Standardization and Validation of Montreal Cognitive Assessment (MoCA) in the Moroccan Population

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Abstract   **Background:** The Montreal Cognitive Assessment (MoCA) is a cognitive screening test designed to assist health professionals in the detection of mild cognitive impairment and Alzheimer's disease (AD). **Objectives:** The aim of our work was to perform the adaptation and standardization of the MoCA in the Moroccan population, taking into account its different demographic characteristics, i.e., age, gender and education level. The second aim was to evaluate the predictive validity of the test in Moroccan patients with Alzheimer's disease. **Patients and Methods / Material and Methods:** First we administered the MoCA-ma to 120 normal participants (60 men and 60 women). All the participants can read and speak Arabic, they had no neurological, neuropsychological, psychiatric or toxic history and they had a preserved cognitive functioning. Subjects were categorized according to age and educational level. Secondly, we administered the MoCA-ma and the Mini-Mental State Examination (MMSE-ma) to 40 healthy controls and 40 subjects fulfilling diagnostic criteria for AD. All the patients diagnosed as having AD underwent complete neurologic and somatic clinical examination, usual laboratory testing and MRI. **Results:** The MoCA-ma norms were established considering significant influential factors. Indeed, the normative data in this version have shown that performance of normal participants depend mainly on age and level of education while gender had no significant influence. The results of validation showed that the MoCA-ma was sensitive enough to detect cognitive impairment in subjects with AD. **Conclusion:** The standardization and validation of the Arabic version of the MoCA-ma provides to physicians an useful brief cognitive screening tool for the detection of AD in the Arabic countries.

Keywords   MoCA-ma, MMSE-ma, Alzheimer's disease, Adaptation, Standardization, Validation, Moroccan population

1. Introduction

Normal aging, mild cognitive impairment (MCI) and dementia represent a continuum of cognitive states in the elderly individuals. Identification of the prodromal phase of Alzheimer's disease (AD) is very important, because it can lead to early therapeutic intervention (medication and cognitive treatment).

However, commonly used instruments, such as the Mini Mental State Examination (MMSE) [1], are not sensitive enough to detect an eventual early cognitive impairment. In this perspective the Montreal Cognitive Assessment (MoCA), which was published in 2005 by Nasreddine ZS [2],

was specially developed and designed to assist health professionals in the detection of mild cognitive impairment and Alzheimer's disease. It (administered approximately in 10 to 15 minutes) allows a comprehensive assessment of major cognitive domains: short-term memory, visuospatial abilities, executive functions, attention, concentration, working memory, language and orientation in time and space. The MoCA has been adapted to different languages and validated in many countries [3-14].

In our context, the first aim of the present work was to perform the adaptation and standardization of the MoCA in the Moroccan population, taking into account its different demographic characteristics, i.e., age, gender and education level.

The second aim was to evaluate the predictive validity of the test in Moroccan patients with Alzheimer's disease (AD).

2. Materials and Methods

2.1. Translation of MoCA in Moroccan Dialect

The original version of MoCA was initially translated in Moroccan dialect. Its final version (MoCA-ma) used in this study contained some cultural and linguistic changes for developing better cultural and language compatibility:

- **Item 1 (Visuospatial/Executive Functions):** Arabic alphabets were used for alternating Trail-making Test Part B and the number of steps required for completion of task was retained.
- **Item 2 (Memory):** The five English words are replaced with five arabic words (أحمر- مسجد- ياسمين - قطن- وجه) to reflect local familiarity.
- **Item 3 (Attention):** for auditory vigilance part Arabic alphabet were recruited with identical response order and character number to original English test.
- **Item 4 (Language-sentence repetition):** The two sentences of the original version were replaced by two sentences in Arabic dialect to reflect local familiarity.
- **Item 5 (Language-verbal fluency):** We chose the letter (ب) for the subtest of the Phonemic letter fluency.
- **Item 6 (Abstraction):** The four English words are replaced with four Arabic words (دراجة - مسطرة - ساعة - قطار) to reflect local familiarity.

Furthermore, one point was added to the total MoCA-ma score if the subject had 12 or less years of formal education, as suggested in Nasreddin's original study [2].

2.2. Pilot Study

The Moroccan version of MoCA (MoCA-ma) was initially tested on 25 healthy persons with intact cognition and no underlying disease. Preliminary results showed good internal consistency. No difficulties were encountered during the testing and subjects gave favourable feed-back when questioned regarding comprehension and ease of the questionnaire.

2.3. Study Population

First, we administered the MoCA-ma to 120 normal participants (60 men and 60 women). All the participants can read and speak Arabic, they had no neurological, neuropsychological, psychiatric or toxic history and they had a preserved cognitive functioning. Subjects, described in the table below (**Table 1**) were categorized according to age group, gender and educational level.

Secondly, we administered the MoCA-ma and the Moroccan version of the Mini-Mental State Examination (MMSE-ma) to 40 normal elderly controls (NC) and 40 subjects with a diagnosis of probable Alzheimer's disease (AD) meeting the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, criteria [16] and the National Institute of Neurological and Communicative Disorders and Stroke/Alzheimer's Disease and Related Disorders Association criteria [17].

All the patients diagnosed as having AD underwent complete neurologic and somatic clinical examination, usual laboratory testing and MRI. All participants were aged 47 years and over and were recruited from among elderly outpatients registered at Rabat Specialty Hospital and community residents in Morocco.

Information sheet and verbal explanation were given before individual verbal informed consent was obtained from all participants.

Table 1. Description of the standardization population of the MoCA-ma: Distribution of subjects by age group, gender and educational level

Age group	Education level	Men	Women
18-39 years	3-6 years	5	5
	7-10 years	5	5
	+11 years	5	5
40-59 years	3-6 years	5	5
	7-10 years	5	5
	+11 years	5	5
60-69 years	3-6 years	5	5
	7-10 years	5	5
	+11 years	5	5
70 years and over	3-6 years	5	5
	7-10 years	5	5
	+11 years	5	5
Total		60	60

2.4. Statistical Analysis

The Statistical Package for Social Sciences **(SPSS)** software version 22.0 was used for the data analyses. Normative data of MoCA-ma test are provided corrected for gender, age group and education level.

MoCA-ma and MMSE-ma scores for each of the two groups (AD and NC) were compared by analysis of covariance (ANCOVA) (with Bonferroni adjustment for multiple testing). Differences between groups regarding demographic variables (age and education level) were investigated using **Levene's test** and **U de Mann-Whitney** value, depending on the measurement of variables.

Sensitivities and specificities were measured at threshold scores. P values below 0.05 were considered statistically significant throughout the analysis.

3. Results

The MoCA-ma norms were established considering significant influential factors. Indeed, the normative data in this version have shown that performance of normal participants depend mainly on age (**Figure 1**) and education level (**Figure 2**) while gender (**Table 2**) had no significant influence.
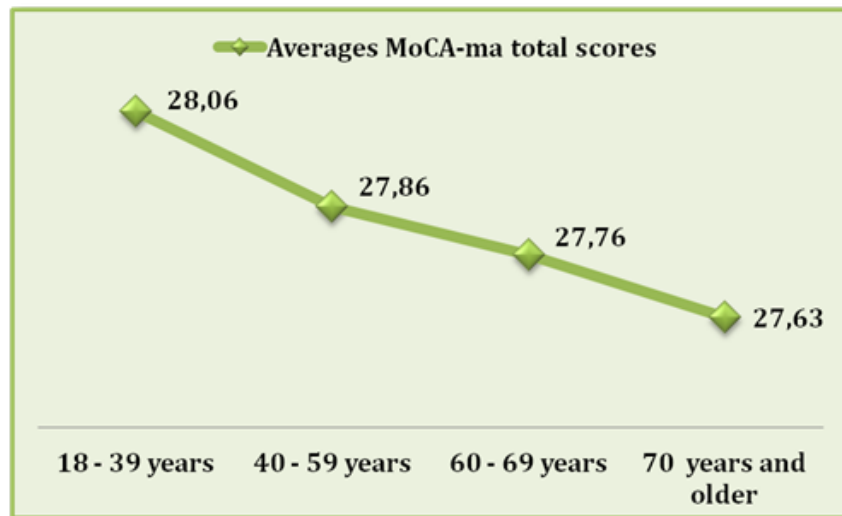
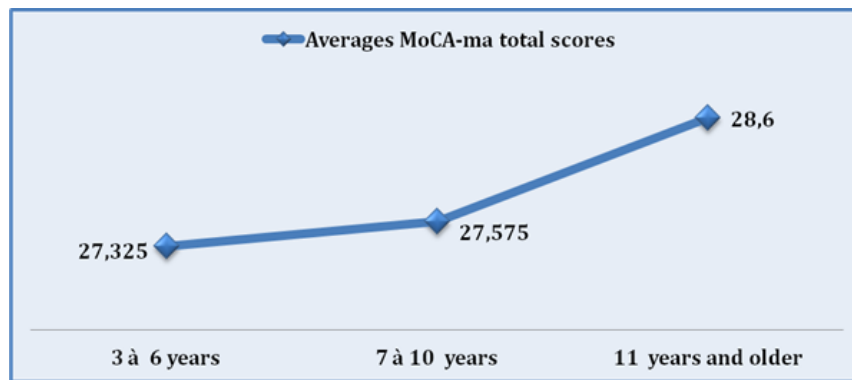**Figure 1.** The results of averages MoCA-ma total scores by age group

Figure 2. The results of averages MoCA-ma total scores by education level

Table 2. The results of averages MoCA-ma total scores by gender

Gender	Averages MoCA-ma total scores
Men	27,59
Women	27,62

The validation study participants comprised 80 elderly persons: 40 with AD and 40 NC. Mean ages, sex ratios, and number of education years were similar in the two groups.

Average MMSE-ma scores of all two groups (**Table 3 and Table 4**) differed significantly from each other (U de Mann-Whitney 92,000, P,0001).

Average MoCA-ma scores also differed significantly between the two groups (U de Mann-Whitney 18,000, P,0001) and remained significant after controlling for the effects of age and level of education (analysis of covariance F 174,436, P.0001). As seen in **Table 5**, the differences between the groups were much more pronounced using the MoCA-ma than the MMSE-ma, and the correlation between the MoCA-ma and the MMSE-ma was high (F (47.389), P .0001) (**Table 6**).

Sensitivity and specificity were determined for patients AD and NC. Cutoff points with sensitivity and specificity levels are presented in **Table 7**.

Table 3. Mean Scores of MMSE-ma and MoCA-ma NC and AD Groups

	AD, Mean + SD	NC, Mean + SD
MMSE-ma scores	21,700 (5,2876)	28,900 (1,3166)
MoCA-ma scores	16,950 (5,3106)	28,475 (1,5019)

Table 4. Comparison between NC and AD Groups

	NC		AD		U de Mann-Whitney	P**
MMSE-ma	28,900[a]	58,20*	21,700[a]	22,80*	92,000	<0,0001
MOCA-ma	28,475[a]	60,05*	16,950[a]	20,95*	18,000	<0,0001

□ Average score
* Average rank
** Threshold of significance at 0.05

Table 5. Analysis of covariance (ANCOVA)

		Sum of squares	ddl	Average square	F	Sig.
MMSE-ma	Intergroup	1036,800	1	1036,800	69,836	,000
	Intragroup	1158,000	78	14,846		
	Total	2194,800	79			
MOCA-ma	Intergroup	2656,513	1	2656,513	174,436	,000
	Intragroup	1187,875	78	15,229		
	Total	3844,388	79			

Table 6. Variance homogeneity test

		Levene's test	ddl1	ddl2	Sig.
MMSE-ma	**Based on the average**	47,389	1	78	,000
	Based on the median	42,009	781	78	,000

Table 7. Computed Cutoff Points of MoCA-ma and MMSE-ma Scores, Sensitivity and Specificity Levels for the identification of AD

	MoCA-ma Cutoff Scores	Sensitivity		Specificity	
		MoCA-ma	MMSE-ma	MoCA-ma	MMS-ma
AD vs NC	26	97.5 %	85 %	85 %	70 %
	25	95 %	72.5 %	97.5 %	72.5 %
	24	92.5 %	62.5 %	100 %	100 %
	23/22	87.5 %	55 %	100 %	100 %
	21	82.5 %	42.5 %	100 %	100 %
	20	77.5 %	50 %	100 %	100 %
	19	65 %	30 %	100 %	100 %

4. Discussion

As compared with a literature review, our results presented in the present study corroborate the results of *Nasreddine ZS* [2, 3], *Rosdinom Razali* [4], *Memoria CM* [5], *Michal Lifshitz* [6], *Jihui Lu* [7], *Karunaratne S* [8], *Freitas S* [9], *Selekler K* [12], *Rahman TT* [13] and *Lee JY* [14].

Indeed, the higher is the level of education more the performance of the general intellectual efficiency, evaluated by MoCA-ma, is better; on the contrary, the performance decreases with age. However, sex had no relevant influence on the performance of our participants; the same conclusion is found in the literature.

In summary, for the standardization of MoCA-ma, we can conclude that the performance of normal participants depend mainly on age and level of education.

A cutoff of 26 in MoCA-ma (scores of 25 or below indicate impairment) yielded the best balance between sensitivity and specificity for the AD groups. In addition, the specificity of the MoCA-ma to exclude elderly normal controls was excellent (85%), although slightly lower than the MMSE-ma (70%). More important, the MoCA-ma's sensitivity in detecting AD was excellent (97.5%), and it was considerably more sensitive than was the MMSE-ma (85%) **(table 7)**.

On the other hand, this study showed a significant positive correlation between MoCA-ma and MMSE-ma scores with a *Pearson* correlation coefficient of 0.890 (p b 0.001). This positive linear relationship between MOCA-ma and MMSE-ma scores was comparable to those reported by the original author of MoCA, which obtained high correlation between both tools with correlation coefficient of 0.87 (p b 0.001) [2].

There are several features in MoCA-ma's design that likely explain its superior sensitivity for detecting AD. The MoCA-ma's memory testing involves more words, fewer learning trials, and a longer delay before recall than the MMSE-ma. Executive functions, higher-level language abilities, and complex visuo-spatial processing can also be mildly impaired in AD participants and are assessed by the MoCA-ma with more numerous and demanding tasks than the MMSE-ma.

Some limitations of this study should be mentioned. First, we could not apply the MoCA-ma to illiterate subjects because some of the MoCA-ma sub-tests (ie, the trail-making B task, the clock drawing task, and the sustained attention task) require literacy. Second, the number of participants in the validation study was relatively small.

5. Conclusions and Recommendations

The standardization and validation of the Arabic version of the MoCA-ma provide to physicians an useful brief cognitive screening tool for the detection of AD in the Arabic countries. It has a high sensitivity rate and is valid as a single

screening instrument for this condition.

In the future, it is recommended that the MoCA-ma be tested for its reliability and validity in a population already prediagnosed as having Mild Cognitive Impairment (MCI) using more strict diagnostic criteria and neuropsychological tests. A cut-off score for MoCA-ma should be determined for it to have high sensitivity and specificity as a screening instrument for MCI.

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