Assessing motor and cognitive regulation in AD, MCI, and controls using the Behavioral Dyscontrol Scale

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Abstract

The objective of this study was to evaluate the utility of the Behavioral Dyscontrol Scale (BDS) as a measure of behavioral regulation in Alzheimer’s disease (AD) and mild cognitive impairment (MCI). Two patient groups (n = 40 MCI and 40 AD) recruited from a memory clinic and an elderly control (EC) group (n = 40) recruited from the community were administered a battery of neuropsychological tests including the BDS and a measure of functioning of activities of daily living (ADLs). Results of ROC analyses revealed that performance on the BDS discriminated between the AD group and the MCI and EC groups but did not discriminate between the MCI and EC groups. Performance on the BDS was an independent predictor of ADLs in patient groups after controlling for the effects of performance on a memory measure.

Keywords: Executive functioning; Frontal lobe; Dementia; Functioning

While assessment tools for memory and language abilities are well developed, assessment of executive functioning is more limited, in part due to the heterogeneity of executive abilities. Commonly used measures of executive abilities include measures of verbal fluency (e.g., COWA), complex sequencing (e.g., Trails B), and set shifting, mental flexibility, and perseveration (e.g., WCST). These standard measures do not, however, capture other abilities thought to be mediated by the frontal lobes, such as regulation of behavior and complex motor

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programming. Luria developed a number of tasks to assess these aspects of frontal lobe functions. He posited that, in the absence of a movement disorder, the inability to learn and execute simple motor programs constituted a failure in the regulation of voluntary motor activity, which is mediated by frontal systems. Some researchers have included Lurian motor sequences in their standardized batteries. The EXIT25 (Royall, Mahurin, & Gray, 1992), for example, is a standardized compilation of executive measures which includes Lurian motor tasks. Malloy et al. (Malloy, Webster, & Russell, 1985) validated some of Luria’s tests of frontal impairment using items from the Luria-Nebraska Neuropsychological Battery (LNNB). Finally, Grigsby, Kaye, and Robbins (1992) developed a stand-alone measure, the Behavioral Dyscontrol Scale (BDS), utilizing many of the same items. Performance on Luria’s motor sequencing tasks is impaired in patients with frontal lobe lesions (Luria, 1966; Malloy et al., 1985). Subsequent research has demonstrated, however, that errors on Lurian motor tasks, while most frequently occurring in patients with frontal lesions, also occur in patients with posterior lesions (Malloy et al., 1985) and with general medically ill patients (Ruchinskas & Giuliano, 2003).

The BDS incorporates motor and cognitive regulation tasks adapted from Luria’s approach to the assessment of frontal systems. In addition to providing information regarding another aspect of frontal lobe functions, the BDS may be useful in terms of discriminating patients with AD from MCI and therefore serve as an indirect measure of disease severity. Further, similar to other executive cognitive measures, the BDS has been shown to be a predictor of functional ability in healthy elderly populations (Grigsby, Kaye, Baxter, Shetterly, & Hamman, 1998) and in medical elderly populations (Grigsby, Kaye, Eilertsen, & Kramer, 2000; Grigsby, Kaye, Kowalsky, & Kramer, 2002; Suchy, Blint, & Osmon, 1997). It is possible that the BDS accounts for a unique aspect of the variance in ADLs not accounted for by other, more traditional measures of executive functioning.

The BDS has nine items that require alternating hand sequences (e.g., tap twice with the right hand, once with the left), inhibition (e.g., tap on “red,” do nothing on “green”), learning complex motor sequences (e.g., fist-edge-palm), alphanumeric sequencing, and awareness of deficit or insight. The final item, which assesses awareness of deficit, is based on a subjective rating by the examiner. Each item is scored on a three-point scale (0–2). Although only a few studies have examined performance on the BDS in elderly populations, the BDS has elderly norms, it has demonstrated reliability and validity with normal elderly (Grigsby et al., 1992), it is easy to administer and score, and it is not part of a battery. The task also measures aspects of executive functions not assessed by other executive tasks. Grigsby and colleagues have demonstrated significant correlations between BDS scores and measures of daily functioning and general cognitive status in a large sample of community-dwelling elderly people (Grigsby et al., 1998) and in a sample of patients presenting at a geriatric outpatient clinic (Kaye, Grigsby, Robbins, & Korzun, 1990). However, previous studies have not examined the diagnostic utility of the BDS in demented populations or in patients with MCI.

The aim of the present study was to extend these findings and explore the utility of the BDS in discriminating between patients diagnosed with MCI and AD, as well as elderly controls (EC). It was predicted that patients with AD would demonstrate impairments on the BDS relative to individuals with MCI and age-matched controls and that patients with MCI would show impairments relative to controls. Although deficits in some executive functions have been reported in patients with MCI (Ready, Ott, Grace, & Cahn-Weiner, 2003), it is not known
Table 1
Demographic and Neuropsychological Data by Group

<table>
<thead>
<tr>
<th></th>
<th>EC (<em>N</em> = 40)</th>
<th>MCI (<em>N</em> = 40)</th>
<th>AD (<em>N</em> = 40)</th>
<th><em>P</em>-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>76.80 (5.5)</td>
<td>75.28 (7.7)</td>
<td>77.61 (5.8)</td>
<td>.26</td>
</tr>
<tr>
<td>Education (years)</td>
<td>13.52 (2.6)</td>
<td>14.30 (2.7)</td>
<td>13.18 (3.1)</td>
<td>.19</td>
</tr>
<tr>
<td>Female (%)</td>
<td>75</td>
<td>55</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>MMSE*</td>
<td>27.38 (2.7)</td>
<td>27.03 (2.1)</td>
<td>21.58 (4.6)</td>
<td>.00</td>
</tr>
<tr>
<td>BDS total score*</td>
<td>17.00 (2.1)</td>
<td>16.43 (2.6)</td>
<td>11.75 (4.3)</td>
<td>.00</td>
</tr>
</tbody>
</table>

*Note. EC, elderly control; MCI, mild cognitive impairment; AD, dementia of the Alzheimer’s type; MMSE, Modified Mini Mental Status Exam; BDS, Behavioral Dyscontrol Scale. Values are expressed as means with standard deviations in parentheses.

*EC and MCI group not significantly different.

whether or not the primarily motor sequencing functions tapped by the BDS are affected early. A secondary aim was to explore the relationship between BDS scores and ADLs in a clinic sample.

1. Participants

Participants with mild-moderate AD (*n* = 40) and MCI (*n* = 40) were recruited from the Butler Hospital Memory Disorders Program. The AD group (mean MMSE = 21.58) consisted of patients who met criteria for “probable Alzheimer’s disease” as defined by the National Institute of Neurological Disorders and Stroke-Alzheimer’s Disease and Related Disorders Association Work Group (McKhann et al., 1984). The MCI group (mean MMSE = 27.03) consisted of patients who met the Mayo Clinic Criteria for MCI (Petersen et al., 2001). The EC group (*n* = 40; mean MMSE = 27.38) consisted of community-dwelling elderly who took part in the San Luis Valley Health and Aging Study (SLVHAS), a population-based study of chronic illness among people age 60 and above. These participants were selected at random from this larger study and were not excluded based on medical or psychiatric conditions. Unlike the MCI group, which consists of patients presenting at a memory clinic, participants from the control group represent a random sample of community-dwelling elders. The three groups did not significantly differ on age or education (*P* > .05). The MCI group had fewer female participants than the AD and control groups (*χ²* = 7.2, *P* = .001; *χ²* = 20, *P* = .001, respectively), though all groups had more females than males. Table 1 contains relevant demographic information on the participants.

2. Methods

The BDS (Grigsby & Kaye, 1996) was administered to all participants. The BDS was administered using standard instructions from the manual and each item was scored using the standard criteria on a three-point scale (0–2). For patient participants (AD and MCI groups), this test was administered in concert with a battery of neuropsychological tests assessing
various cognitive domains. The BDS was not used in the diagnostic process to avoid criterion contamination. All groups were also administered the Mini Mental Status Exam (MMSE; Folstein, Folstein, & McHugh, 1975). Patient groups (i.e., the MCI and AD groups) were administered other measures of executive functioning including: Controlled Oral Word Fluency Test (COWA; Benton & Hamsher, 1976); the DRS Initiation/Perseveration Subscale (DRS-IP; Mattis, 1973) and the Trailmaking Test, Part B (Reitan & Wolfson, 1985). Memory was assessed using the Hopkins Verbal Learning Test—Revised (Benedict, Schretlen, Groninger, & Brandt, 1998), which entails three learning trials followed by delayed recall and recognition trials. Activities of daily living (ADL) were assessed in the patient groups only using the Lawton & Brody ADL Scale (1969). This instrument is filled out by caregivers, and assesses daily performance of both physical (P-ADLs; e.g., bathing, grooming) and instrumental (I-ADLs; e.g., medication adherence, management of finances) activities.

3. Results

Table 1 displays the mean scores on the BDS by diagnostic group. An ANOVA was conducted with group (EC, MCI, and AD) as the independent variable and BDS total score as the dependent measure. Differences between the diagnostic groups were highly significant, $F(2, 119) = 32.74, P < .0001$. Follow-up tests (LSD conducted at $P < .01$ level) revealed that the AD group performed significantly worse than both the MCI and EC groups. The EC and MCI groups, however, did not significantly differ ($P > .05$).

Receiver Operator Characteristic Curves (ROC) were generated to test the diagnostic utility of differentiating the AD group from other groups. The area under the ROC function (AUC) is regarded as an important index because it provides a single measure of overall accuracy that is not dependent upon a particular threshold (Campbell & Deleo, 1989). In examining discrimination between the AD group and other groups, it was noted that the area under the curve (AUC) did not include 0.50 with a 95% confidence interval, suggesting that the discriminating capability of the BDS total score is statistically significant. In contrast, the BDS total score was not useful for discriminating the EC and MCI groups. As can be seen in Table 2, the sensitivity and specificity for discriminating EC from AD (0.83 and 0.73, respectively) is similar to the sensitivity and specificity for discriminating MCI from AD (0.81 and 0.70, respectively). Details of the ROC analysis are presented in Table 2, including

Table 2
Results of receiver operating characteristic (ROC) analyses

<table>
<thead>
<tr>
<th>Groups</th>
<th>Cutoff score</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>AUC</th>
<th>S.E.</th>
<th>95% CI</th>
<th>Positive predictive value (%)</th>
<th>Negative predictive value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC vs. MCI</td>
<td>18</td>
<td>0.50</td>
<td>0.53</td>
<td>0.55</td>
<td>0.07</td>
<td>.42–.67</td>
<td>50.85</td>
<td>52.38</td>
</tr>
<tr>
<td>EC vs. AD</td>
<td>17</td>
<td>0.83</td>
<td>0.73</td>
<td>0.85</td>
<td>0.05</td>
<td>.76–.94</td>
<td>64.8</td>
<td>80.77</td>
</tr>
<tr>
<td>MCI vs. AD</td>
<td>16</td>
<td>0.81</td>
<td>0.70</td>
<td>0.81</td>
<td>0.05</td>
<td>.72–.91</td>
<td>68.8</td>
<td>78.13</td>
</tr>
</tbody>
</table>

Note. Cutoff score, optimal cutoff score; AUC, area under the receiver operating characteristics (ROC) curve; S.E., standard error; 95% CI, 95% confidence interval; EC, elderly control; MCI, mild cognitive impairment; AD, dementia of the Alzheimer’s type.
the sensitivity and specificity associated with optimal cutoff scores and the positive/negative predictive values.

The utility of the BDS for predicting a measure of daily functioning or ADLs in the patient groups was also examined. The MCI and AD groups were combined for these analyses. A stepwise, hierarchical regression analysis was conducted in which total ADL scores served as the dependent variable. The percent of HVLT-R items retained over delay was entered as a predictor at the first step, followed by BDS scores. The BDS scores added significantly, above and beyond memory scores, in predicting ADL scores, $F_{\text{change}}(1, 51) = 9.64, P = .003$). Indeed, BDS scores explained an additional 15% of the variance in ADL scores. The BDS total score correlated more with I-ADLs ($r = .52, P < .0001$) than P-ADLs ($r = .43, P < .001$). Total variance accounted for by both memory and BDS scores was 22%. A second stepwise, hierarchical regression was then conducted to determine if other executive measures explain additional variance in ADL scores. As with the first regression, the percent of HVLT-R items retained over delay was entered as a predictor at the first step, followed by BDS scores. The third step included COWA, DRS-IP, and Trails-B as predictors. These latter executive measures did not add significantly to the prediction of total ADL scores above and beyond BDS and memory scores, $F_{\text{change}}(1, 43) = .74, P = .74$).

### 4. Discussion

The BDS has been demonstrated to have good reliability and is easy to administer and well tolerated by patients. The purpose of this study was to evaluate the utility of the BDS for use in discriminating between patients diagnosed with MCI, AD, and controls and to evaluate its relationship with daily functioning. Analyses revealed that the AD group performed significantly worse than the MCI and EC groups on the BDS. The EC and MCI groups, however, did not significantly differ. This suggests that the BDS may be less useful as a screen for early executive dysfunction. It is interesting to note that executive functions are useful for prediction of conversion from MCI to dementia (Albert, Moss, Tanzi, & Jones, 2001). The tasks assessed by the BDS (i.e., motor sequencing, alphanumeric sequencing, behavioral inhibition, insight) have not been as well studied. It is possible that these abilities are not affected as early as other frontally mediated abilities. A prospective study is needed to address this question. As we did not have other measures of executive functions for the control group, this question was not adequately addressed by this study. Another possibility is that the EC group contained enough individuals with MCI so as to make the comparison meaningless. While this group was selected as a non-clinical control, their mean MMSE score was not significantly different from the MCI group.

The BDS was found to be useful diagnostically and to explain an additional 15% of the variance in daily functioning above and beyond memory scores. This is consistent with prior studies which have demonstrated: (a) the importance of executive functions in general to daily functioning in the elderly (Cahn-Weiner et al., 2000) and (b) the relationship between BDS scores and daily functioning in community-dwelling elderly (Grigsby et al., 1998; Kaye et al., 1990). Furthermore, additional executive measures did not add significantly to the prediction of daily functioning beyond the BDS.
In summary, the BDS appears to be a useful tool in the assessment of elderly patients presenting to a Memory Clinic. It has good psychometric properties, is well tolerated by patients, is useful for discriminating AD from MCI, and predicts daily functioning. It provides a standardized means of administering and scoring some of Luria’s frontal tasks. Future research with this instrument may focus on item analysis, further examination of its discriminatory power with respect to other dementia diagnoses (e.g., vascular dementia), and an examination of its ability to predict functioning longitudinally.

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References


