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Original Article

Construct Validity and Psychometric Properties of the Tamil (India) Version of Montreal Cognitive Assessment (T-MoCA) in Elderly

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SUMMARY

Background: The Montreal Cognitive Assessment (MoCA) is a neuropsychological cognitive tool developed and adapted widely in various languages for screening mild cognitive impairment (MCI).
Objectives: The present study aimed to evaluate the psychometric properties of the Tamil (India) Version of MoCA (T-MoCA) and further examine the construct validity of the tool.
Method: The authors conducted internal consistency, test-retest, sensitivity-specificity, and construct validity using 233 Tamil-speaking elderly participants. The inclusion criteria of the study participants were 0.5 or less than 0.5 scores in the Clinical Dementia Rating scale (CDRs). Further, T-MoCA was used to screen MCI.
Results: The result showed that the T-MoCA had high internal consistency (0.83) and high test-retest reliability (0.92). Receiver operating characteristic (ROC) analyses showed an area under the curve (AUC) of 0.91 (95% CI 0.87–0.94) for detecting MCI. Furthermore, the optimal cut-off score to detect MCI was 24, accommodated a sensitivity and specificity of 88.4% and 77.9%, respectively.
Conclusions: The Tamil (India) version of the MoCA maintained its core diagnostic properties, furnishing it a valid and reliable tool for the screening of MCI. Also, its latent dimensions help to understand the elders' cognitive function in a better way.

1. Introduction

The Montreal Cognitive Assessment (MoCA)[1] is one of the widely using cognitive screening tests for detecting mild cognitive impairment (MCI), an intermediate transitional state between normal cognition and dementia.[2–5] It is a one-page test with a maximum score of 30 points, measuring various cognitive domains. For correcting the educational effect, one-point is added to the total score of individuals who have less than 12 years of education. Because of its high sensitivity in measuring MCI, it has been translated nearly 100 languages.[6] Despite several studies have proved the significant psychometric properties of MoCA in various languages, the Tamil (India) version of MoCA (T-MoCA) have not been explored so far.

In the original study, Nasreddine et al. (2005) suggested a cutoff score of 26 as normal cognition. Several studies are consistent with original findings, revealing that the MoCA provides higher diagnostic accuracy for detecting MCI.[1,2,7] However, some studies concluded that the original study's cutoff score was leading to false-positive diagnosis as MCI and hence used different cutoff scores.[2,8–10] Although adding 1-point reduces the educational effect for individuals with less than 12 years of education, it has been insufficient to compensate for educational differences.[11] A validation study conducted in the Tamil (Srilanka) version of MoCA determined the cutoff score of ≥ 24 to differentiate normal cognition and MCI with the sensitivity of 84.7% and specificity of 76.4%.[12] However, due to cultural and language usability differs between Srilankan Tamil and Indian Tamil-speaking population, culturally appropriate validation study is required to screen MCI and analyse the psychometric properties of T-MoCA among Tamil-speaking Indian elderly. Thus the study aimed to determine the Tamil (India) version of the MoCA as a potential tool for assessing the cognitive function of the elderly, through assessing its psychometric properties, diagnostic accuracy, and by subjecting it to confirmatory factor analysis (CFA). CFA was performed to examine different models of factorial structure of the T-MoCA, to assess the degree of consistency with formerly determined factorial structural model with the sample results.

2. Methods and materials

2.1. Participants

A community-dwelling, Tamil-speaking elderly participants aged 60 years and above were recruited through camps at various places viz., elder care home, memory clinic, religious communities, and counseling centres in four districts of Tamil Nadu, India. The data was collected from 286 participants, out of them, 34 (11.89%) were excluded from the study because of exclusion criteria and the high score in the clinical dementia rating scale (CDRs).[13,14] Furthermore, 19 participants (6.64%) left in-between the study and hence, 233 participants were categorized into two group viz., 104 with normal cognition group (NC-Group) and 129 with the mild cognitive im-

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pairment group (MCI-Group).

For the sample selection, participants had to fulfill the following inclusion/exclusion criteria such as, the subjects to be Tamil speaking, elderly with over 60 years, normal performance in the CDRs (CDR global score of 0), independent in daily activities, absence of psychiatric or neurological diseases, literate with minimum of five years of education – considered as NC-Group. If the participants were examined by psychiatrists/neuropsychologists or geriatric psychologists for memory-related issues within the period of 6 months[15] or/and had a CDR global rating of 0.5,[13] literate with a minimum of five years of education, categorized as the MCI group. Illiterate elderly participants were excluded from the study.

Various demographic characteristics were included in the study like, gender, age cohort, education, health status, instrumental activities of daily living (IADL), and activities of daily living (ADL). Education included three levels such as primary school, higher secondary, and graduation. The IADL status of the participants categorized into six levels such as cooking, cleaning, shopping, medications, driving, and banking and ADL status was categorized into four levels like feeding, bathing, dressing, and toileting.

2.2. Instrument

The Tamil (India) version of the MoCA (T-MoCA) was used in this study with permission obtained from its developer (www.mocatest.org).[1,16] Also, the primary author had completed the mandatory training provided by the MoCA team to administering and scoring the MoCA test. The MoCA consists of 12 items viz., trail-making, cube copy, clock drawing, naming, digit span, sustained attention, serial subtraction, sentence repetition, verbal fluency, abstract reasoning, memory, and orientation. The total score obtained from adding all points of 12 items in the MoCA test, with a maximum of 30 points. A higher score represents better cognitive functioning.

2.3. Procedures

The socio-demographic data, health status, and history of cognitive symptoms were collected initially, followed by the T-MoCA was administered. For the test-retest reliability, after five weeks, a total of 46 elderly people (11 with normal cognition and 19 with MCI group), were selected at systematic random (every fifth participant) from the total of 233 study participants to administer the T-MoCA once again.

2.4. Ethical consideration

This study is part of the doctoral study of the principal author and the permission to conduct the study was sought from the Institutional Doctoral Committee of the research institution (PU/Ph.D/RD1/UDS-PSY-12/2019). The researcher explained the aims and procedures of the study to the participants, who provided the consent to be part of the study.

2.5. Statistical analyses

Statistical analyses including descriptive statistics, group comparison, internal consistency, correlation coefficients, and confirmatory factor analysis (CFA) were performed by using the Jamovi software.[17] Test-retest reliability, sensitivity and specificity, and receiver operating characteristic (ROC) curve analyses were performed by using the Statistical Package for the Social Sciences (SPSS, version 24.0).

The following guidelines were used for the statistical analyses: the descriptive statistics were used for the sample's characteristics. The independent t-test (for continuous variables) was used for the comparison of the two groups in terms of knowing the differences between gender (male and female), locality (urban and rural), study group (NC-group and MCI-group). Also, ANOVA was used for comparison of three groups, such as age cohorts (60–69 years-old, 70–79 years-old, and 80–89 years old) and educational levels (primary, higher school, and graduation) of the participants for knowing the differences between each group on their cognitive functions, effects of age in cognitive impairment, and educational influence on MoCA score of the subjects. The internal consistency reliability of the T-MoCA was assessed using Cronbach's alpha. This reliability value should be equal to or higher than 0.7.[18] Further, test-retest reliability of the T-MoCA was assessed through intra-class coefficients (ICCs) for baseline and retest scores performed after five weeks. The ROC curve analysis was performed to determine sensitivity and specificity for detecting MCI. In this ROC analysis, areas under the curve (AUC) can vary between 0.5 and 1, and larger AUC indicating better diagnostic accuracy.[2,19]

Further, the CFA was conducted to add further evidence to MoCA's construct validity. To evaluate the goodness of fit of the tested factorial models, the indices χ^2/df, Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA) were used. Values of χ^2/df between 2–3, CFI and TLI is > 0.9, and RMSEA < 0.06 indicating a good fit indexes.[2,20,21]

3. Results

3.1. Sample characterization

The total sample was 233 participants comprising of 104 normal cognition and 129 with MCI. The mean T-MoCA score was 20.9 (5.07). The characterization of the study sample of all the sub-groups is given in more details in Table 1.

The total T-MoCA score was compared between the primary groups (normal cognition group and MCI-group), gender, locality, age cohort (60–69 years-old, 70–79 years-old, and 80–89 years old), and the educational level (primary, higher school, and graduation).

Table 1
Descriptive statistics of age cohorts, gender, locality, group and education by MoCA mean and SD.

	N	MoCA mean (SD)
Age cohorts		
60–69 years	118	21.5 (5.05)
70–79 years	82	21.1 (4.84)
80–89 years	33	18.7 (5.29)
Total	233	20.9 (5.07)
Gender		
Male	95	20.8 (4.87)
Female	138	21.0 (5.22)
Locality		
Urban	106	21.2 (5.00)
Rural	127	20.7 (5.14)
Group		
NC-Group	104	24.9 (2.99)
MCI-Group	129	17.7 (4.00)
Education		
Primary	87	19.2 (5.01)
Higher school	109	21.9 (4.61)
Graduation	37	22.4 (5.44)

MCI-Group = Mild Cognitive Impairment Group; NC-Group = Normal Cognition Group.

Statistically, significant differences were not found between groups of varying localities [$t(231) = 0.494$, $p = 0.494$] and gender [$t(231) = -0.344$, $p = 0.731$]. However, significant differences were found between NC-group and MCI-group [$t(231) = 15.3$, $p = 0.001$]. NC-group participants had better performance (M = 24.90, SD = 2.99), when compared to the MCI-group (M = 17.70, SD = 4.00). Additionally, significant differences were found between groups across different age cohorts [F (2, 86.6) = 3.52, $p = 003$] and educational levels [F(2, 94.6) = 9.01, $p = 0.001$]. Post hoc comparisons using the Tukey test on age cohort showed significant differences between the 60–69 years-old group (M = 21.50, SD = 5.05) and 80–89 years old group (M = 18.7, SD = 5.29), but not between the 70–79 years old group (M = 21.1, SD = 4.84) and 80–89 years old group. Further, post hoc analysis on the educational level indicated significant differences between primary educational group (M = 19.2, SD = 5.01) and higher school group (M = 21.9, SD = 4.61), as well as primary group and graduation group (M = 22.4, SD = 5.44). However, significant difference was not found between higher school and graduation group.

3.2. Reliability of T-MoCA (India)

Test-retest reliability data were collected from a subsample of 46 elderly participants (NC and MCI-Group) tested after five weeks from the first test. The test-retest reliability was calculated using Carl Pearson correlation coefficient for the overall scale. The test-retest value of T-MoCA is high (intraclass correlation coefficient [ICCs] = 0.918, $p = 0.001$), which indicates good test-retest reliability over time.

3.3. Internal consistency reliability of T-MoCA (India)

Internal consistency reliability of the T-MoCA was estimated using Cronbach's α. Item reliability statistics for internal consistency of T-MoCA is shown in Table 2. The Cronbach's alpha value of 0.7 to 0.9 was considered as evidence to support good internal consistency of the test.[22,23] The internal consistency of the T-MoCA (India) was high, yielding a Cronbach's alpha of 0.834 indicating good internal consistency.

3.4. Sensitivity and specificity

ROC curve was drawn for MCI-group versus the normal cognition group to determine the discriminatory validity of MoCA Tamil version (Figure 1). Area under the ROC curve (AUC) of the MoCA-Tamil (India) for the identification of MCI was 0.909 (95% confidence interval [CI] = 0.872–0.945). It denotes that the cut-off of 24 points has good ability to diagnose participants with and without MCI based on the Tamil (India) MoCA.

Table 3 presents the sensitivities, specificities, positive predictive values, and negative predictive values of the MoCA-Tamil (India) version at different cut-off values. The cut-off value determined by the developers of the original MoCA was 26.[1] With the use of original cut-off of 26 points, the MoCA-Tamil (India) detected 90.7% of MCI, but specificity was reduced to 61.5% (Table 3).

The optimal cut-off value for the MoCA-Tamil (India) as determined by this study appears to be 24, which is 2 points lower than the original MoCA value. At this cut-off value, the sensitivity (88.4%) and specificity (77.9%) of the MoCA-Tamil (India) in terms of screening MCI was good. Hence, 24 points seemed to provide the best balance between sensitivity and specificity as well as performed as high in positive predictive value (PPV; 83.2%) and negative predictive value (NPV; 84.4%).

3.5. Confirmatory factor analysis (CFA)

The CFA was performed to provide further evidence of the MoCA-Tamil (India) version's construct validity. Four models were

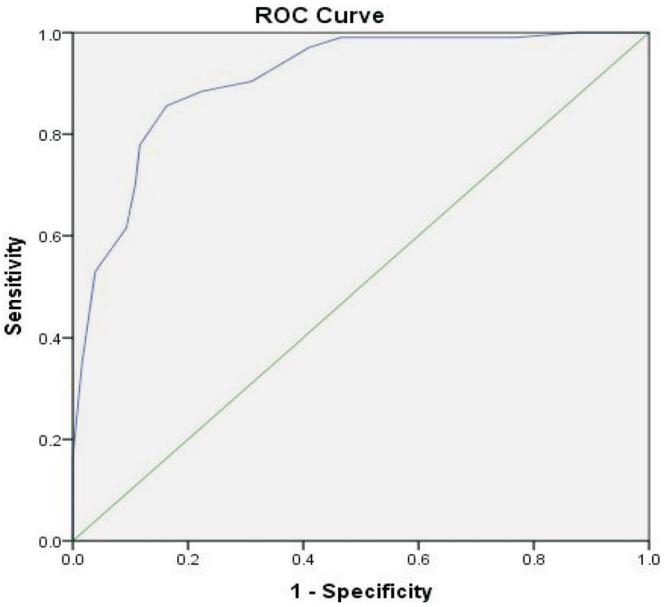

Figure 1. Receiver operating characteristic (ROC) curve analysis of T-MoCA (India) for the detection of normal cognition and MCI-Group.

Table 2
Item reliability statistics for internal consistency of T-MoCA (India).

Item	Mean (SD)	Item-rest correlation	Cronbach's α, If item dropped
Trail making	0.627 (0.48)	0.581	0.819
Cube copy	0.558 (0.49)	0.559	0.820
Clock drawing	2.193 (0.69)	0.546	0.817
Naming	2.755 (0.47)	0.354	0.831
Digit sign	1.567 (0.56)	0.588	0.816
Sustained attention	0.768 (0.42)	0.293	0.834
Serial subtraction	1.798 (0.85)	0.646	0.807
Sentence repetition	1.343 (0.61)	0.586	0.815
Verbal fluency	0.622 (0.48)	0.583	0.819
Abstraction	1.193 (0.69)	0.535	0.818
Memory	2.644 (1.27)	0.601	0.824
Orientation	4.880 (0.96)	0.400	0.834
Scale statistics	1.75 (0.42)		0.834

Table 3
Sensitivity, specificity, PPV and NPV of the T-MoCA (India) for the deduction of normal cognition and MCI-Group.

Cutoff	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
≥ 21	0.69 (69.0)	0.90 (90.4)	89.9	70.1
≥ 22	0.77 (77.5)	0.88 (88.5)	89.3	76.0
≥ 23	0.84 (83.7)	0.86 (85.6)	87.8	80.9
≥ 24	**0.88 (88.4)**	**0.78 (77.9)**	**83.2**	**84.4**
≥ 25	0.89 (89.1)	0.70 (70.2)	78.7	83.9
≥ 26	0.91 (90.7)	0.61 (61.5)	74.5	84.2
≥ 27	0.96 (96.1)	0.53 (52.9)	71.7	91.7
≥ 28	0.98 (98.4)	0.35 (34.6)	65.1	94.7
≥ 29	1.0 (100.0)	0.16 (16.3)	59.7	100.0
≥ 30	1.0 (100.0)	0.01 (1.0)	55.6	100.0

Bold values indicate cutoff point used in the study with values of sensitivity and specificity.
NPV = negative predictive value; PPV = positive predictive value.

examined in the analyses. The first model (one-factor model) intended to explore the unidimensionality of the MoCA, under the name of cognition.[19] The second model (two-factor model) matched the two factor model proposed by Duro et al. (2010). Further, the third model (six-factor model) was based on the original conceptual model proposed by the MoCA's authors.[1] Finally, the researchers included a fourth model (seven-factor model) based on seven cognitive domains.[6]

To determine the best model, the four models were tested using the CFA and the model fit indices. Table 4 summarized the fit statistics for each model. It was observed that different fit model indices reflect good fit of the four models. The first model formed by a single factor (cognition) presented the following indexes: 114 (χ^2), 2.11 (χ^2/df), 0.923 (CFI), 0.906 (TLI), 0.069 (RMSEA). The second model formed by a two-factor (memory and attention/executive functions) presented the following results: 109 (χ^2), 2.05 (χ^2/df), 0.928 (CFI), 0.911 (TLI), 0.067 (RMSEA). Further, the third model formed by a six-factor (executive functions, language, visuospatial skills, short-term memory, attention concentration and working memory, and temporal and spatial orientation) presented the following indexes: 72 (χ^2), 1.80 (χ^2/df), 0.959 (CFI), 0.932 (TLI), 0.058 (RMSEA). Finally, the fourth model formed by a seven-factor (executive functioning, visuospatial abilities, attention concentration and working memory, language, abstract reasoning, memory, and orientation) presented the following indexes: 76 (χ^2), 2.11 (χ^2/df), 0.949 (CFI), 0.906 (TLI), 0.069 (RMSEA). All four models had a relative χ^2 close to between 2 and 3. The CFI and TLI were greater than 0.9, and the RMSEA was less than 0.06, indicating good fit indexes.[2,19–21] However, the six-factor model originally proposed by the MoCA's authors showed a better fit to the data in all the indices as compared to other models. Hence, these fit indices are suggestive to the consistency with the T-MoCA (India) version in regards to the six-factor factorial related validity.

Table 4
Indices of the confirmatory factor analysis models.

Models	χ^2	*df*	*p*	χ^2/df	CFI	TLI	RMSEA
One-factor model	114	54	< .001	2.11	0.923	0.906	0.0690
Two-factor model	109	53	< .001	2.05	0.928	0.911	0.0673
Six-factor model	72	40	< .001	1.80	0.959	0.932	0.0586
Seven-factor model	76	36	< .001	2.11	0.949	0.906	0.0691

CFI = Comparative Fit Index; *df* = degrees of freedom; RMSEA = root mean square error of approximation; TLI = Ticker-Lewis Index; χ^2 = Chi-square test statistic; χ^2/df = relative Chi-square.

4. Discussion

The overall aim of the present study was to evaluate the psychometric properties of the MoCA-Tamil (India) version and analyse its construct related factorial validity in normal cognitive healthy participants as well as in the MCI-group. The T-MoCA's results were not affected by gender or locality. The factor of age had different effects with statistically significant differences between 60–69 years old elderly participants and 80–89 years old participants. The level of education affects the T-MoCA scores between primary and higher levels as well as primary and graduates. It also showed that a higher education corresponds to a higher total score. These results involving the factors of age and education levels seem to be in line with previous validation studies using the MoCA.[19,24–26] This evidence confirmed that the effects of education on performance of neuropsychological tests.[27] Further, positive correlation between the total score and each item of T-MoCA was noticed except naming item. Cognitive domain based correlation was also conducted which showed that domains had significantly higher correlation between them.

The validation of the MoCA in Tamil (India) demonstrated high in test-retest reliability and internal consistency and these were similar to the other language validation studies with MoCA,[2,6,10,25] including MoCA-Tamil (Sri Lanka) version.[12] It was also found that Cronbach's alpha was not increased with the removal of scale items. It shows that the contribution of all items are essential to finding MCI in the MoCA scale.

The ROC curve analysis of the MoCA showed that the MoCA exhibits a better diagnostic accuracy to distinguish participants with MCI and the cognitively healthy participants. As described in Table 3, the optimal cut-off value of ≥ 24 showed normal cognition, and this suggested good sensitivity (88.4%), specificity (77.9%), PPV (83.2%), and NPV (84.4%). The cut-off point reached in the study was the same as the MoCA-Tamil (Sri Lanka) version,[12] but lower than the original cut-off score of 26 points proposed by the MoCA's developers[1] and of the Japanese version,[28,29] and higher than that of the Korean version.[30] These results confirmed that the different cut-off points might be due to the difference in years of education and culture.[9,30]

Based on CFA results, helped to evaluate the different factorial hypothesized models and then proving its construct related validity. As compare to the four different models, results found based on the fit indices confirmed that the construct validity of this instrument is with the MoCA developer's proposed six-dimensional factorial model. These findings are similar to the previous studies.[1,25] The results reveal that an additional support to the uni-dimensionality of the MoCA serves as a good indicator for evaluating individual's global cognition.[31] Hence, this study provides additional evidence for the MoCA which not only measures a global cognitive ability, but also supports multi-dimensionality constructs.

There were some limitations to the present study. The researchers excluded illiterate elderly participants from this study because it is required different procedures that diffuse the entire sample selection. Secondly, the MoCA scores were significantly affected by age and education. The researchers did not test its effect in the cut-off point if it adjusted for the extreme age or low-level education group.[32] Further studies may conduct with illiterate and very poorly educated elderly participants to confirm the normative values established in this study. Also, to establish cut-off points discriminating normal cognition and MCI-group. Further studies should be oriented to determine, both for Tamil (Sri Lanka) MoCA and Tamil (India) MoCA, the cut-off scores distinguishing healthy subjects from those affected by MCI and dementia.

5. Conclusion

The present study reports a comprehensive psychometric analysis of the MoCA-Tamil (India) version. It produces considerable evidence to distinguish cognitive healthy subjects and individuals with MCI by using MoCA Tamil (India) version. Moreover, the data indicate that it has high test-retest reliability, internal consistency, and good sensitivity and specificity for detecting cognitive impairment. Furthermore, the present findings establish the factorial and discriminant validity, which provide good evidence of the construct related validity of the MoCA Tamil version. Thus the MoCA-Tamil (India) version proves to be a reliable tool for assessing global cognition as well as MCI in the elderly population.

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Conflict of interest

The authors have none to declare.

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