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Self-reported executive dysfunction, neuropsychological impairment, and functional outcomes in multiple sclerosis

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Abstract

Although cognitive deficits are common in persons with multiple sclerosis (MS), the relationship between subjective complaints and objective impairment is sometimes obscured. To elaborate this issue, the present study examined the relationship between subjective complaints of dysexecutive syndrome, neuropsychological performance, and self-reported activities of daily living in 42 people with MS and 13 control participants. Regression analyses revealed that subjective complaints of impairment, measured by the Frontal Systems Behavior Scale (FrSBe), emerged as a significant predictor of neuropsychological deficit and poor adaptive function. Accordingly, subjective complaints of dysexecutive function in MS may serve as a potent indicator of cognitive and functional impairment. Implications for research and clinical practice are discussed.

Keywords

Multiple sclerosis; Executive function; Dysexecutive syndrome; Functional outcomes; Disability

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Multiple sclerosis (MS) is a chronic, inflammatory disease that diminishes neural connections within the central nervous system. The disease is marked by a variety of cerebral features such as ventricular enlargement and cortical atrophy. The most common pathological characteristics, however, are areas of demyelination and axonal damage. Although demyelenating lesions may occur anywhere in the brain or spinal cord, they are most apt to manifest in periventricular regions of the frontal and parietal lobes (Sperling et al., 2001). Corresponding with these lesions, 60–70% of people with MS display some form of neuropsychological deficit (Bobholz & Rao, 2003; Rao, Leo, Bernardin, & Unverzagt, 1991). Perhaps given the proclivity of the disease for frontal regions of the brain, deficits on measures of executive function are especially common (Rao et al., 1991). Indeed, frontal

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lobe lesions emerge as potent and specific predictors of impaired executive function in MS (Arnett et al., 1994; Swirsky-Sacchetti et al., 1992).

Notably, such neurocognitive deficit increases patient morbidity, and it is associated with diminished activities of daily living and functional outcomes. For example, neuropsychologically impaired people with MS are likely to be unemployed and unable to manage numerous activities of daily living (e.g., Benedict et al., 2005; Rao et al., 1991). Additionally, given the ostensible frontal lobe involvement with the disease, meaningful changes in behavior and personality occur in people with MS. For instance, Benedict, Priore, Miller, Munschauer, and Jacobs (2001) found that MS was associated with increased neuroticism and decreased empathy, conscientiousness, and agreeableness. Such behaviors are commonly associated with lesions to the frontal lobes and may correspond with symptoms of executive dysfunction including apathy, poor impulse control, and impaired planning and reasoning (Tekin & Cummings, 2002). Despite this possibility, few studies have examined the interrelationship between behavioral changes associated with frontal lobe dysfunction, performance on neuropsychological tests, and activities of daily living among people with MS. Inasmuch as these domains of function interrelate, the presence of MS-related executive dysfunction may correspond with neuropsychological deficit and impaired ability to manage daily activities and functional outcomes.

Chiaravalloti and DeLuca (2003) addressed this issue in part. They investigated whether self-reported symptoms of frontal lobe dysfunction correspond with neuropsychological deficits on measures of executive function in MS. Symptoms of frontal lobe dysfunction were assessed with the Frontal Systems Behavior Scale (FrSBe). The FrSBe is intended to measure neurobehavioral manifestations of prefrontal lesions (Grace, Stout, & Malloy, 1999). Specifically, the FrSBe assesses three frontal system behavioral syndromes, which are labeled apathy (e.g., “I sit around doing nothing”), disinhibition (e.g., “I do risky things just for the heck of it”), and executive function (e.g., “I mix up a sequence and get confused when doing several things in a row”). Although the FrSBe assesses these three domains of frontal lobe lesions, it is commonly referred to as a measure of executive dysfunction (e.g., Goverover, Chiaravalloti, & DeLuca, 2005a). Chiaravalloti and DeLuca found that FrSBe scores correlated with worse performance on the neuropsychological tests, especially those measuring executive function and working memory. These data may have revealed a convincing relationship between behavioral and cognitive symptoms of executive dysfunction, because, like frontal behavioral syndromes, these executive neuropsychological abilities are presumed to reflect frontal lobe integrity.

Goverover et al. (2005a) elaborated upon this finding using the same sample of people as that studied by Chiaravalloti and DeLuca (2003). Patients and family member informants completed the FrSBe, and the discrepancy between patients and their informants was examined. Patients whose self-ratings were discordant with ratings of informants tended to have greater executive dysfunction and working-memory deficits. Goverover et al. asserted that patients with greater executive dysfunction tend to have poorer self-awareness of behavioral problems associated with a dysexecutive syndrome.

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Despite this possibility, the patients in the Chiaravalloti and DeLuca (2003) and Goverover et al. (2005a) studies did not present with significant cognitive impairment. Across a battery of 13 neuropsychological tests, the patients generally performed in a manner commensurate with that of a control group. Only on a measure of sustained auditory working memory did the people with MS perform worse than the control group. Additionally, less than a majority of the patients reported clinically elevated dysexecutive symptoms on the FrSBe. It seems likely that the relationship between neuropsychological performance and dysexecutive symptoms may be especially salient in a group of patients with pronounced cognitive deficit.

Additionally, neither study examined whether presence of dysexecutive symptoms predicted diminished activities of daily living. Prior research shows that cognitive impairment corresponds with diminished activities of daily living in MS (Benedict et al., 2005; Higginson, Arnett, & Voss, 2000; Rao et al., 1991). Yet, no study of people with MS has determined whether self-reported dysexecutive symptoms as assessed by the FrSBe predict poor functional outcomes. From related research involving patients with schizophrenia or dementia, compelling data imply that the FrSBe predicts significant impairment in various activities of daily living (Boyle, Malloy, & Salloway, 2003; Norton, Malloy, & Salloway, 2001; Velligan, Ritch, Sui, DiCocco, & Huntzinger, 2002). Dysexecutive symptoms may also predict impaired activities of daily living in people with MS.

Accordingly, the present study examined whether self-reported dysexecutive symptoms measured by the FrSBe predict impaired neuropsychological function and subjectively reported activities of daily living. Paralleling past research, we hypothesized that scores on the FrSBe would correlate with diminished performance on neuropsychological tests. Specifically, because the FrSBe is designed to assess symptoms reflecting frontal lobe dysfunction, we expected that the FrSBe would correlate significantly with measures of executive function, working memory, and manual dexterity. Additionally, intrusion errors are commonly reported among patients with frontal lobe dysfunction as they try to recall newly learned material (cf. Delis et al., 2005; Rouleau, Imbault, Laframboise, & Bedard, 2001). Consequently, we hypothesized that the FrSBe would predict poor recall accuracy marked by a greater number of recall and recognition intrusion errors. In contrast, capacity to recognize objects tactually is associated with posterior brain lesions, and such astereognosis occurs commonly in people with MS. Thus, we expected that FrSBe scores would not correlate with tactile form recognition skill.

FrSBe scores were also anticipated to correspond with compromised activities of daily living. We anticipated that those aspects of daily function that involve planning and reasoning would be more highly correlated with FrSBe scores than would those that do not. For instance, we expected that FrSBe scores would correlate with measures of work and social functioning more so than with measures of mobility or feeding skill. In examining this relationship, we sought to control for diminished mobility. Prior research revealed that poor mobility is common in people with MS, and it is a potent and salient predictor of compromised activities of daily living (Rao et al., 1991).

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METHOD

Participants

To recruit participants, notices were published in the newsletter of the local National Multiple Sclerosis Society chapter and in newspapers. An investigator also met with MS support groups. All persons volunteered to participate in the present study. Ultimately, data were collected from 42 individuals with MS. Owing to practical limitations, the control group included only 13 participants without MS. Patients were excluded if they had a psychiatric disorder that preceded onset of MS, current or past substance abuse or dependence, history of learning or developmental disorders, or any neurological disease or injury besides MS. Current complaints of depression or anxiety were not criteria for exclusion. The control group was screened for each of these characteristics, including current psychiatric illness. The control group was included to increase the potential range of scores on the self-report and neuropsychological tests. In doing so, we intended to increase the ability of our statistics to detect meaningful relationships among the variables (Stevens, 1986).

Descriptive statistics concerning the patient and control groups appear in Table 1. Parametric and nonparametric statistics revealed that the two groups did not differ according to gender or age, but the control group had more years of education than the patient group.

Diagnoses were confirmed by a board-certified neurologist through chart review—including magnetic resonance imaging (MRI) and other laboratory studies—and physical examination, and these diagnoses were according to the Poser et al. (1983) criteria. The patient group included 22 with a relapsing–remitting course, 8 with either primary progressive or secondary progressive course, and 12 with an uncertain disease course. Average age of onset was 36.26 years ($SD = 9.89$).

Materials

Self-reported dysexecutive symptoms

Frontal Systems Behavior Scale (FrSBe).: The FrSBe, formerly known as the Frontal Lobe Personality Scale (FloPS), is an instrument that measures neurobehavioral traits associated with regions of the prefrontal cortex (Grace et al., 1999). The FrSBe provides measures of three frontal system behavioral syndromes, which are labeled apathy (14 items; FrSBeA; e.g., “I sit around doing nothing”), disinhibition (15 items; FrSBeD; e.g., “I do risky things just for the heck of it”), and executive function (17 items; FrSBeE; e.g., “I mix up a sequence and get confused when doing several things in a row”), as well as a FrSBe total score. Factor analytic data support the validity of the three scales (Grace & Malloy, 2001; Grace et al., 1999). Reliability studies have shown high intrascale reliability in normal and clinical samples (Grace & Malloy, 2001; Grace et al., 1999). The instrument may be administered individually or to an informant. In this study, we relied upon self-reported symptoms.

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Neuropsychological function

Controlled Oral Word Association Test.: The Controlled Oral Word Association Test (COWAT) was administered to assess verbal fluency (Benton & Hamsher, 1989; Spreen & Strauss, 1998). The COWAT consists of three word-naming trials where participants are given a letter (C, F, & L) and are asked to name as many words as they can think of that begin with that letter. The sum of the words generated across three 1-minute trials comprise the total score, which is adjusted for age, sex, and education.

Trail Making Tests (TMT).: The TMT measures scanning and visuo-motor tracking, divided attention, and cognitive flexibility (Reitan & Wolfson, 1993) Time to complete Test A and Test B is measured in seconds.

Digit Span Test.: This measure from the Wechsler Adult Intelligence Scale–III is used to assess auditory attention span (Wechsler, 1997). The age-corrected scaled score was considered in data analyses.

Letter–Number Sequencing.: Also found in the Wechsler Adult Intelligence Scale–III (Wechsler, 1997), the Letter–Number Sequencing task is a measure of auditory working memory.

Seashore Rhythm Test.: The Seashore Rhythm Test is a measure of sustained auditory attention and is a subtest from the Halstead–Reitan Neuropsychological Test Battery (Reitan & Wolfson, 1993). It has previously been used as a sensitive indicator of neuropsychological impairment in people with MS (Basso, Beason-Hazen, Lynn, Rammohan, & Bornstein, 1996). Total correct score was included in data analyses.

Symbol Digit Modalities Test (SDMT).: The SDMT (Smith, 2002) is a measure of visual working memory and is highly sensitive to neuropsychological impairment in people with MS. Because of motor impairments common to MS, the oral version of the test was administered. Total correct score was included in data analyses.

California Verbal Learning Test–II (CVLT-II).: The CVLT-II measures verbal learning and memory (Delis, Kramer, Kaplan, & Ober, 2000). Examinees are presented with 16 words five times. Immediate, delayed, and recognition recall are measured, as are semantic organization and intrusion errors.

Grooved Pegboard Test (GPT).: To assess dexterity, the GPT (Ruff & Parker, 1993) was administered. The total time to complete the test with each hand was summed.

Tactile Form Recognition Test.: This instrument is a subtest of the Halstead–Reitan Neuropsychological Test Battery (Reitan & Wolfson, 1993), and it assesses the presence of astereognosis. Time to identify four shapes with each hand is measured, as is erroneous identification of the shapes. This measure is sensitive to cognitive impairment in MS (Basso et al., 1996).

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Impairment index.: To clarify the degree of neuropsychological deficit, an overall impairment index was calculated. This was done to reveal the clinical meaningfulness of our data. Scores were compared to generally accepted test norms for each test (e.g., Heaton, Miller, Taylor, & Grant, 2004). If an individual performed at or below the 5th percentile, their performance was considered impaired. This impairment criterion is frequently used in clinical practice (cf. Benton et al., 1994) and is more conservative than other standards of impairment (Heaton et al., 1991). Consequently, total number of impaired scores was summed. Regarding the CVLT-II, we opted to include only the total recall score in the impairment index because it is generally considered the most reliable index from the test (Delis et al., 2000), and including multiple indices from the test would likely bias the impairment index to reflect memory deficits primarily.

Disease severity

Timed 25-Foot Walk (Ambulation Index).: The Timed 25-Foot Walk is a component of the Multiple Sclerosis Functional Composite scale (MSFC; Cutter et al., 1999; Fischer, Rudick, Cutter, Reingold, & The National MS Society Clinical Outcomes Assessment Task Force, 1999), and it assesses impaired mobility. Time to walk 25 feet is measured. This index has satisfactory reliability, validity, and sensitivity to clinically relevant change in MS patients, and it is correlated with indices of disease severity such as the Expanded Disability Status Scale (Cutter et al., 1999; Fischer et al., 1999). This instrument was included to control for the effects of diminished mobility upon self-reported functional outcomes.

Functional outcomes

Disability status.: Participants reported whether they were receiving disability benefits. As shown in Table 2, 43% of the MS patients were receiving disability benefits, whereas 0% of the control group were.

Sickness Impact Profile (SIP).: The Sickness Impact Profile is a self-report measure of how well a person manages activities of daily living. It consists of 136 items, and it is commonly used to assess functional outcomes across multiple domains in medical studies (Bergner, Bobbitt, Carter, & Gilson, 1981). Number of endorsed items on each scale is summed and reflects severity of dysfunction in each domain. Higher scores reflect worse functioning.

Incapacity Status Scale (ISS) and Environmental Status Scale (ESS).: These instruments are administered in a structured interview and were developed to assess severity of disability associated with MS (LaRocca & Foley, 1984). The ISS assesses the extent to which a person’s ability to manage a variety of life activities has been compromised by symptoms of MS. The ESS measures the extent to which a person with MS has had to modify their work and home environments consequent to symptoms of MS. Higher scores reflect greater disability. These measures have satisfactory reliability and validity (LaRocca et al., 1984).

Procedure

After obtaining informed consent, participants were administered the neuropsychological test battery, the FrSBe, and the measures of functional outcomes. Level of disease

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impairment was measured with the Timed 25-Foot Walk. All tests were administered according to standardization instructions. This research was approved by the Institutional Review Board of the University of Tulsa.

RESULTS

Plan of analysis

Depiction of neuropsychological status and functional outcomes—To determine whether the patient and control groups differed in neuropsychological status, scores were compared using *t* tests. In performing these analyses, we intended to depict the range of performance in the sample and to reveal whether our sample of MS patients deviated from normal. Likewise, to determine whether the patient and control groups differed in self-reported activities of daily living, scores on the self-report measures were compared with *t* tests. The purpose of doing so was to delineate the range of performance in our groups and to reveal whether our MS patients were complaining of abnormal levels of functioning. To correct for Type I error, a modified Bonferroni correction was implemented. Specifically, only tests that yielded a $p \leq .01$ were considered significant.

Relationship between dysexecutive symptoms and neuropsychological and functional outcomes—To evaluate whether dysexecutive symptoms predict neuropsychological function and adaptive function measures, the multivariate general linear model was used. Significant multivariate effects were followed by univariate multiple regression analyses. From these latter analyses, only those *t* tests that emerged at the $p < .01$ level were considered statistically significant. This modified Bonferroni model of analyzing data was done to control for Type I error. Data from all participants were included in these analyses.

Two separate general linear models were assessed. In particular, scores on the neuropsychological tests served as dependent variables in one analysis, and scores on the functional outcome measures were the dependent variables in the other. These two sets of dependent variables were distinguished out of concern that they reflect distinct domains of function, and combining them into a single analysis may confound or obscure results. Independent variables included age, education, FrSBe Total *Z*-score, and scores on the Ambulation Index.

Age and education were included because these variables often predict performance on neuropsychological tests, and education differed between the control and patient groups. The Ambulation Index was included as a predictor because prior research implies that mobility status predicts impairment on neuropsychological tests and measures of adaptive function. Total score on the FrSBe was used rather than the three subscales owing to significant multicollinearity among them. Specifically, the scales had intercorrelations ranging from .5 to .7, and their tolerances within univariate regression equations were as low as .3. Total raw score was transformed to a demographically corrected *Z*-score based on norms for the test. Independent variables that emerged as significant in these multivariate analyses were then examined in subsequent univariate multiple regression analyses. This method of analysis parallels the strategy of initially testing effects with the multivariate analysis of variance

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and subsequent univariate analysis of variance. The purpose of pursuing this strategy was to reduce the effects of Type I error (cf. Stevens, 1986).

Analyses of neuropsychological performance and self-reported function

Table 3 depicts average neuropsychological test performance of the patient and control groups. The *t* tests revealed that the patient group performed more poorly than the control group on many tests, and the patient group had more impaired scores than the control group. Regarding the FrSBe, a *t* test was computed and revealed that the patient group had significantly higher dysexecutive symptom severity than the control group ($p < .01$). Indeed, the MS group reported symptoms that exceeded 90% of the FrSBe normative sample.

Table 2 shows mean functional outcome scores of the two groups. These analyses show that the patient group reported greater functional impairment than the control group, and the patients achieved scores that typically reflect disability (cf. Bergner et al., 1981). Overall, the data in Tables 2 and 3 indicate that patients displayed a wide range of neuropsychological performance and adaptive function, and scores ranged from normal to impaired.

FrSBe and neuropsychological performance

Multivariate analysis—The general linear model concerning neuropsychological performance revealed that education—Hotelling's $F(10, 33) = 2.73$, $p = .01$, $\eta^2 = .45$—and FrSBe Total *Z*-score—Hotelling's $F(10, 33) = 5.13$, $p < .001$, $\eta^2 = .61$—were significant, whereas age and Ambulation Index scores were not. Owing to their failure to account for significant variance, age and Ambulation Index scores were not entered as predictors in subsequent univariate analyses.

Univariate analyses—To examine the effects of education and FrSBe Total *Z*-scores on neuropsychological performance, multiple regression analyses were performed. Years of education and FrSBe Total *Z*-scores were forcibly entered simultaneously as independent variables. Tolerances for both of these predictors were 1.00, indicating that no multicollinearity existed among the variables. Semipartial correlations are used to indicate the unique variance accounted for by each independent variable.

Results of the regression analyses appear in Tables 4 and 5. The analyses revealed that FrSBe scores accounted for significant variance across many measures of the battery, including Trail Making Tests A and B, Letter Number Sequencing, and the Symbol Digit Modalities Test. From the CVLT-II, FrSBe scores significantly predicted total recall across learning trials, recall intrusion errors, and an inability to distinguish target words from distractors. FrSBe total score also predicted Grooved Pegboard Test performance. Notably, the FrSBe did not predict performance on the Tactile Form Recognition Test or CVLT-II Total Recognition performance. Among those measures for which the FrSBe was a significant predictor, semipartial correlations were substantial and ranged from .32 to .46. As FrSBe scores increased, neuropsychological performance decreased.

Years of education emerged as a significant predictor only on Trail Making Tests A and B and the Seashore Rhythm Test. Inspection of the semipartial correlations revealed that

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higher education corresponded with better neuropsychological performance. The magnitude of these semipartial correlations ranged from .32 to .44.

Total number of impaired scores was also analyzed, and the FrSBe Total *Z*-score and years of education emerged as significant independent variables. As FrSBe scores increased, neuropsychological test scores were more frequently impaired. As years of education increased, there were fewer impaired neuropsychological test scores. The magnitude of these relationships was substantial, and the semipartial correlations ranged from .45 (FrSBe) to .40 (education).

FrSBe and self-reported functional outcomes

Multivariate analysis—The general linear model concerning functional outcomes revealed that the Ambulation Index—Hotelling's $F(15, 36) = 10.62$, $p < .001$, $\eta^2 = .82$—and FrSBe Total *Z*-score—Hotelling's $F(15, 36) = 4.28$, $p < .001$, $\eta^2 = .64$—were significant, whereas age and education scores were not. Owing to their failure to account for significant variance, age and education were not entered as predictors in subsequent univariate analyses, reducing the probability of subsequent Type I error (Stevens, 1986).

Univariate analyses—To examine the effects of the Ambulation Index and FrSBe Total *Z*-scores on functional outcomes, multiple regression analyses were performed, and these results appear in Table 6. Ambulation Index and FrSBe Total *Z*-scores were forcibly entered simultaneously as predictors. Tolerances for both of these predictors were .84, indicating that there was little multicollinearity between the variables.

The analyses revealed that FrSBe scores accounted for significant variance on disability status, ISS and ESS scores, and several SIP scale scores. In particular, the FrSBe achieved significance in the following SIP scales: Sleep and Rest, Emotional Behavior, Body Care and Movement, Social Interaction, Alertness Behavior, Work Behavior, and Recreation and Past-time. Higher FrSBe scores corresponded with worse functional outcomes. Semipartial correlations ranged from .22 to .64. The Ambulation Index accounted for significant variance on the ISS and ESS scores as well as on several SIP scales including Emotional Behavior, Body Care and Movement, Home Management, Mobility, Social Interaction, Ambulation, Communication, Work, Recreation and Past-time, and Eating. Increasing ambulatory disability corresponded with worsening functional outcomes, and semipartial correlations ranged from .30 to .65.

DISCUSSION

Dysexecutive symptoms and neuropsychological function

Prior research has demonstrated a relationship between dysexecutive symptoms and executive function and working memory in people with MS (Chiaravalloti & DeLuca, 2003; Goverover et al., 2005a). In the current investigation, we sought to evaluate this association further. Specifically, we expected that FrSBe scores would correlate with poor performance on measures of executive function, working memory, recall intrusions, and dexterity, but FrSBe scores would not correspond with tactile sensory perception. Our findings were largely consistent with our expectations. Indeed, worsening dysexecutive symptoms on the

FrSBe corresponded with worsening executive function, working memory, recall intrusions, and dexterity, but FrSBe scores failed to correspond with tactile sensory perception.

Relative to the work of DeLuca and colleagues, we replicated and extended their findings. As a replication, we found that increasing self-reported dysexecutive symptoms correlated with worsening executive function and working memory. The magnitude of this relationship was considerable, as FrSBe scores accounted for 10–20% of the variance on neuropsychological tests. Extending the earlier research, we included patients with significant neuropsychological impairment. Thus, the relationship between self-reported dysexecutive symptoms and neuropsychological dysfunction occurs even among patients who manifest meaningful neurocognitive deficit. Additionally, this relationship was demonstrated on a battery of measures that differed from those employed by Chiaravalloti and DeLuca (2003) and Goverover et al. (2005a). Consequently, the association between dysexecutive symptoms and neuropsychological dysfunction appears increasingly reliable.

Dysexecutive symptoms and subjective functional outcomes

As a further extension of previous findings, we examined the relationship between self-reported dysexecutive symptoms and functional outcomes in people with MS. Previous investigations involving people with schizophrenia and dementia showed that elevated FrSBe scores predicted diminished activities of daily living (Boyle et al., 2003; Norton et al., 2001; Velligan et al., 2002), but these studies did not address patients with MS. The current research showed that increasing FrSBe scores correlated with poorer activities of daily living and increasing disability in people with MS.

As might be expected in people with MS, diminished mobility, as indexed by the Ambulation Index, corresponded with almost all aspects of daily functioning. Notably, however, the FrSBe correlated with only some functional outcomes. In particular, FrSBe scores did not seem to correlate with SIP scales related to movement, exertion, or mobility, whereas the Ambulation Index achieved significant correlations with these indices. The FrSBe tended to correspond only with scales that have little to do with such qualities (e.g., Sleep and Rest, Social Interaction, Alertness, etc.). Moreover, FrSBe scores accounted for 5–40% of the variance on functional outcomes. Notably, such values typically approximated those obtained by the Ambulation Index, which has commonly emerged as a potent predictor of functional impairment. Thus, in people with MS, dysexecutive symptoms account for as much impairment in functional outcomes as does compromised mobility.

Implications

These data suggest that FrSBe scores may serve as indicators of frontal lobe dysfunction. Namely, the FrSBe primarily correlated with measures presumed to reflect frontal lobe integrity. For example, FrSBe scores corresponded with performance on measures of concept formation and working memory. The FrSBe also correlated with slowed motor speed on the Grooved Pegboard Test. Yet, FrSBe scores failed to associate with performance on measures of tactile sensation, which are presumed to reflect integrity of posterior portions of the brain. Granted, FrSBe scores corresponded with several indices on the CVLT-II, including total recall. Such a finding may implicate an association between the FrSBe and

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temporal lobe integrity. Yet, the frontal lobes are implicated as a neural substrate of memory accuracy as well as ability to organize information for acquisition and recall. Notably, the FrSBe correlated with CVLT-II indices reflecting intrusions and ability to organize and discriminate target words from distractors, but it did not correspond with recognition memory. This suggests that high FrSBe scores corresponded with inaccurate and sparse recall. Thus, the FrSBe seems to possess some degree of convergent and divergent validity. To further evaluate this issue, it might be worthwhile to examine the relationship between FrSBe scores and functional or structural brain imaging data. For instance, it may be that the FrSBe corresponds with lesion load or cerebral activation specific to the frontal lobes in people with MS. In pursuing such research, a clearer understanding of the neural substrate of FrSBe scores might be gained.

In this context, it seems unexpected that the FrSBe failed to correlate with COWAT performance. Abundant research has shown that COWAT performance is often decreased in people with MS, and frontal dysfunction is the presumed neural substrate of such deficits (e.g., Rao et al., 1991). The absence of a significant relationship between FrSBe and COWAT scores may be attributable to attenuated range of COWAT performance. Notably, COWAT scores of the MS and control groups did not differ. As such, sensitivity of the regression model to detect meaningful relationships between the FrSBe and COWAT may have been limited. Perhaps in a sample of MS patients who display deficits in word fluency, FrSBe scores may emerge as a significant predictor of COWAT impairment.

Past research implied that subjective complaints of neuropsychological impairment in MS were of variable accuracy. Some studies implied that patient complaints of impairment were inaccurate (Beatty & Monson, 1991), whereas other investigations suggested that such complaints were indeed accurate (Benedict et al., 2004). Of particular interest, Goverover et al. (2005a) found that patients with MS were apt to report levels of dysexecutive symptoms that were discrepant from an informant. Notably, the discrepancy between self-reported and informant-rated dysexecutive symptom severity corresponded with increasing neuropsychological impairment. This implies that cognitively impaired MS patients may fail to perceive their own dysexecutive symptoms. Although informants did not participate in the current study, MS patients reported a wide range of dysexecutive symptoms, and these self-reported symptoms correlated with poor executive function, working memory, dexterity, and functional outcomes. Thus, patient reports of deficits in MS appear to possess some accuracy.

Possibly, the presence of emotional distress may mitigate the relationship between subjective reports of dysexecutive symptoms and functional outcomes. For instance, Goverover et al. (2005a) found that depressive symptoms correlated with subjective reports of worsening dysexecutive symptoms. Likewise, depression appears to predict subjective complaints of neuropsychological impairment (Maor, Olmer, & Mozes, 2001; Middleton, Denney, Lynch, & Parmenter, 2006). Depression, which is common in people with MS (Arnett & Randolph, 2006), may influence relationships between self-reported dysexecutive symptoms, neuropsychological function, and functional outcomes. However, one limitation of the present study is that depression was not measured. Hence, this possibility remains untested and awaits further scrutiny.

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For the clinician, these data suggest that patient reports of dysexecutive symptoms (i.e., apathy, disinhibition, poor problem solving) pose a morbidity risk. Specifically, such self-reported symptoms are inclined to correspond with objective deficits in neuropsychological function and poor capacity for self-care. Accordingly, this should inform clinicians as they review patient self-report of function during periodic check-ups. Through such vigilant monitoring, efforts can be made to forestall and offset debilitating declines in the quality of life for people with MS.

Limitations

Despite its strengths, it should be acknowledged that this study has a potentially salient limitation. In particular, we relied primarily upon self-reported symptoms of functional outcomes. It seems likely that patients may be less than accurate informants concerning their capacity to manage activities of daily living, and different results may be observed if objective indictors of functional outcomes were used instead of self-report measures (Goverover et al., 2005b). Nonetheless, our data revealed that patients with higher FrSBe scores correlated with a discrete and relatively objective functional outcome—namely, whether patients were receiving disability benefits. Thus, it seems likely that patient self-reports of functional outcomes possess some degree of accuracy. Regardless, these data contribute to a growing recognition that diminished activities of daily living in MS are not solely accounted for by impaired mobility. Rather, neurocognitive factors are important contributors to the quality of life in people with MS.

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TABLE 1

Descriptive statistics for participant groups

	MS	Control	Contrast
Sex	34 female/ 8 male	11 female/ 2 male	*ns*
Age[a]	42.88 (10.36)	44.69 (11.00)	*ns*
Education[a]	14.95 (2.33)	16.69 (2.32)	$p = .02$
Disease course	22 relapsing remitting 8 chronic progressive 12 uncertain		
Ambulation Index	2.69 (2.03)	0.15 (0.55)	$p < .001$
FrSBe Total *Z*-score	1.60 (1.45)	0.01 (1.13)	$p < .001$

Note. Means; standard deviations in parentheses. MS = multiple sclerosis.

[a]In years.

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TABLE 2

Functional outcomes for participant groups

	MS	Control	Contrast
MS disability[a]	42.5	0	$p = .002$
ISS	14.33 (9.13)	1.15 (1.95)	$p < .001$
ESS	8.33 (6.76)	0.77 (0.28)	$p < .001$
SIP			
Sleep and Rest	11.68 (11.16)	1.31 (3.36)	$p = .002$
Emotional Behavior	10.17 (10.70)	0.95 (2.32)	$p = .003$
Body Care	31.80 (33.85)	1.05 (2.55)	p = .002
Home Management	14.83 (14.86)	0.00 (0.00)	$p = .001$
Mobility	12.16 (16.17)	0.00 (0.00)	$p = .009$
Social Interaction	20.23 (20.56)	4.16 (15.00)	$p = .01$
Ambulation	18.22 (14.64)	0.27 (0.97)	$p < .001$
Alertness Behavior	28.41 (24.45)	0.00 (0.00)	$p < .001$
Communication	9.65 (13.33)	0.00 (0.00)	$p = .01$
Work	15.30 (16.31)	0.00 (0.00)	$p = .001$
Recreation	10.42 (9.16)	0.00 (0.00)	$p < .001$
Eating	2.22 (4.02)	0.00 (0.00)	*ns*

Note. Standard deviations in parentheses. The *p*-values reflect the significance of the *t* test contrasts. MS = multiple sclerosis. ISS = Incapacity Status Scale. ESS = Environmental Status Scale. SIP = Sickness Impact Profile.

[a] In percentages.

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TABLE 3

Neuropsychological test performance across groups

	MS	Control	Contrast
COWAT	40.50 (11.06)	41.54 (5.98)	*ns*
TMT A	32.58 (12.56)	25.08 (9.40)	*ns*
TMT B	83.32 (34.76)	51.08 (14.46)	$p = .002$
CVLT Total *t* score	51.93 (10.67)	60.39 (6.53)	$p = .009$
Digit Span Scaled Score	10.21 (2.99)	10.58 (3.12)	*ns*
Letter Number Sequencing	11.00 (2.98)	11.25 (2.86)	*ns*
Symbol Digit Modality Test	51.54 (11.99)	59.92 (7.75)	*ns*
Seashore Rhythm Test	26.65 (2.60)	26.17 (3.27)	*ns*
Grooved Pegboard Total Time	231.08 (151.55)	107.18 (28.62)	$p = .005$
Tactile Form Recognition Test Total Time	33.88 (26.57)	20.29 (3.93)	*ns*
Impaired Scores	2.60 (1.66)	0.62 (0.77)	$p < .001$

Note. Standard deviations in parentheses. The *p*-values reflect the significance of the *t* test contrasts. MS = multiple sclerosis. COWAT = Controlled Oral Word Association Test. TMT = Trail Making Test. CVLT = California Verbal Learning Test.

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TABLE 4

Regression results: Semipartial correlations of FrSBe scores and education with neuropsychological performance

	Semipartial correlations	
Neuropsychological variables	**FrSBE**	**Education**
COWAT	−.13	.10
TMT A	.33**	−.24
TMT B	40***	−.39**
Digit Span Scaled Score	−.22	.30*
Letter Number Sequencing	−.44***	.26*
Symbol Digit Modalities Test	−.40**	.28*
Seashore Rhythm Test	−.21	.43***
GPT	.47***	.02
Tactile Form Recognition Test Total Time	.25	−.21
Impaired Scores	.45***	−.40***

Note. FrSBE = Frontal Systems Behavior Scale. COWAT = Controlled Oral Word Association Test. TMT = Trail Making Test. GPT = Grooved Pegboard Test.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

TABLE 5

Regression results: Semipartial correlations of FrSBe scores and education with CVLT-II scores

	Semipartial correlations	
CVLT-II indices	**FrSBe**	**Education**
Total Recall	−.37**	.24
Cued Recall Intrusions	.34**	−.11
Cued Recall Discrimination	−.36**	.26*
Recognition	−.15	.21
Recognition False Positives	.45***	−.20

Note. FrSBE = Frontal Systems Behavior Scale. CVLT = California Verbal Learning Test.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

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TABLE 6

Regression results: Semipartial correlations of FrSBe scores and Ambulation Index with functional outcomes

	Semipartial correlations	
Functional outcomes	**FrSBe**	**Ambulation Index**
MS disability	.29**	.43***
ISS	.30***	.61***
ESS	.22*	.59***
SIP		
Sleep	.30**	.38***
Emotional Behavior	.37***	.32**
Body Care	.24**	.59***
Home Management	.05	.62***
Mobility	.14	.36**
Social Interaction	.34**	.32
Ambulation	.14	.65***
Alertness Behavior	.46***	.20
Communication	.08	.60***
Work	.30**	.30**
Recreation	.32**	.47***
Eating	.12	.48***

Note. MS = multiple sclerosis. FrSBE = Frontal Systems Behavior Scale. ISS = Incapacity Status Scale. ESS = Environmental Status Scale. SIP = Sickness Impact Profile.

* $p < .05$.

** $p < .01$.

*** $p < .001$.