Effectiveness of Montreal Cognitive Assessment for the diagnosis of mild cognitive impairment and mild Alzheimer’s disease in Singapore

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INTRODUCTION
Mild cognitive impairment (MCI) is an important clinical entity with significant management implications. However, traditional screening tools lack the sensitivity needed to detect amnestic MCI (MCI-A). Montreal Cognitive Assessment (MoCA) has yet to be validated for the diagnosis of MCI in a multiracial society such as Singapore. We thus aimed to study the effectiveness of MoCA for the diagnosis of MCI-A in the Singapore population.

METHODS
Data on patients with MCI-A and mild Alzheimer’s disease (AD) was obtained from a prospectively collected clinical database between January 2008 and January 2011. Patients with no cognitive impairment (NCI) were recruited from among the spouses and friends of patients attending the memory clinic.

RESULTS
There were a total of 212 participants (103 NCI, 49 MCI-A, 60 mild AD). For the diagnosis of MCI-A, a MoCA score of < 26 for patients with ≤ 10 years of education, and a score of < 27 for patients with > 10 years of education provided a sensitivity of > 94%. For the diagnosis of mild AD, a MoCA score of < 24 for patients with ≤ 10 years of education, and a score of < 25 for patients with > 10 years of education provided a sensitivity of > 85%.

CONCLUSION
In the Singapore population, we recommend cutoff scores of 26/27 and 24/25 be used to detect MCI-A and mild AD, respectively, when using MoCA. For patients with ≤ 10 years of education, a +1 point correction is needed.

Keywords: dementia, mild Alzheimer’s disease, mild cognitive impairment, neuropsychological assessment
attending the memory clinic. Patients with significant symptoms of depression, scoring > 5 on the modified Geriatric Depression Scale (GDS), were excluded from the study. The cognitive tests were performed on both the controls and patients by trained raters. The MMSE and MoCA (version 7.1) cognitive screening tests were used.\(^6,9\) The 15-point GDS was used to exclude patients with significant depressive symptoms.\(^10\) For non-English-speaking participants, the tests were translated to their native languages.

AD was diagnosed using the NINCDS-ADRDA (National Institute of Neurological and Communicative Disorders and Stroke-Alzheimer’s Disease and Related Disorders Association) Alzheimer’s Criteria, based on the history provided by the patients and caregivers.\(^11\) A Clinical Dementia Rating (CDR) of 1 represented mild AD.\(^12\) MCI-A was diagnosed using Petersen’s criteria and defined by the presence of subjective memory concerns, impaired memory function for age and education, a CDR of 0.5, preserved ADL, and the absence of dementia.\(^2\)

Corroborative history from a reliable caregiver was obtained for all patients with MCI-A. All patients in the present study did not fulfil the DSM-IV-TR (Diagnostic and Statistical Manual of Mental Disorders, 4th edition, text revision) criteria for dementia. Diagnoses of MCI-A and mild AD were made by neurologists blinded to the patients’ MoCA scores. Participants with NCI had a CDR score of 0 and an MMSE score of 27–30 (inclusive). NCI participants also had to be deemed cognitively normal based on an absence of significant impairment in cognitive functions or ADL following review by a clinician.

Informed consent was obtained from all participants or their legal guardians before their data were included in the database, as per institutional ethics board requirements.

Demographic characteristics were compared across three groups (NCI, MCI-A and mild AD) using chi-square test for categorical data, one-way analysis of variance for continuous parametric data and Kruskal-Wallis test for continuous nonparametric data. Pairwise comparisons were performed using chi-square test for categorical variables, t-test for continuous parametric variables and Wilcoxon rank-sum test for continuous nonparametric variables. Ordinary least squares linear regression was performed to determine the relationship between age and education, and their effect on MoCA scores. Receiver operating characteristic (ROC) curve analysis was used to determine appropriate age- and education-adjusted MoCA cutoff scores for the detection of MCI-A and mild AD. All statistical analyses were performed using Stata version 10.1 (StataCorp, College Station, TX, USA) software. All tests were two-tailed and conducted at the 5% level of significance.

### RESULTS

Data from a total of 212 participants (103 NCI, 49 MCI-A, 60 mild AD) were analysed. There was a fairly equal distribution of men and women across the three groups. The majority of the patients were of Chinese ethnicity, reflecting Singapore’s cultural makeup. The mean age of the entire cohort was 62.35 years and the mean age of patients with mild AD was 72.58 years. Patients with mild AD had significantly lower education than those with MCI-A and participants with NCI (Table I). NCI participants had a mean MMSE score of 29.19 ± 0.88 and a mean MoCA score of 28.56 ± 1.45. For patients with MCI-A, the mean MMSE and MoCA scores were 28.06 ± 2.12 and 27.00 ± 3.02, respectively. The mean MMSE and MoCA scores for patients with mild AD were 22.93 ± 3.84 and 20.80 ± 4.06, respectively. As shown in Table I, the mean MMSE and MoCA scores for the mild AD group were lower than the scores of patients with MCI-A, which were in turn lower than those of NCI participants.

As linear regression analysis revealed that age (p < 0.001) and education (p < 0.001) were independent factors influencing MoCA scores (Table II), ROC curve analyses were conducted to compare the NCI group against the MCI-A group, and the MCI-A group against the mild AD group, so as to determine optimal cutoff points for the two variables. The most appropriate cutoff point for education was found to be ten years, but there was no clear inflection point for age. Therefore, a decision was made to only apply cutoff points for

### Table I. Demographics and cognitive scores.

<table>
<thead>
<tr>
<th>Variable</th>
<th>NCI (n = 103)</th>
<th>MCI-A (n = 49)</th>
<th>Mild AD (n = 60)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age* (yrs)</td>
<td>56.35 ± 8.27</td>
<td>62.43 ± 9.40</td>
<td>72.58 ± 7.15</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Male gender*</td>
<td>41 (39.81)</td>
<td>27 (55.10)</td>
<td>30 (50.00)</td>
<td>0.177</td>
</tr>
<tr>
<td>Ethnicity*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chinese</td>
<td>96 (93.20)</td>
<td>41 (83.67)</td>
<td>48 (80.00)</td>
<td>0.035</td>
</tr>
<tr>
<td>Malay</td>
<td>2 (1.94)</td>
<td>1 (2.04)</td>
<td>2 (3.33)</td>
<td>0.841</td>
</tr>
<tr>
<td>Indian</td>
<td>2 (1.94)</td>
<td>4 (8.16)</td>
<td>5 (8.33)</td>
<td>0.117</td>
</tr>
<tr>
<td>Eurasian</td>
<td>1 (0.97)</td>
<td>1 (2.04)</td>
<td>1 (1.67)</td>
<td>0.856</td>
</tr>
<tr>
<td>Other</td>
<td>2 (1.94)</td>
<td>2 (4.08)</td>
<td>4 (6.67)</td>
<td>0.309</td>
</tr>
<tr>
<td>Education* (yrs)</td>
<td>12.07 ± 3.20</td>
<td>10.93 ± 4.28</td>
<td>6.97 ± 4.47</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>MMSE* (graded out of 30)</td>
<td>29 (29.19 ± 0.88)</td>
<td>29 (28.06 ± 2.12)</td>
<td>23 (22.93 ± 3.84)</td>
<td>0.0001</td>
</tr>
<tr>
<td>MoCA* (graded out of 30)</td>
<td>29 (28.56 ± 1.45)</td>
<td>28 (27.00 ± 3.02)</td>
<td>21 (20.80 ± 4.06)</td>
<td>0.0001</td>
</tr>
<tr>
<td>GDS‡ (graded out of 15)</td>
<td>1 (2.28 ± 2.89)</td>
<td>2 (2.76 ± 3.07)</td>
<td>2 (2.87 ± 2.75)</td>
<td>0.324</td>
</tr>
</tbody>
</table>

*Data is expressed as mean ± standard deviation. †Data is expressed as no. (%). ‡Data is expressed as median (mean ± standard deviation). AD: Alzheimer’s disease; GDS: Geriatric Depression Scale; MCI-A: amnestic mild cognitive impairment; MMSE: mini-mental state examination; MoCA: Montreal Cognitive Assessment; NCI: no cognitive impairment
education. At the cutoff limit of ten years of education, we found that the sensitivity of MoCA for the differentiation of MCI-A from mild AD dropped drastically from 72.09% to 48.84%. Similarly, for the differential diagnosis of NCI from MCI-A, the sensitivity of MoCA dropped from 88.35% to 50.49%.

Repeat ROC analyses after correction for education demonstrated that a MoCA cutoff score of < 24 for the detection of mild AD, when years of education ≤ 10, had a good sensitivity of 85.00% and a specificity of 80.56%. When years of education > 10, a cutoff score of < 25 was found to give a sensitivity of 90.48% and a specificity of 70.00% for the differentiation of mild AD (Table III).

**DISCUSSION**

Our findings suggest that a MoCA cutoff score of 26/27 differentiates between NCI and MCI-A, while a cutoff score of 24/25 differentiates between MCI-A and mild AD in the Singapore population, with a correction of +1 point when the patient has ≤ 10 years of education. Cutoff scores were chosen based on their balance of sensitivity and specificity. Based on the above criteria, a MoCA cutoff score of < 24 should have been chosen for detecting mild AD in patients with more than 10 years of education, as it had a sensitivity of 95.24% and specificity of 70.00% for the differentiation of mild AD (Table III).

Previous studies validating MoCA have only established single cutoff points – the original cutoff was 25/26 for the detection of cognitive impairment,(6) 25/26 for the detection of MCI using the Japanese version of MoCA,(13) and 23/24 for the detection of cognitive impairment in a community-based cohort in southeastern United States.(14) Our study established education-adjusted MoCA cutoff points for the detection of MCI-A and mild AD as this could assist clinicians in dissociating the two conditions, which tend to have a similar clinical presentation. Although the cutoff point used for years of education in the original study on MoCA was 12 years,(6) we found that a 1-point correction was needed in patients with less than 10 years of education in our study. This change in cutoff score from the original study was effected due to the education system in Singapore, where the average population spends 10 years in school to obtain a basic education. The cutoff scores used in our study differ from the scores determined in the original MoCA study, as well as from other similar studies elsewhere, highlighting the importance of conducting population-specific validations of MoCA in order to maintain its effectiveness as a screening tool.

There were strengths and limitations to this study. Among its strengths are the relatively large sample size of patients, the use of trained raters, and the novelty of establishing two separate cutoff scores for MCI-A and mild AD, as opposed to a single cutoff score for both conditions. However, the study’s retrospective design was a limitation. Additionally, as patients were recruited from a tertiary hospital, generalisation of our results to the larger community will need to be performed with caution.

In conclusion, we recommend that MoCA cutoff scores of 26/27 and 24/25 be used to detect MCI-A and mild AD, respectively, in the Singapore population. An added 1-point correction will be needed for patients with 10 years of education or less.

**ACKNOWLEDGEMENTS**

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REFERENCES