickly as possible. The time to complete the walk was recorded. In the timed turn task, which is a measure of balance/gait, the time required for participants to turn 360° and return to the starting position was recorded.

Global cognitive ability. The Mini-Mental State Examination (MMSE; Folstein et al., 1975) is a brief screening tool for measuring global cognitive functioning. It consists of a variety of questions that potentially tap into different cognitive domains, including orientation, attention, immediate and delayed memory, language, and visual construction. The maximum number of points an individual can obtain is 30, the maximum score corresponding to optimal cognitive function.

Speed of processing. A composite score was calculated by averaging the z-scores from the Trail Making Test Part A (TMT; Reitan & Wolfson, 1986) and the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) Digit Symbol Substitution subtest. As higher values on the TMT represents poorer performance, the score was reversed before it was used for the composite score calculation. The TMT-A is a timed test of psychomotor speed and visual scanning. The time taken for participants to connect numbers that are randomly arranged in ascending order as fast as possible is recorded. The WAIS-R Digit Symbol Substitution subtest is a measure of processing speed. The number of symbols correctly copied by participants beneath a series of digits according to a key displaying the digit and symbol pairs is recorded. Participants are given a maximum of 90 seconds to complete the task. The possible scores range from 0 to 93, with higher scores representing better performance.

Executive function. The z-scores from the TMT Part B and the Letter Series task (Thurstone, 1962) were averaged to derive a composite score for the executive function variable. The score on the TMT was reversed before it was used to calculate the composite score in order to ensure that higher scores represent better performance, prior to conversion to z-scores. The TMT-B is a timed test of cognitive flexibility. The time taken for participants to connect randomly arranged numbers and letters alternately in ascending order is recorded. On the Letter Series task, participants complete series of letters (e.g. a b c a b d a b e a b) by selecting the letter that comes next in the series from a choice of 5 letters. Participants were given 4 sample items prior to the test trial in which they were given 6 minutes to complete 20 letter series. The series range in length from 6 to 15 letters. One point is awarded for each correct item to a maximum possible score of 20.

Episodic memory. The episodic memory composite score was calculated by averaging the z-scores from the Word Recall task (Hultsch et al., 1990) and the Story Recognition test (Hertzog, Dixon, & Hultsch, 1992). Participants were given a list of 30 English nouns to study for 2 minutes on the Word Recall task. The list contained 6 words from each of 5 taxonomic categories presented in unblocked order. After the study list was removed, participants were given 5 minutes to write down as many words as they could recall. One point was awarded for each correct word to a maximum possible score of 30, with higher scores representing better performance. Duplicates and incorrect words were not scored. The Story Recognition test was based on 4 narrative stories selected from a set of 25 structurally equivalent texts developed by Hertzog, Dixon, & Hultsch (1992). There were approximately 300 words in each story, with 160 propositions and related events in the lives of older adults. Twenty-four statements about the story were presented one at a time on a computer screen immediately following the audio presentation of the story. Participants were asked to select one of 2 keys to identify the statement that represented the idea presented in the story (statements presenting a correct idea from the story), and the other key to identify the statement that represented the idea that was not in the story (statements presenting an incorrect idea from the story, and ideas consistent with the theme of the story that were not mentioned). There are eight statements of each type. The number of items correctly completed was recorded.

Verbal ability. The z-scores from the Controlled Association task (Ekstrom et al., 1976) and the Vocabulary survey (Ekstrom et al., 1976) were averaged to calculate the composite score for the verbal ability variable. The Controlled Association task is based on the total number of acceptable words provided by participants that are the same or similar in meaning to some target words within 6 minutes. Participants were first given a sample word (i.e. "weak) for practice. They were then given 4 words ("clear", "dark", "strong", and "wild") during the test trial. Participants completed a 36 item multiple choice Vocabulary survey in which they selected, from 5 options, one word with the same or nearly the same meaning for each item. The time limit for the task was 10 minutes and the maximum possible score was 36.

Statistical analysis

The primary analysis examines the association between cognitive variables and specific factors of the mSIB-R. The relationship between each mSIB-R factor and specific cognitive variables is evaluated using hierarchical multiple regression. Age, education, and number of chronic illnesses were entered together as demographic variables in block 1. As the purpose of this study was on the cognitive correlates of functional abilities, the psychomotor tasks were therefore entered into the model next, before any of the cognitive variables, including general cognitive functioning. This was followed by the MMSE, representing global cognitive functioning. Finally, the cognitive variables were independently entered into the equation The order of entry of the cognitive variables was based on a theoretically based rationale presented by Hultsch et al. (1992). It was argued that processing speed and working memory (i.e. executive function) are basic components to more complex episodic memory tasks, which are in turn less specialized than semantic abilities (i.e. verbal ability). Thus, for the purpose of this study, speed of processing was entered first, followed by executive functioning, episodic memory, and lastly, verbal ability. In order to examine the relative contribution of specific cognitive domains in comparison to global cognitive functioning, the analysis was repeated with the specific cognitive variables entered following the demographic and motor variables, and with the MMSE entered last. As the results remained the same, but with the MMSE no longer a significant predictor, results were not reported except in cases where differences were found.

In order to determine the utility of the self/informant-rated measure (mSIB-R) compared to a performance-based measure (i.e. the Everyday Problems Test; EPT) in predicting mild cognitive impairment, logistic regression was used. First, a model with the EPT total score and all three factors of the self-rated mSIB-R was used. The Wald test was interpreted to determine the significance of each predictor in the model. The analysis was repeated using the informant-rated mSIB-R.

Given the large number of analyses conducted, all significance levels are interpreted at a .01 level in order to protect against Type I error while preventing Type II errors. All analyses were done using SPSS 15.0 for Windows.

Results

Intercorrelation between the mSIB-R factor scores, EPT, and cognitive variables

The intercorrelations between the informant-rated mSIB-R factor scores, EPT, and specific variables are presented in Table 9. The correlation between the informant factors and specific cognitive variables ranged from trivial to large, but with most showing at least a small correlation. The largest correlation ($r = .523$) was seen between social/cognitive engagement and episodic memory. Overall, the social/cognitive engagement factor demonstrated the largest correlations with each cognitive variable compared to the other mSIB-R factors.

Table 9. Intercorrelation between informant mSIB-R factor scores, EPT and specific cognitive variables.

	1.	2.	3.	4.	5.	6.	7.	8
1. Basic living skills factor	1	-	-	-	-	-	-	-
2. Social/cognitive engagement factor	.534**	1	-	-	-	-	-	-
3. Physical/environmental engagement factor	.254**	-.271**	1	-	-	-	-	-
4. EPT	.171*	.431**	.180*	1	-	-	-	-
5. Speed of processing	.304**	.333**	.252**	.328*	1	-	-	-
6. Executive functioning	.270**	.398**	.199**	.579*	.658**	1	-	-
7. Episodic memory	.298**	.523**	.175**	.600*	.522**	.575**	1	-
8. Verbal ability	.038	.221**	.083	.603*	.349**	.425**	.535*	1

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

The intercorrelations between the self-rated mSIB-R factor scores, EPT, and specific variables are presented in Table 10. The correlations between the self-rated factors and specific cognitive variables ranged from trivial to moderate. The largest correlation ($r = .419$) was seen between the physical/environmental engagement factor and speed of processing. None of the cognitive variables, except verbal ability, had significant correlations with the basic living skills factor. Overall, of the mSIB-R factors, the physical/environmental factor showed the largest correlations with each cognitive variable. Compared to the mSIB-R, the EPT appeared to have higher correlations with all cognitive variables, with the exception of processing speed.

Table 10. Intercorrelation between self mSIB-R factor scores and specific cognitive variables.

	1.	2.	3.	4.	5.	6.	7.	8.
1. Basic living skills	1	-	-	-	-	-		-
2. Social/cognitive engagement factor	.168**	1	-	-	-	-		-
3. Physical/environmental engagement factor	.146*	.422**	1	-	-	-		-
4. EPT	-.037	.237**	.332**	1	-	-		-
5. Speed of processing	.101	.209**	.419**	.328**	1	-		-
6. Executive functioning	-.047	.220**	.390**	.579**	.658**	1		-
7. Episodic memory	-.011	.294**	.359**	.600**	.522**	.575**	1	-
8. Verbal ability	-.129*	.167**	.230**	.603**	.349**	.425**	.535**	1

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

Relationship between informant-rated basic living skills factor and cognitive variables

Table 11 presents results from the hierarchical multiple regression. Overall, the model accounted for about 26% of the variance on the informant-rated basic living skills factor. Demographic variables did not account for a significant amount of variance.

Motor skills explained the largest proportion of unique variance on this factor (16.5%), followed by global cognitive functioning, and verbal ability. When the analysis was repeated with the MMSE entered last, motor skills, episodic memory (2.6%) and verbal ability (3.2%) were significant predictors, whereas the MMSE was no longer significant.

Table 11. Summary hierarchical regression analysis for demographic, motor, MMSE, and cognitive variables predicting informant mSIB-R basic living skills factor.

Variable	B	*SE B*	β	*R*	R^2	Adj R^2	ΔR^2
Step 1							
Age	.003	.013	.020				
Education	-.007	.020	-.023				
Chronic Illness	-.008	.074	-.007				
				.175	.031	.017	.031
Step 2							
Dominant Finger Tapping	.098	.103	.110				
Nondominant Finger Tapping	-.175	.103	-.186				
Dominant Grip Strength	-.009	.014	-.105				
Nondominant Grip Strength	-.011	.014	-.127				
Turning Time	-.619	.126	-.469				
Timed Walk	.161	.062	.282				
				.442	.196	.160	.165***
Step 3							
MMSE	.088	.051	.114	.482	.232	.195	.037**
Step 4							
Speed of Processing	.038	.104	.032	.496	.246	.205	.014
Step 5							
Executive Functioning	1.63	.091	.159	.510	.261	.216	.015*
Step 6							
Episodic Memory	.274	.094	.244	.525	.276	.229	.015*
Step 7							
Verbal Ability	-.233	.079	-.214	.553	.306	.257	.030**

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

As presented in Table 12, the overall model accounted for about 32% of the variance on the informant-rated social/cognitive engagement factor. Demographic variables (11.9%), global cognitive functioning (2.8%), and episodic memory (10.9%), individually explained unique variance on this factor at each step they were entered into the model. Executive functions (2.5%) was almost significant at the alpha level. With the MMSE entered last, executive functions (3.3%) and episodic memory (12.3%) were significant predictors.

Table 12. Summary hierarchical regression analysis for demographic, motor, MMSE, and cognitive variables predicting informant mSIB-R social/cognitive engagement factor

Variable	B	*SE B*	β	*R*	R^2	Adj R^2	ΔR^2
Step 1							
Age	.000	.013	-.002				
Education	.032	.020	.104				
Chronic Illness	.066	.073	.053				
				.345	.119	.106	.119***
Step 2							
Dominant Finger Tapping	.176	.102	.189				
Nondominant Finger Tapping	-.253	.103	-.259				
Dominant Grip Strength	-.020	.014	-.223				
Nondominant Grip Strength	.020	.014	.218				
Turning Time	-.306	.125	-.222				
Timed Walk	.063	.061	.106				
				.421	.177	.141	.058*
Step 3							
MMSE	.013	.051	.016	.453	.205	.166	.028**
Step 4							
Speed of Processing	-.023	.104	-.019	.468	.219	.176	.014
Step 5							
Executive Functioning	.118	.091	.111	.494	.244	.199	.025*
Step 6							
Episodic Memory	.577	.093	.495	.594	.353	.311	.109***
Step 7							
Verbal Ability	-.159	.079	-.140	.605	.366	.321	.013*

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

Relationship between the informant-rated physical/environmental engagement factor and cognitive variables

Table 13 showed the results of the final regression model. The overall model explained about 19% of the variance on the informant-rated physical/environmental engagement factor. Only demographic and motor skills were predictors. All other variables did not explain significant amount of unique variance when they were entered at each step.

Table 13. Summary hierarchical regression analysis for demographic, motor, MMSE, and cognitive variables predicting informant mSIB-R physical/environmental engagement factor.

Variable	B	*SE B*	β	*R*	R^2	Adj R^2	ΔR^2
Step 1							
Age	.003	.014	.020				
Education	-.037	.022	-.117				
Chronic Illness	.133	.082	.106				
				.238	.056	.043	.056**
Step 2							
Dominant Finger Tapping	-.006	.115	-.006				
Nondominant Finger Tapping	-.008	.115	-.008				
Dominant Grip Strength	-.006	.015	-.069				
Nondominant Grip Strength	.031	.015	.324				
Turning Time	-.264	.140	-.187				
Timed Walk	-.092	.069	-.151				
				.475	.226	.192	.170***
Step 3							
MMSE	-.014	.057	-.018	.476	.226	.188	.000
Step 4							
Speed of Processing	.106	.116	.084	.484	.234	.192	.007
Step 5							
Executive Functioning	.015	.102	.014	.484	.234	.188	.000
Step 6							
Episodic Memory	.132	.105	.111	.488	.238	.188	.004
Step 7							
Verbal Ability	-.086	.088	-.074	.492	.242	.188	.004

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

Relationship between the self-rated basic living skills factor and cognitive variables

As seen in Table 14, the overall model accounted for 13.9% of the variance on the self basic living skills factor. After entering demographic variables into the model, motor skills added another 8.3% of variance in the model. None of the cognitive variables contributed to unique variance on this factor. Global cognitive functioning was also a significant predictor when MMSE was entered last.

Table 14. Summary hierarchical regression analysis for demographic, motor, MMSE and cognitive variables predicting self mSIB-R basic living skills factor.

Variable	B	*SE B*	β	*R*	R^2	Adj R^2	ΔR^2
Step 1							
Age	-.001	.014	-.006				
Education	-.029	.021	-.093				
Chronic Illness	.028	.080	.023				
				.193	.037	.025	.037*
Step 2							
Dominant Finger Tapping	-.015	.112	-.016				
Nondominant Finger Tapping	-.023	.112	-.024				
Dominant Grip Strength	-.009	.015	-.102				
Nondominant Grip Strength	-.013	.015	-.138				
Turning Time	-.326	.137	-.234				
Timed Walk	-.008	.067	-.013				
				.347	.121	.085	.083**
Step 3							
MMSE	.166	.053	.213	.379	.144	.105	.023*
Step 4							
Speed of Processing	.113	.114	.091	.379	.144	.102	.000
Step 5							
Executive Functioning	-.156	.099	-.144	.408	.166	.121	.023*
Step 6							
Episodic Memory	-.081	.101	-.069	.418	.175	.126	.009
Step 7							
Verbal Ability	-.175	.084	-.152	.437	.191	.139	.016*

$^*p<.05$, $^{**}p<.01$, $^{***}p<.001$

Relationship between the self-rated social/cognitive engagement factor and cognitive variables

The overall model accounted for 13% of the variance on the self social/cognitive engagement factor as seen in Table 15. At about 8%, motor skills explained the largest proportion of the variance on this factor. Apart from motor skills, only episodic memory accounted for unique variance (4.1%) once other variables were added into the model.

Table 15. Summary hierarchical regression analysis for demographic, motor, MMSE and cognitive variables predicting self mSIB-R social/cognitive engagement factor.

Variable	B	*SE B*	β	*R*	R^2	Adj R^2	ΔR^2
Step 1							
Age	.024	.014	.134				
Education	.006	.023	.020				
Chronic Illness	.073	.085	.056				
				.131	.017	.004	.017
Step 2							
Dominant Finger Tapping	.036	.119	.036				
Nondominant Finger Tapping	-.089	.119	-.085				
Dominant Grip Strength	-.041	.016	-.421				
Nondominant Grip Strength	.030	.016	.307				
Turning Time	-.283	.146	-.192				
Timed Walk	.031	.071	.050				
				.308	.095	.059	.078**
Step 3							
MMSE	-.009	.057	-.010	.322	.104	.063	.009
Step 4							
Speed of Processing	.076	.122	.057	.352	.124	.081	.020*
Step 5							
Executive Functioning	.118	.106	.103	.375	.141	.094	.016*
Step 6							
Episodic Memory	.342	.107	.276	.427	.182	.134	.041**
Step 7							
Verbal Ability	-.008	.092	-.007	.427	.182	.130	.008

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

Relationship between the self-rated physical/environmental engagement factor and cognitive variables

The overall model explained about 35% of the variance on the self physical/environmental engagement factor (Table 16). Only demographic and motor variables explained unique variances on this factor. In fact, at 19%, motor skills accounted for the largest proportion of unique variance on this factor. None of the cognitive variables contributed unique variance once demographic and motor variables were entered into the model.

Table 16. Summary hierarchical regression analysis for demographic, motor, MMSE and cognitive variables predicting self mSIB-R physical/environmental engagement factor.

Variable	B	*SE B*	β	*R*	R^2	Adj R^2	Δ R^2
Step 1							
Age	-.012	.012	-.069				
Education	.004	.018	.014				
Chronic Illness	.058	.069	.047				
				.409	.168	.157	.168***
Step 2							
Dominant Finger Tapping	-.060	.097	-.063				
Nondominant Finger Tapping	-.121	.098	-.123				
Dominant Grip Strength	-.004	.013	-.048				
Nondominant Grip Strength	.011	.013	.122				
Turning Time	-.401	.119	-.288				
Timed Walk	-.035	.058	-.059				
				.598	.358	.332	.190***
Step 3							
MMSE	-.032	.046	-.041	.598	.358	.329	.000
Step 4							
Speed of Processing	.047	.099	.038	.605	.366	.335	.008
Step 5							
Executive Functioning	.080	.086	.074	.610	.372	.338	.006
Step 6							
Episodic Memory	.202	.088	.173	.621	.385	.348	.013*
Step 7							
Verbal Ability	-.058	.073	-.050	.622	.387	.348	.002

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

A summary of all hierarchical regression analyses is presented in Table 17.

Table 17. Summary table of hierarchical regression results: significant predictors.

	Informant		Self	
	Model 1	Model 2	Model 1	Model 2
Basic living skills	Motor MMSE Verbal ability	Motor Episodic memory Verbal ability	Motor	Motor MMSE
Social/Cognitive engagement	Demographics MMSE Executive functions* Episodic memory	Demographics Executive functions Episodic memory	Motor Episodic memory	Motor Episodic memory
Physical/environmental engagement	Demographics Motor	Demographics Motor	Demographics Motor	Demographics Motor

Note: Order of entry for Model 1 = demographics, motor, MMSE, speed of processing, executive functions, episodic memory, and verbal ability.

Order of entry for Model 2 = demographics, motor, speed of processing, executive functions, episodic memory, verbal ability, and MMSE.

*approached significance

Predicting cognitive status using self/informant-rated mSIB-R and EPT

In order to evaluate the extent to which the measures could accurately predict cognitive status (intact vs. psychometrically-defined MCI), binary logistic regression was conducted. All individual predictors from each measure were first assessed separately to obtain classification information and are shown in Table 18. On its own, EPT total scores correctly predicted 28.3% of cognitively impaired individuals, followed by the informant-rated social/cognitive engagement factor, at 15.7%. Self-reported physical/environmental engagement factor followed next, at 12.7%. All were significant except for informant-rated physical/environmental engagement and self-rated basic living skills factors. Likewise, EPT total scores generated the highest sensitivity rate followed by the self-reported physical/environmental engagement factor, and the informant-rated social/cognitive engagement factor. Specificity rates, in the 50% range, were low.

Table 18. Individual predictors.

	χ^2	*df*	*p*	%TP	%TN	%OH	Sen	Spec
EPT total	40.10	1	<.001	28.3	96.4	81.7	88.7	57.3
Informant social/ cognitive engagement	18.22	1	<.001	15.7	97.1	78.8	84.4	53.5
Informant basic living skills	7.43	1	<.01	2.0	98.3	76.5	54	50
Informant physical/environmental engagement	1.43	1	>.05	0	100	77.4	-	-
Self social/cognitive engagement	6.93	1	<.01	3.6	97.9	77.1	63.1	50.3
Self physical/environmental engagement	15.77	1	<.001	12.7	97.9	79.1	85.8	50.3
Self basic living skills	.272	1	>.05	0	100	77.9	-	-

Note: %TP = percent true positive, %TN = percent true negative, %OH = overall hit rate, Sen = Sensitivity, Spec = Specificity

Table 19 shows the logistic regression analyses done using various combinations of the top two predictors of each mode of report. This was done in order to evaluate the utility of adding a second self/informant-based measure to the top predictor (i.e. a performance-based measure). All additional predictors would have improved prediction if not for the alpha level correction. Addition of self-rated physical/environmental engagement factor to informant-rated social/cognitive engagement factor, likewise, nearly improved prediction of cognitive status, but it is less than just the EPT alone.

Table 19. Significant improvement in prediction: addition of a second predictor.

	χ^2	*df*	*p*	%TP	%TN	%OH	Sen	Spe
EPT + Informant social/cognitive engagement	4.40	1	<.05	34.7	97.1	83.4	92.2	59.7
EPT + Self physical/environmental engagement	4.03	1	<.05	32.1	96.4	82.5	89.9	58.6
Informant social/cognitive engagement + Self physical/environmental engagement	4.88	1	<.05	17.6	96.6	78.8	83.8	53.9

Note: χ^2, *df* and *p* values for increase in model accuracy with addition of second predictor, %TP = percent true positive, %TN = percent true negative, %OH = overall hit rate, Sen = Sensitivity, Spec = Specificity

Discussion

The purpose of the current study was to examine the association between cognitive functioning and a measure of functional ability, the mSIB-R, and to contrast self and informant ratings of functional ability against a performance-based measure, the EPT. The results showed that functional independence was associated with better cognitive functioning; however, the specific pattern of associations was dependent on the mSIB-R factor examined as well as the rater. As a screening tool for individuals with psychometrically-defined MCI, the mSIB-R appeared equivalent to a performance-based measure, the EPT, at least based on their overall hit rates.

The mSIB-R as a measure of functional ability associated with mild cognitive impairment

As expected, higher cognitive functioning was associated with higher functional independence regardless of the mode of report (self, informant) in this study. Our results are consistent with findings reported in the literature (Burton, Strauss, Hultsch, & Hunter, 2006; Cahn-Weiner et al., 2000; Grigsby et al., 1998; Landi et al., 2001; McGuire, Ford, & Ajani, 2006; Perneczky et al, 2006; Plehn et al., 2004; Tuokko et al., 2005; van Hooren et al., 2005; Warren, Grek, Conn, & Herrmann, 1989; Tam, Chiu, Chiu, & Lui, 2007). Of note, episodic memory, executive functions, and speed of processing demonstrated the largest correlations with the informant-rated social/cognitive engagement and the self-rated physical/environmental engagement factors.

In the past, studies have reported moderate to large correlation coefficients between performance-based measures of functional status and tests of cognitive functioning (e.g. Baird et al, 2001; Bell-McGinty et al., 2002; Burton et al., 2006). We found similar strength of association on our EPT measure. We also found that our report-based measure had small to moderate correlations with cognitive function composite scores. In comparison to other self-report measures (e.g. the SELF-scale, Linn & Linn, 1984) or informant-based measures (e.g. Lawton & Brody's IADL) which had a small to no correlation with tests of cognitive functioning (Jefferson et al., 2006; Plehn et al., 2004), the mSIB-R stands out as a functional measure that appears to be moderately associated with milder cognitive changes.

Mode of report affects the pattern of association between cognition and functional abilities

The literature suggests that chronic illness and motor function account for variance on functional ability over and beyond demographic variables (e.g. Wang et al., 2002). We went one step further by adding cognitive variables into our hierarchical regression model. Findings from our hierarchical regression analyses revealed that the full model accounted for about 19-32% of variance on informant reports, and about 13-35% on self reports. Our findings are similar to those reported in past studies that considered only partial models. For example, Bennett and colleagues (2006) found that a full model comprising demographic, extrapyramidal signs, MRI brain volume, cognition, and depression accounted for about 22-35% of variance on self-reported IADL in community-dwellers who were older (mean age = 85) than our sample. Likewise, age, number of diseases, depression, gender, and cognition (executive functions and memory) accounted for about 32-45% on self-reported IADL and social functioning among a similarly aged community-dwelling sample in another study (Plehn et al, 2004).

Close examination of the cognitive variables' contribution suggested that our findings were similar to those reported by Tuokko and colleagues (2005), where cognitive variables also accounted for about 11% of unique variance on basic living skills. In our study, cognitive variables accounted for the most unique variance on our social/cognitive engagement factor (18.9%). Somewhat similar tasks (social and IADL) were examined by Plehn and colleagues (2004). However, they reported that cognitive variables (i.e. memory and executive functions) contributed to between 7.8-12.2% of unique variance.

Differences in the cognitive predictors of functional abilities emerged when individual mSIB-R factors were evaluated as a function of the mode of report. First, with regard to informant reports, episodic memory and verbal ability predicted basic living skills, which is somewhat different from past studies (e.g. Tuokko et al., 2005; see Table 20). The social/cognitive engagement skills (which are arguably complex activities) of our participants were predicted by executive function and episodic memory, similar to past studies (Bell-McGinty et al., 2002; Cahn-Weiner et al., 2007; Plehn et al., 2004; see Table 20). As changes in episodic memory and executive functions are thought to be the best predictors for the conversion from psychometrically-defined MCI to dementia (e.g. Dickerson, Sperling, Hyman, Albert, & Blacker, 2007; Tabert et al., 2006), poor informant ratings on the social/cognitive engagement factor may signal a need to monitor the cognitive functions of these individuals who may be at risk of cognitive decline. In terms of self-reports, basic living skills were independently predicted by general cognitive ability, whereas social/cognitive engagement skills were predicted only by episodic memory. Finally, regardless of mode of report, none of the cognitive variables predicted physical/environmental engagement skills. This finding may suggest that tasks measured by this factor were highly dependent on motor variables, which is expected given the physical nature of these tasks (i.e. gross and fine motor, work and domestic skills) and our highly functioning sample.

Although some of our results were similar to past studies, a number of reasons may explain the discrepant results, including the multidimensionality of functional ability, the number of cognitive domains included in the prediction model, and the type of measures used (self vs. informant vs. performance-based). First, unlike the component of the basic living skills used by Tuokko and colleagues (2005; see Table 20), our basic living skills factor included tasks purported to assess a verbal aspect of time and punctuality. Moreover, that Cahn-Weiner and colleagues (2000) found executive functions, but not memory, were associated with functional status in contrast to our results likely reflected the type of IADL tasks examined (see Table 20), and highlights the multi-dimensional nature of everyday functioning (Marsiske & Willis, 1995). Next, in a study (Grisby et al., 1998) where executive functions predicted functional status, only executive functions were used in the prediction model. Another study (Plehn et al., 2004) included only memory and executive functions in their prediction model, whereas we included additional cognitive variables (global cognitive functioning, speed of processing and verbal ability) in our model. As such, our results also suggest that executive functions only predict certain kinds of functional skills.

Further, it may not hold up to predicting other aspects of functional status once other cognitive domains are included in the prediction model. Finally, the executive functions domain was not a predictor of functional ability when self-report was used in our study. However, when performance-based measures were used (e.g. Bell-McGinty et al., 2002; Burton et al., 2006; Cahn-Weiner et al., 2000) the executive functions domain was a predictor. Our results also suggested that the association between general cognitive functioning and functional status may not be independent of specific cognitive function, at least when informant reports were used. We found that general cognitive functioning did not retain its association with functional status across all factors once specific cognitive domains were taken into account on informant-reports, contrary to conclusions drawn by Royall and colleagues (2007) in their review of studies on the cognition-functional status association. Therefore, although Royall and colleagues (2007) concluded that the cognition-functional status association is similar regardless of mode of report, our findings suggested differences.

Taken together, these findings suggest that each factor on the informant-rated mSIB-R tapped into specific variables. The association between self-rated mSIB-R factors and cognitive variables is similar, though not identical. Although the different cognitive correlates of each mode of report may relate to the different item composition of the factors, our results, nonetheless, suggest that self-reports may measure variables that informant-reports do not tap into, such as psychological functioning, self-efficacy, or insight. Further investigation is necessary to clarify the differences.

Table 20. Summary of cited studies on the association between cognition and functional status.

Authors	Method	Tasks	Findings
Tuokko et al. (2005)	Informant	Showering, transportation, shopping, meal preparation, housework, medical management	Memory and psychomotor speed related to impairment in all tasks
Bell-McGinty et al. (2002)	Performance	Hygiene, grooming, meal preparation, medical management, housework, shopping, safety, travel, leisure	Executive functions predicted IADL; the only cognitive domain examined
Cahn-Weiner et al. (2007)	Informant	Navigation, housework, money management, memory, tendency to dwell in the past	Memory and executive function predicted IADL; executive functions predicted rate of IADL change
Plehn et al. (2004)	Self	IADL, social functioning	Executive functions predicted IADL; memory predicted social functioning
Cahn-Weiner et al. (2000)	Performance	Safety, medication administration, meal planning and preparation, money management	Executive functions predicted functional status; memory did not predict functional status
Grisby et al. (1998)	Performance and self	Dressing, eating, fine motor, handling money, handling medication	Executive functions predicted functional status; the only cognitive domain examined
Bennett et al. (2006)	Self	Cooking, housework, shopping, reading, hobbies, socializing	Demographic, EP signs, brain MRI, cognitive and depression variables predicted performance on different tasks
Burton et al. (2006)	Performance	Medication use, meal preparation, telephone use, shopping, financial management, household management, transportation	Global cognitive status, cognitive decline, speed of processing, executive functioning, episodic memory, verbal ability were significant predictors of functional status
Current study	Self and Informant	Self Basic living skills (BLS): language, meal preparation, personal self-care, domestic skills Self Social/cognitive engagement (SCE):social interaction, language, time & punctuality, financial & work skills Self Physical/environmental engagement (PE): motor, social interaction, language, domestic skills environmental orientation Informant BLS: motor, meal preparation, personal self-care, domestic & financial skills, time & punctuality Informant SCE: social interaction, language, environmental orientation, work skills Informant PE: motor skills, domestic & work skills	See Table 17

Comparison of report-based and performance-based measures

The performance-based measure used in this study appeared equivalent to the report-based measure in the overall accuracy of classifying cognitive groups. Calculation of sensitivity revealed the EPT (88.7%) to be most sensitive to psychometrically-defined MCI, followed by self-rated physical/environmental engagement factor (85.8%), and informant-rated social/cognitive engagement factor (84.4%). Informant-rated physical/environmental engagement and self-rated basic living skills factors were virtually of no use for the purpose of identifying psychometrically-defined MCI. This set of results is not unexpected, as the tasks (e.g. fine and gross motor skills, domestic skills) examined by these factors represent basic aspects of everyday functioning, the impairment of which are diagnostic of a dementia syndrome. If a combination of measures were considered for screening purposes, the use of the EPT and informant-rated social/cognitive engagement factor may be the most sensitive to psychometrically-defined MCI. This proposal requires additional study as it seemed to be a borderline significant trend.

Limitations, future directions, and conclusion

The current study is not without limitations. As the current study is a cross-sectional study, it is unknown if poor functional status and cognitive function represent longstanding difficulties or recent changes. Hence, the question of the extent of cognitive decline that can be observed on functional tasks remains unanswered. Further, given the documented influence of extraneous factors such as care-giver burden, depression, or lack of insight among patients with dementia (Jorm et al., 1994; Kiyak, Teri, & Borson, 1994; Nygard, 2003), a sample of individuals with dementia may well result in an entirely different set of findings.

There is evidence that poor cognitive functioning predicts functional disability and mortality over a 2-year period, but the extent of cognitive change that can be detected in functional ability is unknown (McGuire et al., 2006). In order to determine the degree of cognitive decline that is associated with changes in functional status, a longitudinal study is needed. The focus of future studies may be to examine the clinical utility of the mSIB-R in predicting mild cognitive decline in the long run, specifically in the prediction of mild cognitive impairment as a clinical entity. Jefferson and colleagues (2006) reported that specific functional tasks such as finances, meal preparation, housekeeping, and shopping (based on informant ratings on the Lawton & Brody's IADL measure) are the earliest IADLs to deteriorate, and Cahn-Weiner and colleagues (2007) indicated that executive dysfunction is associated with a faster rate of overall functional decline. The cognitive domain associated with decline in specific functional domains is unknown. Accordingly, the association between cognitive domains and longitudinal changes on the mSIB-R factors may also be a focus of future investigation.

In conclusion, this study suggests that the relationship between cognition and functional status is dependent in part on the aspect of the functional ability evaluated. As well, the mode of report (self vs. informant) has an impact on the nature of the cognition-functional status association. These results suggest that the informant-rated social/cognitive engagement factor on the mSIB-R may be considered in the measurement of functional status among older adults at risk for cognitive impairment. If deficits are found in this factor, detailed assessment of memory and/or executive functions may be warranted.

Study 3: Prediction of longitudinal outcome

Introduction

Through the previous two studies (Tan et al., in press; Tan et al, 2009), we found that functional ability as measured by a comprehensive measure (mSIB-R) is associated with varying degrees of cognitive impairment. Given the evidence (e.g., Petersen et al., 1999; Petersen 2001) of continuity between MCI and dementia along the continuum of cognitive impairment, would functional ability be useful to predict future cognitive outcome? Studies (e.g., Arnaiz & Almkvist, 2003; Backman et al., 2005; Mickes et al., 2007; Bidzan & Bidzan, 2002; Kuchibhatla & Fillenbaum, 2003; Peres et al., 2008; Purser et al., 2005; Tabert et al., 2002; Touchon & Ritchie, 1999; Wadley et al., 2007) that have looked at predicting MCI and/or dementia suggest that baseline functional status seems to differ among individuals who were diagnosed with MCI and/or dementia a few years later (Peres et al., 2008; Purser et al., 2005; Tabert et al., 2002; Touchon & Ritchie, 1999). Our understanding of the functional ability-MCI/dementia relationship, however, has been obscured by the different methods used in each study to measure functional status (self vs. informant, baseline vs. decline), as well as the problems relating to attrition in longitudinal studies (e.g., Holstein et al., 2006). Participants who were more likely to decline in both functional and cognitive skills were also less likely to continue in longitudinal studies. Consequently, findings based on the remaining elite sample may not be representative of what would be observed in the population. On the other hand, there is clear evidence that cognitive measures have good utility in predicting future MCI and/or dementia (e.g., Backman et al., 2005). The usefulness of functional status over and above cognitive measures in predicting future cognitive status, however, has not been investigated. This issue is of importance because of the uncertainty in the literature regarding the nature and extent of functional deficits associated with MCI (e.g., Griffith et al., 2003; Nygard, 2003; Perneczky et al., 2006; Peterson et al., 2001; Ritchie et al., 2001; Winblad et al., 2004).

The overarching purpose of this third and final study is, therefore, to partial out the differential predictive utility of these methods (self-report of functional status, informant-report of functional status, cognitive measures) with the hope of determining the usefulness of including functional disability in the diagnostic criteria for MCI. Two separate sets of analyses address these gaps in the literature, one focusing on future cognitive status as the outcome, the other focusing on attrition as the outcome. Specifically, we address the following questions: (1) Does functional information at baseline provide predictive utility over and beyond cognitive measures for future MCI classification? (2) Is functional decline associated with future MCI status? (3) Can cognitive and/or functional measures be used to predict attrition?

Method

Participants

A total of 216 individuals continued in the study in year 6. However, two of the participants did not complete the cognitive tasks needed for classifying their cognitive status grouping, and were therefore dropped from future analysis. The final sample consists of 214 individuals ranging in age from 69 to 95 years ($M = 78.54$, $SD = 5.70$). Sixty-four participants were male. The Mini Mental State Examination score of the final sample ranged from 24 to 30, with a mean of 28.74 ($SD = 1.28$).

Cognitive status groups. Based on the results from study 1, where the presence of single/multiple cognitive impairments appears to make a more significant contribution to functional ability than the presence of memory impairment, the participants were divided into three cognitive status groups (intact, single, multiple), using a psychometric rather than a clinical definition of MCI. Participants who performed below (1 *SD* or more) their age- and education-matched peers on one of the cognitive reference measures were classified as MCI1. Those who performed below (1 *SD* or more) their age- and education-matched peers on two or more of the cognitive reference measures were classified as MCI2. The remaining participants were placed in the intact group (Intact). Table 21 shows the number of participants in each cognitive status groups in years 3 and 6.

Table 21. Number of participants in each cognitive status group by testing year.

	Year 3	Year 6
Intact	137	131
MCI1	69	40
MCI2	51	43

Measures

Table 22 presents the measures used in this study. Building on results from the second study, only the best predictors of cognitive status from the mSIB-R were used in the current study. The functional and cognitive ability predictors came from year 3. The cognitive tests for each cognitive domain were not used in the psychometric classification of cognitive status groups.

Table 22. Measures of interest.

Type of measure		Specific tests
Functional ability	Modified Scales of Independent Behavior-Revised (mSIB-R)	- Self physical/environmental engagement factor scores - Informant social/cognitive engagement factor scores - Index of decline: sum of all the items on the mSIB-R that were rated as "independent" in year 3, but no longer rated as "independent" in year 4 (i.e. incident disability).
Cognitive	Perceptual speed	- Trail Making Test Part A (TMT A)
	Executive function	- Trail Making Test Part B (TMT B)
	Visuospatial	- WAIS-III Block design subtest
	Episodic memory	- WAIS-III Digit Symbol recall subtest - Story recognition
	Verbal ability	- WAIS-III Vocabulary subtest
	Premorbid intelligence	- North American Adult Reading Test

Statistical Analyses

In order to determine whether the addition of functional ability measures to cognitive measures improves the prediction of psychometrically-defined MCI status over a three-year period, a MANOVA with year 6 cognitive status as the independent variable, and all the baseline (year 3) report-based functional measures and cognitive measures (see Table 22) as the dependent variables is first conducted. The purpose of this analysis is to investigate the cognitive status group differences on the various dependent variables. Since our interest is univariate, only results of the levels tests will be presented and interpreted. In instances where the levels test generates a significant difference among groups, post-hoc tests using Tukey's HSD are conducted to examine where the group differences lie.

This question will then be evaluated in three stages using multinomial logistic regression, and with year 6 MCI status (Intact vs. MCI1 vs. MCI2) as the outcome to investigate the unique contribution of various year 3 variable sets to differentiating cognitive status.

The purpose of the first stage analysis is to examine the independent contribution of functional ability in predicting future cognitive status, controlling for age and education. If functional ability does not predict year 6 cognitive status in this initial stage, the analyses in stages two and three need not be carried out. Results are interpreted using this procedure: improvement of model fit following the addition of each variable set is evaluated using Chi square statistics. Using deviance criterion, the full model is compared against a constant-only model. The Wald statistics is used to determine the significance of individual predictors (relative to other predictors in the model) in predicting year 6 cognitive status group. Where Wald statistics suggest a significant contribution, the Odds Ratios (ORs) for individual predictor measures are interpreted using the multiple cognitive impairment group as the reference group. Therefore, in stage one, each block of variables is entered into the logistic regression in this manner:

Step 1 → age & education

Step 2 → year 3 functional measures

If functional ability independently predicts year 6 cognitive status in stage one, the following two separate analyses are conducted to examine the unique contribution of functional abilities over and above year 3 cognitive measures <u>or</u> year 3 cognitive status in predicting year 6 cognitive status. In the first analysis, the purpose of entering year 3 cognitive measures into the prediction model is to determine if the inclusion of functional measures improves prediction of year 6 cognitive status, when year 3 cognitive performance is known. In the second analysis, by first entering year 3 cognitive status into the prediction model, whether functional measures provide information regarding *changes* in cognitive status (at year 6) can also be determined. In summary, two separate hierarchical multinomial regression analyses are conducted, the first with baseline (year 3) cognitive measures entered into the model, and the second with baseline (year 3) cognitive status group entered into the model. The same procedure as described above is used to interpret the results. Therefore, each block of variables is entered into the logistic regression in two separate models like these:

Step 1 → age & education		Step 1 → age & education
Step 2→ year 3 cognitive measures	AND	Step 2 → year 3 cognitive status
Step 3 → year 3 functional measures		Step 3 → year 3 functional measures

In the event that both analyses in the second stage are informative, the utility of functional status in predicting change in cognitive status over a 3 year period, given knowledge of baseline (year 3) cognitive status and cognitive performance, is then evaluated. This last analysis determines whether inclusion of year 3 functional measures in the prediction model improves prediction of changes in cognitive status over and above cognitive measures. This is done by entering both year 3 cognitive performance and cognitive status into the model first. Thus, year 3 cognitive status and cognitive measures are entered in step two, followed by the functional measures. The abovementioned procedure is used to interpret the results. Therefore, each block of variables is entered into the logistic regression as follows:

Step 1 → age & education

Step 2 → year 3 cognitive measure & year 3 cognitive status

Step 3 → year 3 functional measures

Classification rates are generated to determine the percent classification accuracy in each significant analysis. A proportional by chance accuracy rate is calculated by taking the sum of squared marginal percentages (found in "case processing summary" at step 0). By definition, the obtained classification rate should be 25% higher or more than the proportional by chance accuracy rate in order to be considered a "good" hit rate (Garson, n.d.).

Investigations regarding the association between functional decline and future cognitive status are conducted using the same analytical steps as described above, except by using indices of functional decline and without using cognitive measures.

The question of whether cognitive and/or functional measures can be used to predicted attrition is answered in two stages using binary logistic regression, and with attrition (remained in year 6 vs. no longer in year 6) as the outcome.

Logistic regression is first conducted separately for each group of measures as shown in Table 22 to predict attrition, controlling for age and education. The purpose of these analyses is to determine whether each type of measurement (functional measure vs. cognitive measures) is independently predictive of attrition. Chi-square statistics is used to test the full model against a constant-only model. Where Wald statistics are significant, ORs are interpreted. The variables are entered in this manner:

Step 1 → age & education	AND	Step 1 → age & education
Step 2 → functional measures		Step 2 → cognitive measures

Logistic regression is then repeated in a hierarchical manner, controlling for age and education in the first step, entering the non-target type of measures into the prediction model in the second step, and finally, entering the target type of measures into the prediction model at the last step. For example, to investigate the unique contribution of report-based functional measures, the target type of measures comprising the mSIB-R informant social/cognitive, mSIB-R self physical/environmental engagement factor scores are entered in the last step. All other non-target measures (i.e. cognitive measures) are entered in the second step. Partial ORs are interpreted to determine the unique contribution of the target measures in predicting attrition when the Wald statistic is significant. The same analyses are repeated, with the mSIB-R entered in the second step and the cognitive measures entered as the target measures in the last step. Therefore, each block of variables are entered in two separate analyses as follow:

Step 1 → age & education		Step 1 → age & education
Step 2 → cognitive measures	AND	Step 2 → functional measures
Step 3 → functional measures		Step 3 → cognitive measures

Results

Does the addition of functional ability to cognitive measures improve the prediction of cognitive status over a three-year period?

Table 23 presents the inter-correlation of all the predictors (cognitive and report-based functional ability measures). The correlations ranged from small to large, with the largest correlation between verbal ability and premorbid intelligence (r = -.635).

Table 23. Intercorrelations among cognitive and functional ability (mSIB-R) measures.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Perceptual speed	1	-	-	-	-	-	-	-	-
2. Executive functions	.628**	1	-	-	-	-	-	-	-
3. Visuospatial	-.318**	-.424**	1	-	-	-	-	-	-
4. Episodic memory - recall	-.274**	-.387**	-.307**	1	-	-	-	-	-
5. Episodic memory - recognition	-.182*	-.337**	.300**	.377**	1	-	-	-	-
6. Verbal ability	-.092	-.225**	.307**	.173**	.399**	1	-	-	-
7. Premorbid intelligence	.004	.177**	-.218**	-.053	-.272**	-.635**	1	-	-
8. Informant social/cognitive engagement	-.165*	-.345**	.210**	.411**	.502**	.242**	-.205**	1	-
9. Self physical/ environmental engagement	-.227**	-.312**	.232**	.374**	.290**	.175*	-.155*	.392**	1

Table 24 shows the means and standard deviations of the participants' performance on the functional and cognitive measures. By gross examination, with the exception of self physical/environmental engagement factor, the multiple domain impairment group appears to obtain the worse performance across all measures.

Table 24. Functional ability and cognitive performance as a function of future cognitive status groups.

	Intact	Single	Multiple
Informant social/cognitive engagement	10.21 (.81)	9.87 (.90)	9.52 (1.51)
Self physical/environmental engagement	10.24 (.66)	9.78 (1.17)	9.85 (1.20)
Perceptual speed (seconds, sd)	33.86 (10.23)	38.70 (14.36)	41.09 (9.34)
Executive function (seconds, sd)	75.43 (25.33)	90.26 (31.95)	108.95 (35.08)
Visuospatial (mean, sd)	40.49 (10.21)	35.87 (9.94)	32.40 (7.34)
Episodic memory – recall (number, sd)	7.08 (2.14)	6.13 (2.43)	4.98 (2.95)
Episodic memory – recognition	89.79 (6.25)	87.55 (6.71)	80.78 (9.90)
Verbal ability (mean, sd)	57.73 (4.76)	55.65 (5.83)	49.95 (8.35)
Premorbid intelligence (errors, sd)	11.82 (6.59)	14.53 (7.96)	19.76 (9.88)

Note: high scores on functional measures represent independence

A MANOVA with year 6 cognitive status group (intact, MCI1, MCI2) as the predictor variable, and year 3 functional and cognitive measures as the criterion variables revealed significant results for all the measures (Table 25). The three cognitive status groups differed on all measures.

Post hoc analysis using Tukey's HSD revealed significantly higher ratings on the informant social/cognitive engagement factor in the intact group than the multiple domain impairment group. Likewise, the single domain impairment group was rated higher than the multiple domain impairment group on this factor. On the self physical/environmental engagement factor, the intact group rated themselves higher than the single impairment and multiple impairment groups. Ratings on functional measures appear to be lowest for the multiple impairment group regardless of mode of report.

Table 25. Univariate test examining cognitive status as between-subject effects.

	df	F	*p*
Informant social/cognitive engagement	2	12.51	.000
Self physical/environmental engagement	2	5.60	.004
Perceptual speed	2	6.25	.002
Executive function	2	17.92	.000
Visuospatial	2	10.41	.000
Episodic memory – digit symbol recall	2	13.46	.000
Episodic memory – story recognition	2	27.12	.000
Verbal ability	2	27.23	.000
Premorbid intelligence	2	18.41	.000

On the cognitive measures, post hoc analysis using Tukeys' HSD showed that the intact group was significantly faster than the single and multiple impairment groups on the measure of perceptual speed. Performance on the measure of executive function was significantly different among the intact, single and multiple impairment groups. Again, the multiple impairment group obtained the worst performance in the executive function domain. On the measure of visuospatial ability, the intact group performed significantly better than the single and multiple impairment groups. On the episodic memory, verbal ability and premorbid intelligence measures, both of the intact and single impairment groups performed significantly better than the multiple impairment group.

A multinomial logistic regression analysis was performed on cognitive status as the outcome variable and two demographic predictors: age and years of education. There was a good model fit on the basis of the demographic predictors, χ^2 (272, N = 214) = 274.51, $p > .05$, Nagelkerke $R^2 = .06$, using the deviance criterion, indicating that the demographic predictors, as a set, reliably distinguished between future cognitive status. The unique contribution of individual predictors to the model suggested that the model without years of education as a predictor did not reliably enhance prediction, $p > .05$. Therefore, to maintain a parsimonious model, years of education was dropped from future analyses.

The independent contribution of year 3 functional ability in predicting future cognitive status, controlling for age, was examined by the same method. The addition of two functional ability measures (mSIB-R informant social/cognitive engagement and self physical/environmental engagement factors) to a model with only age improved the prediction model, $\chi^2_{\text{diff}}(4) = 20.96$, $p < .001$. Using deviance criterion, the full model significantly predicted future cognitive status, $\chi^2(368, N = 189) = 320.28$, $p > .05$, Nagelkerke $R^2 = .18$. Likelihood ratio tests suggest that both individual functional ability predictors reliably contributed to the model. Table 26 shows the logistic regression coefficient, Wald test, and odds ratio for each of the predictors. According to Wald criterion, higher scores on the informant social cognitive engagement measure reliably increased the likelihood of being cognitively intact and being impaired in a single cognitive domain compared to being impaired in multiple cognitive domains over three years. For each unit increase in informant social cognitive engagement scores, the odds of being cognitively intact rather than impaired in multiple domains over three years increased by 104%, and the odds of being impaired in a single cognitive domain rather than in multiple domains increased by 99%. The self physical/environmental engagement measure, however, decreased the likelihood of single domain impairment compared to multiple domain impairment over three years. Each unit increase in the self physical/environmental engagement measure decreased the odds of having single domain impairment rather than multiple domain impairment by 46.2%. In other words, those with high informant rating (indicating independence) are more likely to remain cognitively intact or have cognitive impairment in a single domain than have cognitive impairment in multiple domains. Those with low self rating (less independent), on the other hand, are more likely to be impaired in a single cognitive domain than be impaired in multiple cognitive domains over three years.

The overall classification accuracy rate was 65.6%, which satisfied the proportional by chance accuracy criteria of 56.9%. On the basis of functional ability, classification rates were 94% for cognitively intact, 13.9% for single domain cognitive dysfunction, and 25% for multiple domain cognitive dysfunction.

Table 26. Logistic regression coefficient, standard error, Wald test, and odds ratio for predicting future cognitive status using functional ability.

		B	SE	Wald	p	Odds Ratio
Intact	Age	-.05	.04	1.70	.193	.949
	Informant	.72	.23	9.68	.002	2.044
	Self	.07	.26	.07	.788	1.072
Single	Age	-.11	.05	4.57	.033	.897
	Informant	.69	.30	5.16	.023	1.991
	Self	-.62	.28	5.00	.025	.538

Reference group: multiple domain impairment

The independent contribution of functional ability in predicting future cognitive status over and above cognitive measures was examined by first evaluating a model with only cognitive measures as predictors. Using deviance criterion, there was a good model fit on the basis of cognitive measures predictors, χ^2 (406, N = 212) = 298.61, $p > .05$, Nagelkerke $R^2 = .43$. Although the full model that included cognitive and functional ability measures as predictors significantly contributed to the prediction of future cognitive status (Table 27), χ^2 (356, N = 189) = 254.64, p > .05, Nagelkerke R^2 = .47, addition of functional ability to the prediction model failed to improve the model, χ^2_{diff} (4) = .80, p > .05. In other words, both functional ability measures as a set do not provide significant additive information over and above cognitive measures in predicting future cognitive status.

Relative to other measures in the model, using Wald criterion, higher scores on both episodic memory measures (recall and recognition) increased the likelihood of being intact rather than impaired in multiple domains. For every one symbol recalled on the digit symbol test, the odds of being intact rather than impaired in multiple domains increased by 26.4%. Every one point increase on the story recognition test (i.e. better memory) increased the odds of being cognitively intact rather than impaired in multiple domains by 9.8%. High scores (indicating more errors) on the premorbid intelligence domain decreased the likelihood of being intact rather than impaired in multiple domains. For every one error point increase on the NAART, the odds of being intact rather than impaired in multiple domains decreased by 8%. Despite the inclusion of other measures in the model, the self physical/environment engagement factor provided unique contribution to the prediction of future cognitive status: every unit increase in self ratings decreased the odds of single domain impairment rather than multiple domain impairment by 51%

Table 27. Logistic regression coefficient, Wald test, and odds ratio for predicting future cognitive status using cognitive measures.

		B	SE	Wald	*p*	Odds Ratio
Intact						
	Age	.06	.06	1.08	.299	1.059
	Perceptual Speed	-.03	.03	.91	.341	.973
	Executive functions	-.02	.01	2.90	.089	.982
	Visuospatial	.02	.03	.30	.585	1.017
	Episodic memory – recall	.23	.11	4.38	.036	1.264
	Episodic memory – recognition	.09	.04	6.05	.014	1.098
	Verbal ability	.09	.05	3.05	.081	1.094
	Premorbid intelligence	-.08	.04	4.12	.042	.920
	Informant	.20	.31	.42	.519	1.217
	Self	-.19	.31	.40	.529	.825
Single domain						
	Age	-.06	.06	1.09	.296	.939
	Perceptual Speed	.01	.03	.03	.858	1.005
	Executive functions	-.01	.01	.46	.497	.992
	Visuospatial	-.01	.03	.06	.813	.992
	Episodic memory – recall	.19	.12	2.46	.117	1.213
	Episodic memory – recognition	.04	.04	.97	.324	1.041
	Verbal ability	.08	.05	2.00	.157	1.080
	Premorbid intelligence	-.05	.04	1.25	.263	.954
	Informant	.43	.37	1.34	.247	1.530
	Self	-.71	.30	5.61	.018	.490

Reference group: multiple domain impairment

The utility of functional ability in predicting change in cognitive status over a 3 year period was examined by first evaluating a model with current cognitive status as a predictor. Using deviance criterion, there was a good model fit on the basis of current cognitive status alone, χ^2 (116, N = 213) = 115.80, $p > .05$, Nagelkerke $R^2 = .44$. Although the full model that included current cognitive status and functional ability significantly predicted future cognitive status, using deviance criterion, χ^2 (364, N = 189) = 246.21, $p > .05$, Nagelkerke $R^2 = .50$, addition of functional ability to the prediction model failed to improve the model, χ^2_{diff} (4) = 5.53, $p > .05$ These results suggest that functional ability does not reliably predict change in cognitive status.

In summary, although functional ability is predictive of cognitive status over a three-year period, it does not provide additional information over and above cognitive measures. Moreover, functional ability is also not useful in predicting changes in cognitive status over three years once current cognitive status is known.

Is functional decline associated with future cognitive outcome?

A MANOVA with year 6 cognitive status group (intact, MCI1, MCI2) as the predictor variable, and the index of functional decline scores as the criterion variables revealed significant results for only the informant index of decline, $F(2, 168) = 5.61$, $p < .01$, partial $\eta^2 = .063$. Post hoc analysis using Tukey's HSD revealed significantly more decline among the multiple impairment group ($M = 6.42$) than the intact group ($M = 3.12$).

The independent contribution of functional ability change scores (informant index of decline, self index of decline) in predicting future cognitive status, controlling for age, was examined by multinomial logistic regression. The addition of the functional ability index of decline scores to a model with only age improved the prediction model, χ^2_{diff} (4)

= 12.54, $p < .05$, suggesting that one-year functional ability indices of decline provide predictive information for future cognitive status. Using the deviance criterion, the full model significantly predicted future cognitive status, χ^2 (326, N = 175) = 296.41, $p > .05$, Nagelkerke $R^2 = .14$. Likelihood ratio tests suggest that only the informant index of decline reliably contributed to the model. Table 28 shows the logistic regression coefficient, Wald test, and odds ratio for each of the predictors. According to the Wald criterion, higher scores on the informant index of decline reliably decreased the likelihood of being cognitively intact compared to being impaired in multiple cognitive domains over three years. Every increase in one item that was rated by the informant as independent in year 3 but no longer independent in year 4 decreased the odds of being cognitively intact rather than impaired in multiple domains over three years by 9.9%.

The overall classification accuracy rate was 64%, which satisfied the proportional by chance accuracy criteria of 58.1%. On the basis of index of functional decline, classification rates were 94.5% for cognitively intact, 3.1% for single domain impairment, and 21.2% for multiple domain impairment.

Table 28. Logistic regression coefficient, Wald test, and odds ratio for predicting future cognitive status using index of functional decline

		B	SE	Wald	*p*	Odds Ratio
Intact	Age	-.09	.04	5.67	.017	.917
	Informant	-.10	.05	5.23	.022	.901
	Self	-.05	.05	.84	.358	.954
Single	Age	-.13	.05	7.61	.006	.877
	Informant	-.03	.04	.46	.497	.970
	Self	.01	.05	.04	.835	1.011

Reference group: multiple domain impairment

The utility of the index of functional decline in predicting change in cognitive status over a three-year period was examined by first evaluating a model with current cognitive status as predictor. Using the deviance criterion, there was a good model fit on the basis of current cognitive status alone, χ^2 (116, N = 213) = 115.80, $p > .05$, Nagelkerke $R^2 = .44$. Although the full model that included current cognitive status and functional decline significantly predicted future cognitive status, using the deviance criterion, χ^2 (326, N = 175) = 226.64, $p > .05$, Nagelkerke $R^2 = .49$, addition of functional ability to the prediction model failed to improve the model, χ^2_{diff} (4) = -7.68, $p > .05$. These results suggest that index of functional decline does not reliably predict change in cognitive status.

In summary, an index of functional decline can predict intact vs. multiple domain impairments over three years, especially when informant reports are used. However, it is not useful to predict change in cognitive status over three years when current cognitive status is known. That is, it does not provide a unique contribution to the prediction of cognitive outcome.

Can functional measures and/or cognitive measures be used to predict attrition?

A binary logistic regression analysis was performed on attrition as the outcome measure and two demographic predictors: age and years of education. A test of the full model against a constant-only model was not statistically reliable, χ^2 (2, N = 258) = 2.81, $p > .05$, indicating that the demographic predictors, as a set, are not related to attrition. Therefore, demographic variables were removed from future analyses. Table 29 presents the means and standard deviations of scores on the functional ability measures as a function of attrition groups.

Table 29. Functional ability by attrition.

	Did not attrite	Attrite
Informant	10.09 (.91)	9.55 (1.31)
Self	10.08 (.92)	9.53 (1.28)

Note: higher score indicate independence.

To evaluate the utility of report-based measures in predicting attrition, a binary logistic regression analysis was conducted with attrition as the outcome and measures of functional ability (mSIB-R informant social/cognitive engagement and self physical/environmental engagement factors) as predictors. Testing the full model against a constant-only model generated statistically reliable results, χ^2 (2, N = 226) = 9.556, $p < .01$, Nagelkerke $R^2 = .07$, suggesting that these measures of functional ability reliably distinguished between attrition groups. In particular, as seen on Table 30, the Wald statistic approached significance for informant social/cognitive engagement, indicating that higher informant social/cognitive engagement ratings (i.e., more independent) decreased the likelihood of attrition over three years by 27%. Prediction success was 99.5% for those who did not drop out of the study and 2.7% for those who dropped out of the study, giving rise to an overall classification rate of 83.6%.

Table 30. Logistic regression coefficient, Wald test, and odds ratio for predicting attrition using informant/self-report of functional ability (mSIB-R).

	B	SE	Wald	*p.*	Odds Ratio
Informant	-.32	.17	3.67	.055	.728
Self	-.25	.17	2.17	.141	.777

Table 31 presents the means and standard deviations of the scores on the cognitive measures. A binary logistic regression analysis was conducted with attrition as the outcome and cognitive measures as predictors. The full model was statistically reliable in predicting attrition (Table 32), χ^2 (7, N = 252) = 27.12, $p < .01$, Nagelkerke R^2 = .18. Prediction success was 100% for those who did not drop out of the study and 10% for those who dropped out of the study, giving rise to an overall classification rate of 85.7%.

Table 31. Cognitive performance by attrition.

	Did not attrite	Attrite
Perceptual speed (seconds, sd)	36.20 (11.33)	46.06 (21.78)
Executive function (seconds, sd)	84.80 (31.53)	110.95 (43.65)
Visuospatial (mean, sd)	38.03 (10.17)	30.82 (8.69)
Episodic memory – digit symbol recall (number, sd)	6.48 (2.50)	5.95 (3.10)
Episodic memory – story recognition	87.60 (7.96)	82.73 (10.24)
Verbal ability (mean, sd)	55.81 (6.53)	52.68 (9.13)
Premorbid intelligence (errors, sd)	13.90 (8.17)	17.84 (10.26)

Table 32. Logistic regression coefficient, Wald test, and odds ratio for predicting attrition using cognitive measures.

	B	SE	Wald	p	Odds Ratio
Perceptual speed	.03	.02	2.61	.106	1.029
Executive functions	.01	.01	1.61	.204	1.008
Visuospatial	-.04	.02	2.86	.091	.960
Episodic memory – recall	.14	.08	2.82	.093	1.147
Episodic memory – recognition	-.02	.03	.63	.429	.979
Verbal ability	-.00	.04	.00	.947	.998
Premorbid intelligence	.03	.03	1.18	.278	1.031

In order to evaluate the unique contribution of each domain (functional vs. cognitive ability) in predicting attrition, the measures were entered hierarchically to the logistic regression model. First, when cognitive measures were entered as a block, the results were statistically reliable from a constant-only model, χ^2 (8, N = 225) = 27.57, p < .001, Nagelkerke R^2 = .20. Addition of functional ability measures did not reliably improve the prediction model, χ^2_{diff} (2, N = 225) = 3.07, p > .05, Nagelkerke R^2 = .22.

Next, functional ability measures were entered as a block, generating a prediction model that was reliably different from the constant-only model, χ^2 (2, N = 225) = 9.42, p < .01, Nagelkerke R^2 = .07. Addition of cognitive measures reliably improved the prediction model, χ^2_{diff} (7, N = 225) = 21.71, p < .01. Likelihood ratio tests suggest that episodic memory – recall reliably contributed to the final model. As seen in Table 33, every one symbol recalled (i.e., episodic memory - recall) increased the likelihood of remaining in the study three years later by 24.4%.

Table 33. Logistic regression coefficient, Wald test, and odds ratio for predicting attrition using functional ability and cognitive measures.

	B	SE	Wald	*p*	Odds Ratio
Informant	-.35	.22	2.48	.115	.704
Self	-.15	.21	.52	.472	.863
Perceptual speed	.03	.02	2.49	.115	1.031
Executive functions	.01	.01	1.35	.245	1.008
Visuospatial	-.04	.03	1.81	.178	.964
Episodic memory – recall	.22	.10	4.66	.031	1.244
Episodic memory – recognition	-.00	.03	.00	.973	.999
Verbal ability	-.01	.04	.02	.879	.994
Premorbid intelligence	.04	.03	1.49	.222	1.037

In summary, individuals who were functionally dependent or who performed poorly on cognitive measures were more likely to drop out of the study three years later. Cognitive measures as a set appeared to provide unique contributions to the prediction of attrition more than functional ability measures. Relative to other measures, cognitive measures as a set (particularly episodic memory – recall) appear to provide unique contribution in predicting attrition in three years.

Discussion

The purpose of the current study is to delineate the contribution of various methods (functional vs. cognitive measures vs. functional decline indices) in predicting cognitive status over a period of three years. Consequently, the results of this study may provide some clarity in regards to the predictive utility of including functional ability in the diagnostic criteria for MCI.

Prediction of future cognitive status depends on mode of report

Our results suggest that baseline (year 3) informant and self reports of functional ability differentiated among individuals who were classified as either cognitively intact or impaired three years later. Contrary to findings by Tabert and colleagues (2002), who found that only informant reports of functional abilities was predictive of Alzheimer's Disease at two-year follow up, our self-reports predicted future cognitive status. In fact, we found that the more individuals rated themselves as functionally independent, the higher their likelihood of being impaired in multiple cognitive domains than in a single domain three years later. The difference in the results between Tabert and colleagues' (2002) study and our study likely reflects the nature of our samples (MCI vs. dementia). Indeed, some studies (Albert et al., 1999; Tabert et al., 2002) have suggested that individuals with MCI are more likely to overestimate their level of functional independence than individuals who are cognitively intact or who have been diagnosed with dementia. Our prediction model appears to confirm this suggestion: each unit increase in self ratings decreased the odds of having single domain impairment rather than multiple domain impairment by 46.2% over three years. Therefore, our results suggest that self-reported good functional ability may have a worse cognitive outcome than self-reported poor functional ability.

When cognitive measures were evaluated, our baseline (year 3) measure of executive functions differentiated among all future cognitive status groups. Baseline performance on perceptual speed and visuospatial measures was different only for the intact vs. impaired distinction, whereas the intact/single domain impairment groups outperformed the multiple impairment group on measures of episodic memory, verbal ability, and premorbid intelligence. Results based on logistic regression also suggest that cognitive measures as a set were predictive of future cognitive status. However, in our sample, performance on cognitive measures appeared to predict intact vs. impaired, rather than the severity of impairment over three years according to logistic regression analysis. For example, better episodic memory increased the odds of being cognitively intact rather than impaired in multiple domains by 22%, whereas the same measure did not predict the risk of developing single domain impairment relative to multiple domain impairment. Some of our results differ from Backman and colleagues (2005) but others were aligned with their findings. Backman and colleagues suggested that perceptual speed showed large effects of impairment years before a clinical diagnosis of dementia. In our study, performance on perceptual speed did not affect the risk of being intact rather than impaired in multiple domains relative to other measures. On the other hand, episodic memory (both recall and recognition) was a significant contributor to predicting intact vs. impairment in multiple domains, similar to Backman and colleagues' (2005) findings. Our results also echoed the results reported by Mickes and colleagues (2007) who found the same results among a group of individuals with preclinical Alzheimer's Disease, in that better episodic memory and verbal ability increased the odds of being cognitively intact rather than impaired in multiple domains when only cognitive measures were considered in the prediction model. These results are somewhat surprising in light of our use of single/multiple domain impairments rather than amnestic/nonamnestic groupings.

We found that functional abilities did not provide additive utility over and above age and cognitive measures in predicting future cognitive status. Similar to findings by Kuchibhatla and Fillenbaum (2003), who compared the utility of cognitive and functional measures in predicting dementia, results from this study also suggested that cognitive measures as a set provided unique contribution in the prediction of psychometrically-defined MCI relative to functional measures. This finding is not surprising, given the cognitively and psychometrically defined nature of our cognitive status groups. The use of a clinically defined MCI sample may yield different results.

In our sample, some functional dependence was observed in both cognitive impairment groups, similar to findings reported by others (e.g., Bennett et al., 2006; Griffith et al., 2003; Perneczky et al., 2006). This finding supports recent MCI diagnostic guidelines that allow for some impairment in IADL (Winblad et al., 2004). However, results from this study suggest that inclusion of functional ability measures in addition to cognitive measures does not improve the prediction of future cognitive status, nor do functional ability measures alone predict changes in cognitive status over a three-year period. Therefore, with regards to the diagnostic criteria of MCI, our findings suggest that functional disability must not be an exclusion criterion; however, functional ability does not appear useful as an inclusion criterion for the purpose of predicting future cognitive status. In other words, our results suggest that individuals should not need to be fully independent to fulfill the diagnostic requirement of MCI, but inclusion of functional limitations as a criterion does not improve the predictive utility of future MCI status once cognitive status is known.

Functional decline predicts future cognitive status

Some studies reported that a large proportion of older adults remain stable in their functional abilities over time (Corey-Bloom et al., 1996; Hebert et al.,1997, 1999; Formiga et al., 2007). For example, using a five-point change (out of a possible 87 points for dependency rating) as the cut-off for decline, Hebert and colleagues (1997) reported that around two-thirds of their sample remained stable as assessed by a clinician-rated measure of functional ability. In our sample, we found that the majority of informants (82%) reported at least one item (up to 43 items) of incident functional dependence over the one-year interval. This was true also with self reports (75%), where participants reported decline in up to 34 items (out of 70 items on the mSIB-R).

Detailed examination of the one-year index of functional decline when informant report was used suggests that the likelihood of cognitive impairment is present even if the reported functional decline is very mild (e.g., rating changed from "does very well" to "does fairly well"). Out of 70 items on the mSIB-R, every item (in the form of incident disability) increased the odds of being impaired in multiple cognitive domains by 9.9%. We extended the study by Black and Rush (2002), who reported that baseline functional disability is predictive of cognitive decline (that may not be of clinical significance) over 2 years, by using functional decline to predict future cognitive status (that may be of clinical significance). Although we used a short one-year interval, we found that functional decline is predictive of cognitive status in three years.

Wadley and colleagues (2007) reported that older adults with MCI showed steeper functional declines over three years than those who are cognitively intact, indicating a worse functional outcome for those with MCI. Among our group of older adults with varying degrees of baseline cognitive impairments, however, functional decline did not predict cognitive status in three years once baseline cognitive status was considered. Our findings suggest that one-year functional decline does not provide unique information regarding changes in cognitive status over three years, despite our use of a more liberal cut off for cognitive impairment classification (<1SD) compared to Wadley and colleagues (<1.5SD). In other words, one-year incident functional disability information does not tell us any more about future cognitive status than what we already knew at baseline, suggesting that inclusion of informant-reported functional decline as a diagnostic criterion for MCI may not improve its prognostic utility in the short run.

Taken together, both baseline functional ability and one-year index of functional decline predicted future cognitive status in separate analyses. Our results suggest that they appear rather equivalent in predicting future cognitive status over three years, at least according to their classification rates.

Individuals who perform poorly on functional and cognitive ability measures are more likely to attrite during longitudinal follow-up.

Regardless of measurement method, functional ability and cognitive measures predicted attrition at 3-year follow-up. Relative to self report, poor informant report showed a higher risk of attrition at 27%. Moreover, cognitive measures, particularly the episodic memory (recall rather than recognition) measure, appear to provide unique information relative to other measures in the prediction of attrition. Our results are similar to past studies (e.g., Avlund et al., 1998; Holstein et al., 2006; Ritchie & Toukko, 2007; Sliwinski et al., 2003). For example, Avlund and colleagues (1998) found that poor baseline functional ability is a strong predictor of mortality. Although mortality was not evaluated in our study, we found that baseline functional ability predicted attrition from our study three years later, indicating that those who dropped out showed characteristics that may preclude their ability to continue in the study. Sliwinski and colleagues (2003) suggested that time to drop out explains effects of memory changes among the elder. We found similar results, in that episodic memory - recall provided unique contribution to the prediction of attrition over three years relative to other measures in the prediction model. Given that those with poor baseline performance on both cognitive and functional measures were more likely to attrite, any significant effects observed in the remaining elite sample will likely be larger if those individuals had not dropped out of the study. Therefore, attrition effects need to be considered when interpreting results of this study.

Limitations and conclusion

In the current study, we lost 44 people due to attrition between years 3 and 6. Our findings suggest that these 44 individuals exhibited significantly poorer baseline (year 3) functional and cognitive abilities than those who remained in the study. However, given past reports of functional improvement in community-dwelling population (Hebert et al., 1997, 1999), it is unknown whether any of these individuals who dropped out of the study will also fall into the "improvers" category. Moreover, our baseline (year 3) sample consists of individuals with varying degrees of cognitive impairments. Few of them switched to a worse cognitive status (i.e., intact to single/multiple domain impairment or single to multiple domain impairment) grouping three years later, despite the use of a liberal cut-off (<1SD) for cognitive impairment that presumably allowed more room for impairment to surface. As such, our failure to establish the predictive utility of functional and cognitive measures may well be a function of our high functioning community-dwelling sample and the stability of cognitive status over a short follow-up interval (e.g.

Hebert et al., 1999). A different outcome may be observed in a sample that may exhibit a faster rate of change (e.g., clinical sample, nursing home residents) or over a longer follow-up period.

Results from this study were obtained by analyzing data from year 3 of an ongoing longitudinal study, Project MIND, because the functional measure was only introduced in the third year. This sample represents a subset of the original sample due to attrition, hence the problems associated with attrition (e.g., those with poor baseline functional and cognitive abilities are more likely to attrite) exists even within the baseline sample (year 3) of the current study. However, despite starting off with an elite group, the fact that we found significant effects lends support to the strength of this study.

In future studies, the threshold by which functional ability as measured by the mSIB-R, particularly the informant social/cognitive engagement and self physical/environmental engagement factors, is considered impaired needs to be established. Individuals in our sample who meet the threshold for functional impairment can then be monitored over the long run to identify incident cases of dementia in order to determine the association between dementia and the mSIB-R as a measure of functional ability.

In conclusion, our results suggest that the impact of attrition needs to be taken into consideration in longitudinal studies that examine functional and cognitive ability. Our results also suggest that limitations in functional ability exist among community-dwelling, non-demented, older individuals with varying degrees of cognitive impairment. The diagnostic criteria for MCI should allow for functional disability; however, inclusion of functional disability and/or functional decline to existing diagnostic criteria does not appear to improve the prediction of future cognitive status.

CHAPTER VI

General discussion

From this series of studies, an attempt was made to fill in the gap in the literature by contributing to our understanding of functional ability as it relates to the diagnosis of mild cognitive impairment. The first study showed that a modified version of the Scales of Independent Behavior – Revised (mSIB-R) demonstrated sound psychometric properties as a comprehensive measure of functional ability among community-dwelling, non-demented older adults. This study also confirmed that the impact of the mode of report must be taken into consideration when assessing an individual's functional status: informant-based and self-reports appear to provide different information. Finally, results from the first study suggested that functional status differed depending on the degree of cognitive impairment.

Building upon these results, the second study investigated the association between functional ability and cognitive functioning, two areas that Royall and colleagues (2007) suggested needed to be better integrated in order to offer greater clinical utility. As expected, higher cognitive functioning was associated with functional independence. Again, the specific functional-cognitive ability relationship differed depending on the mode of report and functional factor in question, although episodic memory appears to be a unique cognitive predictor. Compared to a performance-based measure of functional ability, the report-based mSIB-R appeared as accurate in classifying cognitive status groups. These results suggest that cognitive impairment has real-life outcome.

Given the usefulness of the mSIB-R in identifying mild functional changes and its relationship with cognitive functioning, the third study aimed to clarify the utility of functional ability (as measured by the mSIB-R) in predicting future cognitive status over and above cognitive measures. Although baseline functional ability as well as functional decline appears to predict future cognitive status, they do not provide information over and above cognitive measures, nor do they predict changes in cognitive status over three years. In addition, both functional ability and cognitive measures predicted attrition from the study in three years, suggesting that those who dropped out of the study had different characteristics (i.e. poorer functioning) than those who remained in the study. This last set of results confirmed that attrition effects need to be taken into account when interpreting results generated from the remaining, elite sample.

Taken together, the mSIB-R appears to be a useful measure of functional ability sensitive to mild cognitive changes among community-dwelling, non-demented older adults. In fact, the mSIB-R appears useful in predicting who will drop out of the study three years later. The relationship is, however, dependent on the mode of report as well as the type of functional skills examined.

A central goal of this dissertation is to examine the aspect of functional ability most sensitive to changes and associated with future diagnosis of MCI, which may be indicative of a disease process. Integrating results from the three studies, it appears that the informant social/cognitive engagement factor provides the most information regarding cognitive outcome, whether now or in three years. Functional tasks that loaded on this factor included the ability to engage in social interactions (e.g., uses facts to explain or defend a position in a disagreement without losing temper, makes plans with friends to attend activities outside the home), to comprehend and express language (e.g., summarize and tell a story to others, to take down phone messages for others, completes written application forms), to manage own finances (e.g., balances own cheque book monthly, receives bills in the mail and pays them before they're overdue), to engage in work-related activities (e.g., continues to work when there are distractions in the work setting, operates potentially dangerous electrical hand tools and appliances), and to get around in the home/community (e.g., drives a motorize vehicle, rides public transportation). The fact that we found these activities to be dependent on episodic memory and executive functioning is unsurprising, given their cognitively demanding and complex nature. In light of past findings regarding episodic memory and executive functions as the cognitive domains most commonly observed to decline prior to the diagnosis of dementia (e.g., Backman et al., 2005; Mickes et al., 2007), changes in one's ability to perform these functional tasks need to be monitored for deteriorating cognition.

From a clinical standpoint, decline in functional tasks do not only suggest a possibility of an ominous cognitive outcome at an unknown future time frame. In the immediate present, changes in these functional tasks may affect the older adult's ability to function independently and safety in the community (e.g., continue to drive a motorize vehicle when it is no longer safe to do so). Together with having a good understanding of the cognitive skills required of specific functional tasks, detailed assessment of the older adults' functional skills provides essential information about the type of functional skills that need assistance, as well as why the older adult is unable to perform the activity (Loewenstein & Mogosky, 1999; Reuben & Siu, 1992). Consequently, the information can be used to inform decisions regarding the care and management of the older adult, as well as to assist the family in adapting to the loss of independent living skills (Gelinas, Gauthier, McIntyre, & Gauthier, 1998). Without providing adequate support, the older adult's immediate quality of life may also be compromised when they lose their ability to live independently, or when they become institutionalized.

A number of issues bear discussion. First, the ability to perform functional tasks is determined by multiple factors and abilities, including cognition, number of chronic diseases, motor abilities, and emotional status (e.g., Galasko, 1998). We included a variety of cognitive domains, chronic illnesses, and motor abilities in our prediction models; however, although depressed mood is associated with functional dependence (Bennett et al., 2006; Cahn-Weiner et al., 2000), we did not examine the impact of emotional status on the performance of functional tasks in our studies. We are in part limited by our selection process, where older adults with current psychiatric diagnoses (including depression) were excluded. Our baseline (year 3) sample appeared rather euthymic as few participants endorsed items that may indicate depressed mood.

Second, our sample is not a clinical one and the classification scheme is not clinically based but rather represents a heuristic categorization. Conceptually, we modeled our classification scheme after the consensus criteria of Winblad and colleagues (2004) whereas, methodologically, we relied on suggestions in the literature with regard to tasks and cutoffs (1 SD) for screening for MCI in community-dwelling adults (e.g. Ritchie, Artero, & Touchon, 2001; Hong, Zarit, & Johansson, 2003). Like other researchers (e.g. Christensen et al., 2005; Dixon et al., 2007; Ritchie et al., 2001), our focus is more on the phenomenon of greater-impairment-than normal-aging but lesser-impairment-than dementia rather than on a specific set of diagnostic decisions in a clinical setting. We did explore the use of more stringent criteria (e.g. <1.5 SD); however, this resulted in exceedingly small groups. The use of 1 SD criterion possibly underlies the fairly similar performance between the intact and single domain groups.

Finally, groups were formed based on five cognitive reference tasks tapping perceptual speed (Digit Symbol), inductive reasoning (Letter Series), episodic memory (Word Recall), verbal fluency (Controlled Associations) and vocabulary. We recognize that multiple indicators of each cognitive domain would increase the validity of the grouping scheme and that other domains (e.g. visuospatial ability) require study. However, it should be noted that our method of categorizing participants is broadly similar to that of Christensen et al. (2005) and Dixon et al. (2007).

In conclusion, although inclusion of functional disability in the diagnostic criteria of MCI did not improve the prediction of long term cognitive status changes, these results nevertheless suggest that functional disability is associated with poor cognitive status and requires long term monitoring. Therefore, if subtle changes in functional skills were observed, particularly on tasks related to social/cognitive engagement, the older adult should be encouraged to seek a more thorough cognitive work up to rule out an emerging disease.

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