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# Sensitivity and Specificity of the Montreal Cognitive Assessment Modified for Individuals Who Are Visually Impaired

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**Abstract:** Evaluating the cognitive status of individuals who are visually impaired is limited by the design of the test that is used. This article presents data on the sensitivity and specificity of the version of the Montreal Cognitive Assessment for people who are visually impaired. The original validation data were reanalyzed, excluding the five visual items. The results indicated that the specificity was excellent, while sensitivity was reduced; however, the recommended proportionally adjusted cutoff values showed better sensitivity.

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Given the current demographic changes in developed countries, both age-related vision loss and age-related cognitive impairment are on the rise. However, the research literature contains little information on the prevalence of both comorbidities in the same population. In part, this lack of data is based on methodological choices, whereby studies of visual impairment (that is, blindness and low vision) often screen out cognitively impaired individuals, while cognitive researchers are limited by their testing materials when evaluating persons who are visually impaired. Still, in recent years, several epidemiological studies have reported various levels of association between cognitive decline and vision loss in elderly persons, ranging from weak to moderately strong (Anstey, Hofer, & Luszcz, 2003; Anstey, Luszcz, & Sanchez,

2001; Clemons, Rankin, & McBee, 2006; Klaver et al., 1999; Lin et al., 2004; Pham, Kifley, Mitchell, & Wang, 2006; Reyes-Ortiz et al., 2005; Wong et al., 2002). Lindenberger and Baltes (1994) proposed an association between cognitive and visual functioning in aging, whereby both the functional loss of vision and the decline in cognition may be symptoms of common underlying changes at the neurological level and the physiological state of the brain. In a clinical setting, both blind rehabilitation specialists who want to screen a person for cognitive losses and clinical neuropsychologists have difficulty evaluating the cognition of people with visual impairments.

To evaluate cognitive functioning in persons with visual impairments properly, however, researchers and clinicians face the same methodological challenge:

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How does one evaluate cognition with testing tools that are predominantly designed for people with functional vision? The design of typical neuropsychological tests frequently includes visually based material that requires functional vision. For example, the Wisconsin Card Sorting Test asks persons to recognize patterns of color, shape, or the number of symbols displayed on sequentially presented cards. It examines the flexibility to changing patterns of reinforcement, thereby assessing executive functioning. Given the nature of the test materials, it is impossible to use this procedure with individuals who are blind in its current form.

The idea of developing cognitive test materials for persons who are visually impaired is not new, having resulted in such measures as the Vocational Intelligence Scale, the Stanford Ohwaki-Kohls Tactile Block Design Intelligence Test, the Cognitive Test for the Blind (CTB) and the Vision Independent Cognitive Screen. Previous articles have reviewed these attempts in more detail; however, the most striking fact is that the large majority of these tests are no longer commercially available or are still in the development and validation phase (Bylsma & Doninger, 2004; Jones & Marks, 2008). There have been attempts to alter some of the existing and available standard cognitive tests to make them more appropriate for individuals with low vision. For example, Bertone, Wittich, Watanabe, Overbury, and Faubert (2005) presented versions of the Digit Symbol Test that were either magnified or presented in reversed contrast. Reversed polarity has been shown to benefit individuals with poor contrast sensitivity because glare is reduced (Legge, Rubin,

& Schleske, 1987; Sandberg & Gaudio, 2006). However, the ability of persons with macular degeneration to complete these tests heavily depended on their level of visual acuity and was probably also affected by the type of scotoma. In the presence of a central vision loss, the composition of the visual target becomes important because, depending on the density of spatial information, the difficulty of resolving the image changes.

High spatial-frequency components are those that describe parts of an image that contain fine detail, whereas low spatial-frequency components refer to parts of an image that are larger or broader. Bertone et al. (2005) compared individuals' performance on tests that are composed mostly of either low or high spatial-frequency information, such as the Picture Completion subtest of the Wechsler Adult Intelligence Scale and the Hooper Visual Organization Test as examples of tests with low spatial-frequency material, and the Visual Scanning, Number Sequencing, and Motor Speed subtests of the Delis Kaplan Executive Function System as examples of tests with high spatial-frequency content. They concluded that the presence of low spatial-frequency information (which is generally increased with magnification) aided in the successful completion of the tests, whereas reversed polarity showed little benefit. These findings concurred with the findings of a study in which the effect of blur (which reduces high spatial-frequency information) on nonverbal cognitive tests indicated that even a simulated reduction of visual acuity to 20/60 affected performance (Bertone, Bettinelli, & Faubert, 2007).

In the context of evaluations in rehabilitation clinics for persons who are

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blind or have low vision, tests of cognitive function play an important role, and solutions to the evaluation of individuals with impaired vision will become more important over time. The most commonly known form of cognitive loss in elderly people is probably dementia of the Alzheimer's disease type (AD). The early detection of this type of cognitive impairment has become of great importance, for the purpose of both diagnosis and early treatment. Therefore, screening tools have been developed that can identify individuals who are at risk of AD and other forms of dementia. This quest for early detection has given rise to the term *mild cognitive impairment* (MCI), which describes the state of an individual who reports cognitive complaints, usually including memory deficits, but does not meet the standard criteria for dementia (Chertkow, 2002). One of the most commonly used screening tools for MCI in sighted individuals is the Montreal Cognitive Assessment (MoCA). This measure was specifically designed and validated for the detection of MCI, is freely available at <[www.mocatest.org](http://www.mocatest.org)>, is widely used internationally, and has been translated into 29 languages (Nasreddine et al., 2005). However, it requires functional vision to be evaluated in its full version.

The most widely known cognitive screening tool for individuals who are visually impaired is the version of the Mini-Mental State Examination (MMSE) for people who are blind (Reischies & Geiselman, 1997). This version of the MMSE is administered verbally, and all vision-specific items are simply omitted. For this version, adjusted age- and education-specific scoring norms have been presented (Busse, Sonntag, Bischof,

Matschinger, & Angermeyer, 2002). In addition, a telephone version of the MMSE has been validated, which, because it is administered over the telephone, does not require vision (Roccaforte, Burke, Bayer, & Wengel, 1992). These measures were designed, however, to detect more severe cognitive losses, such as in AD, and are less successful when screening for MCI. This drawback has been pointed out for the full version of the MMSE (Ihl, Frolich, Dierks, Martin, & Maurer, 1992; Tombaugh & McIntyre, 1992; Wind et al., 1997) and would likely be present in the version that is adapted for individuals who are visually impaired. The goal of these screening tools is to identify accurately individuals who indeed have a cognitive deficit. Within this context, *sensitivity* refers to the proportion of participants with a clinical diagnosis according to a gold standard, such as an in-depth neuropsychological examination, who fail the test. In contrast, *specificity* refers to the percentage of individuals who pass the test and should do so since they are considered healthy. The sensitivity of the telephone version of the MMSE to detect cognitive impairment was reported to be relatively low, in that only 68% of the persons with a cognitive loss failed the test (Roccaforte et al., 1992). This limited sensitivity may be due, in part, to the comparison standard because the validation study used a second questionnaire as the gold standard, as opposed to a full neuropsychological examination.

It is common in clinical and rehabilitation settings for cognitive screening to be conducted with validated tools, such as the MMSE. However, when such measures are scored, the total score cannot be

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compared to regular normative values, since individuals who are visually impaired cannot complete all the items. A common modification is to adjust the cutoff score by subtracting the value of the omitted items from the total cutoff score. However, these modified versions are rarely evaluated with respect to their sensitivity and specificity. One exception is the age- and education-adjusted cut-off values presented for the MMSE in its version for persons who are blind (Reischies & Geiselmann, 1997); however, the recommendations presented in Reischies and Geiselmann's article seem to be more widely known among researchers and less often used in the clinical low vision and blind rehabilitation community. Even though the logic of subtracting the missing items from the cutoff score seems intuitive, it may not be a valid way of adjustment. Given that it is a common practice in the vision rehabilitation community to omit the visual components of cognitive screening tools, and given the high sensitivity of the MoCA for detecting MCI in its full version, the study presented here set out to determine the sensitivity and specificity of the version of the MoCA-B scale for persons who are visually impaired in which visual items were removed from the scale.

## Method

The original validation data of the MoCA have been presented in more detail previously (Nasreddine et al., 2005; [www.mocatest.org](http://www.mocatest.org)). The original study population included one of three groups of older adults who had undergone extensive neuropsychological examinations to establish their cognitive status. According to these results, they were assigned to three

groups: cognitively normal participants ( $n = 90$ ), participants with mild cognitive impairments (MCI;  $n = 94$ ), and participants with AD ( $n = 93$ ). The results of the neuropsychological examinations were used as the gold standard for comparison with the MoCA, resulting in the sensitivity and specificity values that are displayed in Table 1. For the purpose of establishing sensitivity and specificity values for the MoCA-B, these data were reanalyzed by omitting the first four items on the scale that require vision: (1) the trail-making task, in which the participants were asked to draw a line between stimuli that alternated between numbers and letters in ascending order (starting at 1 to A, to 2, to B, and so on; 1 point); (2) the copy-cube task, in which the participants were asked to copy a three-dimensional drawing of a cube next to the original on the testing sheet (1 point); (3) the clock-drawing task, which required the participants to draw a clock with all its numbers and set the hands indicating the time "ten to eleven" (3 points); and (4) the confrontational naming of animal pictures, whereby the participants saw three line drawings of a lion, a rhinoceros, and a camel, respectively, and had to say each name out loud (3 points). In the maximum possible score of 30 on the MoCA, these four items constituted a possible 8 points, thereby reducing the maximum total score on the MoCA-B to 22.

In its full version, a score of 26 or better indicates a pass on the MoCA. For the MoCA-B, two alternative calculations were used when establishing an adjusted cutoff value. First, the absolute shift was calculated, whereby the cutoff value was reduced by the absolute value of points that were omitted from the measure (that

**Table 1****Sensitivity and specificity values for the MoCA and the MMSE.**

	MoCA <sup>a</sup>	MMSE <sup>a</sup>	MoCA-B Absolute	MoCA-B Relative	MMSE <sup>b</sup> Telephone	MMSE <sup>c</sup> Visually impaired
Cutoff	26	26	17	18	17	15–17
% of total	83	83	77	82	77	68–77
Sensitivity (%)						
MCI	90	18	44	63	–	–
AD	100	78	87	94	67	91–100
Specificity (%)						
	87	100	98	98	100	80–100

Note: MoCA = Montreal Cognitive Assessment, MMSE = Mini-Mental State Examination, MCI = mild cognitive impairment. AD = Alzheimer's disease. Cutoff, sensitivity, and specificity values for the MMSE version for persons who are visually impaired have a range based on the age- and education-specific norms.

<sup>a</sup> Nasreddine et al. (2005).

<sup>b</sup> Roccaforte et al. (1992).

<sup>c</sup> Busse et al. (2002).

is, 8 points). This subtraction moved the cutoff from 25 points to 17 points. Second, the relative shift was calculated, whereby the failure point was moved in proportion to the total score. In its full version, the cutoff point of 25/30 lies at 83% of the total maximum score. In the proportional shift for the MoCA-B, the cutoff lies at 18/22 or a comparable 82% of the maximum possible score. Sensitivity and specificity values were then calculated on the basis of these two cutoff points and compared to the values obtained from the full version of the MoCA.

## Results

The obtained sensitivity and specificity values are displayed in Table 1. The rows contain sensitivity values for the participants with MCI and AD, respectively, followed by specificity values for standard vision observers. The columns contain values from previously published studies and from the analysis of the MoCA-B. Absolute and relative cutoff values were used to calculate both sensitivity and specificity. For comparison, the values reported for the MMSE in its ver-

sion for telephone interviews with persons who are visually impaired are included as well. A comparison of the sensitivity values for those with MCI indicated that using the absolute cutoff value decreases the sensitivity of the MoCA-B to 44%; however, this value increases to 63% when the relative cutoff point is used. When we compared sensitivity for the detection of AD, we found that both the absolute and relative cutoff points resulted in acceptable values of 87% and 94%, respectively. Specificity increased from 87% to 98% with both cutoff points.

## Discussion

The study investigated whether eliminating visual items from the MoCA for the purpose of screening individuals without sufficient functional vision substantially affects the ability of this tool to identify persons who are affected with MCI or AD. With both cutoff points, the MoCA-B's ability to identify normal participants as such increased from 87% to 98%. We suggest that removing items that assess executive functioning makes the test

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easier for healthy participants, resulting in higher specificity values. As for participants with cognitive impairments, the results indicate that the absence of visual items dramatically decreased sensitivity values from 90% to 44% for MCI and from 100% to 87% for AD when the cutoff point was shifted by the absolute value of dropped items. Of course, the MoCA was not initially designed for use without its visual components; therefore, this change in sensitivity is not surprising. However, when the cutoff point was shifted proportionally to the total score, sensitivity improved to 63% and 94% for MCI and AD, respectively; particularly for the MCI group, this value is less than optimal. The discrepancy between the two disability groups appears large. It is based, in part, on the fact that the MoCA was designed to be more sensitive to mild changes in cognitive functioning, which leads to high sensitivity values in persons with AD, since their cognitive changes are already more pronounced. In the MCI group, sensitivity is more easily decreased when items are omitted because these persons have more subtle losses that may escape detection on a test with fewer items. All items on the MoCA were designed specifically because they were considered to be sensitive to cognitive loss in MCI and early AD.

When the AD sensitivity values were compared with previously reported results of the MMSE in its version for persons with visual impairments in telephone interviews, it became apparent that this measure is subject to similar difficulties (see Table 1). However, in interpreting these values, one needs to consider that only Busse et al.'s (2002) study used a full neuropsychological examination as

the gold standard for comparison, whereas Roccaforte et al. (1992) administered the Brief Neuro-psychiatric Screening Test, a similar screening questionnaire, as their comparison standard. As for the assessment of the MCI, it is not yet possible to compare the MoCA-B with the MMSE because mild versions of dementia have not been evaluated with the reduced version of the MMSE. It could be speculated, however, that administration of the version of the MMSE administered by telephone to persons who are visually impaired would most likely result in even lower sensitivity values, since even in its full version the MMSE has been shown to be limited in its ability to detect MCI (Ihl et al., 1992; Tombaugh & McIntyre, 1992; Wind et al., 1997).

The question remains as to why the elimination of visual test items in cognitive screening seems to have such detrimental effects on the detection of MCI. The answer may lie in the type of cognitive functions that are being assessed in items 1–4 of the MoCA. Both the trail-making task and the cube-drawing task assess planning and organization skills. The clock-drawing task engages inhibitory control and memory, while the confrontational naming task requires the recall of vocabulary and semantic knowledge. These skills, or some components of them, may be crucial in the detection of early signs of dementia. Thus, the failure to assess these abilities because of the omission of the items could have reduced the sensitivity of the revised test.

A better approach may be to substitute these items, for example, by including verbal descriptions of animals to replace the confrontational naming task. Verbal

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substitute items to evaluate inhibitory control and organization are generally not used in screening tests and would first require extensive validation with participants who are visually impaired. One possible solution may be simply to create tactile three-dimensional replacements of some of the visual items that are used in the MoCA. Such tactile evaluation does not interfere with the scoring because these items do not depend on performance time. This aspect is also an advantage for testing participants with low vision who can use magnification devices to complete the test. In addition, appropriate age- and education-specific norms for the MoCA-B will need to be established. Finally, the MoCA-B will need to be validated in its adjusted version in a population of individuals who are visually impaired with and without cognitive impairments.

Given the changing population demographics, the screening for early cognitive decline in the context of age-related vision loss and its rehabilitation will become imperative in the coming decades. The importance of using properly adjusted cutoff values recently became clear in a study by Buteau et al. (2008). This team of occupational therapists applied the full 30-point MoCA to a group of 14 individuals with low vision and found that 13 of the participants failed the test, even though an evaluation with an occupational therapy tool indicated that only 1 of these 14 participants actually demonstrated cognitive loss. As is commonplace practice in low vision clinical settings, Buteau et al. failed to adjust the cutoff score and administered the entire scale. Thus, it is probable that at least some of the participants failed some or all of the initial four items for reasons of vision loss

as opposed to cognitive impairment. This point highlights the need to evaluate tests of cognitive function properly for use with people with low vision, as we attempted to do in our study.

In summary, both the sensitivity and the specificity of the MoCA-B in the detection of AD remain excellent even when the visual items are removed from the scale. The test's ability to detect MCI is reduced by the elimination of the visual items, which seem to contain critical evaluation aspects for mild cognitive loss. However, the use of a proportionally reduced cutoff value improved sensitivity. The MoCA is the only screening tool for MCI that is readily available and easy to administer. Given the results presented here, the MoCA-B can be used with reasonable success when screening individuals who are visually impaired who are at risk of MCI. However, the test needs to be used with caution until further improvements are made to increase its sensitivity to higher than 80% when it is used without the items that require functional vision. In the clinical and rehabilitation setting, it is common practice simply to reduce the cutoff value by the absolute number of points; however, our data suggest that a proportional adjustment would be more advisable.

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