International Psychogeriatrics (2012), 24:4, 651–658 © International Psychogeriatric Association 2011
doi:10.1017/S1041610211002298

Psychometrics of the Montreal Cognitive Assessment (MoCA) and its subscales: validation of the Taiwanese version of the MoCA and an item response theory analysis

Chia-Fen Tsai,[1,3,5] Wei-Ju Lee,[4,5,6] Shuu-Jiun Wang,[2,5] Ben-Chang Shia,[7] Ziad Nasreddine[8] and Jong-Ling Fuh[2,5]

[1] *Department of Psychiatry, Neurological Institute, Veterans General Hospital, Taipei, Taiwan*
[2] *Department of Neurology, Neurological Institute, Taipei Veterans General Hospital, Taipei, Taiwan*
[3] *Institute of Brain Science, National Yang-Ming University Schools of Medicine, Taipei, Taiwan*
[4] *Institute of Clinical Medicine, National Yang-Ming University Schools of Medicine, Taipei, Taiwan*
[5] *Faculty of Medicine, National Yang-Ming University Schools of Medicine, Taipei, Taiwan*
[6] *Department of Neurology, Taichung Veterans General Hospital, Taichung, Taiwan*
[7] *Department of Statistics and Information Science, Fu-Jen Catholic University, Taipei, Taiwan*
[8] *Center for Clinical Research, Neurology Service, University of Sherbrooke, Hôpital Charles LeMoyne, Sherbrooke, Quebec, Canada*

ABSTRACT

Background: The Montreal Cognitive Assessment (MoCA) is an instrument for screening mild cognitive impairment (MCI). This study examined the psychometric properties and the validity of the Taiwan version of the MoCA (MoCA-T) in an elderly outpatient population.

Methods: Participants completed the MoCA-T, Mini-Mental State Examination (MMSE), and the Chinese Version Verbal Learning Test. The diagnosis of Alzheimer's disease (AD) was made based on the NINCDS-ADRDA criteria, and MCI was diagnosed through the criteria proposed by Petersen *et al.* (2001).

Results: Data were collected from 207 participants (115 males/92 females, mean age: 77.3 ± 7.5 years). Ninety-eight participants were diagnosed with AD, 71 with MCI, and 38 were normal controls. The area under the receiver operator curves (AUC) for predicting AD was 0.98 (95% confidence interval [CI] = 0.97–1.00) for the MMSE, and 0.99 (95% CI = 0.98–1.00) for the MoCA-T. The AUC for predicting MCI was 0.81 (95% CI = 0.72–0.89) using the MMSE and 0.91 (95% CI = 0.86–1.00) using the MoCA-T. Using an optimal cut-off score of 23/24, the MoCA-T had a sensitivity of 92% and specificity of 78% for MCI. Item response theory analysis indicated that the level of information provided by each subtest of the MoCA-T was consistent. The frontal and language subscales provided higher discriminating power than the other subscales in the detection of MCI.

Conclusion: Compared to the MMSE, the MoCA-T provides better psychometric properties in the detection of MCI. The utility of the MoCA-T is optimal in mild to moderate cognitive dysfunction.

Key words: The Montreal Cognitive Assessment, Alzheimer's disease, mild cognitive impairment, validation, item response theory

Introduction

Mild cognitive impairment (MCI) is considered a transitional state between normal aging and mild dementia, and often precedes dementia (Petersen *et al.*, 1999). MCI is defined as impairment in one or more cognitive domains with the preservation of independence in functional abilities and is recognized as an important target for Alzheimer's disease (AD) prevention studies (Bruscoli and Lovestone, 2004; Dubois and Albert, 2004). Early detection of deficits in patients with symptoms that are too mild to fulfil criteria for dementia is crucial in clinical practice and in research for successful preventive interventions and has been the object of discussion in several studies (Smith *et al.*, 1996; Petersen *et al.*, 2001; Petersen *et al.*, 2004).

The Montreal Cognitive Assessment (MoCA) is a cognitive screening instrument created and validated (Nasreddine *et al.*, 2005) to detect MCI, and is considered superior to the Mini-Mental State Examination (MMSE) (Folstein *et al.*, 1975). The validity of the MoCA has been studied in various

Correspondence should be addressed to: Dr. Jong-Ling Fuh, Neurological Institute, Taipei Veterans General Hospital, Taipei, Taiwan, 112. Phone: +886-2-28762522; Fax: +886-2-28765215. Email: jlfuh@vghtpe.gov.tw. Received 2 Aug 2011; revision requested 30 Aug 2011; revised version received 30 Sep 2011; accepted 4 Oct 2011. First published online 12 December 2011.

clinical groups in many countries (Gill *et al.*, 2008; Lee *et al.*, 2008; Wong *et al.*, 2009; Fujiwara *et al.*, 2010).

Little is known about how well the MoCA subscales assess the entire spectrum of cognitive dysfunction in AD. A thorough understanding of the psychometric properties across a broad range of cognitive dysfunctions is critical for optimal usage in clinical settings. As the development of therapies shifts to earlier interventions, correlated with milder cognitive dysfunction, it is especially important to understand which subscales provide the most reliable data and how the scale as a whole functions. Item response theory (IRT) provides a framework for analyzing this measure in psychometrically sophisticated ways (Hambleton *et al.*, 1991; Emberson and Reise, 2000).

The aims of the current study were to (1) evaluate the reliability and validity of the Taiwanese version of the MoCA (MoCA-T), and (2) apply IRT techniques to analyze how the subscales of the MoCA-T and the instrument as a whole function across the spectrum of AD severity, and to elucidate how individual items play a role in measuring disability.

Methods

Translation and cultural modifications of the MoCA-T

The MoCA is a brief (10 minute) test that evaluates seven cognitive domains: visuospatial/executive functions, naming, verbal memory registration and learning, attention, abstraction, 5-min delayed verbal memory, and orientation. MoCA scores range from 0 to 30. The English version MoCA was translated into Chinese/Taiwanese and independently translated back into English by a neurologist and a psychiatrist. Items on the Chinese/Taiwanese version were identical to the English version with the exception of the following five cultural and linguistic modifications listed below:

(1) Item 1 (Visuospatial/Executive Functions – Alternating Trail Making): We modified Trail Making Part B (Reitan, 1959) by using Chinese nominal sequential words instead of English alphabet . The number of steps required for completion of the task was retained (Lu and Bigler, 2002).
(2) Item 4 (Attention – Auditory Vigilance): Arabic numerals were used instead of English alphabet. The number and positions of responses remained identical to those in the English version.
(3) Item 5 (Language – Sentence repetition): English sentences were replaced with Chinese/Taiwanese sentences.
(4) Item 5 (Language – Verbal fluency): A fruit category fluency task replaced phonemic letter fluency, as there are no letter-equivalent linguistic units in the Chinese language.
(5) Item 8 (Orientation): District was substituted for city. In Taiwan, districts are the conceptual equivalent of cities in North American countries.

Translation and modifications in the final version of the MoCA-T were discussed with and approved by the original author of the MoCA (Z.N.). The MoCA-T test form and administration instructions are available for download at the MoCA official website http://www.mocatest.org.

Participants

The study participants were recruited from the outpatient Memory Clinic of Taipei Veterans General Hospital (TVGH). Diagnostic determinations based on the results of clinical interviews, physical examinations, laboratory findings and image investigations (CT and/or MRI) were made at a clinical consensus meeting. An AD diagnosis was made according to the criteria of National Institute of Neurological and Communicative Disorders and Stroke – Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) (McKhann *et al.*, 1984). Criteria for MCI included: (1) memory complaints, (2) impaired memory function as determined by the modified Chinese Version Verbal Learning Test, and (3) maintenance of daily living activities (Petersen *et al.*, 2001). Criteria for participation included classification as amnestic MCI (single or multidomain); nonamnestic MCI (single or multidomain) patients were excluded. Other inclusion criteria for the study were: (1) probable clinical diagnosis of MCI or AD, and (2) 60 years of age or older. Exclusion criteria were: (1) an MMSE score of < 10 (severe dementia), (2) recent psychiatric comorbidity (clinically diagnosed in the 6 months prior to the current neuropsychological evaluation), (3) motor and/or sensory deficits that constituted confounding variables in the assessment of cognitive functions, and (4) current clinically important systemic or neurological illness that may affect cognition. The study controls were relatives of the participants or volunteers recruited from the hospital. Controls had no or mild memory complaints, were in the normal range on standardized neuropsychological batteries, and had no neurological abnormality. The study protocol was approved by the TVGH Institutional Review Board. All subjects provided informed consent before study participation.

Measures

Each subject completed the MMSE, the MoCA-T, and the Chinese Version Verbal Learning

https://doi.org/10.1017/S1041610211002298 Published online by Cambridge University Press

Table 1. Demographic and clinical characteristics of the study participants

	AD (N = 98)	MCI (N = 71)	NC (N = 38)	P VALUE
Age (years), mean (SD)	79.6 (6.4)	79.2 (6.8)	77.7 (6.0)	0.34
Female (%)	36 (38.7%)	35 (50.7%)	13 (35.1%)	0.60*
Married (%)	64 (65.3%)	41 (57.7%)	25 (65.8%)	0.87*
Education (years), mean (SD)	8.4 (4.9)	8.9 (5.1)	10.1 (4.4)	0.11
MMSE, mean (SD)	18.2 (4.6)	26.0 (3.2)	28.2 (1.7)	< 0.001
MoCA-T total score, mean (SD)	12.6 (5.2)	20.5 (4.0)	25.5 (2.3)	< 0.001
CVVLT, mean (SD)	1.3 (1.9)	6.9 (2.9)	9.4 (1.9)	< 0.001

Note: *The χ2-test was used to examine associations among categorical variables, and ANOVA was used to compare the means of continuous variables. AD = Alzheimer's disease; CVVLT = Chinese Version Verbal Learning Test; MCI = mild cognitive impairment; MoCA-T = Taiwanese version of Montreal Cognitive Assessment; NC = normal controls; SD = standard deviation.

Test. To minimize interference, the MoCA-T was always completed 30 minutes before the neuropsychological battery. MoCA subscales were grouped into five domains: memory (delayed recall, 5 points); visuospatial (trail-making test, 1 point; cube, 1 point; clock drawing, 3 points); frontal functioning including attention, concentration, working memory and abstract thinking (digit span, 2 points; cancellation, 1 point; subtraction, 3 points; verbal abstraction, 2 points); language (nomination, 3 points; sentence repetition, 2 points; phonemic verbal fluency, 1 point); and orientation (time, 3 points; space, 3 points). The Chinese Version Verbal Learning Test was modified from the Rey Auditory–Verbal Learning Test (Vakil and Blachstein, 1993) and has been shown to have good validity in diagnosing AD and MCI (Chang *et al.*, 2010).

Statistics

All statistical analyses were performed using SPSS version 15.0. χ^2 analyses were used to compare demographic and neuropsychological data between normal controls and patients. ANOVA with *post hoc* least significant difference (LSD) tests were performed as appropriate. The relationship between performance on the MoCA-T and MMSE and demographic data were assessed using the Spearman rank correlation.

The ability of the MoCA-T total score and MMSE scores to differentiate MCI patients from controls was examined using receiver operating curve (ROC) analysis. A cut-off score for optimal balance of sensitivity and specificity was derived. A four-week test-retest and inter-rater reliability of the MoCA-T among 20 randomly selected subjects was assessed using the intra-class correlation coefficient. Internal consistency between the ten domain scores was evaluated using Cronbach's α. Two-tailed tests were used throughout all analyses and a p-value < 0.05 was considered statistically significant. IRT, performed by version 9.1.3 of SAS (SAS Institute, Cary, NC, USA), was used empirically to assess the relationship between the total MoCA-T and each of the five domains represented by the subscales (Hambleton *et al*, 1991; Scherbaum *et al*., 2006; Oishi, 2007). These analyses will help to build a framework from which we can better interpret changes in raw scores that occur during clinical research.

Results

Study participants

A total of 207 participants completed the study, including 71 patients with MCI, 98 patients with mild to moderate AD, and 38 controls. The mean age was 77.3 years (SD = 7.5, range 60–92) and the mean educational level was 9.8 years (SD = 5.1, range 0–18); 44% of the participants were female and 71% were married. Participants had a mean MoCA-T score of 18.1 (SD = 6.8, range 2–30) and a mean MMSE score of 22.9 (SD = 5.8, range 10–30). The demographic characteristics of the study sample by diagnosis group are presented in Table 1. Age, sex, and educational year distributions did not differ among the three study groups (AD, MCI, and controls) (Table 1). The mean MMSE and MoCA-T scores were significantly different between groups (by *post hoc* LSD analyses, all p values < 0.001) with highest scores among normal controls, followed by MCI participants and lowest scores among participants diagnosed with AD. There was a significant negative correlation between MoCA-T score and age (Spearman's $r = -0.31$, $p < 0.001$) and a positive correlation between MoCA-T score and years of education (Spearman's $r = 0.43$, $p < 0.001$), while there was no correlation between MoCA-T score and gender ($p = 0.83$).

Reliability and validity of the MoCA-T

Cronbach's α of the MoCA-T was 0.86. The intraclass correlation coefficient between the

https://doi.org/10.1017/S1041610211002298 Published online by Cambridge University Press

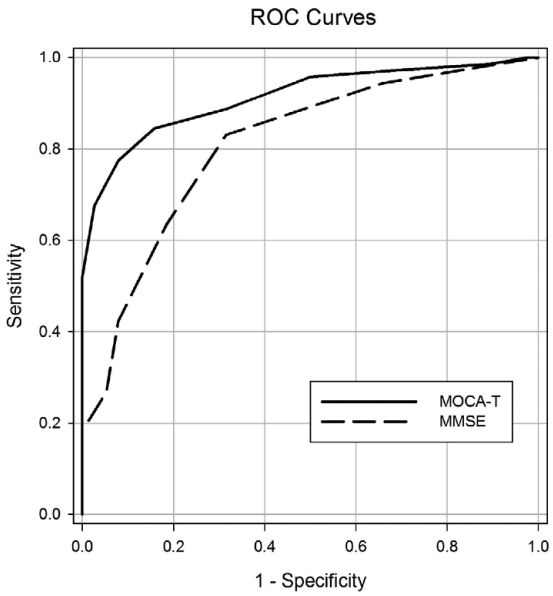

Figure 1. ROC depicting the ability of the MoCA-T and MMSE in detecting MCI patients from controls. (MoCA-T: AUC = 0.91, p<0.001; MMSE: AUC = 0.81, p< 0.001).

baseline and 4-week follow-up data was 0.88 (95% confidence interval [CI] = 0.79–0.93, p < 0.01). There was a positive associated between MoCA-T scores and MMSE scores (r = 0.91, p < 0.001), and between MoCA-T scores and the Chinese Version Verbal Learning Test scores (r = 0.45, p < 0.001). The predictive accuracy of MoCA-T for cognitive impairment was high; the AUC was 0.91 (95% CI = 0.86–1.00, p < 0.001) for MCI and 0.99 (95% CI = 0.98–1.00, p < 0.001) for AD. In contrast, the predictive accuracy of MMSE for MCI was 0.81 (95% CI = 0.72–0.89, p < 0.001) (Figure 1), and for AD was 0.98 (95% CI = 0.97–1.00, p < 0.001). The best cut-off point for discriminating between the MCI group and the control group was 23/24 on the MOCA-T, with a sensitivity of 92% and specificity of 78% while the best cut-off point for discriminating between the AD group and the control group was 21/22 on the MoCA-T, with a sensitivity of 98% and specificity of 95%. True positive and negative predictive values for the MoCA-T were high for MCI (88% and 94%, respectively) and AD (88% and 100%, respectively). In contrast, the MMSE had high sensitivity (95%) and good specificity (98%) for screening AD at the cut-off point of 25/26, but it had poor specificity (63%) for screening MCI at the cut-off point of 27/28.

IRT analysis results

Results from the IRT analysis are presented in Figures 2–4. The item domain curves were rescaled for the purpose of visual inspection to account for differences in the total number of points possible in each domain, allowing for domain performance comparisons across the spectrum of cognitive dysfunction (x-axis).

The steepest aspect of the slopes of each of the domain curves (Figure 3) are as follows: frontal domain, between −2 and 1 SDs of cognitive dysfunction; orientation domain, between -2 and 0 SDs; language domain, between −1 and 1 SDs; visual-spatial domain, between -1 and 1 SDs; and memory domain, between 0 and 1.5 SDs.

In addition to generating domain functions, IRT analyses can be used to generate information functions (see the test information function in Figures 2 and 4). The information function indicates how well a particular instrument captures a latent phenomenon, in this case cognitive dysfunction. An instrument has optimal information at the point where the information curve peaks. Examination of Figure 2 shows that the information curve form MoCA-T total score peaks at the mild levels of cognitive dysfunction (approximately between −1 and 1 SDs of cognitive dysfunction) while information progressively drops off with lower information for measurements corresponding to much of the range of normal cognitive functions or advanced levels of cognitive impairment. The IRT analysis for the subscales revealed that the level of information provided by each of the five domains in the MoCA-T scale were consistent (Figure 4). The frontal domain and language domain provided high discriminating power and a high level of information across all cognitive ability levels. The memory domain provided high discriminating power and a high level of information at a range of mild cognitive impairment only, while the language and visual-spatial domains were not highly discriminative at advanced levels of cognitive impairment. The orientation domain provided a high level of information at moderate to severe levels of cognitive dysfunction but was poor at the lower range of cognitive dysfunction.

The information curve is steepest in the moderate range of cognitive dysfunction, where a unit change in impairment (x-axis) indicates a greater change in MoCA-T domain score (y-axis) than a unit change at mild or advanced ranges of cognitive dysfunction (Figure 3). This pattern suggests that the scale can discriminate best between smaller gradations of impairments at moderate levels of cognitive dysfunction. The left side of the graph (which demarcates between approximately −4.0 and −1.0 SDs, i.e. more severe levels of impairment) depicts a different pattern of results. Only the frontal and orientation domains

https://doi.org/10.1017/S1041610211002298 Published online by Cambridge University Press

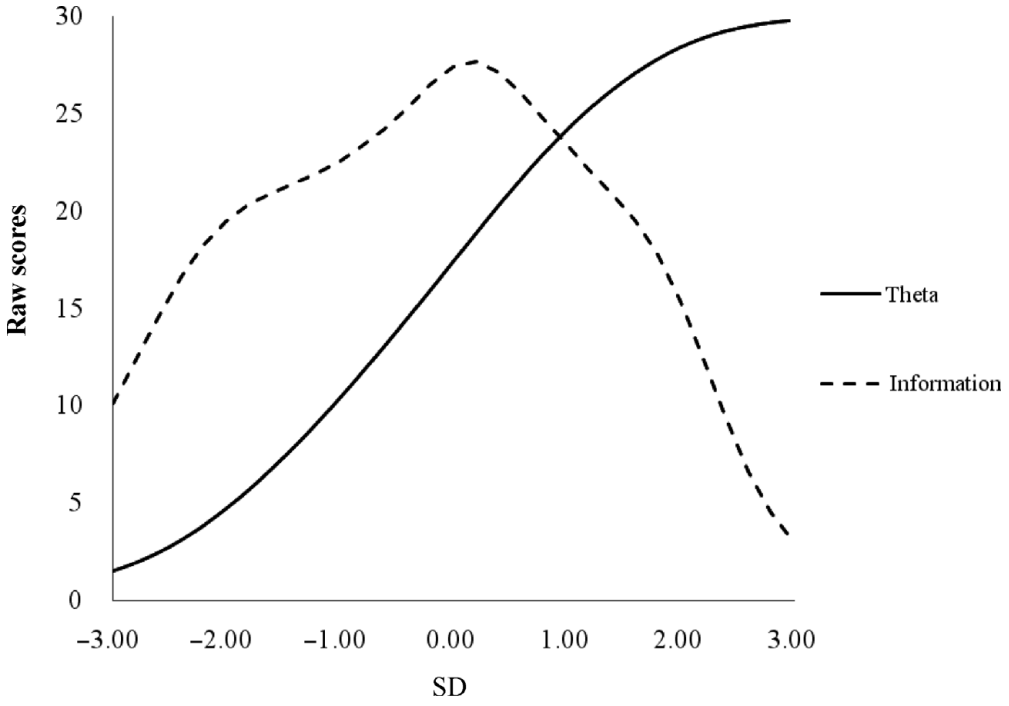

Figure 2. Taiwanese version of Montreal Cognitive Assessment total scale item characteristic curves and test information curve. SD = standard deviation.

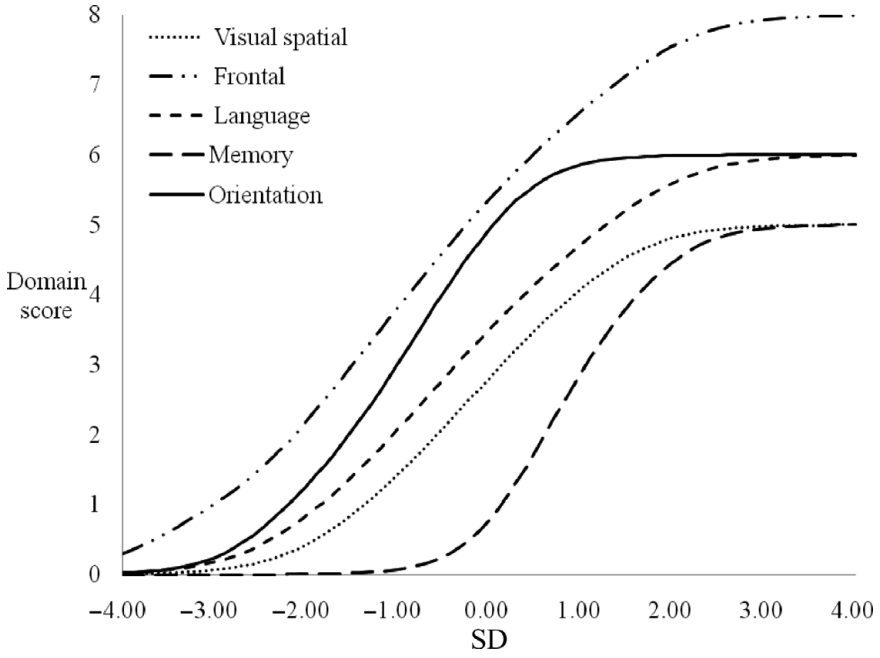

Figure 3. Taiwanese version of Montreal Cognitive Assessment subscale item characteristic curves. SD = standard deviation.

have informative slopes at the severe range of cognitive dysfunction. As a result, the discriminative ability of the subscales remains low, suggesting that the domains and the scale as a whole perform relatively poorly at discriminating among degrees of cognitive dysfunction when the severity of cognitive impairment is advanced.

Discussion

This is the first psychometric study of the MoCA performed through IRT analyses. The current study examined the psychometric properties of the MoCA-T in a clinical setting. The results support the role of MoCA-T as a useful instrument

https://doi.org/10.1017/S1041610211002298 Published online by Cambridge University Press

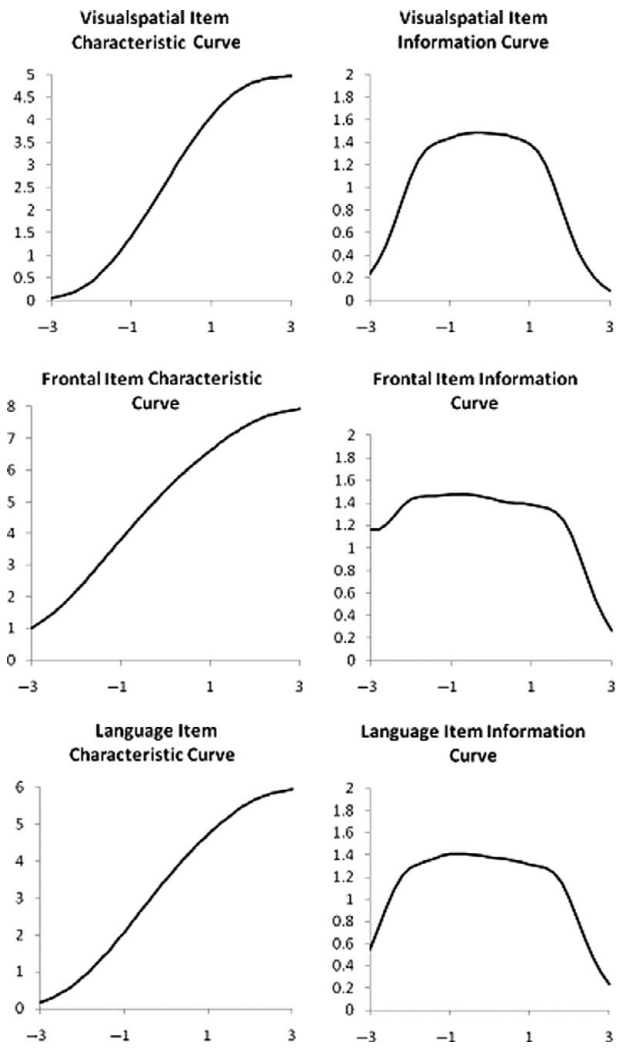

Figure 4. Taiwanese version of Montreal Cognitive Assessment subscale item characteristic and information curves.

in differentiating MCI subjects from cognitively normal controls.

The MoCA-T scores were negatively correlated with age and positively correlated with years of education, while there was no correlation with gender. The MoCA-T demonstrated a diagnostic sensitivity of 92% and specificity of 78% and performed better than the MMSE in differentiating MCI patients from normal controls when a cut-off of 23/24 was applied. The MoCA-T demonstrated high internal consistency, indicating a strong relationship between items. The strong validity of the MoCA-T was confirmed by a high correlation with the MMSE total score and the Chinese Version Verbal Learning Test scores. Several recent studies examining various populations have successfully used the MoCA to detect cognitive deficits in Parkinson's disease (Gill *et al.*, 2008), brain tumours (Olson *et al.*, 2008), AD (Tobinick and Gross, 2008), and cerebral small vessel disease (Wong *et al.*, 2009).

The optimal cut-off point for the MoCA-T (23/24) was lower than that of the original MoCA (25/26) and of the Japanese version (25/26), and higher than that of the Korean version (22/23). The differences in optimal cut-off may be due to differences in years of education. The mean years of education (9.8 ± 5.1) in the current study was lower than that in the original and the Japanese version of the MoCA test, while slightly higher than that of the Korean version (original: 13.3 ± 3.4; Japanese: 12.4 ± 2.5; Korean: 8.3 ± 3.7) (Lee *et al.*, 2008; Fujiwara *et al.*, 2010).

The current study is the first psychometric IRT study of the MoCA. The current analyses were conducted to examine how well each subscale of the MoCA-T and the test as a whole measures cognitive dysfunction at varying levels of cognitive impairment. Results indicated that the MoCA-T subscales measured AD-related cognitive dysfunction best at mild levels of cognitive impairment. Of the five cognitive domains designated a priori (frontal, orientation, language, visual-spatial and memory), performance on the frontal and memory subscales discriminated between levels of cognitive impairment better at the mild stage of cognitive dysfunction than the language and visual-spatial subscale, whereas the orientation subscale was not effective until moderate stages of cognitive impairment. Compared with other subscales, the frontal domain has the best discriminative ability across all levels of cognitive dysfunction. The tasks measuring frontal domain functioning in the present study included digit spans, cancellation, subtraction, and verbal abstraction. These tasks specifically measured attention, concentration, working memory, executive function, and abstract thinking. These findings suggest that frontal mental functioning was one of the first impairments demonstrated by the study population, supporting previous reports. Compared to healthy controls, studies have shown increased executive impairment, especially in the areas of response inhibition, cognitive flexibility, and attention switching in MCI patients (Perry *et al.*, 2000; Kramer *et al.*, 2006; Traykov *et al.*, 2007). Impairments in digit span scores have been implicated as a first indication for conversion from subject memory complaints to MCI (Kurt *et al.*, 2011). The decline in working memory, simple sustained attention, and divided attention in the amnesic MCI group may be early indicators of a possible transition to dementia from MCI (Gagnon and Belleville, 2011; Saunders and Summers, 2011).

The memory domain test was particularly sensitive to a mild stage of cognitive impairment.

https://doi.org/10.1017/S1041610211002298 Published online by Cambridge University Press

Deficits in delayed recall are the cardinal feature of MCI (Petersen, 2004). Therefore, tests of delayed recall are especially useful in improving the psychometric properties of the MoCA-T in studies investigating the mild, preclinical stages of MCI, and recent clinical trial studies (Doody *et al.*, 2009) have taken this into consideration. While the 5-word delayed recall test was sensitive to mild stages of cognitive impairment, it had poor sensitivity to moderate and severe levels of cognitive dysfunction. The 5-word delayed recall is more difficult than the 3-item recall in the MMSE, and may cause a floor effect among more severe levels of cognitive dysfunction. The visual-spatial, orientation, and language domains demonstrated both ceiling and floor effects, and therefore the discriminative abilities of these subscales were relatively poor at the very mild and advanced stages of cognitive impairment.

The magnitude of cognitive impairment represented by each point on the MoCA-T score varied across levels of dysfunction. This phenomenon is most clearly demonstrated in Figure 2, which shows that at a range of high cognitive performance (MoCA-T total raw scores > 24), even small changes in raw MoCA-T score are associated with relatively large changes in cognitive function (θ). A similar pattern was observed in the low range of MoCA-T total raw scores. In the mild stage of cognitive dysfunction, between approximately -1.0 and 2.0 SDs of cognitive function, each MoCA-T raw score represents an incrementally smaller change in underlying cognitive dysfunction. These results will benefit clinicians and researchers alike in better understanding the information provided by MoCA scores of their patients with dementia and will help determine the influence of cognitive dysfunction on subsequent outcomes and response to treatment.

There are some limitations that must be considered when interpreting the results of the current study. Differences in language, variety of disease, and clinical setting make it difficult to directly compare our data with current publications. In addition, the current sample size was relatively small and did not allow a case match by age and level of education. Lastly, only subjects with AD and amnestic type MCI were enrolled in the current study which may limit application to other types of dementia and MCI.

In conclusion, the MoCA-T has high sensitivity and good specificity in the detection of MCI and mild to moderate AD, and performs significantly better than the MMSE. The MoCA-T effectively characterized subjects with AD, but performed poorly in normal or severely impaired participants. These results corroborate the MoCA's utility as a potential complement to the MMSE as a cognitive screening instrument, especially in the detection of MCI patients.

Conflict of interest

None.

Description of authors' roles

J.L. Fuh designed the study and supervised the data collection. C.F. Tsai and W.J. Lee wrote the paper. J.L. Fuh and S.J. Wang collected the data. J.L. Fuh and Z. Nasreddine assisted with writing the article. B.C. Shia was responsible for the statistical design of the study and for carrying out the statistical analysis.

Acknowledgements

The current study was supported by grants from Taipei Veterans General Hospital (V100C-059, VGHUST100-G7-1-3), NSC support for Centre for Dynamical Biomarkers and Translational Medicine, National Central University, Taiwan (NSC 99-2911-I-008-100), and the Ministry of Education (Aim for the Top University Plan), Taipei, Taiwan.

References

Bruscoli, M. and Lovestone, S. (2004). Is MCI really just early dementia? A systematic review of conversion studies. *International Psychogeriatrics*, 16, 129–140.

Chang, C. C. *et al.* (2010). Validating the Chinese version of the verbal learning test for screening Alzheimer's disease. *Journal of the International Neuropsychological Society*, 16, 244–251.

Doody, R. S. *et al.* (2009). Donepezil treatment of patients with MCI: a 48-week randomized placebo-controlled trial. *Neurology*, 72, 1555–1561.

Dubois, B. and Albert, M. L. (2004). Amnestic MCI or prodromal Alzheimer's disease? *The Lancet Neurology*, 3, 246–248.

Emberson, S. E. and Reise, S. P. (2000). *Item Response Theory for Psychologists*. Mahwah, NJ: Lawrence Erlbaum Associates.

Folstein, M. F., Folstein, S. E. and McHugh, P. R. (1975). Minimental state: a practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, 12, 189–198.

Fujiwara, Y. *et al.* (2010). Brief screening tool for mild cognitive impairment in older Japanese: validation of the Japanese version of the Montreal Cognitive Assessment. *Geriatrics and Gerontology International*, 10, 225–232.

Gagnon, L. G. and Belleville, S. (2011). Working memory in mild cognitive impairment and Alzheimer's disease:

https://doi.org/10.1017/S1041610211002298 Published online by Cambridge University Press

contribution of forgetting and predictive value of complex span tasks. *Neuropsychology*, 25, 226–236.

Gill, D. J., Freshman, A., Blender, J. A. and Ravina, B. (2008). The Montreal Cognitive Assessment as a screening tool for cognitive impairment in Parkinson's disease. *Movement Disorder*, 23, 1043–1046.

Hambleton, R. K., Swaminathan, H. and Rogers, H. J. (1991). *Fundamentals of Item Response Theory*. Newbury Park, CA: Sage Publications.

Kramer, J. H. *et al.* (2006). Multiple cognitive deficits in amnestic mild cognitive impairment. *Dementia and Geriatric Cognitive Disorders*, 22, 306–311.

Kurt, P., Yener, G. and Oguz, M. (2011). Impaired digit span can predict further cognitive decline in older people with subjective memory complaint: a preliminary result. *Aging and Mental Health*, 15, 364–369.

Lee, J. Y. *et al.* (2008). Brief screening for mild cognitive impairment in elderly outpatient clinic: validation of the Korean version of the Montreal Cognitive Assessment. *Journal of Geriatric Psychiatry and Neurology*, 21, 104–110.

Lu, L. and Bigler, E. D. (2002). Normative data on trail making test for neurologically normal, Chinese-speaking adults. *Applied Neuropsychology*, 9, 219–225.

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price, D. and Stadlan, E. M. (1984). Clinical diagnosis of Alzheimer's disease. Report of the NINCDS-ADRDA work group under the auspices of Department of Health and Human Services Task Force on Alzheimer's disease. *Neurology*, 34, 939–944.

Nasreddine, Z. S. *et al.* (2005). The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*, 53, 695–699.

Oishi, S. (2007). The application of structural equation modeling and item response theory to cross-cultural positive psychology research. In A. D. Ong and M. H. M. Van Dulmen (eds.), *Oxford Handbook of Methods in Positive Psychology* (pp. 126–138) New York: Oxford University Press.

Olson, R. A., Chhanabhai, T. and McKenzie, M. (2008). Feasibility study of the Montreal Cognitive Assessment (MoCA) in patients with brain metastases. *Supportive Care in Cancer*, 16, 1273–1278.

Perry, R. J., Watson, P. and Hodges, J. R. (2000). The nature and staging of attention dysfunction in early (minimal and mild) Alzheimer's disease: relationship to episodic and semantic memory impairment. *Neuropsychologia*, 38, 252–271.

Petersen, R. C. (2004). Mild underlying cognitive dysfunction as a diagnostic entity. *Journal of Internal Medicine*, 256, 183–194.

Petersen, R. C., Smith, G. E., Waring, S. C., Ivnik, R. J., Tangalos, E. G. and Kokmen, E. (1999). Mild cognitive impairment: clinical characterization and outcome. *Archives of Neurology*, 56, 303–308.

Petersen, R. C. *et al.* (2001). Current concepts in mild cognitive impairment. *Archives of Neurology*, 58, 1985–1992.

Reitan, R. M. (1959). Validity of the trail making test as an indication of organic brain damage. *Perceptual and Motor Skills*, 8, 271–276.

Saunders, N. L. and Summers, M. J. (2011). Longitudinal deficits to attention, executive, and working memory in subtypes of mild cognitive impairment. *Neuropsychology*, 25, 237–248.

Scherbaum, C. A., Cohen-Charash, Y. and Kern, M. J. (2006). Measuring general self-efficacy: a comparison of three measures using item response theory. *Educational and Psychological Measurement*, 66, 1047–1063.

Smith, G. E., Petersen, R. C., Parisi, J. E. and Ivnik, R. J. (1996). Definition, course, and outcome of mild cognitive impairment. *Aging, Neuropsychology, and Cognition*, 3, 141–147.

Tobinick, E. L. and Gross, H. (2008). Rapid cognitive improvement in Alzheimer's disease following perispinal etanercept administration. *Journal of Neuroinflammation*, 5, 2. doi:10.1186/1742-2094-5-2.

Traykov, L. *et al.* (2007). Executive functions deficit in mild cognitive impairment. *Cognitive and Behavioral Neurology*, 20, 219–224.

Vakil, E. and Blachstein, H. (1993). Rey auditory-verbal learning test: structure analysis. *Journal of Clinical Psychology*, 49, 883–890.

Wong, A. *et al.* (2009). The validity, reliability and clinical utility of the Hong Kong Montreal Cognitive Assessment (HK-MoCA) in patients with cerebral small vessel disease. *Dementia and Geriatric Cognitive Disorders*, 28, 81–87.