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Cognitive Performance on the Mini-Mental State Examination and the Montreal Cognitive Assessment Across the Healthy Adult Lifespan

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Abstract

Objective—We sought to compare age-related performance on the Mini-Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA) across the adult lifespan in an asymptomatic, presumably normal, sample.

Background—The MMSE is the most commonly used brief cognitive screening test; however, the MoCA may be better at detecting early cognitive dysfunction.

Methods—We gave the MMSE and MoCA to 254 community-dwelling participants ranging in age from 20 to 89, stratified by decade and we compared their scores using the Wilcoxon signed rank test.

Results—For the total sample, the MMSE and MoCA differed significantly in total scores as well as in visuospatial, language, and memory domains (for all of these scores, $P < 0.001$). Mean MMSE scores declined only modestly across the decades; mean MoCA scores declined more dramatically. There were no consistent domain differences between the MMSE and MoCA during the 3rd and 4th decades; however, significant differences in memory ($P < 0.05$) and language ($P < 0.001$) emerged in the 5th through 9th decades.

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Authors' Contributions

Shea Gluhm: Organization and execution of research project; acquisition of participants and data; analysis and interpretation of data; writing of first draft of the manuscript.

Jody Goldstein: Conception, organization, and execution of research project; review and critique of statistical analysis; review and critique of manuscript.

Kiet Loc: Organization and execution of research project; acquisition of participants and data; review and critique of statistical analysis; review and critique of manuscript.

Alexandra Colt: Organization of research project; writing of first draft of the manuscript.

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Jody Corey-Bloom: Conception, organization, and design of research project; review and critique of statistical analysis; review and critique of manuscript.

Conflicts of Interest

Dr. Corey-Bloom has received personal compensation from Isis Pharmaceuticals for consulting services and has been the principal investigator on a number of clinical trials for dementia supported by Elan, Teva, Siena, Prana, Huntington Study Group, and Cure HD Initiative. The other authors declare no conflicts of interest.

Conclusions—We conclude that the MoCA may be a better detector of age-related decrements in cognitive performance than the MMSE, as shown in this community-dwelling adult population.

Keywords

Mini-Mental State Examination (MMSE); Montreal Cognitive Assessment (MoCA); cognitive decline; healthy sample

Clinicians use cognitive assessments both to diagnose and to track individuals at risk for, or affected by, disorders that impair cognition. Researchers also use cognitive testing to determine the eligibility of normal controls, monitor the status of affected participants, and evaluate the efficacy of experimental treatments in clinical trials. In all of these settings, assessments must be capable of identifying characteristic deficits, yet brief enough for practical use.

Currently, the Mini-Mental State Examination (MMSE) is the most frequently used brief cognitive instrument.^{1–3} The MMSE was developed in 1975 as a global assessment of cognitive status.^{4,5} A perfect score is 30 points; a score of 24 is the recommended,⁴ and most frequently used,² cutpoint for dementia; a score of 23 or lower indicates dementia. A cutoff score for lesser forms of impairment, eg, mild cognitive impairment, has not been established or implemented with any consistency.² The ease of giving the MMSE and its utility in detecting Alzheimer disease have made it a popular neuropsychological tool.⁵ However, the extent of its usefulness has been questioned, especially for milder forms of cognitive impairment^{1–3} and for dementing disorders characterized by executive, visuospatial, or complex attentional deficits.^{6,7} Age and education have been found to account for 12% of the variance in MMSE scores.² Further, ceiling effects that have been observed in clinical samples, eg, individuals with early Parkinson disease,^{2,8,9} may limit the test's applicability in general populations.^{2,5}

The newer, less-used Montreal Cognitive Assessment (MoCA) may have sensitivity and specificity superior to the MMSE for a variety of dementing disorders and general cognitive deficits.^{1,3,6,7,10} Like the MMSE, the MoCA is a brief 30-point assessment of global cognition that evaluates a broad array of cognitive domains; unlike the MMSE, one of the domains that the MoCA tests is executive function.^{1,3} The MoCA was originally intended to identify mild cognitive impairment and early Alzheimer disease, with a proposed cutoff score of 26, and with 25 indicating impairment³; however, some research has suggested that a lower cutpoint (eg, 23) or age- and education-stratified normative data would yield more accurate results.^{10,11} Additional advantages of the MoCA are that it is less susceptible to educational and cultural artifacts and it eliminates most ceiling effects in normal control groups.^{1,3} Thus, the MoCA appears to be a better brief global cognitive assessment for both clinical and general populations than the MMSE.

Our objective, therefore, was to examine performance on the MMSE and MoCA across the healthy adult lifespan. To our knowledge, no prior study has compared performance on these instruments in a large, community-dwelling, “normal” adult sample.

METHODS

Participants

We gave the MMSE and MoCA on the same day to 254 neurologically healthy adults ranging in age from 20 to 89 years, stratified by decade. Half took the MMSE first, and half took the MoCA first.

Most of the participants were spouses and friends of patients seen at the University of California, San Diego (UCSD) Huntington's Disease Clinical Research Center and UCSD Shiley-Marcos Alzheimer's Disease Research Center. We recruited other participants from the San Diego community as part of a convenience sample. We obtained human subjects research approval from the UCSD Institutional Review Board and a signed informed consent form from each participant. Participants received no reimbursement for taking part in the study. Inclusion criteria for the study were completion of both the MMSE and MoCA, no reported history of neurologic or psychiatric disorders, and no use of psychoactive substances or medications.

Measures

Based on previous research,¹² we grouped the individual items on the MMSE and MoCA in 6 cognitive domains: executive function, serial subtraction, language, memory, orientation, and visuospatial (Table 1). We compared total scores using the full 30-point scales. When we compared results across domains, however, we excluded the executive function items because they are covered in the MoCA but not in the MMSE. We also excluded the serial subtraction items from both tests because of differential weighting: the MMSE has a maximum of 5 points for the task; the MoCA has a maximum of 3 points.

Statistical Analysis

We examined the raw data for outliers and for parametric distribution requirements. In comparing MMSE and MoCA scores stratified by participants' decade of age, we used analysis of variance (ANOVA) to examine the impact of education on variation, and we used Chi-squared (χ^2) tests to determine sex-based effects. Because of significantly non-normal distributions, we used Wilcoxon signed rank tests to analyze performance on the total and individual cognitive domain scores for the MMSE and MoCA across decades. For the cognitive domains, we compared the percentage of incorrect answers because of differential allotment of points for the various domains on each test. We used Bonferroni correction for multiple comparisons to maintain at least a 0.05 Type I error level.

RESULTS

Table 2 shows demographic data and test scores by decade of age. Of the 254 participants, 66.9% were Caucasian. There were no statistically significant differences in educational levels across decades. Male-to-female ratios were not significantly different except in the 4th decade, which had more women than men ($\chi^2 = 4.17$, $P < 0.05$). The MMSE had a much narrower distribution of total scores and many more maximal values (Figure 1) than did the MoCA (Figure 2).

Mean MMSE scores worsened only modestly across the decades; mean MoCA scores showed a much more dramatic decline (Figure 3). The total sample had significant differences between MMSE and MoCA total scores (Wilcoxon $z = -10.87$, $P < 0.001$), as well as the visuospatial (Wilcoxon $z = -4.91$, $P < 0.001$), language (Wilcoxon $z = -8.55$, $P < 0.001$), and memory (Wilcoxon $z = -6.83$, $P < 0.001$) domains (Table 3). Significant differences emerged between MMSE and MoCA total scores for the 3rd through 9th decades (range: Wilcoxon $z = -3.04$, $P = 0.002$ — Wilcoxon $z = -5.16$, $P < 0.001$) (Table 3). There were no consistent domain differences between the MMSE and MoCA during the 3rd and 4th decades; however, in the 5th through 9th decades, significant differences emerged for memory (range: Wilcoxon $z = -2.05$, $P = 0.040$ — Wilcoxon $z = -3.75$, $P < 0.001$) and language (range: Wilcoxon $z = -3.48$, $P = 0.001$ — Wilcoxon $z = -3.92$, $P < 0.001$) (Table 3).

In addition, we used a Bonferroni correction to account for the 40 multiple comparisons that we had analyzed in the study. Even at a significance level of 0.001, there were significant differences between total MMSE and MoCA scores for the 5th through 9th decades; beginning in the 6th decade, the memory and language domains were the most significantly different between the MMSE and MoCA.

DISCUSSION

We compared performance on the MMSE and MoCA across 7 decades to determine whether the MoCA was better than the MMSE at detecting age-related cognitive decline. To our knowledge, ours is the first study to examine differences between the MMSE and MoCA across the adult lifespan in a sample of “normal” adults.

We found that across all decades, mean total scores on the MoCA were lower than those on the MMSE. These findings imply that the MoCA may be a more challenging test for cognitively intact individuals, eliminating the ceiling effects often described for the MMSE¹³ and observed in our sample. We also found that the difference between total MMSE and MoCA scores widened with age, suggesting that the MoCA detects age-related early cognitive decline better than the MMSE. The largest difference between total MMSE and MoCA scores was in the 9th decade: our oldest participants scored an average of >3 points lower on the MoCA than on the MMSE. Although some of these “normal” participants may have been in the earliest stages of a dementing condition, our findings still suggest that the MoCA was able to detect cognitive deficits that were not apparent with the MMSE.

Even though the MMSE allots more total points to language assessment, it was the MoCA, and not the MMSE, that better detected age-related language decline, starting in the 6th decade. The MoCA was also better than the MMSE at detecting short-term memory deficits.

The only other study we are aware of that compared performance on the MMSE and MoCA in community-dwelling participants examined elderly adults aged 70 years (mean age = 79) living in the southeastern US.¹⁰ The authors found that the MoCA was more effective than the MMSE at identifying older adults with and without early cognitive impairment. Our study not only supports their findings, but reveals significant differences between mean total MMSE and MoCA scores across all decades of adult life.

In analyzing the MoCA results, we incorporated the suggested 1-point total score correction for individuals with 12 years of education.³ Because another study had reported that the recommended 1-point education correction adversely affected the reliability of the MoCA,¹⁴ we also calculated total means for the MoCA without the education correction. This recalculation led to a decrease of 0.1 point for the total MoCA scores for most decades, a difference that did not change the significance of the results.

Our investigation had some limitations. It was not a longitudinal study. It was also not a population-based study, but rather a relatively small convenience sample from 1 academic medical center. Although we tried to ensure that our participants were cognitively normal, we did not use additional standardized tests of medical, functional, or psychiatric performance that might have excluded people with cognitive impairments. Finally, our participants had relatively high education levels, perhaps limiting the generalizability of our findings.

Nevertheless, although the MMSE is the most frequently used brief cognitive measure, we found that the MoCA was better able to detect age-related cognitive decline across the adult lifespan. Our findings may have important implications for cognitive research, especially

studies that screen normal community-dwelling populations for evidence of cognitive impairment.

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FIGURE 1.
Distribution of Mini-Mental State Examination (MMSE) total scores for all participants.

FIGURE 2.
Distribution of Montreal Cognitive Assessment (MoCA) total scores for all participants.

FIGURE 3.
Mean Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) total scores across decades.

TABLE 1

Grouping of MMSE and MoCA Domains with Point Values for Each Component

Measure	Executive Function	Serial Subtraction	Language	Memory	Orientation	Visuospatial
Mini-Mental State Examination (MMSE) (30 points)		Serial 7s (5)	Name Objects (3) Pen/Watch (2) Repeat (1) 3- Stage Command (3) Read and Obey (1) Write Sentence (1)	Recall (3)	Orientation (10)	Copy Design (1)
Montreal Cognitive Assessment (MoCA) (30 points)	Trail Making Test Part B (1) Digit Span (2) Target Detection (1) Fluency (1) Abstraction (2)	Serial 7s (3)	Naming (3) Sentence (2)	Recall (5)	Orientation (6)	Cube (1) Clock (3)

Domain groupings based on Strauss et al. 12

Demographics and Clinical Measures Grouped by Decade

TABLE 2

Decade (years)	N	Age in years	Education in years	Men, %	Total MMSE Score; Range	Total MoCA Score; Range
3rd (20s)	43	23.6 (3.0)	15.6 (1.6)	44.2	29.7 (0.5) 28–30	28.9 (1.7) 25–30
4th (30s)	24	34.0 (3.3)	16.5 (2.2)	29.2 [*]	28.8 (1.4) 26–30	27.8 (2.0) 23–30
5th (40s)	25	43.9 (2.4)	15.1 (2.0)	52.0	29.1 (0.9) 27–30	27.4 (2.3) [‡] 20–30
6th (50s)	51	54.8 (3.0)	14.9 (2.1)	60.8	28.8 (1.2) 26–30	27.0 (2.2) [‡] 21–30
7th (60s)	46	64.7 (2.9)	14.7 (2.6)	37.0	28.9 (1.3) 26–30	26.8 (2.7) [‡] 18–30
8th (70s)	39	74.5 (2.8)	15.5 (2.5)	41.0	28.8 (1.3) 26–30	26.9 (2.3) [‡] 20–30
9th (80s)	26	83.6 (2.5)	16.2 (2.2)	65.4	28.7 (1.1) 26–30	25.1 (2.1) [‡] 19–30
Total	254					
Mean		54.3 (19.8)	15.4 (2.2)	47.2	29.0 (1.2) 26–30	27.2 (2.4) [‡] 18–30

Data are mean (standard deviation) except for men, shown as a % of the sample.

^{*}Significantly more women than men, $P < 0.05$.

[‡]Wilcoxon nonparametric T -test; significant after Bonferroni correction for multiple comparisons.
MMSE indicates Mini-Mental State Examination; MoCA, Montreal Cognitive Assessment.

TABLE 3

Percentage of Incorrect Answers on MMSE and MoCA Domains Across Decades

	Mean Percentage of Incorrect Answers on Domains [*]									
	Total (n = 254)	20s (n = 43)	30s (n = 24)	40s (n = 25)	50s (n = 51)	60s (n = 46)	70s (n = 39)	80s (n = 26)		
Language										
MMSE	[†] 1.4	1.1	1.1	1.1	[†] 1.1	[†] 1.0	[†] 2.1	[†] 2.8		
MoCA	9.8	7.0	8.3	8.0	8.6	10.9	11.3	16.2		
Memory										
MMSE	[†] 11.0	3.1	11.1	10.7	[†] 10.5	13.0	12.0	[†] 20.5		
MoCA	25.6	10.2	14.2	24.0	27.1	29.1	25.6	53.9		
Orientation										
MMSE	0.8	0.2	0.4	1.2	2.0	0.4	0.3	1.2		
MoCA	1.4	0.4	0.0	0.7	4.3	1.1	0.4	1.9		
Visuospatial										
MMSE	[†] 3.5	2.3	4.2	4.0	2.0	4.4	2.6	7.7		
MoCA	9.4	1.7	10.4	11.0	9.8	12.5	9.6	12.5		

* Statistically significant mean percentages of incorrect answers are in bold type.

[†] Significant after Bonferroni correction for multiple comparisons.

MMSE indicates Mini-Mental State Examination; MoCA, Montreal Cognitive Assessment.