Published in final edited form as:

Alzheimer Dis Assoc Disord. 2019 ; 33(3): 226–232. doi:10.1097/WAD.0000000000000310.

Discriminative ability of Montreal Cognitive Assessment subtests and items in racial and ethnic minority groups

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Abstract

Introduction: The Montreal Cognitive Assessment (MoCA) is a popular screening tool for Mild Cognitive Impairment (MCI). The psychometric properties of the MoCA have not been widely examined in minority groups. We aimed to analyze the discriminate ability of subtests and items by race and ethnicity given gold-standard clinical diagnosis of cognitive status.

Methods: Data come from the National Alzheimer's Coordinating Center Uniform Data Set March 2018 data freeze. Stepwise regression was used to determine which subtests predicted cognitive status (normal cognition, MCI, or dementia), by race/ethnicity. Item discrimination and difficulty was calculated by race/ethnicity and cognitive status.

Results: In our sample (n=3,895), with an average age of 69.7, 80.7% were non-Hispanic White, 15.0% were non-Hispanic Black, and 4.2% were Hispanic. Among non-Hispanic Whites all subtests, education, and age predicted clinician diagnosis, while visuospatial/executive, attention, language, delayed recall, and orientation subtests were predictive among non-Hispanic Blacks and visuospatial/executive, delayed recall, and orientation subtests and education were predictive among Hispanics. Item discrimination and difficulty varied by race ethnicity and cognitive status.

Conclusions: By understanding the psychometric properties of MoCA subtests, we can focus on subtests that have higher discrimination and more diagnostic utility. Subtests should be further evaluated for use in screening of minority individuals.

Keywords

Alzheimer's disease; dementia; Montreal Cognitive Assessment; screening; race; ethnicity; disparities

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Conflicts of interests: The authors declare that they have no conflicts of interest.

Background

Dementia, a broad category of neurodegenerative disorders, affects approximately 8.8% of the population aged 65 and older.[1] As the population ages, the number of older adults at risk for developing dementia will increase.[2] Mild cognitive impairment (MCI) is defined as cognitive impairment that is greater than expected for one's age but is not as severe as dementia.[3] Most people with MCI do not progress to develop dementia; a review of 41 studies found that less than half of individuals with MCI develop dementia.[4] Diagnosis of MCI is difficult to ascertain,[3,5] however, early detection is crucial to prevent further impairment, manage patients comorbid conditions, and allow patients to express their directives before impairment becomes too severe.[6]

Racial and ethnic minority groups have disproportionally high rates of dementia.[7,8] African Americans have double the risk of developing late onset Alzheimer's disease (AD), the most common type of dementia, compared to their White counterparts.[7] Hispanics also have a high burden of AD, with one and a half times the risk of developing late onset AD compared to their White counterparts.[7] This disparity in dementia burden is potentially attributed to a higher burden of risk factors, especially socioeconomic risk factors, for dementia among minority populations.[7,9,10] However, we must consider if these are true differences in dementia incidence and distribution of risk factors or are the result of measurement bias in these populations when examining rates of cognitive impairment as well as its associated risk factors.

The Montreal Cognitive Assessment (MoCA) is widely accepted to be a better test for detecting MCI than the Mini-Mental State Examination (MMSE), one of the most frequently used neuropsychologic tests.[11–13] The MoCA is one page, 30 point assessment, covering eight cognitive domains, with a suggested cutoff of 26 for cognitive impairment.[11] The validation study of the MoCA found that with a cutoff of 26 or less, the MoCA had a much higher sensitivity compared to the MMSE (90% vs 18%, respectively).[11] However, the utility of this cutoff has been widely questioned,[14,15] especially for use in minority populations.[16–19]

The MoCA is an important tool for detection of MCI and dementia; however, the psychometric properties of its subtests and items have not been widely studied.[20] A study that did examine MoCA subtests and items individually among Brazilians, aged 60 and over and with over four years of formal education, found that word repetition, inverse digits, serial 7, phrases, verbal fluency, abstraction, and word recall discriminated between MCI and normal aging and that the clock drawing, rhinoceros naming, delayed recall of five words, and orientation discriminated between MCI and AD.[21] Additionally, Roalf and colleagues examined the ability of MoCA subtests and items to discriminate between healthy controls and affected individuals (MCI, AD, Parkinson's disease, or Parkinson's disease dementia) in a sample of almost 2000 community dwelling individuals (>80% Caucasian) with the goal of creating a short version of the examination.[22] They found that the clock drawing, serial 7s, orientation-place, delayed recall, abstraction, rhinoceros naming, trails, and fluency subtests discriminated between the two groups.[22] Another study among over 400 individuals evaluated in a clinical research setting (76.7% Caucasian),

looking to create an abbreviated MoCA with the three items with the largest effect sizes, found that serial 7s and delayed recall were the best items for distinguishing between normal aging and MCI while the serial 7s, delayed recall, and orientation items were the best at discriminating between MCI and AD.[20]

However, these studies did not examine differences by race or ethnicity. Performance on cognitive testing is, in part, affected by a range of exposures throughout the lifecourse;[23] these exposures are unequally distributed by race and ethnicity and their presence can explain differences in the burden of dementia as well as performance on cognitive tests. Therefore, because exposures vary by race and ethnicity, and because such exposures are predictive, it is imperative to consider race and ethnicity when interpreting performance on cognitive tests. Underlying the consideration of exposure is the consideration of outcome. To clearly delineate exposure risks in a population, we also need to accurately determine who has, and has not, the outcome of interest, in this case, dementia. If the measurement of dementia varies by race and ethnicity, we will inaccurately label exposures as risk factors. To take one of the first steps in disentangling these issues, we aimed to analyze the discriminative ability of each MoCA subtest/item to distinguish between 1) normal aging and MCI and 2) MCI and dementia by race/ethnicity, when controlling for age and education level. We further aimed to analyze the discrimination of MoCA items by race/ethnicity and cognitive status.

Methods

Population:

Data for these analyses come from the National Alzheimer's Coordinating Center (NACC) Uniform Data Set (UDS) March 2018 data freeze. NACC maintains a database of information collected through Alzheimer's Disease Centers (ADCs) throughout the United States. Each center enrolls subjects according to their own protocol; however, data is collected through a standardized evaluation, administered by clinicians and their trained staff, including a range of cognitive measures, neuropsychological tests, and clinician assessment.[24]

Measures:

Cognitive status was determined using clinician diagnosis, which was recorded as normal, impaired but not MCI, MCI, and dementia. Only individuals who were judged as normal, MCI, or dementia were included in these analyses. Individuals who were impaired but did not have MCI were not included due to the unclear etiology of their impairment.

Overall baseline raw MoCA scores were used. Possible MoCA scores range from 0 to 30. MoCA subtest and individual item scores [visuospatial/executive (trails, cubes, clock contour, clock numbers, clock hands), naming, attention (digits, letters, serial 7s), language (repetition, fluency), abstraction, delayed recall, orientation (date, month, year, day, place, and city)] were used to predict clinician diagnosis. Standard MoCA scoring criteria was used.[11] Although the MoCA, has a one-point educational adjustment for those who have 12

or less years of education, raw MoCA scores were used and this adjustment was not included.

Race and ethnicity were categorized into a three-level race/ethnicity variable: non-Hispanic White, non-Hispanic Black, and Hispanic. Education was categorized as high school or less (12 years or less), college (13 to 16 years), and more than college (>16 years). Age was recorded as a continuous variable.

Data Analysis:

Individuals who completed a MoCA at their baseline visit and were included in the March 2018 data freeze were included in these analyses. Moreover, only individuals who reported either being White or Black, reported their ethnicity (Hispanic/Latino or non-Hispanic/Latino), and reported their years of education were included in these analyses. Our final sample included 3,895 people. Descriptive statistics were calculated for population characteristics including race/ethnicity, age, and education. A Bonferroni correction was made to correct for multiple comparisons. An alpha of 0.05 was divided by 15, the number of comparisons made, and p=0.003 was used as our criteria for statistical significance. Stepwise multinomial logistic regression was used to determine which subtests best predicted cognitive status, by race/ethnicity. Finally, we calculated item discrimination and difficulty by race/ethnicity. Items with a discrimination greater than 0.40 were considered to have high discrimination.[25] All analyses were conducted using SAS ® software, version 9.4. The statistical program, G*Power, was used to conduct post-hoc power analyses to determine if we were adequately powered to examine correlation of MoCA items with total score by cognitive status among the smaller non-Hispanic Black and Hispanic groups.[26]

Results

Overall, our final sample of 3,895 participants was relatively balanced in regards to age; 56.8% female and 43.2% male with a mean age of 69.7. 80.7% were non-Hispanic White, 15.0% were non-Hispanic Black, and 4.2% were Hispanic. Of the Hispanic participants, 94.5% co-identified as White while the remaining 5% co-identified as Black. They mostly had some college or more than a college education (43.8% and 40.5%, respectively) while few reported less than a high school education (15.7%). Almost half (48.4%) were judged to be cognitively normal by a clinician. The remaining had either MCI (24.0%) or dementia (27.6%). Sex significantly differed between non-Hispanic Whites and non-Hispanic Blacks only. Both years of education and MoCA score significantly differed between non-Hispanic Whites and non-Hispanic Blacks as well as between non-Hispanic Whites and Hispanics. Cognitive status significantly differed between non-Hispanic Whites and non-Hispanic Blacks as well as between non-Hispanic Blacks and Hispanics. The non-Hispanic Black group had significantly more females compared to the non-Hispanic White group. Non-Hispanic Blacks and Hispanics comprised a higher proportion of the sample with less than or equal to 12 years of education and smaller proportion of those with over 16 years of education. Non-Hispanic Blacks had more individuals with clinician diagnosed normal aging but less individuals with normal MoCA scores (≥26) than the Non-Hispanic White group (58.9% vs 46.7% 26.8% vs 37.5%, respectively) (Table 1).

Table 2 show the results of the stepwise multinomial logistic regression. In the overall sample, all subtests, education, and age were significant in predicting clinician diagnosis. Delayed recall was the first variable included in the stepwise model followed by orientation, attention, language, visuospatial/executive, education, age, naming, and abstraction. This held true for non-Hispanic Whites, however, the order of variables included slightly differed. Delayed recall was still included first but it was followed by attention, orientation, visuospatial/executive, language, age, naming, education, and abstraction. However, fewer subtests predicted clinician diagnosis among non-Hispanic Blacks or Hispanics. Among non-Hispanic Blacks, orientation, delayed recall, visuospatial/executive, language, and attention subtests were significant predictors of clinician diagnosis, listed in the order of inclusion in the stepwise regression. Among Hispanics, orientation, delayed recall, and education were significant predictors of clinician diagnosis, listed in order of inclusion.

Subtests were then deconstructed into items. Among non-Hispanic Whites, delayed recall had high discrimination in the normal cognition group, while serial 7s, repetition, abstraction, and delayed recall had high discrimination in the MCI group. In the non-Hispanic White dementia group, all items, except clock contour, had high discrimination (Table 3A). Among non-Hispanic Blacks, serial 7s, abstraction, delayed recall had high discrimination in the normal cognition group, while trails, digits, serial 7s, repetition, abstraction, and delayed recall had high discrimination in the MCI group. In the non-Hispanic Black dementia group, all items except trails, cubes, clock contour, and digits had high discrimination (Table 3B). Among Hispanics, clock contour, clock numbers, digits, serial 7s, repetition, abstraction, and delayed recall had high discrimination in the normal cognition group while clock hands, serial 7s, repetition, abstraction, and delayed recall had high discrimination in the MCI group. In the Hispanic dementia group, all items had high discrimination except clock contour, letters, fluency, day, and city (Table 3C). A summary of item discrimination by race/ethnicity and cognitive status is presented in Table 4.

Discussion

Our findings suggest that not all MoCA subtests demonstrate clinical utility, especially in minority populations. While most subtests did significantly differ between either normal aging and MCI or MCI and dementia in our total sample, when the sample was restricted to minority groups, these differences did not persist. Additionally, MoCA items demonstrated different levels of discrimination by race/ethnicity and cognitive status.

When conducting stepwise analyses to determine which subtests best predict clinician diagnosis of either normal aging or dementia, compared to MCI, we found that while all subtests included in the MoCA were important for the total sample and non-Hispanic Whites, fewer subtests were significant among non-Hispanic Blacks and Hispanics. Moreover, education was not included in the final stepwise model among non-Hispanic Blacks, though it was included in the model for Hispanics, suggesting that education does not explain the variability in diagnosis among non-Hispanic Blacks and that the one point educational adjustment may not adjust for the variability of diagnosis among this groups. This demonstrates that the MoCA and its subtests may have less diagnostic utility among minority populations.

When deconstructing the MoCA into items, few items explain the variability in MoCA score in the normal cognition groups, but as impairment progresses more items explain individual difference in MoCA score. We found some differences in discrimination of items by race/ethnicity and by cognitive status. Among non-Hispanic Whites with normal cognition, delayed recall is the only item with high discrimination, suggesting this is the driving force of variability of total MoCA scores in this group. On the contrary, among both non-Hispanic Blacks and Hispanics with normal cognition, multiple items had high discrimination. Among non-Hispanic Blacks, serial 7s, abstraction, and delayed recall had high discrimination while among Hispanics, clock contour, clock numbers, digits, serial 7s, repetition, abstraction, and delayed recall had high discrimination, meaning that variability of MoCA scores in these groups are due to variation in these items. These items are relatively more difficult than the other items for these groups and show variability without any cognitive impairment. This may be problematic because cognitive tests are designed so that individuals with normal cognition receive perfect scores, so these items may not be useful in these minority groups.

Some items had similar patterns of discrimination among all race/ethnicity and cognitive status groups. Delayed recall had high discrimination regardless of race/ethnicity or cognitive status. This subtest was also important in literature reviewed in distinguishing between 1) normal aging and any impairment, 2) normal aging and MCI, and 3) MCI and dementia.[20–22] Additionally, clock contour had low discrimination regardless of race/ethnicity or cognitive status, except in Hispanics with normal cognition, likely due to a potential ceiling effect. Previous work has found that most individuals get full points on the clock contour, with 100% of individuals in the normal aging group and MCI group scoring full points, while 90.4% of individuals with AD scored full points.[21] Clock contour is necessary for the clock hands and clock numbers items, but the low discrimination observed in most groups suggests that this item may be best ungraded.

Among non-Hispanic Blacks, cubes did not have high discrimination in any cognitive status group with less than half of individuals in each group scoring correctly on this item. In non-Hispanic Whites and Hispanics, this showed a high discrimination in those with dementia, while in the other cognitive status groups over half of individuals in these groups scored correctly. Additionally, the day orientation item did not have high discrimination in any cognitive status group among non-Hispanic Blacks, with more than half of individuals in each group answering this question correctly. A similar pattern was observed in Hispanics, however, this item had high discrimination among non-Hispanic Whites. Among Hispanics, fluency did not have high discrimination in any of the cognitive status groups while fluency had high discrimination among non-Hispanic Whites and non-Hispanic Blacks with dementia. More than half of Hispanics with normal cognition and MCI received full points on this item however, less than 20% of those with dementia scored full points on this item. Moreover, the city orientation item did not have high discrimination in any of the cognitive status groups among Hispanics, even though it did among non-Hispanic Whites and non-Hispanic Blacks with dementia. More than half of Hispanic individuals in all cognitive status groups got this question correct, although orientation was the first variable included in the stepwise regression among Hispanics. This may be driven by the other orientation items, which did demonstrate high discrimination among Hispanics with dementia (date, month,

year, and place). Additionally, these differences observed in the Hispanic group may be due to the small number of Hispanics compared to the number of non-Hispanic Whites and non-Hispanic Blacks included in our sample.

Much of the normative work involving the MoCA and validation studies have been limited to non-Hispanic White populations, which may explain why these subtests and items do not perform as well in minority groups. Moreover, studies examining the performance of the MoCA subtests have concluded that the cutoff of 26 is too high for use in minority populations.[16–19] This is evident in these analyses, given that over half of non-Hispanic Blacks were judged as cognitively normal, while using the MoCA cutoff of 26, almost 75% screened as cognitively impaired. Additionally, the ability of the MoCA subtests to discriminate between MCI and normal aging or dementia among minority populations demonstrated in these analyses may explain why the total cutoff score should be lower to correctly identify impairment in minority populations. By addressing these racial/ethnic disparities in screening we can reduce the misclassification of cognitive impairment in minority groups.

These analyses have a few limitations to consider. Individuals included in the NACC database tend to be more educated than the general United States population. However, we did control for years of education in these analyses. Moreover, recruitment is referral based and some ADCs require participants to consent to autopsy,[24] which may introduce selection bias into our sample, excluding individuals who may have different views on research and autopsy. Also, clinician diagnosis was likely made after MoCA administration. This may have influenced clinician decision and introduced some degree of circularity. Our sample also has a relatively small number of non-Hispanic Blacks and even fewer Hispanics, potentially underpowering the analyses focusing solely on these groups. We conducted post-hoc power analyses using alpha=0.05 at power=0.80 to determine if we were adequately powered to examine correlation of MoCA items with total score by cognitive status among the smaller non-Hispanic Black and Hispanic groups. Among non-Hispanic Blacks with normal cognition (n=345), MCI (n=158), and dementia (n=83), we were powered to detect correlations as low as 0.15, 0.22, and 0.30, respectively. Among Hispanics with normal cognition (n=72), MCI (n=45), and dementia (n=47), we were powered to detect correlations as low as 0.32, 0.40, and 0.39, respectively. This is now included in the discussion section. Additionally, we were unable to examine differences in Hispanics by country of origin, which is important to consider given that the term Hispanic refers to a heterogeneous group. It is also important to note that while all non-Hispanic Whites and non-Hispanic Blacks had the MoCA administered in English, 12.2% of Hispanics had their MoCA administered in Spanish, with the remaining 87.8% in English. Nevertheless, the NACC data set is still unique given that most studies focus on majority populations and do not include many minority members. Additionally, due to the nature of NACC coding, we could not distinguish performance on the individual naming items. NACC coding of the MoCA naming subtest is coded as a quantitative variable from zero to three, rather than focusing on the rhinoceros, camel, and lion items individually. Previous work did find that the rhinoceros naming item discriminates between MCI and AD,[21] however we could not establish this using our sample.

Conclusions:

Early detection of MCI is crucial to improve health outcomes of individuals who develop MCI. In our analyses we found that while most of the subtests work well in the non-Hispanic White group, few of them discriminated between MCI and either normal aging or dementia in minority groups. This suggests a need to further evaluate subtests for use in screening of non-Hispanic Blacks and Hispanics.

Acknowledgements:

Sadaf Milani is currently funded through the training grant #T32AG000270 (PI Wong) from the National Institute on Aging/National Institutes of Health. She was also funded for a portion of this work through the Graduate School Fellowship at the University of Florida. Drs. Marsiske and Striley are partially funded by the 1Florida Alzheimer's Disease Research Center, funded by the National Institute on Aging, P50 AG047266 (PI Todd Golde, MD, PhD). The NACC database is funded by the National Institute on Aging/National Institutes of Health Grant U01 AG016976. NACC data are contributed by the National Institute on Aging -funded ADCs: P30 AG019610 (PI Eric Reiman, MD), P30 AG013846 (PI Neil Kowall, MD), P50 AG008702 (PI Scott Small, MD), P50 AG025688 (PI Allan Levey, MD, PhD), P50 AG047266 (PI Todd Golde, MD, PhD), P30 AG010133 (PI Andrew Saykin, PsyD), P50 AG005146 (PI Marilyn Albert, PhD), P50 AG005134 (PI Bradley Hyman, MD, PhD), P50 AG016574 (PI Ronald Petersen, MD, PhD), P50 AG005138 (PI Mary Sano, PhD), P30 AG008051 (PI Thomas Wisniewski, MD), P30 AG013854 (PI M. Marsel Mesulam, MD), P30 AG008017 (PI Jeffrey Kaye, MD), P30 AG010161 (PI David Bennett, MD), P50 AG047366 (PI Victor Henderson, MD, MS), P30 AG010129 (PI Charles DeCarli, MD), P50 AG016573 (PI Frank LaFerla, PhD), P50 AG005131 (PI James Brewer, MD, PhD), P50 AG023501 (PI Bruce Miller, MD), P30 AG035982 (PI Russell Swerdlow, MD), P30 AG028383 (PI Linda Van Eldik, PhD), P30 AG053760 (PI Henry Paulson, MD, PhD), P30 AG010124 (PI John Trojanowski, MD, PhD), P50 AG005133 (PI Oscar Lopez, MD), P50 AG005142 (PI Helena Chui, MD), P30 AG012300 (PI Roger Rosenberg, MD), P30 AG049638 (PI Suzanne Craft, PhD), P50 AG005136 (PI Thomas Grabowski, MD), P50 AG033514 (PI Sanjay Asthana, MD, FRCP), P50 AG005681 (PI John Morris, MD), P50 AG047270 (PI Stephen Strittmatter, MD, PhD). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

References

1. Langa KM, Larson EB, Crimmins EM, et al. A Comparison of the Prevalence of Dementia in the United States in 2000 and 2012. JAMA Intern Med. 2017;177(1):51–58. [PubMed: 27893041]
2. Prince M, Bryce R, Albanese E, Wimo A, Ribeiro W, Ferri CP. The global prevalence of dementia: a systematic review and metaanalysis. Alzheimers Dement. 2013;9(1):63–75.e62. [PubMed: 23305823]
3. Petersen RC, Caracciolo B, Brayne C, Gauthier S, Jelic V, Fratiglioni L. Mild cognitive impairment: a concept in evolution. J Intern Med. 2014;275(3):214–228. [PubMed: 24605806]
4. Mitchell AJ, Shiri-Feshki M. Rate of progression of mild cognitive impairment to dementia--meta-analysis of 41 robust inception cohort studies. Acta Psychiatr Scand. 2009;119(4):252–265. [PubMed: 19236314]
5. Albert MS, DeKosky ST, Dickson D, et al. The diagnosis of mild cognitive impairment due to Alzheimer's disease: recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. Alzheimers Dement. 2011;7(3):270–279. [PubMed: 21514249]
6. Okie S Confronting Alzheimer's disease. N Engl J Med. 2011;365(12):1069–1072. [PubMed: 21992119]
7. Assoc As. 2018 Alzheimer's disease facts and figures. Alzheimers & Dementia. 2018;14(3):367–425.
8. Mayeda ER, Glymour MM, Quesenberry CP, Whitmer RA. Inequalities in dementia incidence between six racial and ethnic groups over 14 years. Alzheimers Dement. 2016;12(3):216–224. [PubMed: 26874595]
9. Chin AL, Negash S, Hamilton R. Diversity and disparity in dementia: the impact of ethnoracial differences in Alzheimer disease. Alzheimer Dis Assoc Disord. 2011;25(3):187–195. [PubMed: 21399486]

10. Yaffe K, Falvey C, Harris TB, et al. Effect of socioeconomic disparities on incidence of dementia among biracial older adults: prospective study. Bmj. 2013;347:f7051. [PubMed: 24355614]
11. Nasreddine ZS, Phillips NA, Bedirian V, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J Am Geriatr Soc. 2005;53(4):695–699. [PubMed: 15817019]
12. Damian AM, Jacobson SA, Hentz JG, et al. The Montreal Cognitive Assessment and the mini-mental state examination as screening instruments for cognitive impairment: item analyses and threshold scores. Dement Geriatr Cogn Disord. 2011;31(2):126–131. [PubMed: 21282950]
13. Markwick A, Zamboni G, de Jager CA. Profiles of cognitive subtest impairment in the Montreal Cognitive Assessment (MoCA) in a research cohort with normal Mini-Mental State Examination (MMSE) scores. J Clin Exp Neuropsychol. 2012;34(7):750–757. [PubMed: 22468719]
14. Luis CA, Keegan AP, Mullan M. Cross validation of the Montreal Cognitive Assessment in community dwelling older adults residing in the Southeastern US. Int J Geriatr Psychiatry. 2009;24(2):197–201. [PubMed: 18850670]
15. Carson N, Leach L, Murphy KJ. A re-examination of Montreal Cognitive Assessment (MoCA) cutoff scores. Int J Geriatr Psychiatry. 2018;33(2):379–388. [PubMed: 28731508]
16. Goldstein FC, Ashley AV, Miller E, Alexeeva O, Zanders L, King V. Validity of the montreal cognitive assessment as a screen for mild cognitive impairment and dementia in African Americans. J Geriatr Psychiatry Neurol. 2014;27(3):199–203. [PubMed: 24614202]
17. Rossetti HC, Lacritz LH, Hynan LS, Cullum CM, Van Wright A, Weiner MF. Montreal Cognitive Assessment Performance among Community-Dwelling African Americans. Arch Clin Neuropsychol. 2017;32(2):238–244. [PubMed: 28365749]
18. Sink KM, Craft S, Smith SC, et al. Montreal Cognitive Assessment and Modified Mini Mental State Examination in African Americans. J Aging Res. 2015;2015:872018. [PubMed: 26618003]
19. Milani SA, Marsiske M, Cottler LB, Chen X, Striley CW. Optimal cutoffs for the Montreal Cognitive Assessment vary by race and ethnicity. Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring. 2018;10:773–781.
20. Horton DK, Hynan LS, Lacritz LH, Rossetti HC, Weiner MF, Cullum CM. An Abbreviated Montreal Cognitive Assessment (MoCA) for Dementia Screening. Clin Neuropsychol. 2015;29(4): 413–425. [PubMed: 25978540]
21. Cecato JF, Martinelli JE, Izbicki R, Yassuda MS, Aprahamian I. A subtest analysis of the Montreal cognitive assessment (MoCA): which subtests can best discriminate between healthy controls, mild cognitive impairment and Alzheimer's disease? Int Psychogeriatr. 2016;28(5):825–832. [PubMed: 26620850]
22. Roalf DR, Moore TM, Wolk DA, et al. Defining and validating a short form Montreal Cognitive Assessment (s-MoCA) for use in neurodegenerative disease. J Neurol Neurosurg Psychiatry. 2016;87(12):1303–1310. [PubMed: 27071646]
23. Glymour MM, Manly JJ. Lifecourse social conditions and racial and ethnic patterns of cognitive aging. Neuropsychol Rev. 2008;18(3):223–254. [PubMed: 18815889]
24. Beekly DL, Ramos EM, Lee WW, et al. The National Alzheimer's Coordinating Center (NACC) database: the Uniform Data Set. Alzheimer Dis Assoc Disord. 2007;21(3):249–258. [PubMed: 17804958]
25. Ebel R, Frisbie D. Essentials of Educational Measurement. Prentice Hall; 1991.
26. Faul F, Erdfelder E, Buchner A, Lang A-G. Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. Behavior Research Methods. 2009;41(4):1149–1160. [PubMed: 19897823]

Table 1:

Characteristics of NACC study participants included in these analyses, by race/ethnicity (n=3,895).

Characteristic	Total (n=3,895)	Non-Hispanic Whites (n=3,145; 80.7%)	Non-Hispanic Blacks (n=586; 15.0%)	Hispanics (n=164; 4.2%)
Mean Age (SD)	69.7 (9.8)	69.6 (10.0)	70.1 (8.7)	68.9 (9.9)
Sex[A]				
Male	1683 (43.2%)	1461 (46.5%)	163 (27.8%)	59 (36.0%)
Female	2212 (56.8%)	1684 (53.6%)	423 (72.2%)	105 (64.0%)
Years of Education[A, B]				
≤12	611 (15.7%)	404 (12.9%)	153 (26.1%)	54 (32.9%)
13–16	1706 (43.8%)	1372 (43.6%)	263 (44.9%)	71 (43.3%)
>16	1578 (40.5%)	1369 (43.5%)	170 (29.0%)	39 (23.8%)
Cognitive Status[A, C]				
Normal	1886 (48.4%)	1469 (46.7%)	345 (58.9%)	72 (43.9%)
MCI	936 (24.0%)	733 (23.3%)	158 (27.0%)	45 (27.4%)
Dementia	1073 (27.6%)	943 (30.0%)	83 (14.2%)	47 (28.7%)
MoCA Score[A, B]				
≥26	1461 (37.5%)	1268 (40.3%)	157 (26.8%)	36 (22.0%)
<26	2434 (62.5%)	1877 (59.7%)	429 (73.3%)	128 (78.1%)

Post-hoc Bonferroni correction to account for multiple comparisons was conducted and $p<0.003$ was considered statistically significant

[A] $p<0.003$ between non-Hispanic Whites and non-Hispanic Blacks

[B] $p<0.003$ between non-Hispanic Whites and Hispanics

[C] $p<0.003$ between non-Hispanic Blacks and Hispanics

Table 2:

Summary of Stepwise multinomial logistic regression for MoCA subtests and clinician diagnosis of normal cognition (NC) or dementia (dem), with MCI as the reference group. Missing entries in the table are those not selected by the stepwise algorithm.

		Overall				Non-Hispanic Whites				Non-Hispanic Blacks				Hispanics			
Variable	**Dx**	**Order**	**B**	**SE B**	**β**	**Order**	**B**	**SE B**	**β**	**Order**	**B**	**SE B**	**β**	**Order**	**B**	**SE B**	**β**
Visuospatial/Executive	NC	5	0.32	0.72	0.24**	4	0.41	0.06	0.32**	3	0.25	0.11	0.17*	3	0.35	0.20	0.28
	Dem		−0.26	0.05	−0.20**		−0.26	0.05	−0.12**		−0.63	0.19	−0.43*		−0.73	−0.28	−0.57**
Naming	NC	8	0.35	0.11	0.12*	7	0.45	0.13	0.16**								
	Dem		−0.22	0.10	−0.08*		−0.32	0.11	−0.11*								
Attention	NC	3	0.24	0.06	0.19**	2	0.39	0.08	0.32**	5	0.11	0.11	0.08				
	Dem		−0.23	0.05	−0.25**		−0.33	0.06	−0.27**		−0.48	0.14	−0.37**				
Language	NC	4	0.44	0.06	0.25**	5	0.45	0.07	0.25**	4	0.52	0.13	0.28**				
	Dem		−0.20	0.06	−0.11*		−0.23	0.07	−0.13*		0.11	0.21	0.06				
Abstraction	NC	9	0.14	0.08	0.06	9	0.21	0.10	0.08*								
	Dem		−0.29	0.08	−0.12**		−0.36	0.09	−0.14**								
Delayed Recall	NC	1	0.61	0.03	0.63**	1	0.67	0.04	0.69**	2	0.48	0.07	0.45**	2	0.46	0.14	0.44**
	Dem		−0.22	0.04	−0.22**		−0.17	0.05	−0.18**		−0.37	0.15	−0.34*		−0.15	0.22	−0.15
Orientation	NC	2	0.85	0.12	0.64**	3	0.92	0.14	0.70**	1	0.66	0.24	0.42*	1	1.02	0.56	0.91
	Dem		−0.85	0.07	−0.64**		−0.81	0.07	−0.62**		−0.88	0.20	−0.56**		−1.53	0.44	−1.36**
Age	NC	7	0.00	0.01	0.00	6	0.01	0.01	0.03								
	Dem		−0.04	0.01	−0.19**		−0.04	0.01	−0.19**								
Education	NC	6	−0.10	0.02	−0.16**	8	−0.09	0.02	−0.14**					4	−0.16	0.06	−0.36*
	Dem		0.09	0.02	0.31**		−0.09	0.02	0.09*						0.02	0.09	0.04
R^2		0.67				0.69				0.59				0.65			

* $p < 0.05$;

** $p < 0.001$

Table 3A:

Discrimination (Pearson Correlation) of MoCA items with total score by cognitive status among non-Hispanic Whites (n=3,145). Bolded items area those with high (>0.40) discrimination.

MoCA Item	Normal Cognition (n=1,469)		MCI (n=733)		Dementia (n=943)	
	Discrimination Index (Pearson Correlation)	Difficulty (% Correct)*	Discrimination Index (Pearson Correlation)	Difficulty (% Correct)*	Discrimination Index (Pearson Correlation)	Difficulty (% Correct)*
Trails	0.28	87.1	0.36	73.4	**0.58**	**41.0**
Cubes	0.36	71.6	0.31	53.6	**0.44**	**31.4**
Clock Contour	0.11	99.1	0.14	96.5	0.34	90.7
Clock Numbers	0.19	95.6	0.22	85.0	**0.60**	**54.0**
Clock Hands	0.35	79.7	**0.46**	**60.6**	**0.53**	**26.7**
Naming	0.27	89.5	0.28	78.6	**0.49**	**57.3**
Digits	0.27	90.8	0.36	83.8	**0.50**	**59.8**
Letters	0.17	97.3	0.26	90.2	**0.56**	**61.2**
Serial 7s	0.33	89.1	**0.46**	**71.9**	**0.75**	**34..4**
Repetition	0.36	73.9	**0.49**	**55.5**	**0.53**	**31.0**
Fluency	0.33	83.5	0.35	67.9	**0.44**	**40.1**
Abstraction	0.37	81.3	**0.45**	**66.0**	**0.58**	**34.6**
Delayed Recall	**0.71**	**31.1**	**0.61**	**5.2**	**0.49**	**1.4**
Date	0.13	97.8	0.33	84.7	**0.50**	**48.3**
Month	0.05	99.5	0.10	97.8	**0.52**	**74.4**
Year	0.02	99.5	0.18	97.8	**0.62**	**70.6**
Day	0.06	99.3	0.26	92.9	**0.43**	**61.4**
Place	0.13	98.3	0.28	90.6	**0.51**	**56.0**
City	0.02	99.2	0.11	98.2	**0.48**	**85.2**

*For non-binary items, % of individuals scoring full points

Table 3B:

Discrimination (Pearson Correlation) of MoCA items with total score by cognitive status among non-Hispanic Blacks (n=586). Bolded items area those with high (>0.40) discrimination.

MoCA Item	Normal Cognition (n=345)		MCI (n=158)		Dementia (n=83)	
	Discrimination Index (Pearson Correlation)	Difficulty (% Correct)*	Discrimination Index (Pearson Correlation)	Difficulty (% Correct)*	Discrimination Index (Pearson Correlation)	Difficulty (% Correct)*
Trails	0.39	71.0	**0.49**	58.2	0.28	18.1
Cubes	0.34	42.9	0.37	28.5	0.28	18.1
Clock Contour	0.02	99.4	0.06	98.1	0.39	86.8
Clock Numbers	0.23	90.4	0.34	82.3	**0.48**	41.0
Clock Hands	0.37	69.6	0.37	51.9	**0.47**	13.3
Naming	0.31	75.4	0.38	60.1	**0.60**	32.5
Digits	0.35	78.3	**0.42**	**73.4**	0.28	47.0
Letters	0.06	95.1	0.24	87.3	**0.51**	53.0
Serial 7s	**0.53**	**70.7**	**0.60**	**48.7**	**0.59**	15.7
Repetition	0.37	60.6	**0.40**	**39.2**	**0.57**	30.1
Fluency	0.38	75.9	0.38	51.3	**0.48**	31.3
Abstraction	**0.46**	**63.2**	**0.47**	**50.0**	**0.49**	19.3
Delayed Recall	**0.53**	**15.4**	**0.60**	**3.2**	**0.48**	6.0
Date	0.12	97.4	0.30	93.0	**0.54**	39.8
Month	0.10	99.4	0.22	98.7	**0.60**	68.7
Year	0.04	99.4	0.18	98.1	**0.56**	68.7
Day	0.03	98.6	0.29	94.9	0.35	60.2
Place	0.18	95.7	0.32	80.4	**0.44**	36.1
City	0.01	99.1	0.21	98.7	**0.45**	85.5

*For non-binary items, % of individuals scoring full points

Table 3C:

Discrimination (Pearson Correlation) of MoCA items with total score by cognitive status among Hispanics (n=164). Bolded items are those with high (>0.40) discrimination.

MoCA Item	Normal Cognition (n=72)		MCI (n=45)		Dementia (n=47)	
	Discrimination Index (Pearson Correlation)	Difficulty (% Correct)*	Discrimination Index (Pearson Correlation)	Difficulty (% Correct)*	Discrimination Index (Pearson Correlation)	Difficulty (% Correct)*
Trails	0.16	75.0	0.26	68.9	**0.64**	**29.8**
Cubes	0.28	56.9	0.26	51.1	**0.56**	**23.4**
Clock Contour	**0.40**	**97.2**	−0.13	97.8	0.22	89.4
Clock Numbers	**0.42**	**91.7**	0.29	88.9	**0.56**	**38.3**
Clock Hands	0.38	72.2	**0.40**	**57.8**	**0.43**	**23.4**
Naming	0.39	77.8	0.29	60.0	**0.51**	**48.9**
Digits	**0.51**	**70.8**	0.24	62.2	**0.67**	**46.8**
Letters	0.11	95.5	−0.04	93.3	0.38	66.0
Serial 7s	**0.52**	**69.4**	**0.46**	**53.3**	**0.70**	**21.3**
Repetition	**0.47**	**47.2**	**0.45**	**40.0**	**0.57**	**25.5**
Fluency	0.31	66.7	0.36	60.0	0.32	19.2
Abstraction	**0.61**	**61.1**	**0.40**	**42.2**	**0.59**	**23.4**
Delayed Recall	**0.72**	**23.6**	**0.48**	**6.7**	**0.56**	**4.3**
Date	0.01	98.6	0.25	86.7	**0.59**	**29.8**
Month	-	100.0	0.24	97.8	**0.58**	**53.2**
Year	0.21	98.6	-	100.0	**0.54**	**61.7**
Day	0.14	98.6	0.15	95.6	0.25	51.1
Place	−0.09	98.6	−0.03	95.6	**0.61**	**44.7**
City	−0.09	98.6	0.13	97.8	0.36	78.7

*For non-binary items, % of individuals scoring full points

Table 4:

High discrimination MoCA items (>0.40) by cognitive status and race/ethnicity among NACC participants (n=3,895)

Normal Cognition (n=1,886)			MCI (n=936)			Dementia (n=1,073)		
Non-Hispanic Whites (n=1,469)	**Non-Hispanic Blacks (n=345)**	**Hispanics (n=72)**	**Non-Hispanic Whites (n=733)**	**Non-Hispanic Blacks (n=158)**	**Hispanics (n=45)**	**Non-Hispanic Whites (n=943)**	**Non-Hispanic Blacks (n=83)**	**Hispanics (n=47)**
Delayed Recall	Serial 7s Abstraction Delayed Recall	Clock Contour Clock Numbers Digits Serial 7s Repetition Abstraction Delayed Recall	Clock Hands Serial 7s Repetition Abstraction Delayed Recall	Trails Digits Serial 7s Repetition Abstraction Delayed Recall	Clock Hands Serial 7s Repetition Abstraction Delayed Recall	Trails Cubes Clock Numbers Clock Hands Naming Digits Letters Serial 7s Repetition Fluency Abstraction Delayed Recall Date Month Year Day Place City	Clock Numbers Clock Hands Naming Letters Serial 7s Repetition Fluency Abstraction Delayed Recall Date Month Year Place City	Trails Cubes Clock Numbers Clock Hands Naming Digits Serial 7s Repetition Abstraction Delayed Recall Date Month Year Place