The Pennsylvania State University

The Graduate School

Department of Psychology

AWARENESS OF EXECUTIVE FUNCTIONING DEFICITS IN MULTIPLE SCLEROSIS: SELF VERSUS INFORMANT RATINGS OF IMPAIRMENT IN PATIENTS VERSUS CONTROLS AND THEIR RELATIONSHIP WITH OBJECTIVE COGNITIVE PERFORMANCE

A Thesis in

Psychology

by

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Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Philosophy

August 2007

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ABSTRACT

Informant ratings of cognitive dysfunction have been demonstrated to be more accurate than self ratings in many neurological populations. The current study investigated the accuracy of self and informant ratings of executive dysfunction, the factors contributing to discrepancies between self and informant ratings, and the factors contributing to the ratings themselves in a multiple sclerosis (MS) and control sample. 97 individuals with MS and 27 healthy controls completed a neuropsychological battery, self-ratings of depression, and the Dysexecutive Questionnaire (DEX), a measure of executive dysfunction. DEX informant ratings and informant ratings of depression were obtained for all participants. Self DEX ratings were significantly different between the MS and control groups with the MS participants rating themselves as significantly more impaired. However, informant ratings were similar between the two groups. For the MS participants, objective performance on executive tasks was more highly correlated with self DEX ratings than with informant DEX ratings. Groups were created to examine factors related to discrepancies between self DEX ratings and objective performance on executive tasks, informant DEX ratings and objective performance on executive tasks, and between self DEX and informant DEX ratings. Results indicated that discrepancies between self DEX ratings and objective performance on executive tasks were not related to executive functioning or depression for either the MS or the control groups. However, the discrepancies between informant DEX ratings and objective performance on executive tasks were related to executive functioning for the MS participants. The participants whose informants underestimated their problems with executive functioning performed the worst, suggesting that informants may be overlooking the cognitive impairments of significantly impaired MS patients. Though the discrepancy between self and informant ratings of cognitive impairment has been used as a measure of insight in clinical and research applications, it was not significantly correlated with cognitive performance for either group. MS participants with higher levels of depression had higher self than informant DEX ratings. Implications of these findings are discussed regarding reliability of self-report in MS populations, the influence of depression in ratings, and the relationship between executive functioning and anosognosia.

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ACKNOWLEDGEMENTS

Sincere thanks to my committee, my friends and family, and the participants who made this research possible. A special thanks to my mentor, Dr. Peter Arnett, who is a model of not only excellence in research, but also in character.

This dissertation is dedicated to the memory of Emily Wagner Hopkins (1921-2006).

Literature Review

Executive functions control the way we plan, initiate, and manage our behavior and our awareness of ourselves as individuals. When damage to the frontal lobes results in impairments in executive functioning, awareness of these deficits may also be impaired. It is well established that individuals with executive functioning deficits may have difficulties with planning, inhibiting behavior, and perseveration. However, it is not clear at what point executive functioning becomes impaired enough to affect awareness, though it is often assumed that neurological patients' awareness is impaired. Understanding the accuracy with which neurological patients can report on their functioning is an important issue for assessment and rehabilitation.

Multiple sclerosis (MS) is a degenerative neurological disorder that results in physical disability and cognitive deficits. The disease course of MS is marked by periods of worsening and recovery and is extremely unpredictable. This unpredictability may affect patients' awareness of their deficits in a complex way. If it is found that individuals with MS can provide an accurate account of their cognitive difficulties, it may suggest that simple screening measures are useful tools for clinicians to determine which patients might benefit from a neuropsychological evaluation. Awareness of deficits is also important from a rehabilitation perspective. If it is found that MS patients are unable to accurately gauge their abilities, this poses a significant challenge to their participation in and setting of appropriate goals for rehabilitation.

The most commonly used method of measuring awareness of cognitive deficits in traumatic brain injury (TBI) is examining the discrepancy between self and

informant (such as family member, spouse, or close friend) ratings of cognitive dysfunction (Fleming, Strong, & Ashton, 1996). However, this is based on the assumption that informants are more objective and accurate raters of cognitive dysfunction than patients themselves. Though this assumption appears to be valid in TBI samples, it may not be valid for individuals with MS. This study addresses this issue. However, if significant others are aware of cognitive problems that MS patients are not aware of, this might increase caregiver strain. Alternatively, if caregivers or friends are unaware of cognitive problems that patients are experiencing, it may lead them to hold unreasonable expectations for what the patients might accomplish or the way that they might behave. It is not known at what point problems become severe enough that significant others notice cognitive impairment. Awareness may vary among significant others or on factors such as the level of depression the patient is experiencing. This study seeks to address these questions as they apply to individuals diagnosed with MS. I will first provide a brief overview of MS and associated symptoms, with a focus on cognitive, behavioral and emotional symptoms, then provide a description of the proposed study.

MS- An overview

Multiple sclerosis is a common neurodegenerative disease that causes a wide range of physical, cognitive, emotional, and behavioral symptoms. The disease process is characterized by the destruction of the myelin sheath in multiple areas of the central nervous system (CNS). Sclerotic plaques form in the areas of damage and inhibit the transmission of nerve impulses. MS is widely considered to be an autoimmune

disorder, though the exact cause remains unknown (Sheremata, Honig, & Bowen, 1999).

The typical age of onset is early adulthood, with age 30 as the peak. The prevalence of MS varies geographically and is higher in the regions of the world further from the equator (Beatty, 1996). In the US and Europe, MS is the most frequent cause of chronic neurologic disability in young adults (Sheremata et al., 1999). It is estimated that between 250,000 and 350,000 people in the United States (US) have MS (Tröster, 1998). The disease affects twice as many women as men and, in the US, it is more prevalent in non-Hispanic Caucasians than other races (Beatty, 1996). Due to the fact that MS is diagnosed clinically and is characterized by many nonspecific symptoms, many individuals struggle with unexplained symptoms for years before definitive diagnosis and treatment.

Four standard clinical courses of the disease are recognized: relapsing-remitting, secondary progressive, primary progressive, and progressive-relapsing (Lublin & Reingold, 1996). The relapsing-remitting type is the most commonly occurring type of MS (Lezak, Howieson, & Loring, 2004) and is characterized by episodes of worsening (exacerbations) that typically last for days to weeks, followed by partial to complete recovery until the next attack. Most individuals with relapsing-remitting MS will go on to exhibit secondary progressive MS (Lezak et al., 2004). The secondary progressive type occurs in individuals who previously demonstrated the relapsing-remitting type, but then develop a pattern of worsening between exacerbations as well. The primary progressive type is characterized by a gradual and unremitting progression of the illness, while the progressive-relapsing type consists of

gradual neurologic deterioration from onset compounded by discrete attacks of worsening (Lublin & Reingold, 1996). Both within and across courses, the symptoms of MS can vary greatly, due to the haphazard distribution of demyelination throughout the white matter of the CNS.

Physical symptoms

Typical motor symptoms may include limb heaviness, weakness, stiffness, gait abnormalities, difficulties with balance, limb coordination, and problems with fine motor control. People with MS may also experience sensory problems including optic neuritis, numbness, pain, and parethesias (dull, tingling sensations usually manifest in the extremities). Genitourinary symptoms such as bowel and bladder dysfunction and sexual dysfunction are also common (Sheremata et al., 1999).

Fatigue

Approximately 40% of individuals with MS report experiencing disabling fatigue, while up to 80% of individuals with MS experience fatigue in some form (Schwartz, Coulthard-Morris, & Zeng, 1996). The type of fatigue experienced in MS is often described as being qualitatively different than the fatigue experienced by individuals who do not have MS after heavy exertion or lack of sleep (Krupp, Alvarez, LaRocca, & Scheinberg, 1988). When judging the relative impact of all of their MS symptoms, individuals with MS have been shown to rate fatigue as their most disabling symptom (Arnett et al., 2006). The level of fatigue experienced by individuals with MS does

not typically correlate to their level of neurologic disability (Fisk, Pontefract, Ritvo, Archibald, & Murray, 1994; Krupp et al., 1988).

Depression

Depression is recognized as having a lifetime prevalence rate of approximately 50% in people with MS (Patten & Metz, 1997; Sadovnick et al., 1996; Sheremata et al., 1999). Incidence rates are also disproportionately high. In a study analyzing the results from the Canadian Community Health Survey, Patten, Beck, Williams, Barbui, and Metz (2003) found that while the 12 month period prevalence of major depression overall was 7.4%, the rate of major depression for people with MS was 15.7%. Though the challenges of living with an unpredictable neurological illness are certainly adequate to strain coping mechanisms and perhaps precipitate a depressive reaction, the neurochemical effects of the illness may also play a role (Sadovnick et al., 1996). In a recent review of the literature, Dalton and Heinrichs (2005) reported that while patients with multiple sclerosis consistently report higher levels of depression than healthy controls, the data are mixed regarding whether people with MS experience depression at higher rates than people with similar medical illnesses.

Because the symptoms of MS can overlap with, mask, and exacerbate symptoms of depression, there is debate in the literature regarding the best way to measure depression in MS. While some researchers have suggested that using standard self-report inventories such as the Beck Depression Inventory (BDI) may inflate estimated rates of depression in MS due to the somatic symptoms (Nyenhuis et al., 1998; Nyenhuis et al., 1995), more recently, Moran and Mohr (2005) reported that

successful treatment of depression in MS resulted in reductions in every item on the BDI. This finding suggests that it may not be necessary to eliminate somatic symptoms from score calculations in MS samples as they may be true reflections of depression. However, this question requires further study.

Depression in MS has also been found to be related to cognitive deficits, particularly speeded attentional and executive functioning (Arnett, Higginson, & Randolph, 2001; Arnett, Higginson, Voss, Bender et al., 1999; Arnett, Higginson, Voss, Wright et al., 1999). Notably, depression has been found to affect MS patients' perceptions of their cognitive difficulties (Bruce & Arnett, 2004; Carone, Benedict, Munschauer, Fishman, & Weinstock-Guttman, 2005; Maor, Olmer, & Mozes, 2001; Matotek, Saling, Gates, & Sedal, 2001). It may also be that cognitive dysfunction contributes to the development of depression, through the moderation of low use of active coping strategies (Arnett, Higginson, Voss, & Randolph, 2002).

Cognitive Deficits

Though it was not until the 1980s that neuropsychologists began to focus research efforts on understanding cognitive dysfunction in MS (Beatty, 1996), about half of all of individuals with MS experience cognitive deficits. These deficits are often severe enough to impact their day-to-day functioning (Bobholz & Rao, 2003; Brassington & Marsh, 1998; Rao, Leo, Bernardin, & Unverzagt, 1991; Rao, Leo, Ellington et al., 1991). The cognitive symptoms in MS reflect a pattern of subcortical dementia (Sheremata et al., 1999). Research has revealed that the domains most commonly affected include memory, conceptual reasoning, speed of information processing,

attention, concentration, and executive functioning (Bobholz & Rao, 2003; Brassington & Marsh, 1998). Interestingly, cognitive impairment has been shown to be only weakly correlated to neurological disability level or the amount of time an individual has been affected by MS (Beatty, Goodkin, Hertsgaard, & Monson, 1990; Rao, Leo, Ellington et al., 1991), though one longitudinal study demonstrated that patients with cognitive deficits displayed increased cognitive dysfunction over a three-year period (Kujala, Portin, & Ruutiainen, 1997). Consistent correlations between brain lesion magnitude and cognitive dysfunction have been reported (Benedict, Bakshi, Simon, & Munschauer, 2002; Huber et al., 1992; Huber et al., 1987; Rao, Leo, Haughton, St.Aubin-Faubert, & Bernardin, 1989). Though there is a general consensus on the cognitive domains most frequently impacted by MS, the pattern and severity of cognitive impairments exhibited vary significantly from individual to individual (Bobholz & Rao, 2003). Because of its particular relevance to the present study, I will review the literature on deficits of executive functioning in MS further following a broader discussion of executive functioning.

Executive Functioning

Executive functions are localized to the frontal lobes of the brain, which occupy about one third of the cerebral cortex (Malloy, Cohen, & Jenkins, 1998). Though initially believed to be "silent areas," the importance of the frontal lobes and their functions has been recognized more recently (Malloy et al., 1998; Manchester, Priestley, & Jackson, 2004). Animal studies, clinical studies of patients with damage to the frontal lobes, and studies of patients undergoing psychosurgery have all greatly contributed

to our understanding of the function of the frontal lobes (Damasio & Anderson, 1993; Malloy et al., 1998). The frontal lobes' many functions include pyramidal motor functions, sensorimotor integration in complex volitional movement, and executive functions (Malloy et al., 1998). Stuss and Benson suggest: "In a number of ways, study of the frontal lobes might be described as the study of the qualities that differentiate a human being from other animals" (p.1) (1986).

One of the most well-studied aspects of frontal lobe functioning is executive functioning. Executive functions include planning, initiating, and managing complex behavior as well as self-awareness and self-monitoring. Damasio and Anderson (1993) describe executive functioning as "the ability to initiate, stop, and modify behavior in response to changing stimuli" (p. 431). As Lezak (2004) describes it, "executive functions are intrinsic to the ability to respond in an adaptive manner to novel situations and are also the basis of many cognitive, emotional, and social skills" (p. 611). She further suggests that executive functions have four components, "volition, planning, purposeful action, and effective performance" (p. 611), and maintains that it is rare for an individual to experience deficits in one of these areas alone. Volition, as described by Lezak, includes intention, motivation, and the awareness of self and environment. In extreme cases of volitional deficits, individuals are profoundly apathetic and or lack an appropriate understanding of their deficits or their environment. The planning component involves the ability to assemble the components necessary to complete a task while envisioning and responding to challenges and inhibiting nonproductive behavior. Purposive action includes putting plans into action using skilled manipulations of "sequences of complex behavior"

(p.621). Lastly, effective performance involves the perception and correction of mistakes.

While Lezak's conceptualization of executive functions is based on cognitive domains affected, Malloy et al. (1998) offer a more elaborate description based on anatomical areas affected. They suggest that executive functions include:

1) Formulating goals with regard for long-term consequences.
2) Generating multiple response alternatives
3) Choosing and initiating goal-directed behaviors
4) Self-monitoring the adequacy and correctness of the behavior
5) Correcting and modifying behaviors when conditions change
6) Persisting in the face of distraction (p. 574)

Malloy et al. (1998) identify three prefrontal syndromes. These include the dysexecutive syndrome, the disinhibited syndrome, and the apathetic-akinetic syndrome. The dysexecutive syndrome is defined as "an inability to integrate disparate sensory elements into a coherent whole, a stereotyped or limited response repertoire, easy loss of task set, perseverative or inflexible behavior, and lack of self-monitoring of errors" (p. 577). Malloy et al. (1998) further suggest that the cognitive sequelae of the dysexecutive syndrome include impaired working memory and learning, lack of learning strategies, limited memory for temporal and contextual cues, difficulty switching set, and impaired free recall with intact recognition memory. The authors define the disinhibited syndrome as being characterized by anosmia, amnesia with confabulation, as well as pronounced inhibition deficits demonstrated in personality, behavior, and performance on neuropsychological tests. Emotional reactivity and socially inappropriate and impulsive behavior may be evident as well as increased distractibility and impaired attention (Malloy et al.,

1998). Lastly, Malloy et al. (1998) define the apathetic-akinetic syndrome as being characterized by diminished responsiveness in emotional response and behavior.

Clearly, difficulties in responding to changing environmental demands may be evident in both cognition and social behavior and thus may be evident in inventories of social functioning as well as cognitive testing. Deficits in this domain can lead to "a more general problem with evaluating the consequences and implications of … behavior" (p. 424) (Damasio & Anderson, 1993). Dyscontrol of emotional response may also be evident with patients veering from apparent apathy and flat affect to violent expressions of aggression or inappropriate sexual comments (Damasio & Anderson, 1993). Malloy et al. (1998) maintain that the structured nature of neuropsychological tests may mask executive deficits and encourage the examination of the discrepancy between patient and caregiver responses on measures of executive deficits. However, it is not clear that informant ratings are any more accurate, particularly in neurologic populations that are not grossly impaired.

Executive functioning in MS

Executive functioning deficits have been reported throughout the MS literature (Benedict, Fischer et al., 2002; Bobholz & Rao, 2003; Rao, Leo, Bernardin et al., 1991). It has been found that when compared to matched controls, MS patients perform significantly worse on executive measures such as measures of verbal fluency (Beatty, Hames, Blanco, Paul, & Wilbanks, 1995; Foong et al., 1999; Huber et al., 1992), abstraction (Beatty et al., 1995; Foong et al., 1999; Huber et al., 1992), problem solving (Beatty & Monson, 1996), inhibition (Foong et al., 1999), visual

working memory (Foong et al., 1999), planning tasks (Arnett et al., 1997; Foong et al., 1999), task shifting (Stablum, Meligrana, Sgaramella, Bortolon, & Toso, 2004), and semantic encoding (Arnett et al., 1997). However, it is not clear whether cognitively impaired MS patients with executive functioning deficits are aware of their deficits. I will first review the literature on awareness of cognitive deficits in general and then address the study of awareness of executive dysfunction.

Awareness of cognitive deficits

Anosognosia is a term that originally exclusively meant the lack of awareness of hemiplegia and now refers to diminished awareness of any neurological deficit (Schacter, 1990). Prigatano and Schacter (1991) admit that there is no easy way to define awareness or consciousness. They suggest that brain damage may impair awareness of deficits both subjectively and objectively: the awareness that one has a problem (subjective) and the awareness of how that problem negatively impacts one's life (objective). Anosognosia may also be defined as impaired higher order processing of a specific cognitive ability (Cosentino & Stern, 2005). In the present study, awareness is defined as the ability to use insight to accurately and critically assess and report one's own level of cognitive functioning. Additionally, the present study is an investigation of global awareness- a sense of overall functioning, not local awareness of individual errors as they are made (McAvinue, O'Keefe, McMackin, & Robertson, 2005). In other words, the focus of this study is not on an individual's ability to report that he or she has just made an error, but rather his or her ability to sense and judge how frequently he or she experiences lapses in cognitive functioning.

The majority of the literature on awareness of cognitive deficits involves the often severe anosognosia seen following brain injury (Prigatano & Schacter, 1991). Allen and Ruff (1990) compared patients with severe traumatic brain injuries, mild-moderate traumatic brain injuries, and controls on the correlation of a self-report measure of cognitive functioning with objective cognitive testing. They found that while the brain injured participants consistently rated themselves as more impaired than controls, differences emerged between the mild-moderate and severely injured groups. While the severely brain injured group over-estimated their abilities in sensorimotor and attentional functioning, they rated themselves fairly accurately on arithmetic and language skills. The mild-moderate brain injury group under-estimated their abilities in sensorimotor functioning, language, and reasoning ability. The controls were relatively accurate in their ratings, but tended to over-estimate their learning and logical thinking skills. Their findings suggest that awareness of deficits may be different across domains and that individuals with less severe brain injury may retain awareness of their cognitive deficits. They also suggest that neurologically healthy individuals may not be accurate in their ratings of their cognitive functioning.

In fact, these findings are consistent with the majority of research in self-evaluation in healthy populations that has suggested that the average person will report him or herself to be above average in a variety of domains (Alicke, 1985; Dunning, Meyerowitz, & Holzberg, 1989). In a meta-analysis of the relationship between subjective report and objective measurement of performance across many domains, Mabe and West (1982) found that the average correlation was .29. Within the cognitive domain, Paulhus, Lysy, and Yik (1998) report that in undergraduate

samples, the correlations between self-report of general intelligence level and IQ scores are quite low (.20- .25), while they are slightly higher (.32- .38) in general samples. These findings demonstrate that healthy people tend to overestimate their abilities- both relative to others and in an absolute sense. However, in a related study in the confidence judgment literature, Pallier et al. (2002) found that the correlations between self-rating and objective performance ranged from .49- .68 for a variety of cognitive tasks. It is important to note that this study employed a different methodology than the previously cited studies in that participants were asked to indicate how confident they were about their answer to each test item, rather than their performance as a whole, their performance in general, or their performance relative to the average person. This suggests that the ability to rate oneself accurately varies depending on modality and method of rating.

Some researchers have targeted "incompetent" individuals in order to better understand why people seem to be so inaccurate at reporting on their abilities. Kruger and Dunning (1999) suggest that less talented individuals may lack the intellectual ability to appraise their performance accurately. For example, they demonstrated that undergraduates in the bottom quartile on assessments of logical reasoning, humor, and grammar consistently not only rated themselves as performing at a much higher level relative to others, but also at a level higher than that of their more competent co-participants. While anosognosia has been conceptualized as a largely neurological phenomenon (Cosentino & Stern, 2005), Kruger and Dunning's (1999) findings suggest that incompetence may be seen as a "psychological analogue to anosognosia." These findings suggest that a certain level of skill is required to be able

to accurately rate one's level of skill relative to others. It is notable that the tasks that the researchers used in their analyses are heavily reliant on executive skills, thus offering further support for the idea that insight is tied to executive ability (Lezak et al., 2004; Malloy et al., 1998; Schacter, 1990). Regardless, it is important to note that Kruger and Dunning (1999) required participants to rate themselves relative to others- not to report the frequency of problems experienced or absolute performance. This type of miscalibration may not be applicable to understanding anosognosia because it requires another layer of awareness- not only whether or not one is skilled at something, but also whether one is more or less skilled relative to the average person. However, it is useful to understand that neurologically healthy individuals might also find it difficult to accurately assess their functioning.

Within the MS literature, research examining anosognosia has been inconclusive, with a number of researchers maintaining that people with MS are generally accurate in their report of their cognitive functioning (Chiaravalloti & DeLuca, 2003; Kujala, Portin, & Ruutiainen, 1996; Matotek et al., 2001; Randolph, Arnett, & Higginson, 2001), and some studies disputing this (Beatty & Monson, 1991; Christodoulou et al., 2005; Gold et al., 2001; Hoogervorst et al., 2001; Maor et al., 2001; Marrie, Chelune, Miller, & Cohen, 2005). Investigations have varied based on method of reporting (self-rated vs. interview) and area of cognitive domain tested. Kujala, Portin, and Ruutiainen (1996) found that the self-report of memory difficulties of MS patients with early cognitive decline was significantly correlated to their actual performance on tests of memory and learning. Matotek et al. (2001) found that in a sample of 39 MS patients and 40 controls, subjective cognitive difficulties

correlated with performance on verbal fluency and working memory measures for the MS patients, while for the controls, subjective cognitive difficulties correlated only with level of depression. Randolph et al. (2001) found that patients' complaints of memory problems significantly correlated not only with their performance on memory tasks, but also attentional and executive tasks.

In contrast, Gold et al. (2001) found that subjective cognitive complaints did not correlate with Symbol Digit Modalities Test performance in a large sample of MS patients. Maor et al. (2001) reported that subjective cognitive complaints and objective cognitive performance (measured by the Neurobehavioral Cognitive Status Examination) did not correlate, though subjective cognitive complaints did correlate with depression levels. Christodoulou et al. found that self-reported cognitive dysfunction and objective measures of cognitive performance did not correlate at baseline or at a follow-up visit 24 weeks later (2005). However, it should be noted that participants in this study were taking part in a placebo-controlled study of donepezil to improve cognitive performance, so the generalizability of the results may be limited. Additionally, patients experiencing significant depression were excluded from participation in the study, thus restricting the range of depression experienced and limiting the conclusions that could be drawn regarding the role of depression in the awareness of cognitive dysfunction.

Beatty and Monson (1991) also reported variability across their sample of MS patients, suggesting that individuals who performed poorly on both a memory measure and an executive functioning measure had more significant problems with accurately reporting their own memory skills than patients who did well on both tests

or patients who performed poorly on one of the tests. The authors conclude "patient self-reports about memory are likely to be unreliable sources of information for clinical purposes" (p. 309).

It may be that the relationship between metacognition and performance is not a linear one. Marrie et al. (2005) found that, overall, MS patients with subjective cognitive complaints measured by the Perceived Deficits Questionnaire, 20-item self-report questionnaire of general cognitive impairment, were no more likely to experience cognitive dysfunction than MS patients who did not report a significant number of cognitive difficulties. However, the authors examined this relationship further and found that while minor declines in processing speed measures were associated with subjective cognitive complaints, marked declines in processing speed measures were not associated with subjective cognitive complaints. The investigators also reported that patients with depressed mood were more likely to report cognitive impairment. However, it should be noted that the participants included in the study were referred for clinical assessment of cognitive dysfunction and the results may not be generalizable to community-based samples. Additionally, Marrie et al. (2005) did not include a control group, so it is not certain whether these results are unique to neurological populations or if they may exist in the population at large.

Schwartz, Kozora, and Zeng (1996) reported that MS patients' self-report of cognitive difficulties (determined through interview) suggested a curvilinear relationship between awareness of cognitive deficits and performance on a battery of cognitive tests:

"There was a linear trend indicating increasingly poor performance as the number of patient-reported cognitive complaints increased from none to two, but patients who reported three or more cognitive complaints performed better than those who complained of moderate (i.e. one or two) numbers of complaints and similarly to those who reported no complaints" (p. 181).

Unfortunately, the majority of studies of metacognition and its correlation to actual performance have tested only linear relationships between self report of cognitive dysfunction and objective cognitive testing.

Measuring awareness of deficit

Though a variety of methods have been developed to measure awareness of cognitive deficits, Noe et al. (2005) and Bogod, Mateer, and MacDonald (2003) suggest that there is no gold standard for measuring awareness. The most common method in the brain injury literature has been to obtain ratings both from the patient and a significant other and use the discrepancy between self rating and informant rating to determine level of insight or awareness of the injury (Fleming et al., 1996). However, this suggests that patients are incapable of accurately perceiving their deficits, an assumption that may be true for patients with severe brain injuries but not MS patients, who tend to have less severe impairments.

As Fleming et al. (1996) note, significant others of patients with brain injury or disease "themselves may demonstrate varying levels of denial and decreased awareness" (p. 4). Cavallo, Kay, and Ezrachi (1992) systematically examined the possibility of variability between family members in rating the level of cognitive impairment displayed by patients with head injury. They examined the responses to a

self-rated and informant-rated measure of cognitive impairment by dividing participants into a high agreement group in which there was agreement between the patients and the informants on the ratings, a high disagreement group in which the patients endorsed more problems than the informants, and a high disagreement group in which the informants endorsed more problems than the patients. Surprisingly, the patient groups were not significantly different in age, sex, duration of coma, time since injury, education level, or type of relationship between the informant and patient; suggesting that the source of the variation between the ratings was due to reporting style of the informant. Unfortunately, this study did not include objective measures of cognitive performance.

Other investigators have explored the relationship between self and informant ratings of cognitive dysfunction and their relationship to cognitive test performance in samples of individuals with MS. Taylor (1990) examined the relationship between self and informant-rated "everyday cognitive difficulties" and their relationships with objective cognitive measures in a sample of 29 participants with MS who were taking part in a drug trial. He found that while the self and informant ratings of cognitive problems significantly correlated with each other (r = .72), only the informant ratings were significantly correlated with the total cognitive test score (r = .50). The discrepancy between self and informant ratings correlated most highly (r = -.44 and r = -.38) with the two primarily executive measures used in the study and did not correlate significantly with the memory tests used. The investigator interpreted this evidence to suggest that study participants underestimated their cognitive problems

due to limited insight (a frontal problem) and not due to forgetting their difficulties due to memory deficits (Taylor, 1990).

Carone, Benedict, Munschauer, Fishman, and Weinstock-Guttman (2005) attempted to replicate and extend Taylor's (1990) findings. They examined awareness of cognitive dysfunction in a sample of 122 MS patients and 37 controls and their significant others using the MS Neuropsychological Questionnaire (MSNQ), a self-report measure that examines general neuropsychological impairment. For the participants with MS, the informant-rated MSNQ scores significantly correlated with performance on all of the neuropsychological tests used in the study [the Judgment of Line Orientation Test, the Controlled Oral Word Association Test, the California Verbal Learning Test-II (CVLT-II), the Brief Visuospatial Memory Test-Revised, the Paced Auditory Serial Addition Test, the Symbol Digit Modalities Test, and the Wisconsin Card Sorting Test], whereas self-rated MSNQ scores significantly correlated with only one neuropsychological test index (delayed recall on the CVLT-II). The investigators found that there were no significant differences in the discrepancies between self and informant ratings of cognitive dysfunction between MS patients and controls. The authors used these discrepancies to classify the participants with MS based on whether they had over- or under-estimated their cognitive abilities or had rated them accurately relative to the ratings of their significant others. They found that patients classified as being over-estimators performed worse than accurate raters and under-estimators on a variety of cognitive tasks. Additionally, the investigators found that participants classified as under-estimators reported significantly higher levels of depression than the other two

groups. However, this study incorporated MS patients who were participating in a study of the "cognitive correlates of euphoria" as well as patients referred for clinical evaluation, a potential source of selection bias that limits the generalizability of these findings (Carone et al., 2005).

Unlike Carone et al. (2005), Randolph et al. (2001) found that MS patients' ratings of memory problems were at least as accurate and sometimes better than the ratings of significant others when compared to actual neuropsychological test performance. On further examination of these data, Randolph, Arnett, and Freske (2003) concluded that while the participants with MS did have objective cognitive difficulties, their report of memory difficulties was partially mediated by depressive attitudes.

Awareness of deficit in executive functioning

While metamemory has been explored to some degree in MS populations, the awareness of executive dysfunction is less well-understood. The frontal lobes play a key role in self-awareness and reality monitoring (Stuss, 1991). Therefore, the metacognitive aspects of executive dysfunction are rather complex, as it is a question of awareness of lack of awareness. Despite the challenges inherent in measuring awareness of problems with executive functioning, a number of self-report questionnaires have been developed for use in neurological populations. Examples of these questionnaires include the Behavior Rating Inventory of Executive Functions (BRIEF), the Dysexecutive Questionnaire (DEX), the Frontal Behavior Inventory (FBI), the Frontal Systems Behavior Scale (FrSBe), the Iowa Rating Scales of

Personality Change (IRSPC), and the Neuropsychiatric Inventory (NPI) (Malloy & Grace, 2005). As Malloy and Grace (2005) suggest, "clinicians and investigators can now choose among several measures that have research supporting the reliability and validity of the instrument" (p. 26).

Chiaravalloti and DeLuca (2003) used the Frontal Systems Behavior Scale (FrSBe) to measure self- and informant-rated executive functioning and their correlation to actual test performance in a sample of 26 MS patients and 15 healthy controls. They found that patient and family ratings on the FrSBe significantly correlated with neuropsychological test performance on measures of information processing, working memory, and executive tasks. Chiaravalloti and DeLuca (2003) also found that the informant-rated FrSBe apathy and executive dysfunction subscales were significantly correlated to the patients' level of physical disability, though physical disability was not correlated to FrSBe self ratings. The investigators found no correlation between disease duration and informant or self ratings on the FrSBe. In a further investigation of the same sample, Goverover, Chiaravalotti, and DeLuca (2005) found that the concordance between MS patient self ratings and informant ratings was correlated with a variety of neuropsychological measures, suggesting that discrepancies between self and informant ratings on the FrSBe may be indicative of cognitive dysfunction. However, the researchers calculated concordance as the absolute value of the difference between the informant and self ratings, so it is not clear whether overestimation or underestimation of cognitive difficulties on the part of the MS patients might be driving this effect.

The DEX is a 20-item self-report measure of executive dysfunction that targets emotional functioning, motivation, behavior, and cognitive functioning (Wilson, Alderman, Burgess, Emslie, & Evans, 1996). It is available in self-rated and informant-rated versions. The DEX has been used extensively in research examining awareness of executive functioning deficits in neurological populations, such as TBI (Alderman, Dawson, Rutterford, & Reynolds, 2001; Bennett, Ong, & Ponsford, 2005; Odhuba, van den Broek, & Johns, 2005), alcoholism (Heffernan, Ling, & Bartholomew, 2004), and schizophrenia (Evans, Chua, McKenna, & Wilson, 1997). An advantage of the DEX is that it consists of questions describing specific behaviors or experiences, which have been found to elicit responses from neurological populations more concordant with informant responses than open-ended questions (Sherer et al., 1998). Results from prior research have typically indicated that patients rate their problems as significantly less severe than their significant others do (Alderman et al., 2001; Wilson et al., 1996; Wilson, Evans, Emslie, Alderman, & Burgess, 1998), though Odhuba et al. (2005) found that brain injured patients' DEX self ratings were more highly correlated with the executive tests used in the study than their families' DEX ratings.

In contrast to cognitively impaired populations who tend to under-report on this measure, research has indicated that neurologically healthy individuals may over-report. Chan (2001) examined the self and informant-rated DEX and their relationship with objective cognitive measures in a neurologically healthy control group and found that, although there were no significant differences between self-rated and informant-rated DEX questionnaires, there was a trend for the participants to rate

themselves as experiencing more pathological behavior than their significant others rated them as experiencing. Hart, Whyte, Kim, and Vaccaro (2005) found similar results in another sample of neurologically healthy controls. Burgess, Alderman, Evans, Emslie, and Wilson (1998) also found that controls rated themselves higher on the DEX than their informants and in their study, significantly so.

Considering previous research regarding awareness of cognitive dysfunction in MS, it is clear that there are several gaps in the literature that the proposed study might address.

Therefore, the questions to be addressed by this study are:

Question 1: Are individuals with MS similar to individuals with brain injuries in that they show a compromised ability to accurately rate their level of executive dysfunction? Or are they more similar to controls?

Given that the question of whether individuals with MS can accurately report problems with executive functioning is an important one for assessment and treatment planning and that the literature regarding this has been inconclusive, this is a central question addressed by this study. It may be that previous research regarding awareness of cognitive deficits in MS has been inconclusive because investigators have tended to use measures that assess awareness of cognitive functioning in general. As described previously, Allen and Ruff (1990) found that brain injured patients' accuracy in rating their abilities varied by cognitive domain. It may then follow that this is applicable to MS populations as well. For this reason, the measure examined in the present study examines one cognitive domain only- executive functioning, a domain often impaired in MS and critical to awareness. This study

utilizes a widely-used measure of awareness of executive dysfunction, not an open-ended interview regarding general cognitive complaints.

As executive functioning involves complex behavior, planning, and self-awareness, it is clear that impairment in these areas may result in problems in employment, recreation, and interpersonal relationships. Thus, executive functioning deficits may have a profound impact on the lives of individuals with MS. The conclusions that can be drawn from previous research in this area have been limited due to the use of a small sample (both studies used the same sample) (Chiaravalloti & DeLuca, 2003; Goverover et al., 2005) and the use of the absolute value of concordance as a measure of insight (Goverover et al., 2005). This study replicates and expands on this previous work by using a much larger sample of MS patients.

It is also critical for this type of investigation to include a sample of neurologically healthy individuals that are similar to the MS sample included. In this way, I can determine whether effects observed are due to MS or are true for the population at large.

Question 2: Are the significant others of individuals with MS accurate in rating patients' executive functioning? Are the significant others of controls accurate in rating controls' executive functioning?

As reviewed previously, it is standard practice in neurology and neuropsychology to consider the difference between informant ratings and self ratings of cognitive dysfunction as a measure of awareness in neurological populations (Fleming et al., 1996; Ownsworth, Clare, & Morris, 2006). However, it is not clear from the existing literature in MS (Carone et al., 2005; Randolph et al., 2001; Taylor, 1990) whether

the significant others of MS patients do a better job of rating patients' level of cognitive impairment than the patients themselves. It is clearly inappropriate to use the discrepancy between informant ratings and patient ratings uniformly in MS populations if MS patients are as or more accurate in rating their level of cognitive dysfunction. Therefore, the present study addresses this question as it regards accurate rating of executive dysfunction. Again, the previous studies (Chiaravalloti & DeLuca, 2003; Goverover et al., 2005) in this area were limited by a small sample size and this study replicates and expands on this previous work by using a much larger sample. This investigation additionally helps us to understand the relationship between self and informant-ratings of executive dysfunction and their relationship to performance on objective cognitive measures in neurologically healthy people.

Question 3: Do depression and/or demographic variables contribute to a person's rating of their own cognitive impairments? Do depression and/or demographic variables contribute to a significant other's rating of someone's cognitive impairments?

As reviewed previously, research has demonstrated that depression affects the reporting of general cognitive difficulties (Carone et al., 2005; Maor et al., 2001; Matotek et al., 2001) and memory difficulties (Bruce & Arnett, 2004; Randolph et al., 2003). It may also be that depression affects the reporting of executive dysfunction. As previous research has indicated that MS patients high in depression over-report their cognitive dysfunction (Carone et al., 2005; Maor et al., 2001), a reasonable hypothesis might be that those patients who overestimate the extent of their cognitive difficulties may score higher on measures of depression. It is not clear what effect patients' depression levels might have on the accuracy of informant ratings.

Other variables that may affect patient and significant other ratings of executive dysfunction include age, sex, level of education, symptom duration, and diagnosis duration. Marrie et al. (2005) found that age moderated the relationship between performance on memory measures and subjective complaints in that subjective complaints decreased with increasing age of the participants. In the same study, the investigators found that participants who did not have a post-secondary education were more likely to report subjective cognitive complaints. In contrast, previous research in awareness of executive functioning in MS has not found an effect for age or education (Chiaravalloti & DeLuca, 2003). However, the same caveat regarding this latter study applies. The present study examines the effect of the variables in a larger sample.

It is also important to examine the role of these factors in the control participants. The only studies that I am aware of that examined neurologically healthy individuals and their responses on the DEX did not examine the influence of outside factors (Chan, 2001). A number of researchers (Burgess et al., 1998; Chiaravalloti & DeLuca, 2003; Hart et al., 2005) have included controls as a comparison group in examining neurological patients' awareness of executive dysfunction, but did not report analyses of these factors in the control group. The present study examines whether effects observed are due to MS or are true for the population at large.

Question 4: Are cognitive functioning, depression, and/or demographic variables related to discrepancies between self and informant ratings on the DEX?

It is clear that discrepancies between self ratings and informant ratings on the DEX exist for both neurological populations and neurologically healthy controls (Burgess

et al., 1998; Chan, 2001). However, if these discrepancies are not pure measures of awareness, do depression or demographic factors play a role? It is not presently clear why these discrepancies in ratings exist. It may be that if MS patients are experiencing only minor executive functioning deficits, they are able to effectively compensate for them and prevent significant others from noticing any problems, resulting in a discrepancy between patient and informant ratings. The same may be true for minor lapses in executive functioning experienced by neurologically healthy individuals. Alternatively, informants may interpret depression or aging as signs of executive dysfunction and base their ratings on these outside factors rather than true observations of cognitive failures.

Method

Participants

The MS participants for this study were recruited from a local MS society in the mid-Atlantic United States. The control participants were referred by MS participants or were recruited through flyers posted in the community and distributed by study staff at a local event held by the National MS Society. Eligibility was determined through a phone screening interview completed by study staff. Exclusion criteria included a history of or current substance abuse, nervous system disorder other than MS, severe motor or visual impairment that would interfere with cognitive testing, premorbid history of a learning disability, severe physical or neurological impairment that made testing at the university location impossible, or inability to come to the testing center due to distance. Additional exclusion criteria for the control participants were history

of any neurological disease, uncontrolled hypertension, and diabetes. A total of 101 individuals with MS and 27 control participants completed the testing. Four participants with MS were excluded from the data analysis for the following reasons: MS diagnosis could not be verified (1), history of electroconvulsive therapy (1), history of stroke (1), and history of significant loss of consciousness following a motor vehicle accident (1).

All participants provided informed consent (reviewed and approved by the Institutional Review Board) and were reimbursed 75 dollars for their time. All MS participants and some control participants were provided with written neuropsychological evaluations of their performance as well as verbal feedback at the completion of their participation. Each MS participant had been diagnosed by a board-certified neurologist with definite or probable MS using Poser et al.'s (1983) criteria. Disease course was classified according to Lublin and Reingold's (1996) suggested criteria. No MS participants were experiencing an exacerbation at the time of testing (as determined through the initial phone screening).

The MS participants (n = 97) consisted of 17 men (17.5%) and 80 women (82.5%), all Caucasians. Their mean age was 47.34 years (SD = 8.95), the mean number of years since MS diagnosis was 10.77 (SD = 7.85), and the mean number of years since the first MS symptom was 14.97 (SD = 8.76). Most participants had a relapsing-remitting course of MS (74, 76.3%), followed by secondary progressive (18, 18.6%), primary progressive (4, 4.1%), and progressive relapsing (1, 1%). The majority of the patients were right-handed (76, 78.4%) and married (68, 70.1%). Their average level of education was 14.28 years (SD = 2.01).

The control participants (n = 27) included 5 men (18.5%) and 22 women (81.5%) and the majority were Caucasian (26, 96.3%). Their mean age was 45.63 (SD = 12.46) and their average level of education was 15.07 years (SD = 2.13). As was true for the participants with MS, the majority of the controls were right-handed (21, 77.8%) and married (16, 59.3%).

The informants in the study were selected by the participants as someone who knew them well. The majority were spouses (65.5%), while others were friends (10.3%), adult children (8.6%), siblings (6.0%), parents (6.0%), or unmarried partners (3.4%). Unfortunately, the type of relationship to the participant was not indicated by 8 of the informants.

Cognitive Measures

The Visual Elevator (VE) is a subtest of the Test of Everyday Attention (Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994) that measures attentional switching and cognitive flexibility. Participants are shown a series of pictures of elevators and arrows pointing up or down and are asked to count out what "floor" they are on as quickly as possible. The raw score for this test is the number of correct "switches" (changes in elevator direction) made per second. Robertson et al. (1994) note that individuals who perform poorly on the VE also tend to perform poorly on the Wisconsin Card Sorting Test, a widely-used test that is sensitive to executive dysfunction. The one week test-retest reliability for the VE raw accuracy score is 0.71 for controls and 0.90 for stroke patients(Robertson et al., 1994). Robertson et al. (1994) found that stroke patients scored significantly worse than controls on the VE.

This task is included in an executive index including the COWA, Animal Naming, Stroop, Shipley abstraction scale, and RS. The formation of this index score will be described in a later section.

The Controlled Oral Word Association Task (COWA) is a measure of verbal association fluency (Spreen & Benton, 1969). Participants are asked to state aloud as many words as they can think of beginning with a specific letter of the alphabet, excluding proper nouns and the same word with a different ending (Lezak et al., 2004). The raw score is the total number of acceptable words listed for 3 different letters (F, A, and S) in one minute. Retest reliability has been found to be .88 for adults 19-42 days after first administration (des Rosiers & Kavanagh, 1987, as cited by (Spreen & Strauss, 1998). The COWA has been found to be sensitive to deficits of executive functioning (Lezak et al., 2004) as it requires the maintenance and switching of a fairly complex task set (Damasio & Anderson, 1993; Malloy et al., 1998). This task is included in the executive index.

Animal naming is a category-specific verbal fluency test. Participants are asked to list as many animals as they can think of as quickly as they can. Like the COWA, the raw score is the number of acceptable responses produced in one minute. The semantic cue provided typically aids individuals in their performance on this test. Individuals with frontal lobe lesions have been found to produce poorer performance on this test (Lezak et al., 2004). This task is included in the executive index.

The 10/36 Spatial Recall Task is a test of visuospatial learning and memory (Lezak, 1995). Participants are shown ten black circles on a grid for 10 seconds and then are asked to reproduce the pattern from memory by placing checkers on a blank

grid. This process is repeated for three trials. The score is calculated from total correct across all trials (Rao & the Cognitive Function Study Group of the National Multiple Sclerosis Society, 1990). A delayed recall trial is administered after a 30 minute delay and the raw score is the number of checkers correctly placed. This test is included in a non-executive index including the SRT and SDMT, in order to establish the specificity of DEX ratings.

The version of the Stroop Color-Word test employed in this study consists of two parts (Trenerry, Crosson, DeBoe, & Leber, 1989). The first part of the test requires the examinee to read through a list of 112 color words (e.g., blue, green) presented in four vertical columns on a sheet of paper as quickly as possible. The second part requires the participant to inhibit the reading response and respond by naming aloud the color of the ink that the words are printed in, which conflicts with the actual word printed (e.g. the word "tan" printed in blue ink). This widely-used and challenging task requires inhibition of an overlearned response (reading) (Lezak et al., 2004; Malloy et al., 1998). Both parts of the Stroop test have been demonstrated to have a test-retest coefficient of .84 (Dikmen, 1999). This task is included in the executive index.

The verbal selective reminding task (SRT) used in the study consists of a list of 12 words that are read aloud to participants. The experimenter then instructs the examinee to report the words back in any order. Examinees are reminded of any items missed and asked to produce the entire list again. This procedure continues until participants reach the 6^{th} trial. This technique allows for analysis of memory in terms of storage, retention, and retrieval in verbal learning so that impairment in both

memory and learning can be examined (Buschke & Fuld, 1974). The long-term storage and continuous long-term retrieval scores from this test were used. This test is included in the non-executive index.

The Shipley Institute of Living Scale is an easily-administered paper-and-pencil test of vocabulary and verbal abstraction (Lezak et al., 2004; Zachary, 1986). It is composed of 40 multiple-choice vocabulary items and 20 abstract verbal reasoning items. For the vocabulary portion of the test, examinees are given a target word and four options and are instructed to circle the word whose meaning most closely matches the meaning of the target word. The abstraction portion of the test requires the examinees to complete a series of numbers or letters. Raw scores for this test are the number of vocabulary items correct and double the number of abstract items correct. Tables are available for age and education based norms. The correlation between Shipley scores and Wechsler Adult Intelligence Scale Revised (WAIS-R; (Wechsler, 1981) full scales IQ scores was found to be .87 for a mixed psychiatric sample of 100 inpatients. The abstraction portion of this test is used to provide a measure of abstract verbal reasoning, a component of executive functioning. This task is included in the executive index.

The reading span task (RS) used in this study is a computer-administered test that is similar to the task developed by Daneman and Carpenter (1980; Daneman & Merikle, 1996) and is also described in Bruce and Arnett (2005). Participants are presented with a sentence on the computer screen with a word after it (e.g. “The brilliant trial attorney dazzled the jury with his mature knowledge of the case. like”) and are asked to remember the word that appeared after the end of the sentence. The

oral reading prevents subvocal repetition of the target words, a common encoding strategy. In the early trials, examinees are presented with two sentences and are then asked to report the target words. As the task goes on however, examinees are presented with up to five sentences before they are asked to report the target word, so task demands on working memory increase considerably. The total number of target words recalled during the task is the raw score for this task. This task is included in the executive index.

The Symbol-Digit Modalities Test- Oral Form (SDMT) is an adaptation of the Wechsler Digit Symbol Test (1981) in which a sheet of symbols that correspond with the numbers 1-9 are given to the participant. The participant is instructed to use the key at the top of the page to match the symbols with the appropriate numbers and read the numbers aloud. The raw score is the total number correct in 90 seconds. This task measures complex scanning and visual tracking (Lezak et al., 2004) as well as working memory (Smith, 1982). While both written and oral forms are available, the oral form of this measure was used in the present study so that any motor-writing difficulties secondary to MS would not confound test performance (Arnett, Higginson, Voss, Wright et al., 1999). Test-retest reliability for the oral form of the SDMT has been found to be .76 (Smith, 1982). This test is included in the non-executive index.

As stated previously, the Dysexecutive Questionnaire (DEX) is a 20-item self-report measure of executive dysfunction that targets emotional functioning, motivation, behavior, and cognitive functioning (Wilson et al., 1996). The DEX is

available in self-rated and informant-rated versions. Each item is rated on a 0-4 point Likert scale that ranges from "never" to "very often." Items include:

- I find it hard to stop repeating saying or doing things once I've started.
- I have difficulty thinking ahead or planning for the future.
- I lose my temper at the slightest thing.

The DEX was produced as a component of the Behavioural Assessment of the Dysexecutive Syndrome (BADS) system, but is not "formally a part of the BADS in the sense that it is not used in the calculation of the profile score for the battery" (p. 16) (Wilson et al., 1996). Reliability information for the DEX is not provided in the BADS manual. However, Mathias (2003) evaluated the reliability of the DEX in a sample including patients with Parkinson's disease and controls. He found that Cronbach's α for the self-report version of the DEX was .91 for Parkinson's patients and .83 for controls. For the informant-rated version, Cronbach's α was found to be .92 for the Parkinson's group and .83 for controls. In a sample of patients with traumatic brain injury, Bennet, Ong, and Ponsford (2005) found that Cronbach's α for the DEX self-rated version was .92 while the informant-rated version was .93. Norris and Tate (2000) suggest that the validity appears adequate. Evans et al. (1997) found that patients with schizophrenia and brain-injured patients scored significantly worse than control participants on the DEX when informant-rated scores were compared. In the validation study of the DEX, Wilson et al. found (1998) that in a mixed sample of patients with brain injury and illness, the informant-rated version of the DEX correlated highly with the patients' total score on the BADS (r = -0.62), suggesting that the DEX is sensitive to executive dysfunction. As there is no gold standard for

measuring awareness of executive dysfunction (Bogod et al., 2003; Noe et al., 2005), the DEX was selected for use in the present study for its ease of administration and interpretation (i.e. it is relatively short and behaviorally-anchored).

Psychosocial Measure

The psychosocial interview included in this study includes several questions regarding participant demographics, education, employment history, living arrangements, difficulties with speech and language, history of depression, history of MS symptoms, and medication use. This interview provides demographic information for the present study.

Disability and Depression Measures

The Kurtzke Extended Disability Status Scale (EDSS)(Kurtzke, 1983), a rating scale derived from a standard neurological examination, is the most commonly used measure of disease severity in MS (Lezak et al., 2004). The EDSS provides a 0-10 rating of disability due to MS, ranging from no disability to death due to MS in half-point increments. Higher scores indicate more significant impairment. A score of 5 would indicate that the participant is able to walk for about 200 meters without aid or rest, but the disability is severe enough to impair full daily activities. For this study, the EDSS was converted into a self-rated questionnaire in consultation with a board-certified neurologist. Participants were asked to rate for symptoms of ambulation difficulties, motor-related problems, bowel and bladder dysfunction, and visual, oral, and sensory functioning on a four-point scale. The EDSS rating was then determined

by an experienced neuropsychologist with expertise in MS. This measure is included to provide a gross measure of disease severity about the participants with MS.

The Beck Depression Inventory-II (BDI-II) is a frequently used, 21-item, self-rated measure of the mood, cognitive, motivational, and somatic symptoms of depression (Beck, Steer, & Brown, 1996). Each item is rated on a scale of 0-3, with higher scores indicating more severe depressive symptoms. An analysis of the BDI-II's internal consistency revealed that in a sample of psychiatric outpatients, the coefficient alpha was .91 (Beck, Steer, Ball, & Ranieri, 1996). Its construct validity has also been demonstrated, in that the BDI-II has been found to be significantly correlated (.89) with the depression scale of another widely-used self-rated inventory, the SCL-90-R (Derogatis, 1983).

The Chicago Multiscale Depression Inventory (CMDI) is a self-rated depression inventory that was developed for use in medical patient populations and has been shown to be internally consistent, reliable, and valid (Nyenhuis et al., 1998). Participants rate how well terms describe them based on a 5 point Likert-type scale ranging from 1: "Not at all" to 5 "Extremely." The scale's 42 items can be considered as mood, evaluative, and vegetative subscales or combined to create an overall score. The mood scale includes items such as "blue", while the evaluative scale includes items such as "a failure", and the vegetative scale includes items such as "uninterested in sex." The mood and evaluative scales can be used to estimate depression in medical patients whose depression scores might otherwise be inflated by their somatic symptoms. The coefficient alpha for the full scale was found to be .89 and convergent validity was demonstrated with the CMDI and the BDI, Profile of

Mood States (POMS), and Geriatric Depression Scale (GDS) (Nyenhuis et al., 1998). In the present study, a self-rated version was completed by the participants and an informant-rated version of this questionnaire was completed by the significant others. For the purposes of this study, the combined mood and evaluative scales were used.

Procedure

Two packets of questionnaires were mailed to each participant approximately one week prior to their testing day. One packet was to be completed by the participant while the other was to be completed by someone who knew the participant well. The participant questionnaire packet included the EDSS and the DEX. The significant other questionnaire packet included informant-rated versions of the DEX and the CMDI.

Prior to any test administration on the day of testing, all participants were interviewed by trained clinical graduate students who completed a brief psychosocial interview developed specifically for this study. Following this interview, participants completed the BDI-II, the CMDI, the VE, the COWA, Animal Naming, the 10/36 Spatial Recall Test, the Stroop task, the SRT, the Shipley Institute of Living Scale, the RS, and the SDMT. The tests were administered as a part of a larger testing battery in four different, alternating orders to control for fatigue and administration order effects on test performance (see Appendix).

Results

Preliminary data analysis

The DEX scores were examined first. To examine scale reliability, Cronbach's α was obtained for the self-rated and informant-rated versions of the DEX. The test revealed adequate inter-item reliability for both the self-rated (α = .863) and the informant-rated (α = .903) DEX. Z-scores based on the control population's scores were calculated in order to provide a common metric for comparison. The control data was used for this purpose because the DEX manual (Wilson et al., 1996) does not provide normative data. This reference population also ensures that the data used for creating the z-scores is from a similar population to the MS patients. No self-rated DEX scores were missing from the data; however, three informant-rated DEX scores (2 in the MS group and 1 in the control group) were missing.

A one-way, between-subjects analysis of variance test (ANOVA) revealed that the self-rated DEX z-scores for the MS patients and controls were significantly different ($F(1, 122) = 3.954$, $p < .05$, partial $\eta^2 = .031$), with the MS patients rating themselves significantly higher (more executive dysfunction) than the control participants (see Table 1). However, a one-way, between-subjects ANOVA revealed that informant-rated DEX z-scores for the MS patients and controls were not significantly different ($F(1, 119) = 1.068$, $p > .05$, partial $\eta^2 = .009$) (see Table 1).

Using a paired samples t-test, it was found that within the MS group, self-rated DEX scores were significantly higher than informant-rated DEX scores ($t = 2.154$, $df = 96$, $p < .05$) (see Table 1). However, within the control group, self-rated

Table 1
Group DEX Means (z-scores)

Self-rated DEX

	N	M(sd)	F	p
MS	97	.58 (1.41)	3.954	<.05
Controls	27	.00 (1.00)		

Informant-rated DEX

	N	M(sd)	F	p
MS	95	.30 (1.10)	1.068	NS
Controls	26	.00 (1.00)		

MS DEX scores

	M(sd)	t	p
Self-rated	.58 (1.41)	2.15	<.05
Informant-rated	.25 (1.11)		

Control DEX scores

	M(sd)	t	p
Self-rated	.00 (1.00)	-.001	NS
Informant-rated	.00 (1.00)		

and informant-rated DEX scores were not significantly different (t = -.001, df = 26, p > .05) (see Table 1).

The relationship between the self-rated and informant-rated versions of the DEX for the controls and MS patients was examined using Pearson's correlations. It was found that the correlations were significant with medium effects for both the MS (r = .370, p < .001) and the control groups (r = 0.412, p < .05).

One-way, between-subjects ANOVAs were used to compare the MS and control groups on reported levels of depression, using the self and informant-rated CMDI and the BDI-II (see Table 2). No significant differences were found between the groups based either the self-rated (F(1, 122)= 2.528, p > .05, partial η^2 = .020) or the informant-rated CMDI (F(1, 122)= 2.048, p > .05, partial η^2 = .017). However, the groups were significantly different based on the BDI-II (F(1, 122)= 9.22, p < .005, partial η^2 = .070).

The cognitive test data were initially examined for outliers within the MS sample. Z-scores were calculated using the MS participants as a reference group in order to ensure that data labeled as outliers were, in fact, unusual for the sample and did not represent real differences between the control and MS groups. The determination of outliers was based on a cut-off of three standard deviations above or below the mean (Ratcliff, 1993). Using this method it was determined that there was one outlier in the COWA scores, one in the Shipley abstraction scale scores, and two in the VE scores. These scores were removed from the following analyses. The same process was repeated for the control sample and no outliers were found.

Table 2
Group Means Depression Measures (z-scores)

Self-rated CMDI (Mood and Evaluative Scales)

	N	M(sd)	F	p
MS	97	.47 (1.44)	2.53	NS
Controls	27	0 (1)		

Informant-rated CMDI (Mood and Evaluative Scales)

	N	M(sd)	F	p
MS	92	.39 (1.27)	2.09	NS
Controls	26	0 (1)		

BDI-II

	N	M(sd)	F	p
MS	97	.70 (1.08)	9.22	<.005
Controls	32	0 (1)		

Primary data analysis

All cognitive tests [Visual Elevator (VE), Controlled Oral Word Association Test (COWA), Animal Naming, 10/36 Spatial Recall Test (10/36), Stroop task, verbal selective reminding task (SRT), Shipley Institute of Living Scale, reading span task (RS), and Symbol-Digit Modalities Test- Oral Form (SDMT)] were z-scored based on the controls' scores. To avoid error due to multiple comparisons, multivariate analysis of variance tests (MANOVA) were used to compare MS and control groups on performance on the cognitive tasks.

In the first MANOVA, MS and control groups were compared on the following executive measures: VE, COWA, Animal Naming, Stroop, Shipley Abstraction Scale, and RS (see Table 3). The MANOVA revealed significant results for the multivariate test, [Lambda $_{(6, 98)}$ = .832, p < .005, partial η^2 = .168]. On examination of the follow-up univariate tests, significant results were found for the VE ($F_{(1, 103)}$ = 4.93, p < .05, partial η^2 = .046), the COWA ($F_{(1, 103)}$ = 4.10, p < .05, partial η^2 = .038), the Stroop ($F_{(1, 103)}$ = 7.12, p < .01, partial η^2 = .065), and the RS ($F_{(1, 103)}$ = 8.31, p < .005, partial η^2 = .075). The univariate tests were nonsignificant for the Shipley abstraction scale ($F_{(1, 103)}$ = .05, p > .05, partial η^2 = .001) and Animal Naming ($F_{(1,103)}$ = 3.18, p > .05, partial η^2 = .030).

In the second MANOVA, MS and control groups were compared on the following non-executive measures (see Table 3): 10/36, SRT, SDMT. The MANOVA revealed significant results for the multivariate test, [*Lambda* $_{(5, 118)}$ = .863, p < .005, partial η^2 = .137]. On examination of the follow-up univariate tests, significant results were found for the 10/36 immediate recall ($F_{(1, 122)}$ = 5.11, p < .05, partial η^2 = .040),

Table 3: Group Test Means (MS vs. Controls)

SDMT z-score

	N	M(sd)	F	p
MS	97	-1.20 (1.31)	19.26	<.001
Controls	27	0.00 (1.00)		

VE z-score

	N	M(sd)	F	p
MS	95	-0.85 (1.72)	6.00	<.05
Controls	27	0.00 (1.00)		

COWA z-score

	N	M(sd)	F	p
MS	96	-0.53 (0.93)	6.60	<.01
Controls	27	0.00 (1.00)		

Animals z-score

	N	M(sd)	F	p
MS	96	-0.49 (1.19)	3.73	NS
Controls	27	0.00 (1.00)		

10/36 Spatial Recall delayed recall z-score

	N	M(sd)	F	p
MS	97	-0.56 (1.18)	5.10	<.05
Controls	27	0.00 (1.00)		

10/36 Spatial Recall immediate recall z-score

	N	M(sd)	F	p
MS	97	-0.49 (1.00)	5.11	<.05
Controls	27	0.00 (1.00)		

Reading Span z-score

	N	M(sd)	F	p
MS	94	-0.76 (1.06)	11.13	≤.001
Controls	27	0.00 (1.00)		

Selective Reminding Task CLTR z-score

	N	M(sd)	F	p
MS	97	-0.38 (1.14)	2.47	NS
Controls	27	0.00 (1.00)		

Selective Reminding Task LTS z-score

	N	M(sd)	F	p
MS	97	-0.44 (1.20)	4.06	NS
Controls	27	0.00 (1.00)		

Shipley Abstraction z-score

	N	M(sd)	F	p
MS	97	-0.09 (1.00)	0.19	NS
Controls	27	0.00 (1.00)		

the 10/36 delayed recall ($F_{(1, 122)} = 5.10$, $p < .05$, partial $\eta^2 = .040$), and the SDMT ($F_{(1, 122)} = 19.26$, $p < .001$, partial $\eta^2 = .136$). The univariate tests were nonsignificant for the SRT long term storage ($F_{(1, 122)} = 3.04$, $p > .05$, partial $\eta^2 = .024$) and the SRT continuous long term retrieval ($F_{(1,122)} = 2.47$, $p > .05$, partial $\eta^2 = .020$).

The self-rated and informant-rated DEX scores were correlated with cognitive test scores to explore the relationships between the individual tests and DEX ratings (see Table 4). The test z-scores were examined to ensure that there were high intercorrelations within the executive tests (VE, COWA, Animal Naming, Stroop, Shipley abstraction scale, and RS) and the non-executive tests (10/36, SRT, and SDMT). All intercorrelations were $r \geq .300$ or higher for the executive tests and $r \geq .292$ or higher for the nonexecutive tasks. Additionally, Cronbach's α was calculated for each index score. The internal consistency was adequate for both the executive index (0.82) and the non-executive index (0.80). Thus, the measures were combined by obtaining the average z-score to form executive and non-executive indices for the remaining analyses. There were several missing cases for the Stroop test: 11 in the MS group were missing due to the fact that the test was not added to the test battery until after the initiation of the study, 5 were mis-administered (2 in the control group and 3 in the MS group), and 3 participants (in the MS group) were color-blind. The RS was missing for two participants. There were no other missing cases for any of the cognitive tests and no participants were missing more than 2 test index scores. For participants who were missing test data, their index scores reflect the average of the available tests.

Table 4: Correlations between cognitive tests and DEX ratings

Executive index tests and DEX ratings: MS Participants

	SDMT	SRT LTS	SRT CLTR	10/36 IR	10/36 DR
DEX self	-.302**	-.304**	-.350**	-.172	-.052
DEX informant	-.094	-.100	-.140	-.110	-.037

Executive index tests and DEX ratings: Controls

	VE	COWA	Animals	Stroop	RS	Shipley
DEX self	-.299**	-.216*	-.152	-.466**	-.257*	-.383**
DEX informant	-.169	-.228*	-.211**	-.240*	-.062	-.215*

Non-executive index tests and DEX ratings: MS Participants

	VE	COWA	Animals	Stroop	RS	Shipley
DEX self	-.307**	-.259*	-.173	-.443**	-.261*	-.334**
DEX informant	-.150	-.214*	-.213*	-.206*	-.088	-.183*

Non-executive index tests and DEX ratings: Controls

	SDMT	SRT LTS	SRT CLTR	10/36 IR	10/36 DR
DEX self	-.227	-.029	.004	.101	-.097
DEX informant	.047	.028	-.081	-.004	-.171

* = $p \leq .05$
** = $p \leq .01$

Question 1

In order to address Question 1 (whether MS patients are accurate in rating their executive dysfunction), the relationship between participants' self-rated DEX z-scores and their executive index scores was examined using Pearson's correlations. The correlation was significant and had a medium effect size (r = -.405, p < .001). The same procedure was repeated for the control participants in order to examine whether participants in a control sample similar to the MS sample are able to rate themselves accurately. The correlation was non-significant, but revealed a small effect size (r = -.213, p > .05). Fisher's r to z transformation was performed in order to examine whether the two correlations were significantly different. However, the test did not reveal significant results (p > .05).

Simultaneous regression analyses were performed to determine which measures of the executive index (the Shipley abstraction scale, the FAS, Animals, the VE, and the AFRS) were significant predictors of the self-rated DEX score. These analyses were completed separately for MS and control participants. I will first describe the results for the MS participants. The regression model was significant, however, the Shipley abstraction scale was the only significant individual predictor variable (see Table 5; adjusted R^2 = .132, $F_{(5,92)}$ = 3.789, p < .01). For the controls, the model was not statistically significant.

Table 5: Simultaneous Regression self-rated DEX predicted by Executive Measures

MS participants

	Beta	**p**	**Semi-partial**
Shipley Abstraction	-.294	.025	-.222
FAS	-.087	.478	-.069
VE	-.073	.568	-.056
AFRS	-.088	.442	-.075
Animals	.025	.830	.021

Control participants

	Beta	**p**	**Semi-partial**
Shipley Abstraction	-.110	.707	-.079
FAS	-.377	.189	-.281
VE	-.054	.811	-.050
AFRS	.266	.445	.161
Animals	.012	.964	.009

In order to examine what factors might contribute to discrepancies between DEX self-ratings and actual performance, discrepancy scores (difference between the self-rated DEX and the executive index) were calculated for all participants. The discrepancy data were examined with the Kolmogorov-Smirnov Test for Normality and were found to be normally distributed ($p > .05$). In order to examine differences between accurate raters and two types of inaccurate raters (problem overestimators and problem underestimators), cut-offs were established to divide the participants into three groups, as in Cavallo et al. (1992). Cut-offs were based on quartiles obtained from the control sample to divide each population into accurate raters (25-75th percentile of discrepancy scores, self ratings on the DEX and objective testing mostly agree), problem overestimators ($\leq$ 25th percentile, self ratings on the DEX indicate more problems than objective testing), and problem underestimators ($\geq$ 75th percentile, self ratings on the DEX indicate fewer problems than objective testing).

The following analyses were performed separately for the MS and the control groups. I will first report the results for the MS group. Using the cut-offs described above, there were 26 participants in the problem overestimator group, 47 participants in the accurate rater group, and 24 participants in the problem underestimator group. Chi square tests for independence revealed no significant differences for sex ($\chi^2(2, N = 97) = 0.982$, $p > .05$) between the three accuracy groups. The three accuracy groups (i.e. accurate, overestimators, and underestimators) were compared on other demographic and illness variables using one-way, between-subject, ANOVAs (see Table 5). As ANOVA depends on assumptions of normality and homogeneity of variance, all variables were tested for violations of these assumptions using the Kolmogorov-Smirnov Test for Normality and Levene's Test of Equality of Error Variances. The results of these tests are

only reported in this discussion when significant – all unreported tests did not have significant results and therefore do not represent violations of these assumptions.

It was found that Levene's Test of Equality of Error Variances was significant for age ($F_{(2, 94)} = 3.748$, $p < .05$), symptom duration ($F_{(2, 94)} = 3.788$, $p < .05$), and diagnosis duration ($F_{(2, 94)} = 4.451$, $p < .05$); suggesting that these variables violated the assumption of homogeneity of variances. For this reason, the Browne-Forsythe statistic, a robust test of equality of means, was used to examine differences between the accuracy groups based on these variables in addition to ANOVA. There were no significant differences between the three groups based on age as measured by ANOVA ($F_{(2, 94)} = .449$, $p > .05$, partial $\eta^2 = .009$) or by the Browne-Forsythe statistic (.477, $p > .05$) (See Table 6). This was also true for symptom duration using both the ANOVA ($F_{(2, 94)} = .154$, $p > .05$, partial $\eta^2 = .003$) and the Browne-Forsythe statistic

Table 6: Means by Discrepancy and Accuracy Groups

	Problem overestimator		**Accurate**		**Problem underestimator**	
	MS (26)	Control (7)	MS (47)	Control (13)	MS (24)	Control (7)
Age	48.15 (6.06)	41.71 (15.09)	46.45 (9.73)	45.69 (12.82)	48.21 (10.11)	49.43 (9.02)
Sx Duration	15.62 (9.55)	--	14.47 (7.18)	--	14.54 (10.79)	--
Dx Duration	11.46 (8.60)	--	10.40 (6.18)	--	10.75 (10.00)	--
Education	13.50 (1.84) $_b$	16.43 (2.23) $_a$	14.96 (2.11) $_a$	15.15 (2.04)	13.79 (1.59) $_b$	13.57 (1.27) $_b$
Exec.Index	-.38 (.15)†	.37 (.26)†	-.54 (.11)†	.06 (.18)†	-.81 (.16)†	-.48 (.26)†
CMDI	.74 (1.44)	.51 (1.24)	.50 (1.53)	-.02 (.95)	.11 (1.20)	-.47 (.65)

	Informant problem overestimator		**Informant accurate**		**Informant problem underestimator**	
	MS (14)	Control (6)	MS (55)	Control (14)	MS (26)	Control (6)
Age	45.57 (8.08)	38.50 (13.47)	46.22 (8.88)	46.64 (11.39)	51.15 (8.94)	50.33 (14.07)
Sx Duration	14.57 (8.75)	--	15.15 (8.53)	--	14.42 (9.72)	--
Dx Duration	9.07 (5.54)	--	10.62 (7.90)	--	12.00 (9.02)	--
Education	14.36 (1.91)	15.50 (1.64)	14.24 (2.10)	15.00 (1.88)	14.27 (2.01)	15.17 (3.25)
Exec. Index	-.14 (.77) $_b$	.41 (.76) $_b$	-.44 (.70) $_b$	.07 (.58)	-1.07 (.90) $_a$	-.63 (.52) $_a$
CMDI	.44 (1.00)	.62 (1.24)	.42 (1.43)	-.24 (.59)	.63 (1.70)	.07 (1.42)

	Informant > self		**Agreement**		**Self > informant**	
	MS (24)	Control (6)	MS (30)	Control (14)	MS (41)	Control (6)
Age	45.08 (9.81)	53.00 (8.00) $_b$	47.33 (10.21)	38.93 (11.05) $_a$	48.98 (7.30)	53.83 (12.42) $_b$
Sx Duration	15.13 (9.92)	--	13.87 (8.28)	--	15.44 (8.66)	--
Dx Duration	10.79 (8.29)	--	9.23 (7.39)	--	11.88 (8.06)	--
Education	14.54 (2.19)	16.00 (1.67)	13.87 (1.89)	14.21 (1.85)	14.39 (2.04)	16.50 (2.35)
Exec. Index	-.29 (.75)	-.13 (.29)†	-.60 (.65)	.13 (.21)†	-.71 (.96)	-.24 (.30)†
CMDI	.12 (.95)	.19 (1.30)	.12 (1.16) $_a$	-.14 (.74)	.96 (1.74) $_b$	.25 (1.34)

Note: Means with different subscripts (a,b) are significantly different in the Tukey HSD comparison.
† Estimated marginal mean values and standard error values reported due to covariate.

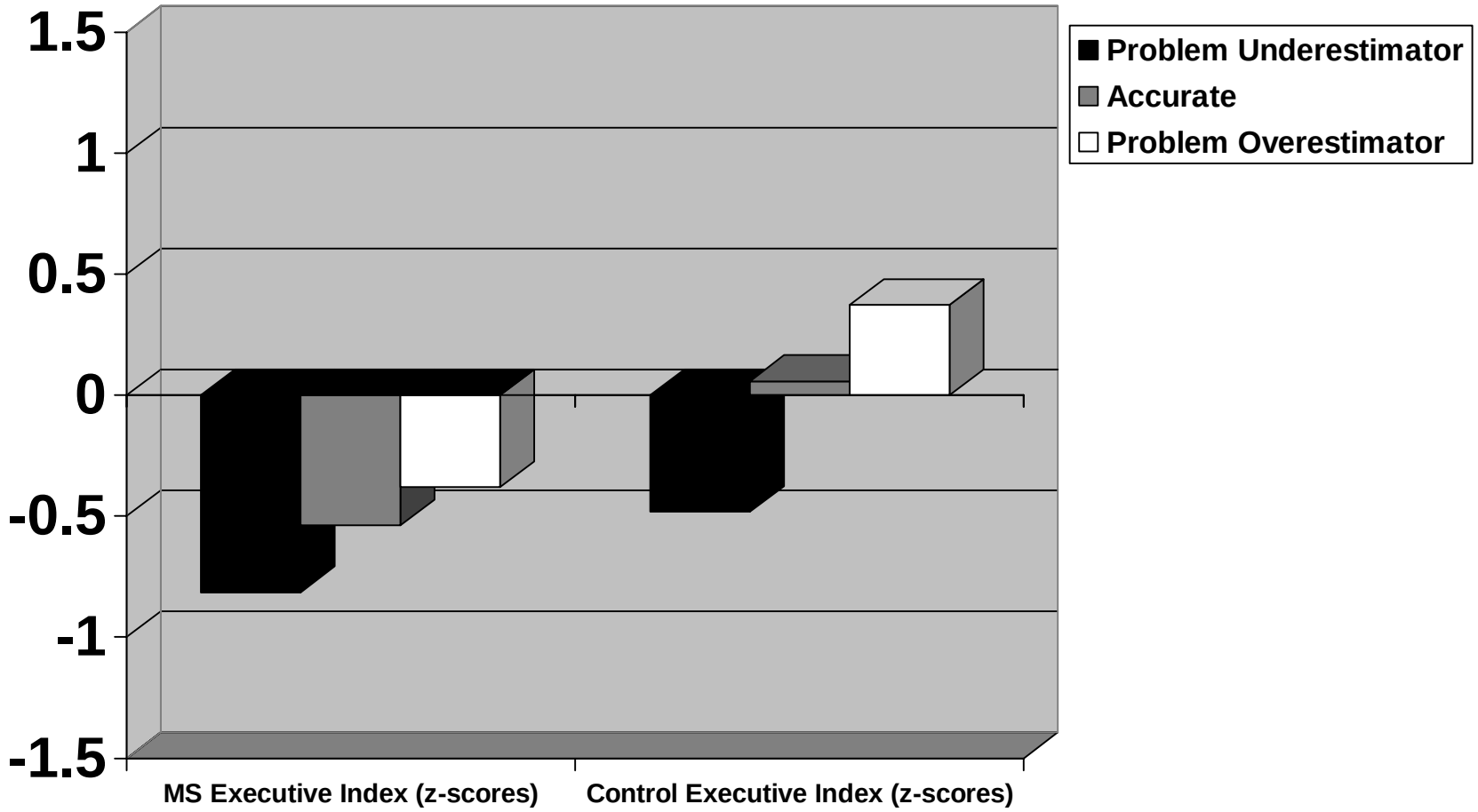
(.133, $p > .05$), as well as for diagnosis duration, again using both the ANOVA ($F_{(2, 94)} = .149$, $p > .05$, partial $\eta^2 = .003$) and the Browne-Forsythe statistic (.126, $p > .05$).

However, ANOVA revealed significant differences between the three groups on years of education ($F_{(2, 94)} = 5.85$, $p < .005$, partial $\eta^2 = .111$). Tukey's Honestly Significant Difference (HSD) post-hoc test was used to determine the nature of the differences between the groups. Significant differences were found between the accurate group ($M = 14.96$, $SD = 2.11$) and the problem overestimator group ($M = 13.50$, $SD = 1.84$, $p < .01$) and the problem underestimator group ($M = 13.79$, $SD = 1.59$, $p < .05$).

ANOVA was used to determine whether the discrepancy scores indicate valid differences between the accuracy groups on objective cognitive tests. Because the groups were found to be significantly different in years of education, this variable was entered as a covariate in an analysis of covariance (ANCOVA) with the executive index as the dependent variable. The test did not reveal significant results ($F_{(2, 93)} = 2.102$, $p > .05$, partial $\eta^2 = .043$) (see Figure 1). ANOVA was used to compare the three accuracy groups on levels of depression as measured by the CMDI (Mood and Evaluative scales combined). It was predicted that the problem overestimators would demonstrate significantly higher levels of depression than the accurate raters and the problem underestimators. However, the ANOVA did not reveal a significant difference between the three groups ($F_{(2, 94)} = 1.257$, $p > .05$, partial $\eta^2 = .026$).

Now, I will report the results of the analyses for the control participants. Using the cut-offs described previously, there were 7 participants in the problem

Figure 1: Executive Functioning by Self Accuracy Group



overestimator group, 13 participants in the accurate rater group, and 7 participants in the problem underestimator group. Unfortunately, the sample did not include enough males to analyze possible sex differences between the accuracy groups. ANOVA was used to compare the three accuracy groups on age and education. A one-way ANOVA with age as the dependent variable did not reveal significant differences between the three groups ($F_{(2, 24)} = .654$, $p > .05$, partial $\eta^2 = .052$). However, a one-way ANOVA with years of education as the dependent variable did reveal significant differences between the three groups ($F_{(2, 24)} = 3.869$, $p < .05$, partial $\eta^2 = .244$). Tukey's HSD post-hoc test was used to determine the nature of the differences between the groups. Significant differences were found between the problem underestimator group ($M = 13.57$, $SD = 1.27$) and the problem overestimator group ($M = 16.43$, $SD = 2.23$, $p < .05$).

ANOVA was used to determine whether the discrepancy scores indicate valid differences between groups on objective cognitive tests, with the level of accuracy as the grouping variable and the executive index as the dependent variable. Because the groups were found to be significantly different in years of education, this variable was entered as a covariate in an analysis of covariance (ANCOVA) with the executive index as the dependent variable. This test did not reveal a significant difference between the three groups ($F_{(2, 23)} = 2.492$, $p > .05$, partial $\eta^2 = .178$) (see Figure 1). ANOVA was also used to examine differences between the groups on depression. The test did not reveal significant accuracy group differences on the CMDI (Mood and Evaluative scales) ($F_{(2, 24)} = 1.785$, $p > .05$, partial $\eta^2 = .129$).

The MS and control groups were combined to examine whether a disproportionate number of MS patients were included in one of the three accuracy groups. However, the chi square test for independence revealed that the distributions of the two groups were not significantly different (χ^2 (2, N = 124) = .018, p >.05).

To provide another way to examine these data, impaired (executive index z-score < -1.5 standard deviations) and non-impaired (executive index z-score > -1.5 standard deviations) groups were created. It was found that 11 participants demonstrated impaired performance on the executive index, all of them in the MS group. Because all impaired participants were in the MS group, the following analysis was completed for the MS participants only. A chi square test for independence was used to determine if the impaired participants were more likely to fall in one of the three accuracy groups. However, the test did not reveal significant results (χ^2 (2, N = 97) = 2.870, p >.05).

Question 2

In order to address Question 2 (whether the significant others of MS patients are accurate in rating the patients' executive functioning skills), the relationship between the informant-rated DEX z-scores for the MS patients and the executive index scores was examined using Pearson's correlations. The correlation was significant and had a small effect size (r = -.213, p < .05). The procedure was repeated for the control participants in order to examine whether the significant others of controls are able to rate the controls accurately. As was true for the controls' self ratings, this correlation was not significant (r = -.053, p > .05). Fisher's r to z transformation was performed

in order to examine whether the two correlations were significantly different. However, the test did not reveal significant results ($p > .05$). Fisher's r to z transformation was also used to examine whether the correlations between the self-rated DEX and the executive index and the informant-rated DEX and the executive index were significantly different for both participant groups. However, the tests revealed no significant differences for the MS or control groups ($p > .05$)

In order to examine how participants with discrepancies between informant ratings and their actual performance differ from participants whose informants' ratings were accurate, discrepancy scores (difference between the informant-rated DEX and the executive index) were calculated for all participants and the participants were categorized based on the accuracy of their significant others' ratings, following the same procedure described for the self-rated accuracy groups. Participants were divided into three groups using the control sample as a reference group: accurate informants (informant ratings on the DEX and executive index mostly agree, 25-75th percentile), problem overestimating informants (informant ratings on the DEX indicate more problems than the executive index, $\leq$ 25th percentile), and problem underestimating informants (informant ratings on the DEX indicate fewer problems than the executive index, $\geq$ 75th percentile).

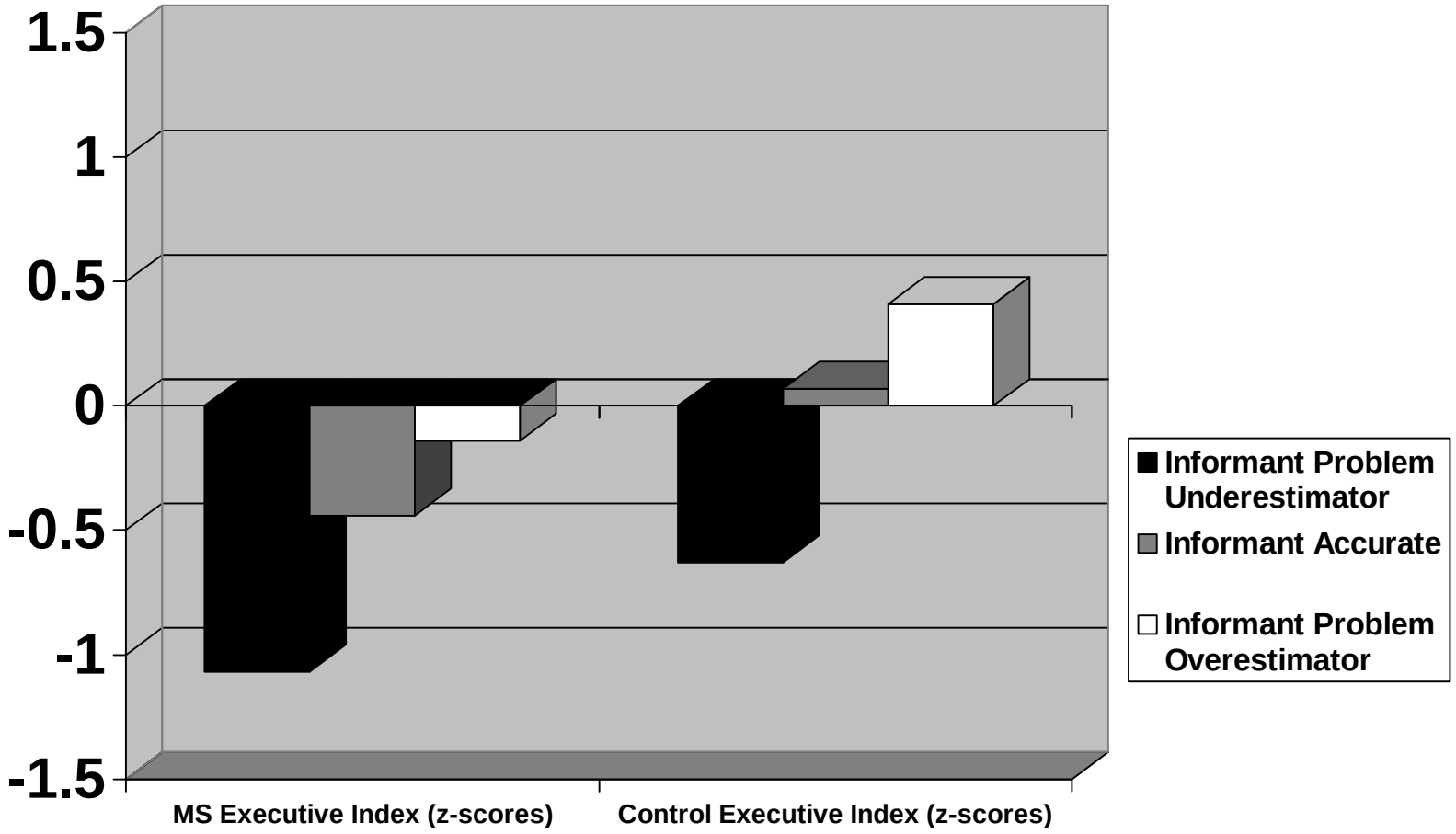
Again, the participant groups were analyzed separately and I will first report the analyses for the MS group. Using the cut-offs described previously, there were 14 participants in the informant problem overestimating group, 55 participants in the informant accurate rating group, and 26 participants in the informant problem

underestimating group. Chi square tests for independence revealed no significant differences for sex (χ^2 (2, N = 95) = 2.146, p >.05) between the three accuracy groups.

As described previously, the three informant accuracy groups (i.e. accurate informants, overestimating informants, and underestimating informants) were compared on other demographic and illness variables using ANOVA and multivariate analysis of variance (MANOVA) (see Table 5). Due to the high intercorrelations between the variables and in order to reduce risk of error due to multiple comparisons, MANOVA was used to compare the three informant accuracy groups on age, symptom duration, and diagnosis duration. The multivariate test was not significant (Lambda $_{(8, 180)}$ = .873, p > .05), so the univariate tests were not examined. A one-way ANOVA with years of education as the dependent variable did not reveal significant differences between the three groups ($F_{(2, 92)}$ = .020, p > .05, partial η^2 = .000).

Again, ANOVA was used to determine whether the discrepancy scores indicate valid differences between groups on objective cognitive tests, with the level of informant accuracy as the grouping variable and the executive index as the dependent variable. This test revealed a significant difference between the three groups ($F_{(2, 92)}$ = 8.516, p < .001, partial η^2 = .156). Tukey's HSD post-hoc test was used to determine the nature of the differences between the groups. Significant differences were found between the informant problem underestimator group (M = -1.07, SD = .90) and the informant problem overestimator group (M = -.14, SD = .77, $p \leq .001$) and the informant accurate group (M = -.44, SD = .70, p < .005) (see Figure 2). However, ANOVA did not reveal significant informant accuracy group

Figure 2: Executive Functioning by Informant Accuracy Group



differences on the CMDI (Mood and Evaluative scales) ($F_{(2, 92)} = .196$, $p > .05$, partial $\eta^2 = .004$).

Now, I will report the results of the analyses for the control participants. Using the cut-offs described previously, there were 6 participants in the informant problem overestimating group, 14 participants in the informant accurate rating group, and 6 participants in the informant problem underestimating group. ANOVA was used to compare the three informant accuracy groups on age and education. One-way ANOVA's with age ($F_{(2, 23)} = 1.451$, $p > .05$, partial $\eta^2 = .112$) and education ($F_{(2, 23)} = .108$, $p > .05$, partial $\eta^2 = .009$) as the dependent variables did not reveal significant differences between the three groups. Unfortunately, the sample did not include enough males to analyze possible sex differences between the informant accuracy groups.

ANOVA was used to determine whether the discrepancy scores indicate valid differences between groups on objective cognitive tests, with the level of informant accuracy as the grouping variable and the executive index as the dependent variable. This test revealed a significant difference between the three groups ($F_{(2, 23)} = 4.591$, $p < .05$, partial $\eta^2 = .285$). Tukey's HSD post-hoc test was used to determine the nature of the differences between the groups. Significant differences were found between the informant problem underestimator group ($M = -.63$, $SD = .52$) and the problem overestimator group ($M = .41$, $SD = .76$, $p < .05$) (see Figure 2). In examining the variables of interest for violations of assumptions, it was found that Levene's Test of Equality of Error Variances was significant for the CMDI (Mood and Evaluative scales) ($F_{(2, 23)} = 5.517$, $p < .05$). Using the rationale described previously, the

Browne-Forsythe statistic was used to examine differences between the discrepancy groups based on depression in addition to ANOVA. There were no significant differences between the three groups as measured by ANOVA ($F_{(2, 23)} = 1.644$, $p > .05$, partial $\eta^2 = .125$) or by the Browne-Forsythe statistic (1.100, $p > .05$).

As before, the MS and control groups were combined to examine whether a disproportionate number of MS patients were included in one of the three informant accuracy groups. However, the chi square test for independence revealed that the two groups were not significantly different ($\chi^2 (2, N = 121) = 1.060$, $p > .05$).

A chi square test for independence was used to examine whether the previously described impaired MS group was more likely to fall into one of the informant accuracy groups. However, this test could not be interpreted when examining all three informant accuracy groups due to the fact that no impaired participants were in the informant problem overestimator group and chi square analyses depend on no cell values being under 1. Therefore, this analysis was completed comparing the accurate informant group and the informant problem overestimator group. The test revealed significant results ($\chi^2 (1, N = 81) = 9.640$, $p < .005$, Fisher's Exact Test). The accurate informant group had 3 (5.5%) impaired participants and the informant problem underestimator group had 8 (30.8%).

Question 3

In order to more thoroughly investigate the meaning of the DEX ratings and address the initial portion of Question 3, two stepwise linear regressions (one for MS patients and one for control participants) were conducted with the self-rated DEX as the

criterion variable. The predictor variables were the executive index score, the non-executive index score, and the CMDI (Mood and Evaluative scales only). The non-executive index score was entered because previous research (Randolph et al., 2003) has indicated that executive functioning deficits may predict MS patients' metamemory ratings. It may be that when people report cognitive difficulties, they do not distinguish between cognitive domains and simply answer based on cognitive difficulties in general. This analysis addressed the specificity of the DEX in this population. The CMDI was entered to examine the role of depression in reporting of executive functioning deficits in this sample. As stated previously, research has suggested that depression affects the reporting of general cognitive difficulties (Carone et al., 2005; Matotek et al., 2001) and memory difficulties (Bruce & Arnett, 2004; Randolph et al., 2003). However, for the MS participants, it was found that the model only retained the executive index score as a significant predictor (adjusted R^2 = .155, $F_{(1,95)} = 18.593$, $p < .001$). For the controls, the model only retained the CMDI (Mood and Evaluative scales) as a significant predictor (adjusted $R^2 = .264$, $F_{(1,25)} = 10.315$, $p < .005$).

Stepwise linear regressions were also completed for the informant-rated DEX to examine the variables that contribute to the ratings. The informant-rated DEX z-score was the criterion variable and the executive index score, the non-executive index score, and informant-rated CMDI (Mood and Evaluative scales only) were the predictor variables. These analyses address the latter part of Question 3. For the MS participants' self-rated DEX scores, the model retained the executive index score (adjusted $R^2 = .052$, $F_{(1,90)} = 6.021$, $p < .05$) and the informant-rated CMDI (adjusted

R^2 = .195, $F_{(2,89)}$ = 12.046, p < .001) as significant predictors of the informant-rated DEX scores. The non-executive index score was not a significant predictor. For the controls, the model only retained the informant-rated CMDI as a significant predictor (adjusted R^2 = .519, $F_{(1,24)}$ = 27.937, p < .001). The executive and non-executive indices were not significant predictors.

Question 4

To address Question 4, a discrepancy score was calculated between the self-rated DEX z-score and the informant-rated DEX z-score for both MS and control participants. As described previously, each population was divided into three groups based on the lowest quartile, the middle two quartiles, and the upper quartile of the discrepancy scores obtained from the control sample. These groups are a self-informant high agreement group (participant ratings and informant ratings on DEX mostly agree), a high disagreement group in which the participants endorsed more problems than the significant others, and a high disagreement group in which the significant others endorsed more problems than the participants, following Cavallo et al. (1992).

As described previously, each group (MS vs. control) was tested separately. I will first describe the results for the MS group. Using the cut-offs described previously, there were 24 participants in the high disagreement (informant problem rating > self rating) group, 30 participants who rated themselves about the same on the DEX as their informants did (the agreement group), and 41 participants in the high disagreement (self rating > informant problem rating) group (see Table 5). The

chi square test for independence was used to examine possible sex differences between the three self-informant agreement groups and revealed no significant differences ($\chi^2(2, N = 50) = 0.14, p > .05$).

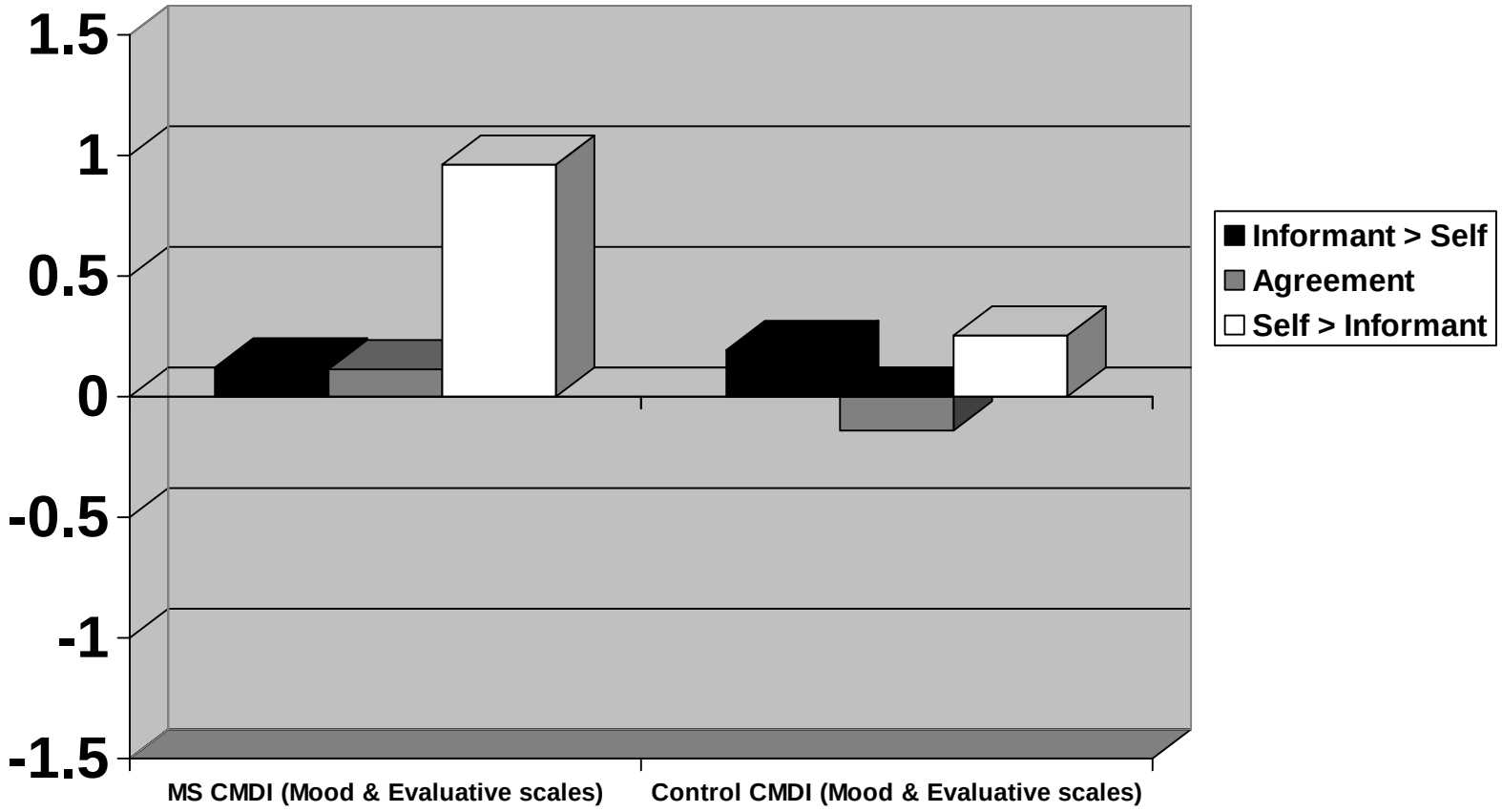
In examining the variables of interest for violations of assumptions, it was found that Levene's Test of Equality of Error Variances was significant for age ($F_{(2, 92)} = 3.380, p < .05$). Using the rationale described previously, the Browne-Forsythe statistic was used to examine differences between the discrepancy groups based on age in addition to ANOVA. There were no significant differences between the three groups based on age as measured by ANOVA ($F_{(2, 92)} = 1.438, p > .05$, partial $\eta^2 = .030$) or by the Browne-Forsythe statistic (1.327, $p > .05$). Due to the high intercorrelations between the variables and in order to reduce risk of error due to multiple comparisons, MANOVA was used to compare the three discrepancy groups on symptom duration and diagnosis duration. The multivariate test was not significant (Lambda $_{(4, 182)} = .976, p > .05$), so the univariate tests were not examined. A one-way ANOVA with years of education as the dependent variable did not reveal significant differences between the three groups ($F_{(2, 92)} = .878, p > .05$, partial $\eta^2 = .019$).

As the discrepancy between self and informant ratings of executive functioning has previously been used as a measure of insight (Fleming et al., 1996), it is important to examine whether there are valid differences between the agreement groups on objective cognitive tests. Therefore, in a one-way ANOVA, level of agreement was the grouping variable while the executive index was entered as the dependent variable. However, ANOVA revealed no significant differences between the three agreement groups ($F_{(2, 92)} = 2.006, p > .05$, partial $\eta^2 = .042$). To determine if

the agreement groups differed in level of depression, a one-way ANOVA was completed with the CMDI (Mood and Evaluative scales) as the dependent variable. However, it was found that Levene's Test of Equality of Error Variances was significant for this variable ($F_{(2, 92)} = 4.113$, $p < .05$). Using the rationale described previously, the Browne-Forsythe statistic was used to examine differences between the discrepancy groups based on depression in addition to ANOVA. Both the ANOVA ($F_{(2, 92)} = 4.211$, $p < .05$, partial $\eta^2 = .084$) and the Browne-Forsythe statistic (4.989, $p < .01$) revealed significant differences between the groups. Tukey's HSD post-hoc test was used to determine the nature of the differences between the groups. Significant differences were found between the agreement group ($M = .12$, $SD = 1.16$) and the high disagreement (self problem rating > informant rating) group ($M = .96$, $SD = 1.74$, $p < .05$), with a trend ($p = .057$) suggesting a significant difference between the high disagreement (informant problem rating > self rating) group ($M = .12$, $SD = .95$) and the high disagreement (self problem rating > informant rating) group (see Figure 3).

Now, I will report the results of the analyses for the control participants. Using the cut-offs described previously, there were 6 participants in the high disagreement (informant problem rating > self rating) group, 14 participants who rated themselves about the same on the DEX as their informants did (the agreement group), and 6 participants in the high disagreement (self rating > informant problem rating) group. ANOVA was used to compare the three informant accuracy groups on age and education. A one-way ANOVA with age as the dependent variable revealed significant differences between the three groups ($F_{(2, 23)} = 5.838$, $p < .01$, partial $\eta^2 =$

Figure 3: Depression by Discrepancy Group



.337). Tukey's HSD post-hoc test was used to determine the nature of the differences between the groups. Significant differences were found between the agreement group (M = 38.93, SD = 11.05) and the high disagreement (self problem rating > informant rating) group (M = 53.83, SD = 12.42, $p < .05$) and between the agreement group and the high disagreement (informant rating > self problem rating) group (M = 53.00, SD = 8.00, $p < .05$). One-way ANOVA also revealed significant results for years of education ($F_{(2, 23)} = 3.687$, $p < .05$, partial $\eta^2 = .243$). As before, Tukey's HSD post-hoc test was used to determine the nature of the differences between the groups. However, Tukey's HSD did not reveal significant differences between the agreement groups on multiple comparisons, save for a trend suggesting a significant difference between the agreement group (M = 14.21, SD = .52) and the high disagreement (self problem rating > informant rating) group (M = 16.50, SD = .79, p = .059). Again, the sample did not include enough males to analyze possible sex differences between the agreement groups.

ANCOVA was used to determine whether the discrepancy scores indicate valid differences between the agreement groups on objective cognitive tests, with the level of agreement as the grouping variable, education and age as covariates, and the executive index as the dependent variable. This test did not reveal a significant difference between the three groups ($F_{(2, 21)} = .443$, $p > .05$, partial $\eta^2 = .040$). A one-way ANOVA completed with the CMDI (Mood and Evaluative scales) as the dependent variable and level of agreement as the grouping variable also did not reveal significant differences between the groups ($F_{(2, 23)} = .401$, $p > .05$, partial $\eta^2 = .034$) (see Figure 3).

I will combine the MS and control groups to examine whether a disproportionate number of MS patients are included in one of the three agreement groups. The chi-square test for independence revealed no significant differences between the groups (MS vs. control) based on membership in the three agreement groups (χ^2 (2, N = 121) = 4.942, $p > .05$).

A chi square test for independence was used to examine whether the previously described impaired group was more likely to fall into one of the agreement groups. However, the test did not reveal significant results (χ^2 (2, N = 95) = 2.570, $p > .05$).

Discussion

In this study, I explored whether self-report and informant-report of executive dysfunction correlated with objective cognitive testing in MS and control samples. Beyond this, I also examined the relationship between DEX ratings and DEX discrepancies and demographic variables, depression, and performance on cognitive tasks. However, prior to addressing these central questions of this study, I will discuss some of the preliminary results.

It is first important to establish that the MS participants in this study demonstrate cognitive impairments similar to those seen in other samples of individuals with MS. Naturally, there is inherent variability in the disease characteristics of MS samples; however the results suggest that the participants in this study are representative of a mildly cognitively impaired, community-based sample. As expected, the MS participants performed significantly worse than the control participants on the majority of the executive and non-executive tasks. This finding

suggests that the MS participants are experiencing executive dysfunction that is apparent on cognitive testing and which therefore should be apparent on self and/or informant report.

Because the results established that the MS participants are experiencing higher levels of executive dysfunction than healthy controls, one is left with the question of whether this is reflected in self and informant report. As reviewed previously, some researchers have suggested that MS patients are able to accurately report their functioning (Chiaravalloti & DeLuca, 2003; Kujala et al., 1996; Matotek et al., 2001; Randolph et al., 2001), whereas others have suggested little to no correlation between self-report and objective testing (Beatty & Monson, 1991; Christodoulou et al., 2005; Gold et al., 2001; Hoogervorst et al., 2001; Maor et al., 2001; Marrie et al., 2005). The finding that the MS and control self-rated DEX scores are significantly different is support for the findings of the former group. The MS group is experiencing higher levels of executive dysfunction and they (as a group) report significantly more executive dysfunction than the control group. I will further explore the implications of these findings later in the discussion.

I will now review the central questions posed by this study and then address the results as they pertain to each question.

Question 1: Are individuals with MS similar to individuals with brain injuries in that they show a compromised ability to accurately rate their level of executive dysfunction? Or are they more similar to controls?

The results indicate that, unlike most findings in the traumatic brain injury literature (Fleming et al., 1996), the self-ratings of the MS participants in this study were highly correlated to their actual performance on the measures of executive functioning. The

more executive dysfunction demonstrated on the cognitive measures, the higher the MS participants rated themselves on the DEX, suggesting that, as a group, the MS participants did not demonstrate anosognosia. This finding has important clinical implications in that it suggests that the self-rated DEX is a viable screening measure for executive dysfunction at least in mildly impaired MS patients. Using this type of simple, quick-to-administer screening measure may assist neurologists and other health professionals in appropriately referring their patients with MS to clinical neuropsychologists for more comprehensive evaluations of their functioning.

With respect to the control participants, their DEX self-ratings did not significantly correlate with their actual performance on the cognitive tasks. A possible interpretation of this finding is that this has more to do with the restricted range of the controls' performance on the cognitive tasks. There was less variation in the controls' scores on the cognitive measures, leaving less variance to be accounted for in the statistical analyses. Additionally, the control sample size was relatively small, thereby limiting statistical power. However, this finding corresponds with Chan's (2001) report from a sample of 93 neurologically healthy participants, suggesting that it may be more than simply a statistical artifact. An intriguing alternative explanation for this finding is that, as individuals living with a chronic neurological illness, the MS participants were more attuned to errors in their thinking and thus, better able to accurately report their level of functioning. In other words, a cognitive failure on the part of a person with MS may be more personally significant than for a neurologically healthy person and may affect the way that that individual considers his or her cognitive abilities. Therefore, by virtue of thinking about and attending to their

cognitive functioning more than the average person and the increased personal relevance of cognitive failures, the MS participants were better able to report on their cognitive functioning. To my knowledge, there are few other studies that have examined the accuracy of control ratings on the DEX by testing the correlation with objective cognitive measures, so this question will require further study.

However, analyzing the participants as a single group does not allow examination of the ways in which individuals who overestimate or underestimate their level of functioning differ from those who are accurate in their ratings. For that reason, discrepancy groups were formed. It was hypothesized that individuals higher in executive dysfunction would be more likely to under-report their level of dysfunction on the DEX and that individuals higher in depression would be more likely to over-report their level of dysfunction on the DEX. These hypotheses were only partially supported by the results. When the discrepancy groups (problem overestimators, accurate raters, and problem underestimators) were examined, there were no significant differences between the three groups in terms of the executive index or depression level. Even an examination of the most impaired MS participants did not yield significant differences in terms of which accuracy group they fell in-unlike Beatty and Monson's (1991) findings in metamemory. This finding suggests that, at least when executive dysfunction is mild, it may not result in anosognosia. Alternatively, it may be that other factors, such as coping style, personality style (such as level of neuroticism), or cultural, occupational, familial and environmental demands play a larger role in determining awareness of executive functioning deficits (Ownsworth et al., 2006). Regarding depression, the lack of significant differences

between the accuracy groups on this variable may be due to the fact that the MS participants were not significantly more depressed than the controls when depression was measured by the CMDI mood and evaluative scales, suggesting that overall, the MS group was not particularly depressed. It may be that in a sample with overall higher levels of depression, the problem overestimators would be the most depressed, as found by Maor et al. (2001) and Marrie et al. (2005). However, as I will later discuss, the self and informant discrepancy groups were significantly different on depression, suggesting that while it may not be related to accuracy of ratings, it is related to discrepancies between self and informant.

It is important to note that the accuracy groups were significantly different on level of education, with the accurate rating group demonstrating the most years of education, consistent with Randolph et al.'s (2001) findings in metamemory in MS. These findings may be partially explained by Kruger and Dunning's (1999) suggestion that skill is required to be able to accurately rate one's own performance- it may be that the more intellectually "skilled" participants (i.e., those that were best equipped to rate themselves accurately) were those that had higher levels of education. However, for this to be the case, one would expect this pattern to be reflected in the control sample as well, which, as I will now discuss, it was not.

As was found in the MS sample, the control accuracy groups were not significantly different in terms of executive index scores or depression. However, the three groups were significantly different in terms of years of education. Unlike the MS group in which the accurate raters had the highest levels of education, in the control sample, the problem overestimator group demonstrated the highest level of

education. It is possible that individuals with higher levels of education are more likely to rate themselves negatively in general and this pattern emerged because for the MS participants, ratings indicative of more impairment are more likely to be accurate ratings, whereas in the control sample, ratings indicative of more impairment are more likely to be problem overestimators. However, this requires further study.

Question 2: Are the significant others of individuals with MS accurate in rating patients' executive functioning? Are the significant others of controls accurate in rating controls' executive functioning?

This question is particularly clinically relevant due to the common practice of assuming that informant ratings of cognitive deficits are more accurate than self ratings in neurological populations (Bogod et al., 2003; Fleming et al., 1996; Manchester et al., 2004). The results indicate that, although the informant-rated DEX scores of the MS participants were significantly correlated with the participants' actual performance on the executive measures, the effect size was much smaller than seen in the self-ratings (though the difference between them did not achieve statistical significance). Coupled with the finding that the informant-rated DEX scores for the MS participants were not significantly different from the informant-rated DEX scores for the controls while the self-ratings were, one can conclude that the significant others of the MS participants are not reporting dysfunction at higher levels than the significant others of neurologically healthy individuals. One possible explanation for this finding is that the types of executive errors that the participants with MS observed and reported on the self-rated DEX are not witnessed by family members. Items such as "I find it difficult to stop myself from doing something even if I know I

shouldn't," or "I have trouble making decisions, or deciding what I want to do," may represent an internal experience rather than an observable behavior in a mildly impaired patient who retains good insight. Considering that the participants in this investigation represent a mild to moderately impaired sample, it may be that they were still able to conceal or downplay subtle cognitive difficulties around family members, but that these subtle changes were detected on cognitive testing.

Clearly, if clinicians were to use informant ratings as a gold standard in a population such as our MS participants, they would be greatly underestimating the level of dysfunction experienced. This finding also has significant implications for work with families of MS patients. If the significant others of MS patients are likely to be less aware of the cognitive deficits that the patients experience, this tendency creates potential for misinterpretation of executive functioning problems, such as initiating or inhibiting behavior. Significant others who do not accurately perceive patients' executive dysfunction may have unrealistic expectations of the patients' behavior, motivation level, and ability to work towards goals. Education regarding executive dysfunction and its neurological basis may be helpful in these cases.

Though the results suggest that as a group, the informants in the MS group were not as successful at accurately reporting executive dysfunction, there is of course, individual variability within the sample. When examining the discrepancies between informant ratings and cognitive performance through examining the accuracy groups, some interesting results emerged. It was found that the informant problem underestimator group performed significantly worse on the cognitive tests than the accurate and the informant problem overestimator groups. This finding

indicates that it is not the case that the informant problem underestimator group is composed of individuals who simply performed in the average range while their significant others believed them to be in the superior range. In fact, not only were these participants' significant others inaccurate in rating their level of executive functioning, but these patients were the most impaired participants in the sample. Further substantiation is provided by the finding that significantly more impaired MS participants were in the informant problem underestimator group than in the agreement group. This finding has significant implications for research. Goverover et al. (2005) used the absolute value of the discrepancy between self and informant ratings as a measure of insight in their study of executive dysfunction awareness in MS and found that the discrepancy correlated with cognitive impairment. This was interpreted to suggest that cognitive impairment negatively influenced self-awareness. If the same method had been employed in this sample, the results would also have suggested that cognitive impairment negatively influenced self-awareness. However, this is an inaccurate assumption. The results of the present investigation suggest that, although cognitive impairment is related to the discrepancy between informant and self ratings, it is due to the informants' inaccurately low ratings of executive dysfunction, not the MS participants underestimating their difficulties.

Regarding the control participants, the only variable found to be significantly different for the three informant accuracy groups was their performance on the executive index. As was true for the MS group, the controls in the informant problem overestimator group performed the best on the cognitive measures while the controls in the informant problem underestimator group performed the worst. This finding

indicates that even in neurologically healthy samples, there is variability in the ability of informants to make accurate ratings of executive dysfunction.

Question 3: Do depression and/or demographic variables contribute to a person's rating of their own cognitive impairments? Do depression and/or demographic variables contribute to a significant other's rating of someone's cognitive impairments?

The results of the regression analyses suggested that for the MS participants, the DEX self-ratings were an accurate reflection of executive dysfunction and were not influenced unduly by depression or generalized cognitive problems. However, for the controls, depression was the only significant predictor to emerge from the model. These results are consistent with Matotek et al.'s (2001) report (described previously) suggesting that subjective cognitive difficulties correlated with objective performance for MS patients, but for controls, subjective cognitive difficulties correlated only with depression. This might suggest that in non-impaired populations, individuals do not have the experience of executive dysfunction on which to base their ratings and therefore, negative self-evaluation stemming from depressive cognitions is the driving force in their self-ratings.

In regards to the informant ratings, for the MS participants, the executive index score and the informant-rated depression score were the only significant predictors of the informant DEX ratings, whereas for the controls, the informant-rated depression score alone was found to be a significant predictor. This finding suggests that beyond rating the actual cognitive performance of the participants, the significant others in both groups were also influenced by their impression of the participants'

level of depression. Alternatively, it may be that the informants each reflected their own response bias- i.e. those that rated their significant others as having high levels of executive dysfunction would also rate their significant others as having high levels of depression. It is interesting that, for the control group, the participants' level of depression (both self-rated and informant-rated) predicted the DEX ratings while for the MS participants, only the participants' informant-rated CMDI was related to the informant-rated DEX. It is difficult to determine the reasons behind these relationships. One possibility is the proposition put forth previously in this discussion that the MS participants were simply better able to rate their own cognitive functioning due to its increased relevance to them. The greater contribution of depression in the control self and informant ratings and in the MS informant ratings may be an indicator of their inaccuracy. Future research may elucidate this question.

Question 4: Are cognitive functioning, depression, and/or demographic variables related to discrepancies between self and informant ratings on the DEX?

Perhaps one of the most interesting findings from this investigation was that the self and informant discrepancies, used as a measure of insight in both research (Carone et al., 2005; Goverover et al., 2005; Hart et al., 2005; Taylor, 1990) and clinical practice (Fleming et al., 1996), was not significantly correlated with objective cognitive performance. This is unlike the findings of Carone et al. (2005), Goverover et al. (2005), and Taylor (1990) in the MS literature. It may be that the general underestimation of executive dysfunction by the informants in the present study is responsible for the lack of correlation between objective testing and the self and

informant discrepancy. Regardless, this finding suggests that the discrepancy between informant and self ratings of executive dysfunction is not always an effective measure of insight into cognitive deficits. Alternatively, it may be that the self and informant discrepancy method somehow captures a measure of insight that is not an intrinsic part of executive functioning as measured by the executive tasks used in this study. The definition of executive functioning is itself a fluid concept and the question of whether insight is always negatively affected by executive dysfunction is still an open one (Ownsworth et al., 2006).

Another important finding is that the MS patients with higher self than informant DEX ratings were significantly more depressed than the agreement or higher informant than self DEX rating groups. Although depression did not emerge as a significant predictor of self DEX ratings, this finding suggests that depression is a contributing factor in the discrepancies between self and informant ratings. Additionally, these results are in agreement with Carone et al.'s (2005) findings regarding self and informant discrepancies in reports of general cognitive impairment. It may be that MS patients experiencing a higher level of depression are more influenced by negative cognitive schemata (Beck, 1979) that lead them to see rate their behaviors more negatively.

In the control group, the self-informant agreement discrepancy groups differed only based on age and education. It is not clear why the controls in the agreement group were younger than the participants in both disagreement groups. It may be that there were different expectations for the cognitive functioning of older people that lead to disagreements in ratings between self and informants. However, both

disagreement groups were significantly different from the agreement group, suggesting that there is no clear pattern.

Limitations

There are a number of limitations to the conclusions that can be drawn from the current study. First, this sample of individuals with MS was demonstrating only mild to moderate symptoms of cognitive dysfunction; i.e. only 11 MS participants could be classified as objectively impaired (greater than 1.5 standard deviations below the mean) on executive tasks. However, this limited impairment is characteristic of community-based samples and is more reflective of the type of awareness of deficits seen in a mildly impaired sample. In this way, this study addresses a relatively neglected population, as many studies of awareness of deficits in MS have relied on clinic-based samples (Carone et al., 2005; Christodoulou et al., 2005; Taylor, 1990).

Another limitation of the present study is the size of the control sample. A larger sample would have afforded more power to the statistical analyses. However, the inclusion of a neurologically healthy control group in a study of this type is fairly uncommon. While Chiaravalloti and DeLuca (2003) and Goverover et al. (2005) included controls in their studies of awareness of executive dysfunction in the MS literature, their results were not analyzed as thoroughly as the MS participants' results.

This study is limited by its specific applicability to a mildly impaired MS sample and awareness of executive dysfunction as measured by the DEX. Future research in this area should explore awareness in a variety of cognitive domains

(though meta-memory has already been significantly examined) or perhaps the utilization of multiple measures of awareness in order to determine which are most effective.

Lastly, this study is correlational in nature and cannot be used to examine causal relationships. Though such a study would be very challenging in its logistics, an ideal way to study the influence of MS on awareness of executive dysfunction would be to follow individuals with MS over time and assess their level of anosognosia at more than one time-point. Even more ideal would be to target individuals prior to their diagnosis with MS to obtain baseline measures. However, due to the inherent difficulties in pinpointing the time of onset of the illness, this type of study would be highly impractical, if not impossible.

Conclusions

These data indicate that mild to moderately cognitively impaired individuals with MS can provide accurate self-ratings of executive dysfunction. Even though their cognitive performance on measures of executive functioning was well below that of the controls, the MS participants' self-ratings of executive dysfunction were still more highly correlated with objective cognitive testing than that of their significant others. Future research could examine the utility of using self-report measures of cognitive dysfunction such as the DEX as an economical screening measure for subsequent referrals to more comprehensive neuropsychological testing. Additionally, researchers examining anosognosia in mildly impaired neurological populations should not simply rely on discrepancies between self and informant ratings, as

informants may underestimate the level of actual impairment. These data also suggest that it is possible to preserve some level of self-awareness of deficits even with executive functioning impairments that affect daily behavior and performance on objective cognitive tests.

This investigation significantly extends the work of Chiaravalotti & DeLuca (2003) and Goverover et al. (2005) in that a much larger sample of both MS and control participants was used and that the accuracy of informant ratings were questioned. Additionally, it represents the first exploration of the accuracy of self and informant ratings of executive dysfunction in MS and controls that also incorporates an investigation of the factors contributing to discrepancies between self and informant ratings as well as the factors contributing to the ratings themselves. Replication of these findings may suggest avenues to pursue in increasing our understanding of the relationship between executive functioning deficits and anosognosia.

Appendix: Test Orders

Order A

Psychosocial Interview
Visual Screen
Digit-Symbol Copy from the WAIS-III
Computerized Analysis of Response Bias
10/36 Spatial Recall, Immediate Recall
False Memory Task, Slow lists (A lists)
Shipley Institute of Living Scale
Number Repetition Test, Standard
10/36 Spatial Recall, Delayed Recall
10/36 Spatial Recall, Copy
Beck Depression Inventory-II
Affective Reading Span + Free Recall at end
Chicago Multiscale Depression Inventory
Fatigue Severity Scale
Brief Pain Inventory, Short Form
Verbal Selective Reminding Test, Immediate Recall
Symbol Digit (Oral form w/ incidental recall)
Test of Everyday Attention: Visual Elevator, Form B
Symbol Digit (Oralmotor)
Verbal Selective Reminding Test, Delayed Recall
Number Repetition Test, Yoked
State Trait Anxiety Inventory
Beck Depression Inventory-1, Lauren Strober version
False Memory Task, Fast lists (B lists)
Controlled Oral Word Association Test (COWAT)
Cued Reading Span + Free Recall at end
Stroop Color-Word Test
Motivation Rating Scale (Participant)
Motivation Rating Scale (Experimenter on participant)
MS Rating Scale ***(MS Participants Only)***
SCID Interview for MDE
Debriefing

Order B

Psychosocial Interview
Visual Screen
Digit-Symbol Copy from the WAIS-III
Computerized Analysis of Response Bias
Verbal Selective Reminding Test, Immediate Recall
Symbol Digit (Oral form w/ incidental recall)
Fatigue Severity Scale
Test of Everyday Attention: Visual Elevator, Form B
Symbol Digit (Oralmotor)
Verbal Selective Reminding Test, Delayed Recall
Number Repetition Test, Yoked
Beck Depression Inventory-II
Affective Reading Span + Free Recall at end
Chicago Multiscale Depression Inventory
10/36 Spatial Recall, Immediate Recall
False Memory Task, Fast lists (B lists)
Shipley Institute of Living Scale
10/36 Spatial Recall, Delayed Recall
10/36 Spatial Recall, Copy
Number Repetition Test, Standard
State Trait Anxiety Inventory
Beck Depression Inventory-1, Lauren Strober version
False Memory Task, Slow lists (A lists)
Brief Pain Inventory, Short Form
Controlled Oral Word Association Test (COWAT)
Cued Reading Span + Free Recall at end
Stroop Color-Word Test
Motivation Rating Scale (Participant)
Motivation Rating Scale (Experimenter on participant)
MS Rating Scale ***(MS Participants Only)***
SCID Interview for MDE
Debriefing

Order C
Psychosocial Interview
Visual Screen
Digit-Symbol Copy from the WAIS-III
Computerized Analysis of Response Bias
10/36 Spatial Recall, Immediate Recall
False Memory Task, Fast lists (A lists)
Shipley Institute of Living Scale
Number Repetition Test, Standard
10/36 Spatial Recall, Delayed Recall
10/36 Spatial Recall, Copy
Beck Depression Inventory-II
Affective Reading Span + Free Recall at end
Chicago Multiscale Depression Inventory
Fatigue Severity Scale
Brief Pain Inventory, Short Form
Verbal Selective Reminding Test, Immediate Recall
Symbol Digit (Oral form w/ incidental recall)
Test of Everyday Attention: Visual Elevator, Form B
Symbol Digit (Oralmotor)
Verbal Selective Reminding Test, Delayed Recall
Number Repetition Test, Yoked
State Trait Anxiety Inventory
Beck Depression Inventory-1, Lauren Strober version
False Memory Task, Slow lists (B lists)
Controlled Oral Word Association Test (COWAT)
Cued Reading Span + Free Recall at end
Stroop Color-Word Test
Motivation Rating Scale (Participant)
Motivation Rating Scale (Experimenter on participant)
MS Rating Scale ***(MS Participants Only)***
SCID Interview for MDE
Debriefing

Order D
Psychosocial Interview
Visual Screen
Digit-Symbol Copy from the WAIS-III
Computerized Analysis of Response Bias
Verbal Selective Reminding Test, Immediate Recall
Symbol Digit (Oral form w/ incidental recall)
Fatigue Severity Scale
Test of Everyday Attention: Visual Elevator, Form B
Symbol Digit (Oralmotor)
Verbal Selective Reminding Test, Delayed Recall
Number Repetition Test, Yoked
Beck Depression Inventory-II
Affective Reading Span + Free Recall at end
Chicago Multiscale Depression Inventory
10/36 Spatial Recall, Immediate Recall
False Memory Task, Slow lists (B lists)
Shipley Institute of Living Scale
10/36 Spatial Recall, Delayed Recall
10/36 Spatial Recall, Copy
Number Repetition Test, Standard
State Trait Anxiety Inventory
Beck Depression Inventory-1, Lauren Strober version
False Memory Task, Fast lists (A lists)
Brief Pain Inventory, Short Form
Controlled Oral Word Association Test (COWAT)
Cued Reading Span + Free Recall at end
Stroop Color-Word Test
Motivation Rating Scale (Participant)
Motivation Rating Scale (Experimenter on participant)
MS Rating Scale ***(MS Participants Only)***
SCID Interview for MDE
Debriefing

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EDUCATION

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Brown Medical School, Providence, Rhode Island (7/2006- 6/2007), Clinical Internship

HONORS AND AWARDS

2006 National Academy of Neuropsychology Student Research Award
2005 Psi Chi, Penn State Chapter Graduate Instructor of the Year
2005 University Teaching Fellowship recipient, Penn State University
2001 University Fellowship recipient, Penn State University
1999 Walkley Prize for outstanding original research in psychology, Wesleyan University

PUBLICATIONS

Peer Reviewed Journals

Motl, R.W., Arnett, P.A., **Smith, M.M.**, Barwick, F.H., Ahlstrom, B.P., & Stover, E.J. (in submission) Worsening of Symptoms is Correlated with Physical Activity in Individuals with Multiple Sclerosis.

Arnett, P.A., **Smith, M.M.**, Barwick, F.H., Benedict, R.H.B., & Ahlstrom, B.P. (in submission) Oralmotor Slowing in Multiple Sclerosis: Relationship to Complex Neuropsychological Tasks Requiring an Oral Response.

Smith, M.M., & Arnett, P.A. (in press). Dysarthria Predicts Poorer Performance on Cognitive Tasks Requiring a Speeded Oral Response in an MS Population. *Journal of Clinical and Experimental Neuropsychology.*

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Book Chapters

Arnett, P.A. & **Smith, M.M.** (in press) Cognitive Functioning and Everyday Tasks in Multiple Sclerosis. In *Everyday Functioning: Translating Laboratory Performance to the Real World,* New York, NY: Guilford Press.

Selected Posters and Presentations

Smith, M.M. & Arnett, P.A. Perfectionistic concern over mistakes and physical disability predict depression in an MS population: Replication and extension. Presented at the 2006 National Academy of Neuropsychology Conference, San Antonio, TX.

Smith, M.M. & Arnett, P.A. Dysarthria predicts poorer performance on cognitive tasks requiring a speeded oral response in an MS population. Presented at the 2005 National Academy of Neuropsychology Conference, Tampa, FL.

Smith, M.M. & Arnett, P.A. Significant other vs. self ratings of executive dysfunction: MS participants vs. controls. Presented at the 2005 International Neuropsychological Society Conference, St. Louis, MO.

Smith, M.M. & Arnett, P.A. The validity of a self-report measure of executive functioning in an MS population. Presented at the 2004 National Academy of Neuropsychology Conference, Seattle, WA.

Smith, M.M. & Arnett, P.A. Stability of coping strategies in multiple sclerosis: data from a longitudinal study. Presented at the 2004 International Neuropsychological Society Conference, Baltimore, MD.

Smith, M.M. & Arnett, P.A. Perfectionism and physical disability predict depression in an MS population. Presented at the 2003 National Academy of Neuropsychology Conference, Dallas, TX.