Journal of the Neurological Sciences 381 (2017) 110–116

Contents lists available at ScienceDirect

Journal of the Neurological Sciences

journal homepage: www.elsevier.com/locate/jns

# Proposed cut scores for tests of the Brief International Cognitive Assessment of Multiple Sclerosis (BICAMS)

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ARTICLE INFO

*Keywords:*
Multiple sclerosis
Cognition
BICAMS
Assessment

ABSTRACT

*Objective:* Cognitive impairment (CI) is common in multiple sclerosis (MS). An international consensus committee developed the Brief International Cognitive Assessment for Multiple Sclerosis (BICAMS) to screen for CI commonly seen in MS. BICAMS cut scores would allow clinicians to, efficiently and effectively, identify patients with possible CI and could aid in clinical decision-making. The aim of this study was to establish cut scores for the neuropsychological tests of the BICAMS.

*Methods:* This study utilized data collected from MS Centers in the United States. ROC curve analysis identified cut scores yielding the best balance of sensitivity and specificity. We tested two definitions of impairment: 1.5 and 2 standard deviations (SD) below the normative mean.

*Results:* All cut scores yielded excellent or good sensitivity and specificity for identifying impaired cognitive performance. The following cut scores yielded the best balance between sensitivity and specificity: On the Symbol Digit Modalities Test, 44 for 1.5 SD below the mean and 38 for 2 SD below the mean; on the California Verbal Learning Test – II learning trials, 39 (1.5 SD) and 35 (2 SD); and on the Brief Visuospatial Memory Test-Revised learning trials, 17 (1.5 SD) and 16 (2 SD).

*Conclusions:* Cut scores can accurately identify cognitive impairment on all subtests of the BICAMS. Use of cut scores may improve the efficiency of screening for cognitive impairment by reducing administrative burden and simplifying interpretation.

## 1. Introduction

Up to 70% of individuals with multiple sclerosis (MS) will develop cognitive impairment [1–4]. Although cognitive symptoms vary among individuals, the most common symptoms in MS include slowed processing speed and difficulty with visual and verbal memory – particularly impaired acquisition of new information [4–7].

Cognitive dysfunction can be instrumental in loss of employment and lowered quality of life [8–10]. Early detection of cognitive symptoms may lead to improved long-term outcomes via earlier initiation of pharmacologic or behavioral interventions [11,12]. Self-report is commonly used to screen for cognitive dysfunction. Unfortunately, in MS, self-reported cognitive dysfunction is unreliable. Studies demonstrate that perceived cognition is more strongly associated with emotional distress than neuropsychological findings [13,14]. Thus, objective tests are the best way to diagnose and track cognitive change over

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http://dx.doi.org/10.1016/j.jns.2017.08.019
Received 19 February 2017; Received in revised form 11 August 2017; Accepted 14 August 2017
Available online 16 August 2017
0022-510X/ 

time.

To meet this need, an international consensus committee developed the Brief International Cognitive Assessment for Multiple Sclerosis (BICAMS). This brief cognitive battery, which takes less than 15 min to administer, targets the most common features of cognitive dysfunction experienced by individuals with MS (processing speed and impaired learning) [15]. Two primary goals of the BICAMS were to: (1) design a quick and easy way for medical staff to identify cognitive dysfunction and (2) aid clinical decision-making – such as determining the need for comprehensive neuropsychological testing.

While one focus of the BICAMS is ease of administration (including administration by individuals without neuropsychological training), the scoring is burdensome, time consuming, and leaves room for error. Specifically, the measures within the BICAMS yield raw scores, which then need to be converted to demographically corrected standard scores. The standard scores are then converted to percentile scores, which can be categorized in terms of severity. This multi-step process can be time-consuming and presents multiple opportunities for error. In our own research, we found that administration of the BICAMS tests combined with hand scoring took approximately 30 min ($M$ = 27.09, SD = 8.14; results not yet published), almost twice as long as the committee's projected goal of 15 min. Finally, the labeling of percentile scores on individual tests may create the temptation to over-interpret the findings without consideration of factors such as emotional distress, fatigue, and effort – all factors assessed in a more comprehensive evaluation. Therefore, while the BICAMS in many ways meets its intended purpose, clinicians may revert to measures such as the Mini Mental State Exam (MMSE), which are more familiar to the medical community but are not sensitive to the impairments commonly seen in MS [16,17].

We propose that an alternative, simplified scoring method could use cut scores, which would identify individuals whose performance is below the expected level, would reduce administration time, and simplify interpretation. Identifying cut scores will bring the scoring process in line with the assessment process (straightforward, efficient), and, further, allow the scores to more specifically speak to the intended targets of the BICAMS, including identifying the presence of cognitive dysfunction or performance worthy of additional exploration. In that vein, the aim of the present study was to identify cut scores, at 1.5 and 2 standard deviations below the mean, for each test used in the BICAMS (Symbol Digit Modalities Test, SDMT; Brief Visuospatial Memory Test-Revised, BVMT-R; and California Verbal Learning Test-Second Edition, CVLT-II). Examining cut scores at 1.5 and 2 standard deviations below the mean will increase clinical utility by allowing clinical providers to choose between sensitivity and specificity based on their specific needs.

## 2. Methods

### 2.1. Recruitment

Data for this study was collected from three sources at MS Centers in the United States: source 1 [blinded for review]; source 2 [blinded for review]; and source 3 [blinded for review]. The collapsed dataset encompassed cognitive variables collected for both clinical purposes, and in the context of neuropsychological studies. The majority of the source 1 [blinded for review] and all of source 2 [blinded for review] data came from patients referred for clinical assessments. Clinical evaluations were de-identified and entered into the database. Additional data was collected from cognitive research studies. All of the data from source 3 [blinded for review] came from an iPad BICAMS validation study. To maintain consistency in administration across sources, traditional paper administration was used for this cut score study. Participants were chosen for the BICAMS cut score study if they completed the SDMT, BVMT-R, or CVLT-II. Due to the heterogeneous nature of the data sources, not all participants completed all measures. Each institution's research review board approved collection and all use of research and clinical datasets.

### 2.2. Measures

The primary measures for this study are components of the BICAMS [15]. The BICAMS was developed by a multinational committee of cognition experts to assess domains commonly affected by MS. Additionally, the committee chose a battery of tests that could be used internationally, had multiple validated versions for re-test over time, could be completed in 15 minutes or less, needed no specialized equipment, and could be administered by medical professionals without specific training in neuropsychology. The BICAMS includes three well-known neuropsychological instruments: the oral SDMT, the first five learning trials of the CVLT-II, and the three BVMT-R learning trials. The assessment tool demonstrates strong psychometrics (sensitivity 94% and specificity 86%) if dysfunctional performance is noted on at least one of the three subtests [18].

#### 2.2.1. Symbol Digit Modalities Test (SDMT)

The SDMT screens for organic cerebral dysfunction. It is a commonly used measure in MS to assess processing speed. Test takers quickly pair geometric shapes to one of nine numbers, based on a provided key, for 90-seconds [2,13,19]. The outcome is total number of correctly paired shapes. Upper motor extremity weakness may confound the written version of this test, therefore the oral version is recommended for MS [13,15,20].

#### 2.2.2. California Verbal Learning Test – Second Edition (CVLT-II), learning trials

The CVLT-II is a verbal learning and memory test frequently used in MS [2]. Given that memory acquisition is a primary deficit in MS (rather than recall or recognition), the BICAMS only includes the first five learning trials of this measure. Individuals are read a list of 16 words that are grouped into four semantic categories. The participant is required to verbally produce as many words as they can recall. This process is repeated five times. The final score is calculated by totaling the number of correct words over all five trials [15].

#### 2.2.3. Brief Visuospatial Memory Test – Revised (BVMT-R), learning trials

The BVMT-R is a visual, nonverbal test of learning and memory. As with the CVLT-II, only the learning trials of the BVMT-R are incorporated into the BICAMS. Individuals tested are asked to study a figure with six geometric shapes for 10 s. The figure is removed and the participant is asked to accurately draw as many of the geometric shapes as they can remember, while simultaneously placing them in the correct location on the page. The three learning trials are scored based on accuracy (1 point) of each shape and location (1 point). A total score is derived from summing up the total number points across all three learning trials [21].

### 2.3. Statistical Analysis

Total raw scores for each cognitive test were converted to $z$-scores (SDMT) or $T$-scores (BVMT-R, CVLT-II) based on published healthy normative data in respective manuals. Each group was then dichotomized into “impaired” vs. “unimpaired,” using two definitions of impairment: 1.5 or 2 standard deviations (SD) below the normative means, as both criteria are used as determinants for impairment in neuropsychological research [22–24]. Cut scores were then determined using receiver-operating-characteristic (ROC) curve analysis, which plots true positive rate vs. false positive rate (sensitivity vs. 1-specificity). For each analysis, raw scores were run against the transformed total score for that measure. Finally, once optimal cut scores were determined for each measure, positive predictive values (PPV) and negative predictive values (NPV) were calculated (see Table 4).