The Montreal Cognitive Assessment, MoCA: A Brief Screening Tool For Mild Cognitive Impairment

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OBJECTIVES: To develop a 10-minute cognitive screening tool (Montreal Cognitive Assessment, MoCA) to assist first-line physicians in detection of mild cognitive impairment (MCI), a clinical state that often progresses to dementia.

DESIGN: Validation study.

SETTING: A community clinic and an academic center.

PARTICIPANTS: Ninety-four patients meeting MCI clinical criteria supported by psychometric measures, 93 patients with mild Alzheimer's disease (AD) (Mini-Mental State Examination (MMSE) score $\geq$17), and 90 healthy elderly controls (NC).

MEASUREMENTS: The MoCA and MMSE were administered to all participants, and sensitivity and specificity of both measures were assessed for detection of MCI and mild AD.

RESULTS: Using a cutoff score 26, the MMSE had a sensitivity of 18% to detect MCI, whereas the MoCA detected 90% of MCI subjects. In the mild AD group, the MMSE had a sensitivity of 78%, whereas the MoCA detected 100%. Specificity was excellent for both MMSE and MoCA (100% and 87%, respectively).

CONCLUSION: MCI as an entity is evolving and somewhat controversial. The MoCA is a brief cognitive screening tool with high sensitivity and specificity for detecting MCI as currently conceptualized in patients performing in the normal range on the MMSE. **J Am Geriatr Soc 53:695–699, 2005.**

Key words: MoCA; mild cognitive impairment; Alzheimer's; cognitive assessment

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Mild cognitive impairment (MCI) is an intermediate clinical state between normal cognitive aging and dementia, and it precedes and leads to dementia in many cases. Neuropsychological, neuropathological, and imaging studies also support MCI's transitional nature.[1] The concept of MCI is new, evolving, and somewhat controversial, but there is rough consensus as to its clinical definition and prognosis, and it is a common and important condition.[2] Neuropsychological testing with standardized tests is often used to assess and characterize MCI patients,[2,3] but many clinicians lack easy and timely access to such assessments or to tertiary care memory clinics. Accessibility will become even more of a problem in coming years given the substantial increase in the proportion of elderly in the population.

Although several screening instruments are available for detecting dementia, the Mini-Mental State Examination (MMSE)[4] is the most widely used by frontline physicians. Difficulties with the MMSE in detecting early dementia have been reported.[5–7] Most individuals meeting clinical criteria for MCI score above 26 on the MMSE, which is also the range for normal elderly individuals. Family physicians are left with no clearly accepted and easily administered

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tool to evaluate MCI. To address this problem, the Montreal Cognitive Assessment (MoCA) was developed as a tool to screen patients who present with mild cognitive complaints and usually perform in the normal range on the MMSE. This study assessed the sensitivity and specificity of the MoCA in patients with MCI and Alzheimer's disease (AD) and normal elderly controls.

METHODS

MoCA Development

The MoCA was developed based on the clinical intuition of one of the authors (ZN) regarding domains of impairment commonly encountered in MCI and best adapted to a screening test. An initial version covered 10 cognitive domains using rapid, sensitive, and easy-to-administer cognitive tasks. Iterative modification of the MoCA took place over 5 years of clinical use. An initial test version was administered to 46 consecutive patients (mostly diagnosed with MCI or AD) presenting to the University of Sherbrooke Neuro Rive-Sud (NRS) memory clinic with cognitive complaints, a MMSE score of 24 or higher, and impaired neuropsychological assessment. They were compared with 46 healthy controls from the same community with normal neuropsychological performance. Five items did not discriminate well and were replaced. Scoring was then adjusted, giving increased weight to the most discriminant items. The current study used this final revised version of the MoCA, now covering eight cognitive domains.

Evaluation of the MoCA in AD and MCI

In the current study, three participant groups were recruited: patients with mild AD, patients meeting criteria for MCI, and normal elderly controls (NC). The MoCA was administered to all groups, and its sensitivity and specificity were compared with those of the MMSE for detection of MCI and mild AD, with clinical diagnosis in a memory clinic (supported by neuropsychological evaluation) as the criterion standard. The MoCA was administered in French and English as appropriate. The French version is identical to the English version except for the sentences used in the repetition task.

Study Participants

The three groups were recruited from the Jewish General Hospital (JGH) Memory Clinic in Montreal, a tertiary care referral center, and the University of Sherbrooke NRS memory clinic in a south-shore community of Montreal. The review board of both institutions approved the study protocol.

The MCI group consisted of 94 elderly participants. MCI in these centers is a clinically oriented diagnostic label (as is dementia), applied after evaluation by trained neurologists or geriatricians and a standardized mental status battery. The definition of MCI corresponded to previously established criteria.[1,8–10] This study's criteria, reviewed previously[2] and adapted from a previous study,[8] included the presence of subjective complaints of gradual memory loss over at least 6 months reported by the patient or family members. There had to be objective evidence of memory loss demonstrated on clinical memory tests administered by the physician. There had to be general preservation of other cognitive domains, although subtle changes in other domains were present in 35% of cases. There was preserved functioning in terms of activities of daily living, with only mild if any impairment in instrumental activities (e.g., keeping memory lists). There had to be absence of other obvious medical, neurological, or psychiatric explanation for the memory loss (with the exception of mild depression) and insufficient findings to warrant a clinical diagnosis of dementia.[9] This bedside assessment was later supported by performance on neuropsychological tests of delayed memory (Rey Auditory Verbal Learning Test[11] and Delayed Visual Reproduction and Logical Memory, two subtests of the Wechsler Memory Scale[12]). Four subjects had mild memory loss according to these tests, as well as impairment in multiple other cognitive domains. Ninety subjects had primarily memory loss, below normative values on age- and education-adjusted norms on at least one of these three tests (at least a 1.0–standard deviation (SD) decrease in all cases and a 1.5-SD decrease in 85/90 cases). No subjects were judged as having preserved memory.

The AD group consisted of 93 participants with a diagnosis of probable AD meeting the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition,* criteria[13] and the National Institute of Neurological and Communicative Disorders and Stroke/Alzheimer's Disease and Related Disorders Association criteria.[14] These individuals were all mildly demented, and all but three had MMSE scores of 17 or greater. The MoCA was not used to make a diagnosis of MCI or AD and was collected independently of the diagnostic assessments.

The NC group consisted of 90 healthy elderly volunteers recruited from the community, with no memory or cognitive complaints and normal baseline neuropsychological performance. A subset (n = 51) also had a neurological examination and computed tomography scan, which were normal.

Demographic information is summarized in Table 1. The JGH and NRS groups were similar except that the NRS group was largely French speaking (87%) and the JGH

Table 1. Subject Demographics

Characteristic	Age (Average ± Standard Deviation)	Education (Average ± Standard Deviation)	Female n (%)
Controls (n = 90)	72.84 ± 7.03	13.33 ± 3.40	54 (60)
Mild cognitive impairment (n = 94)	75.19 ± 6.27	12.28 ± 4.32	41 (44)
Alzheimer's disease (n = 93)	76.72 ± 8.83*	10.03 ± 3.84*	55 (59)

* $P < .05$.

group was English speaking (100%). After adjusting for education (the French sample had fewer years of education), the two language subsamples obtained equivalent scores on the MMSE and MoCA in each of the three diagnostic groups.

AD participants were significantly older than MCI and NC participants ($F_{2,272} = 6.26$, mean squared error (MSE) = 55.56, $P = .002$), but the latter two groups did not differ from each other. Mean years of education also differed, $F_{2,271} = 17.30$, MSE = 15.00, $P < .001$), with the AD participants having significantly less education than the NC or MCI participants. Again, the MCI and NC groups did not differ from each other.

Cognitive Testing

The MMSE, the MoCA, and the same neuropsychological battery were administered to all groups in both institutions. The MMSE and MoCA were administered on the same day or within 3 months for all participants except four, for whom administration was less than 12 months apart.

Montreal Cognitive Assessment

The final version of the MoCA (available at www.mocatest.org) is a one-page 30-point test administered in 10 minutes. Details on the specific MoCA items are as follows. The short-term memory recall task (5 points) involves two learning trials of five nouns and delayed recall after approximately 5 minutes. Visuospatial abilities are assessed using a clock-drawing task (3 points) and a three-dimensional cube copy (1 point). Multiple aspects of executive functions are assessed using an alternation task adapted from the Trail Making B task (1 point), a phonemic fluency task (1 point), and a two-item verbal abstraction task (2 points). Attention, concentration, and working memory are evaluated using a sustained attention task (target detection using tapping; 1 point), a serial subtraction task (3 points), and digits forward and backward (1 point each). Language is assessed using a three-item confrontation naming task with low-familiarity animals (lion, camel, rhinoceros; 3 points), repetition of two syntactically complex sentences (2 points), and the aforementioned fluency task. Finally, orientation to time and place is evaluated (6 points).

RESULTS

Psychometric Properties of the MoCA

To determine whether the French and English versions of the MoCA were equivalent, Francophone and Anglophone participants matched on age and who had 11 or more years of education were selected for each clinical group. MoCA scores did not differ significantly between Francophone and Anglophone participants when collapsed over clinical group (t (172) = 0.12, $P = .91$; Francophone mean ± SD = 23.6 ± 6.4; Anglophone = 23.7 ± 4.1), or when the three clinical groups were considered separately (all $t < 2.1$, all $P > .06$). Therefore, results from the two centers and the two languages of testing were collapsed for analyses.

Test-retest reliability data were collected from a subsample of 26 participants (patients and controls) tested, on average, 35.0 ± 17.6 days apart. The mean change in MoCA scores from the first to second evaluation was 0.9 ± 2.5 points, and correlation between the two evaluations was high (correlation coefficient = 0.92, $P < .001$).

The internal consistency of the MoCA was good, yielding a Cronbach alpha on the standardized items of 0.83. Item analysis revealed that the following items discriminated reliably between all three groups, with the AD participants performing most poorly, followed by the MCI participants: trail making, cube drawing, clock drawing, naming, delayed recall, phonemic fluency, abstraction, and orientation. The following tasks discriminated the AD participants from the MCI participants and NCs, who did not differ from each other: digit span, sustained attention, and the serial 7 calculation task. These tasks test attentional processes, which appeared to be largely preserved in the MCI sample. Finally, the AD and MCI participants performed similarly poorly on the sentence repetition task. Thus, all items were successful in discriminating between at least two of the groups, and the majority discriminated between all three groups in a stepwise fashion. Delayed recall was the most impaired item in MCI participants.

Group Differences and Sensitivity and Specificity of the MMSE and MoCA

Initial analyses indicated that persons with 12 years of education or less tended to have worse performance on the MoCA. To correct for education effects, 1 point was added for participants with 12 years of education or less on their total MoCA score (if < 30). Figure 1 shows the education-adjusted mean MMSE and MoCA scores of NC, MCI, and AD participants. Average MMSE scores of all three groups differed significantly from each other ($F_{2,272} = 166.20$, MSE = 5.40, $P < .001$). Average MoCA scores also differed significantly between the three groups ($F_{2,274} = 232.91$, MSE = 12.84, $P < .001$) and remained significant after controlling for the effects of age and education (analysis of covariance $F_{2,269} = 183.32$, MSE = 11.18, $P < .001$). As seen in Figure 1, the differences between the groups were much more pronounced using the MoCA than the MMSE, and the mean score of the MCI participants fell within the normal range on the MMSE and in the abnormal range on

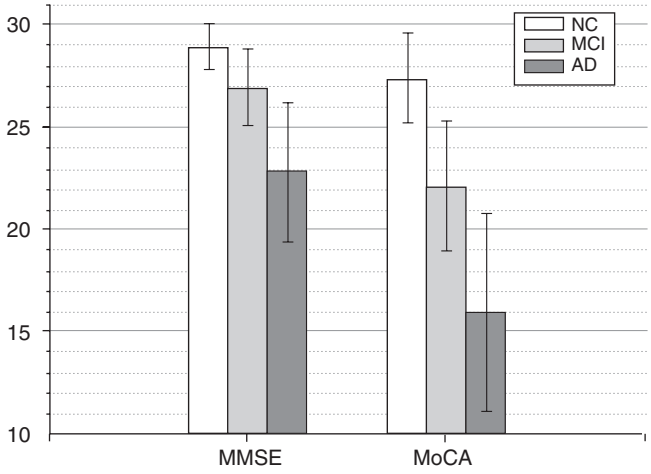

Figure 1. Mean Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) scores ± standard deviations for normal controls (NCs) and subjects with mild cognitive impairment (MCI) and Alzheimer's disease (AD).

the MoCA. The correlation between the MoCA and the MMSE was high (r (274) = 0.87, $P < .001$).

Sensitivity and specificity were determined using clinical diagnosis as the standard for patients and controls. A cutoff of 26 (scores of 25 or below indicate impairment) yielded the best balance between sensitivity and specificity for the MCI and AD groups. A cutoff score of 26 was also used for the MMSE for comparison purposes, because there was no optimal single score, and it has been demonstrated that no single cutoff score serves all purposes.[6]

Sensitivity was calculated separately for the MCI and AD groups. The MoCA exhibited excellent sensitivity in identifying MCI and AD (90% and 100%, respectively). In contrast, the sensitivity of the MMSE was poor (18% and 78%, respectively). Specificity was defined as the percentage of NCs that scored at or above the cutoff score of 26. The MMSE had excellent specificity, correctly identifying 100% of the NCs. The MOCA had very good to excellent specificity (87%). Moreover, positive and negative predictive values for the MoCA were excellent for MCI (89% and 91%, respectively) and AD (89% and 100%, respectively).

Participants' MMSE and MoCA Scores Distribution

As demonstrated by the standard deviation bars in Figure 1 and the scatterplot distribution of scores in Figure 2, the MMSE scores of NCs had considerable distributional overlap with the MCI participants and, to some degree, with mild AD patients. In fact, the majority of MCI participants and some mild AD participants had MMSE scores in the normal range. In contrast, few MCI participants and no AD participants scored in the normal range on the MoCA.

When MMSE and MoCA scores were plotted together (Figure 2), a striking pattern emerged. The large majority of NC participants scored in the normal range, and the large majority of AD patients scored in the abnormal range on both MMSE and MoCA. In contrast, 73% of MCI participants scored in the abnormal range on the MoCA but in the normal range on the MMSE.

DISCUSSION

The MoCA demonstrated high test-retest reliability, good internal consistency, and equivalence in its two language forms. Content validity was established via a close correlation between MoCA and MMSE scores.

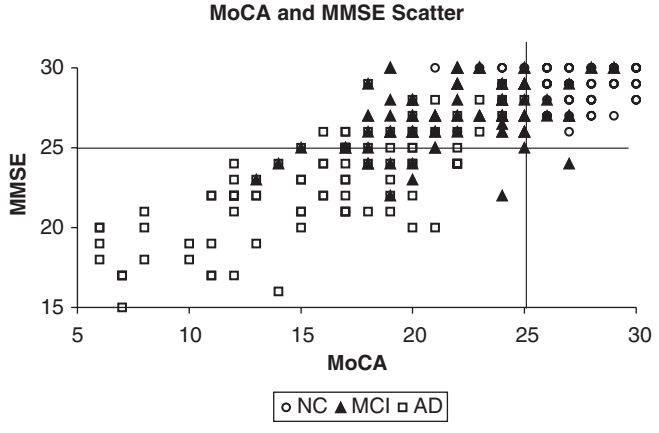

Figure 2. Scatter plot of Montreal Cognitive Assessment (MoCA) and Mini-Mental State Examination (MMSE) scores for normal controls (NCs) and subjects with mild cognitive impairment (MCI) and Alzheimer's disease (AD).

The specificity of the MoCA to exclude elderly normal controls was good (87%), although slightly lower than the MMSE. More important, the MoCA's sensitivity in detecting MCI was excellent (90%), and it was considerably more sensitive than was the MMSE. The MoCA also detected mild AD with high sensitivity (100%) and excellent specificity (87%). Results were comparable in two separate institutions, indicating that it is useful in an academic setting (JGH) and a community setting (NRS memory clinic). Although the AD participants were older and less well educated than the MCI and NC participants, the critical MCI and NC groups were equivalent to each other in terms of age and education.

There are several features in MoCA's design that likely explain its superior sensitivity for detecting MCI. The MoCA's memory testing involves more words, fewer learning trials, and a longer delay before recall than the MMSE. Executive functions, higher-level language abilities, and complex visuospatial processing can also be mildly impaired in MCI participants and are assessed by the MoCA with more numerous and demanding tasks than the MMSE.

When considering MMSE and MoCA performance in the same participants (Figure 2), an important pattern emerged. The majority of NC participants scored in the normal range, and the majority of AD patients scored in the abnormal range on both tests, but three-quarters of the MCI participants scored in the abnormal range on the MoCA but were considered normal according to the MMSE. In clinical practice, patients screened and found to have a MoCA score over 26 would be extremely unlikely to meet clinical and neuropsychological criteria for MCI even after extensive evaluation. In general practice therefore, using the MoCA as a screening tool should provide quick guidance for referral and further investigation of MCI.

The following presents a practical approach to evaluating patients presenting with cognitive complaints. Patients who present with cognitive complaints and functional impairment are most likely to suffer from dementia. The MMSE could be administered first because it is likely to be abnormal (78% of those with mild AD had an abnormal MMSE score). If the MMSE is normal ($\geq$26), the MoCA should then be administered (100% of those with mild AD had an abnormal MoCA score). In contrast, patients who present with cognitive complaints but no functional impairment are likely to be normal or have MCI. In these patients, one should administer the MoCA first because the MMSE will most likely produce a normal score in either case. The MoCA is highly acceptable to the MCI population, many of whom find the MMSE's cognitive tasks insultingly simple. This approach improves efficiency in evaluating patients with cognitive complaints. Separating patients with MCI from those with AD will still rely on clinical judgment, particularly in assessing whether the patient has functional impairment. Both groups will usually have abnormal MoCA scores.

There are no screening tools that can quickly assess very different levels of cognitive impairment. The MoCA is useful for the mild stages of the cognitive impairment spec-

trum (including MCI and mild AD), and the MMSE is superior for more-advanced stages (AD patients with more-significant functional impairment).

There are currently no other screening tools to quickly and reliably distinguish MCI from normal controls. Measures such as the Short Test of Mental Status (STMS),[15] Memory Impairment Screen,[16] and 7-Minute Screen[17] have been validated for dementia but not MCI. A recent study showed that neither the STMS nor the MMSE can be used alone to diagnose MCI or dementia.[18] The Cognitive Capacity Screening Examination has 74.3% sensitivity for detection of MCI, and when combined with the MMSE, it achieved a sensitivity of 83%, but this combined total score was derived from two scales and scored out of 47 points,[19] making it lengthy and potentially cumbersome to use. The DemTect[20] has been reported to be useful for distinguishing MCI, AD, and normal controls, but compared with the MoCA, the DemTect achieves lower sensitivity for MCI (80%, compared with the MoCA's 90%) and assesses fewer cognitive domains (6 domains, compared with the MoCA's 8).

In summary, the current concepts of normal cognitive aging, MCI, and dementia diagnosis are evolving, and new assessment tools for executive function and attention might alter assessment of these categories.[21] Nevertheless, MCI is now recognized as an important and diagnosable entity, a high-risk state for progression to AD, and drug studies of MCI subjects are currently underway.[22] Rapid, accurate diagnosis of MCI will become increasingly important to clinicians. The MoCA is a simple, stand-alone cognitive screening tool with superior sensitivity. It covers important cognitive domains, can be administered in 10 minutes, and fits on one page. Moreover, the data indicate that it has excellent test-retest reliability and positive and negative predictive values for MCI and AD. It is sensitive to the presence of MCI and is feasible to use in a clinical setting, where assessment time is often limited. The MoCA promises to fill an urgent unmet need for a brief screening tool capable of detecting patients with MCI and distinguishing them from cognitively intact older people.

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