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Montreal Cognitive Assessment (MoCA): an update normative study for the Portuguese population

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Resumo Alargado em Português

Introdução

Aos longos das últimas décadas é notório o crescente e vincado envelhecimento da população portuguesa (PORDATA, 2021). Esta alteração demográfica implica novos desafios para a investigação, nomeadamente, o aumento de casos de demência a e necessidade do rastreio do declínio cognitivo leve, que poderá indiciar o início de um processo demencial (Bellevile et al., 2017; Freitas et al., 2011). Para tal, os testes de rastreio cognitivo são ferramentas essenciais, sendo o *Montreal Cognitive Assessment* (MoCA) amplamente utilizado por todo o mundo, que colmatou algumas lacunas de testes já existentes, tais como o *Mini Mental State Examination* (MMSE), demonstrando elevada robustez enquanto prova de rastreio. (Freitas, et al., 2010; Freitas et al., 2014; Freitas, et al., 2015a).

Em Portugal, o MoCA foi adaptado e validado à população portuguesa, tendo sido estabelecidas normas de interpretação desta prova por Freitas e colegas (Freitas et al., 2011). Embora estas normas tenham sido estabelecidas, as mudanças geracionais, assim como o envelhecimento da população e aumento da esperança média de vida implicam uma constante atualização das normas. Além disso, a crescente heterogeneidade das pessoas idosas, gerou a necessidade de se segmentarem por intervalos etários as normas no grupo etário de pessoas com 65 anos ou mais.

Este estudo pretende estabelecer normas estratificadas atualizadas para a população portuguesa de adultos e idosos, tanto para o as pontuações totais como para as pontuações de cada domínio cognitivo contemplados na avaliação do MoCA, contribuindo assim para uma avaliação cognitiva mais fiável na utilização da versão portuguesa do MoCA.

Metodologia

A amostra total deste estudo é constituída por 860 participantes saudáveis a nível cognitivo e com idade igual ou superior a 25 anos, residentes no território português. Os critérios de inclusão para este estudo foram: (i) idade igual ou superior a 25 anos; (ii) escolaridade formal realizada em Portugal e ser falante nativo da língua portuguesa; (iii) ausência de deficiência visual, motora ou auditiva significativa que pudesse comprometer o desempenho da avaliação; (iv) sem histórico de abuso de substâncias ou álcool; (v) ausência de distúrbios neurológicos / psiquiátricos ou doenças crônicas que

possam comprometer a cognição; (vi) autonomia na realização das atividades de vida diária; (vii) sem queixas depressivas significativas; (viii) nenhum medicamento que possa afetar a cognição. Para confirmar esses critérios, uma psicóloga conduziu uma entrevista com base em um questionário sociodemográfico, um inventário do estado clínico atual e hábitos e um histórico médico. Na fase seguinte, os participantes responderam a uma bateria de testes de avaliação neuropsicológica: (i) Irregular Word Reading Test (TeLPI; Alves et al., 2009); (ii) Mini-Mental State Examination (MMSE; Folstein et al., 1975; Guerreiro et al., 1994); (iii) Clinical Dementia Rating scale (CDR; Garret et al., 2008; Hughes et al., 1982); Geriatric Depression Scale (GDS-30; Barreto et al., 2008; Yesavage et al., 1983); (iv) Subjective Memory Complaints scale (SMC; Ginó et al., 2008; Schmand et al., 1996); (v) Clock-Drawing Teste (CDT; Critchley, 1953); (vi) Montreal Cognitive Assessment (MoCA; Nareddine et al., 2005; Freitas et al., 2010).

Resultados

Participaram no estudo 860 indivíduos (média idade = 59,60 ± 14,548 [25-99]; média escolaridade = 8,17 ± 4,567 [1 - 27]). Apenas as variáveis que demonstraram um grande *Effect Size* foram consideradas como critério normativo e, das variáveis contempladas, apenas a variável idade e nível de educação demonstraram este efeito. Ambas as variáveis apresentaram contributos significativos para a predição do resultado total do MoCA. Após esta análise foram estabelecidos os novos dados normativos para o score global e subscores da prova para os intervalos de idade definidos (referir quais) e níveis de escolaridade considerados.

Discussão

O presente estudo fornece uma atualização dos dados normativos do MoCA para a população portuguesa, aumentando assim o valor e rigor deste instrumento na avaliação de défice cognitivo ligeiro. A existência de mais grupos etários nesta atualização de normas representa um aumento do rigor clínico considerável. Além disso, o facto deste estudo oferecer dados normativos para os domínios cognitivos avaliados pelo MoCA, amplia significativamente as possibilidades de utilização desta ferramenta ao nível da avaliação e intervenção

Palavras-chave

Declínio cognitivo ligeiro; Rastreio cognitivo; Normas; Avaliação psicológica, Montreal Cognitive Assessment

Introduction

The present dissertation in Clinical and Health Psychology aimed to analyse the influence of sociodemographic variables on the participant's performance and establish a new normative data for the adult and elderly Portuguese population, to ensure a more precise use of the instrument.

The MoCA is a recognized brief cognitive screening instrument that evaluates six cognitive domains: executive function; visuo-spatial capacity; memory, attention, concentration and working memory; language and, finally, orientation. The application is simple and have a total score is a maximum of 30 points, where the higher the score obtained, the better the performance. The MoCA has proven to be a test with good psychometric properties and with a great sensitivity of early detection of mild cognitive decline, these characteristics address many of the failures pointed to the Mini Mental State Examination (MMSE), a cognitive screening test widely used throughout the world, which proved its robustness as a screening test.

The study sample is composed of 860 adults and older adults that are cognitively healthy. They were stratified according to various sociodemographic variables with a distribution like that observed in the Portuguese population. The results showed that the sociodemographic variables age and educational level contributes significantly to the explanation of the total explained variance of the MoCA total scores with a large effect size. The new normative data for the Portuguese population were established considering age and educational level and include normative data for the subscores of MoCA.

The present study provides an increase of the value of the MoCA as a screening assessment tool for MCI cases and improve the reading and comprehension of observed performances in terms of clinical characterization and enhances the development and monitoring more suited interventions.

This dissertation, in accordance with the regulation of the 2nd cycle of studies leading to the master's degree in Clinical and Health Psychology, was prepared as an article for submission to Archives of Gerontology and Geriatrics and is awaiting a response.

Índice

Lista de Tabelas

Lista de Acrónimos

ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
CDR	Clinical Dementia Rating Scale
CDT	Clock-Drawing Test
GDS-30	Geriatric Depression Scale
MCI	Mild Cognitive Impairment
MLR	Multiple Linear Regression
MMSE	Mini-Mental State Examination
MoCA	Montreal Cognitive Assessment
MUA	Moderately Urban Areas
NUTS-II	Nomenclature of Territorial Units for Statistics - II
PRA	Predominantly Rural Areas
PUA	Predominantly Urban Areas
SD	Standard Deviation
SMC	Subjective Memory Complaints Scale
SPSS	Statistical Package for the Social Sciences
VIF	Variance Inflation Factor

Montreal Cognitive Assessment (MoCA): an update normative study for the Portuguese population

Abstract

The Montreal Cognitive Assessment (MoCA) is an important brief cognitive screening instrument that is known for its good psychometric properties and sensitivity to detect mild cognitive impairment (MCI). After ten years, it became relevant to update the previous Portuguese normative study due to changes in the population and some limitations present in the study itself. The MoCA was applied to 860 cognitively healthy adults, stratified according to sociodemographic variables verified in the Portuguese population. The new normative data were defined considering the strata of the variables age and educational level, as these showed to have a large effect size on MoCA scores.

Keywords:

Mild cognitive impairment; Cognitive screening; Norms; Psychological assessment; Montreal Cognitive Assessment

Introduction

Over the last decades, the growing aging of the Portuguese population has been notorious. According to PORDATA (2021), the aging rate in 2020 was 165.1%, when in 2010 it was registered to be of 121.6% and at the beginning of 2000 of 98.8%. These indicators of aging rate are inevitably related to the increase in average life expectancy that in 2000 was approximately 76.4 years and in 2018, 80.9 years (PORDATA, 2020), which prompts new challenges and concerns and, consequently, the existence of a larger study on how to respond to emerging needs adequately. In several previous studies, age

has been indicated as a potential risk factor for the presence of dementia, since the process of aging is often accompanied by a set of cognitive deficits and there is a higher prevalence of dementia in older people (Bellevile et al., 2017; Freitas et al., 2011). Mild Cognitive Impairment (MCI) is characterized by many authors as the transitory process between normative aging and the initial dementia process, in which there is a significant cognitive deficit, although not sufficient to meet the criteria necessary for the diagnosis of dementia (Bellevile, et al., 2017; Ciesielska, et al., 2016; Conti et al., 2015; Petersen, 2016). This knowledge, associated with the impact that dementia can have on the individual and the people around them, highlight the crucial necessity of detecting early cognitive decline and investing on adequate screening tests, capable of achieving this purpose. At this stage, the impact of the decline is still small and therapeutic interventions may increase the range of operation, which therefore allows the improvement of the quality of life of individuals (Bellevile, et al., 2017; Freitas, et al., 2011; Freitas, et al., 2013; Hayek et al., 2020).

The *Montreal Cognitive Assessment* (MoCA) is a recognized instrument of brief cognitive screening, developed by Nasreddine and colleagues (2005). Its purpose is to evaluate the tenuous forms of cognitive decline (Freitas et al., 2013; Freitas et al., 2015a; Roebuck-Spencer et al., 2017), and its application is intended for adults of any age, although they must have at least one year of schooling (Freitas et al., 2010). The MoCA was originally developed for the evaluation of six cognitive domains: executive function; visuo-spatial capacity; memory; attention, concentration and working memory; language and, finally, orientation (Nasreddine et al., 2005). Posterior studies, based on both the Classic Theory of Tests and the Item Response Theory, demonstrate the validity and clinical usefulness of these subscores (Freitas et al., 2012; Freitas et al., 2015b). This instrument allows the monitoring of results over time through its reapplication since the authors have created new versions to reduce the learning effects. In addition to the alternative versions of the original test, MoCA also assumes a blind-adapted version - the MoCA Blind - in which only the visual items were removed. The MoCA 5 minute test/telephone and the MoCA Audiovisual (MoCA, 2019) are, as well, adapted versions of the original tool.

The MoCA has proven to be a test with good psychometric properties and with a great sensitivity of early detection of mild cognitive decline. Over time, it has shown to address many of the failures pointed to the Mini Mental State Examination (MMSE), a cognitive screening test widely used throughout the world, which proved its robustness as a screening test (Freitas, et al., 2010; Freitas et al., 2014; Freitas, et al., 2015a). Given these characteristics, researchers have developed several studies for the use of MoCA in several other clinical conditions, namely neurological, psychiatric, and other conditions

(MoCA, 2019). In addition to this valence, its good properties have also allowed its adaptation to be carried out in many countries of the world and its translation into many languages (MoCA, 2019; Freitas, et al., 2010; Freitas, et al., 2014).

In Portugal, the MoCA was translated, adapted, and validated for the Portuguese population by Freitas and colleagues (2010), presenting, similarly to the original version, good psychometric properties, making this a tool of relevance to use in both clinical practice and scientific research. The Portuguese interpretation standards of the MoCA are segregated by age groups from 25 to 49 years, 50 to 64 and from 65 up, as well as by educational levels, despite in other countries the MoCA standards related to age being different (Freitas, et al., 2011). The rules of interpretation of an assessment instrument, whether it is the MoCA or other, allow the performance of an individual to be compared with a reference group. The definition of norms may include many variables, however, age has been shown to be relevant for the delivery of an individual, since the increase in age is generally associated with a decrease in the performance of an individual in the MoCA (Freitas, et al., 2011; Hayek, et al., 2020).

Although the Portuguese interpretation standards of the MoCA are already stipulated, the aging of the population and the challenges associated with the increasing in life expectancy obligate to rethink its structuring, since a composite age group with people aged 65 years or older, nowadays, covers not only a large number of people, but also a very heterogenous one. Given this necessity, the present study aims to establish updated stratified norms for Portuguese adults and older adults population, both for the total score and the subscores of each cognitive domain, therefore contributing to a more reliable cognitive assessment when using the Portuguese version of the MoCA.

Methods

Participants

The research carried out in this study was based on a community-based sample of volunteers from all geographic regions of the Portugal continental territory to improve the representativeness of the Portuguese population. Participants were recruited from national health and social support services. The following demographic and clinical inclusion criteria were considered in the initial subject selection: (i) age equal to or above 25 years; (ii) formal schooling performed in Portugal and being a native Portuguese speaker; (iii) lack of significant visual, motor or auditory impairment that could

compromise the assessment performance; (iv) no history of substance or alcohol abuse; (v) no neurological/psychiatric disorders or chronic diseases that may compromise cognition; (vi) autonomy in performing daily living activities; (vii) no significant depressive complaints; (viii) no medication that may affect cognition. To confirm these criteria, a psychologist conducted an interview based on a sociodemographic questionnaire, an inventory of current clinical health status and habits, and on a medical history. In older participants, the confirmation of these data was carried out by resorting to a close informant (individual in cohabitation, close relative, or community center directors). On a second stage, to be included in this study all subjects were required to display normal performance on the assessment battery compiled for this study (whose instruments have accessible Portuguese-validated norms; see Materials).

Informed consent was obtained from the participants after the aims and procedures of the investigation, as well as the confidentiality requirements, were fully explained by a member of the research group. The present research complied with the ethical guidelines for human experimentation stated in the Declaration of Helsinki, and it was approved by the Faculty of Psychology and Educational Sciences Scientific Committee of University of Coimbra.

Materials and procedure

The neuropsychological assessment battery used in this study include:

a) An extensive sociodemographic questionnaire and inventory of current and past health status, habits, and medical history.
b) The Irregular Word Reading Test (Teste de Leitura de Palavras Irregulares; Alves et al., 2009), which is a tool that consists of a list of 46 irregular words that the participant reads. It allows the estimation of premorbid intelligence.
c) The Mini-Mental State Examination (MMSE - Folstein et al., 1975; Guerreiro et al., 1994) which is a global cognitive assessment tool that evaluates six cognitive domains: orientation, repetition, attention and calculation, language and visual construction and verbal recall.
d) The Clinical Dementia Rating scale (CDR - Garret et al., 2008; Hughes et al., 1982), which is a global staging tool for dementia that is based on the evaluation of cognitive function and functional capacity (according to six cognitive-behavioral categories: memory, orientation, sense and problem solving, community activities, home activities and hobbies, and personal care). A global score of 0 was used as a criterion for inclusion.
e) The Geriatric Depression Scale (GDS-30; Barreto et al., 2008; Yesavage et al., 1983), which is a brief scale composed of 30 dichotomous response questions that

assess emotional and behavioral symptoms of depression. Subjects with a total score of 21 or more points were excluded.

f) The Subjective Memory Complaints scale (SMC; Ginó et al., 2008; Schmand et al., 1996), which is a scale composed of 10 multiple-choice items that assess the presence of subjective memory complaints (maximum score: 21 points).
g) The Clock-Drawing Teste (CDT; Critchley, 1953), which is a screening tool for cognitive dysfunction that evaluates executive function and visuo-spatial capacity.
h) The Montreal Cognitive Assessment (MoCA; Nareddine et al., 2005; Freitas et al., 2010), which evaluates six cognitive domains: executive function; visuo-spatial capacity; memory, attention, concentration and working memory; language and, finally, orientation. The total score is a maximum of 30 points, where the higher the score obtained, the better the performance.

Each participant was evaluated in a single session by a psychologist with expertise in neuropsychological assessment and the instruments were administered in the fixed order by which they are here presented. Participants with normal performances on these instruments were included in the final study sample and performed the MoCA.

Variable Definitions and Sample Stratification

The study sample was constituted by 938 subjects, of which 5 were eliminated due to the exhibition of a GDS-30 score equal our higher than 21 points and 33 due to significant deviations from the norms regarding their performances in the MMSE and CDT. Ultimately, the final sample was composed by 860 participants who were stratified according to the following sociodemographic variables:

a) age (six age intervals: 25 - 39 years; 40 - 49 years; 50 - 59 years; 60 - 69 years; 70 - 79 years; 80 or more years);
b) gender (female and male);
c) education level (four education levels were considered, according to the number of years successfully completed in the Portuguese educational system: 1–4 years [primary education], 5–9 years [middle school], 10–12 years [high school], and more than 12 years of education [university/college]; these categories correspond to the Portuguese educational system);
d) geographic region (according to the Nomenclature of Territorial Units for Statistics [NUTS-II] classification [Instituto Nacional de Estatística, 2010], the Portuguese continental territory is divided into five geographic regions: North, Center, Lisbon, Alentejo, and Algarve);
e) geographic localization (coast and inland);

f) residence area (according to the Types of Urban Areas [Instituto Nacional de Estatística, 2010], categorized into predominantly urban areas [PUA], moderately urban areas [MUA], and predominantly rural areas [PRA].

Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS), version 27.0. Descriptive statistics were computed for all sociodemographic and health variables. Cronbach's alpha coefficients and the observed correlations (using the Pearson correlation coefficient; Cohen, 1988) were also calculated as indicators of psychometric validity. Student's *t* test and analysis of variance (ANOVA) were used to examine the differences in the MoCA scores between subgroups stratified according to sociodemographic variables. To verify the influence of geographic localization and the type of residence areas on the MoCA scores, while considering the influence of age and education, analysis of covariance (ANCOVA) was computed. To estimate the effect sizes, Eta squared (η2) was calculated (Cohen, 1998). Only the variables with a large effect size will be considered as normative criteria. The Pearson correlation coefficient (*r*; Cohen, 1988) and the Multiple linear regression (MLR) were used to examine the significance of these variables as influencing factors for the MoCA. Then, using the variance inflation factor (VIF) statistics (Meyers et al., 2006), multicollinearity was examined and the analysis of effect sizes in the regression was treated with the coefficient of determination (R2). As last, the stratification and determination of the norms of MoCA was performed according to the sociodemographic variables most significantly linked with the MoCA scores.

Results

The final study sample was composed of 860 participants (mean age = 59.60 ± 14.548 years, age range = 25-99; mean education = 8.17 ± 4.567 years, education range = 1 - 27). Table 1 provides the sociodemographic characteristics of the participants, being possible to verify the mimicry of the distribution observed in the Portuguese population.

Table 1 - Sociodemographic characterization of the population sample

Variables	*Levels*	*Sample*	*n (%)*	*Portugal*[1] *(%)*
Age (years)	25-39	109	12.7	17.3

[1] The values (%) of the Portuguese population correspond to the data of the resident population of continental Portugal aged over 24 years (Instituto Nacional de Estatística, 2020).

	40-49	73	8.5	22.5
	50-59	180	20.9	14.4
	60-69	255	29.7	12.7
	70-79	201	23.4	9.5
	≥80	42	4.9	6.6
Gender	Male	321	37.3	47.2
	Female	539	62.7	52.8
Education level	Primary	331	38.5	19.6
	Middle	235	27.3	28.2
	High	154	17.9	25
	University	138	16.0	23.3
Geographic region	North	473	55.0	35.6
	Center	180	20.9	22
	Lisbon	74	8.6	28.5
	Alentejo	39	4.5	7
	Algarve	12	1.4	4.4
	Açores	77	9.0	2.5
Geographic localization	Coast	745	86.6	
	Island	115	13.4	
Residence area	PUA	543	63.1	73.2
	MUA	136	15.8	14.3
	PRA	170	19.8	12.5

In this sample, MoCA exhibited an internal consistency of .610, measured by the Cronbach alfa. The analyses of the relationships between the sociodemographic variable and the MoCA indicate that both age ($F_{(5, 860)} = 22.448$, $p < .001$), and education ($F_{(3, 858)} = 78.458$, $p < .001$) had significant effects on the distribution of MoCA scores, accompanied by a large effect size ($\eta p^2 = .117$ and $\eta p^2 = .216$, respectively; see Table 2).

Table 2 - Analysis of Group Differences on the MoCA Scores While Controlling for the Effect of Covariates and Estimation of the Effect Sizes

Variables	MoCA M ± SD	F (ANCOVA)	Effect Size
Age			
25-39 years	28.06 ± 1.992		
40-49 years	26.27 ± 2.874	F (5,860) = 22.448, p<.001	Large .117
50-59 years	24.70 ± 3.384		

60-69 years	24.10 ± 3.530		
70-79 years	22.83 ± 4.122		
≥80 years	21.31 ± 4.826		
Gender			
Female	24.20 ± 4.021	F (1,858) = 12.904	Small .015
Male	24.96 ± 3.706	p<.001	
Educational Level			
Primary	21.89 ± 3.817		
Middle	25.43 ± 3.247	F (3,858) = 78.458	Large .216
High	26.21 ± 2.693	p<.001	
University	27.16 ± 2.631		
Geographic Region			
North	24.75 ± 3.957		
Center	23.65 ± 4.300		
Lisbon	25.39 ± 3.289	F (5,853) = 7.047	Small .040
Alentejo	25.69 ± 3.435	p<.001	
Algarve	23.58 ± 3.476		
Açores	23.30 ± 3.146		
Geographic Localization			
Coast	24.56 ± 3.995	F (1,858) = 10.775	Small .012
Island	23.97 ± 3.431	p=.001	
Residence Area			
PUA	25.06 ± 3.904	F (2,847) = 9.208	Small .021
MUA	24.22 ± 3.329	p<.001	
PRA	22.98 ± 4.050		

Simple and multiple linear regressions were applied to compare the independent influences of age and educational level on the MoCA scores and to see the additional

contributions and interactions of these variables. The results obtained are presented in Table 3. Age and educational level contribute significantly to the prediction of the MoCA scores ($F_{(2, 858)} = 26.787$, $p < .001$). According to the beta weights (see Table 3), the educational level showed a higher prediction of MoCA scores. The adjusted $R2$ value is .356, which indicates that 35.6% of the variance observed in MoCA scores is explained by the model.

Table 3 - Regression analysis of the MoCA scores

			Adjusted R^2
Age	F (1,858) = 31.860 p<.001	β = -.459, t= -15.138 p<.001	.210
Educational level	F (1,858) = 20.855 p<.001	β = .516, t= 17.617 p<.001	.265
Age/Educational level	F (2,858) = 26.787 p<.001	Age: β = -.322, t= -11.045 p<.001 Educ. level: β = .407, t=13.990 p<.001	.356

The results obtained with the multiple linear regression analysis indicate that age and educational level must be considered in the development of normative data for the MoCA in the Portuguese population. Therefore, the normative data were set on and stratified according to the distributional properties of the variables. MoCA scores are presented as the mean ± standard deviation (SD). Performances below 1.5 SD can be considered as cut-off points for the possible presence of cognitive impairment (Table 4). MoCA subscores are also presented as means ± SD in Table 5.

Table 4 - Normative data of the MoCA total scores according to age and educational level

	Educational Level (years)				
Age	Primary (1-4)	Middle (5-9)	High (10-12)	University (>12)	All Education
(n)	(6)	(31)	(34)	(38)	
25-39	24.17±2.229	27.42±1.893	28.50±1.542	28.82±1.522	28.06±1.992
SD[2]	22, 21, 20	26, 25, 24	27, 26, 25	27, 27, 26	26, 25, 24
(n)	(16)	(23)	(20)	(14)	
40-49	23.50±2.921	26.13±2.702	26.70±1.750	29.07±0.917	26.27±2.874
SD[2]	20, 19, 17	23, 22, 21	25, 24, 23	28, 28, 27	23, 22, 21
(n)	(73)	(57)	(23)	(25)	
50-59	23.10±3.267	25.04±3.240	26.22±2.354	27.24±2.420	24.71±3.367
SD[2]	20, 18, 17	22, 20, 19	24, 23, 22	25, 24, 22	21, 20, 18

[2] MoCA values below 1 *SD*, 1.5 *SDs*, and 2 SDs, respectively. *SD*: Standard Deviation

(n)	(104)	(68)	(49)	(34)	
60-69	22.04±3.387	25.29±3.172	25.41±2.499	26.15±2.721	24.10±3.530
SD[2]	19, 17, 15	22, 21, 19	23, 22, 20	23, 22, 21	21, 19, 17
(n)	(106)	(46)	(26)	(23)	
70-79	21.22±4.094	24.37±3.946	24.62±3.034	25.13±2.322	22.83±4.122
SD[2]	17, 15, 13	20, 18, 16	22, 20, 19	23, 22, 20	19, 17, 15
(n)	(26)	(10)	(2)	(4)	
≥80	19.08±4.516	25.60±2.119	22.50±3.536	24.50±3.416	21.31±4.826
SD[2]	15, 12, 10	23, 22, 21	19, 17, 15	21, 19, 18	16, 14, 12
(n)	(331)	(235)	(154)	(138)	(860)
All ages	21.89±3.817	25.43±3.247	26.21±2.693	27.16±2.631	24.48±3.924
SD[2]	18, 16, 14	22, 21, 19	24, 22, 21	25, 23, 22	21, 19, 17

Table 5 - Normative data of the MoCA cognitive domains subscores according to age and educational level

Age	Educ. level	Executive function M ± SD	Visuo-spatial capacity M ± SD	Memory M ± SD	Attention, concentration and working memory M ± SD	Language M ± SD	Orientation M ± SD
25-39	Primary (1-4)	3.17 ± 1.169	3.33 ± 1.211	3.83 ± 1.169	4.83 ± 1.941	5.50 ± .837	6.00 ± .000
	Middle (5-9)	3.67 ± .661	3.80 ± .484	4.37 ± .890	5.50 ± .820	5.57 ± .857	6.00 ± .000
	High (10-12)	3.47 ± .861	3.74 ± .618	3.82 ± 1.086	5.68 ± .535	5.21 ± 1.067	5.97 ± .171
	University (>12)	3.42 ± .683	3.87 ± .343	4.08 ± .941	5.68 ± .525	5.32 ± .933	6.00 ± .000
40-49	Primary (1-4)	2.25 ± 1.000	3.06 ± .854	3.25 ± .931	3.25 ± .931	4.13 ± 1.147	5.94 ± .250
	Middle (5-9)	3.25 ± .967	3.40 ± .940	4.00 ± 1.026	4.25 ± 1.020	4.65 ± 1.099	5.95 ± .224
	High (10-12)	3.65 ± .587	3.60 ± .598	3.55 ± 1.468	3.70 ± 1.559	5.30 ± .657	6.00 ± .000
	University (>12)	3.86 ± .363	4.00 ± .000	4.57 ± .756	4.57 ± .756	5.64 ± .497	6.00 ± .000
50-59	Primary (1-4)	2.11 ± 1.234	2.96 ± .924	3.20 ± 1.431	3.43 ± 1.399	3.99 ± 1.136	5.99 ± .120
	Middle (5-9)	2.92 ± .967	3.29 ± .848	3.42 ± 1.446	4.15 ± 1.127	4.85 ± 1.017	5.94 ± .416
	High (10-12)	3.57 ± .590	3.70 ± .470	3.22 ± 1.126	4.09 ± 1.240	5.35 ± .714	6.00 ± .000
	University (>12)	3.76 ± .597	3.72 ± .737	3.44 ± 1.325	4.56 ± 1.417	5.68 ± .748	5.92 ± .277
60-69	Primary (1-4)	1.96 ± 1.224	2.47 ± .955	3.07 ± 1.430	3.57 ± 1.337	4.19 ± 1.239	5.86 ± .375
	Middle (5-9)	2.93 ± 1.047	3.15 ± .946	3.25 ± 1.312	4.13 ± 1.271	4.52 ± 1.074	5.93 ± .250
	High (10-12)	3.53 ± .776	3.21 ± .999	2.57 ± 1.410	4.66 ± 1.536	5.43 ± .651	5.98 ± .146
	University (>12)	3.71 ± .576	3.74 ± .666	2.91 ± 1.764	4.85 ± 1.048	5.44 ± .746	5.79 ± .880
70-79	Primary (1-4)	1.84 ± 1.161	2.34 ± 1.047	2.59 ± 1.334	3.28 ± 1.450	3.84 ± 1.126	5.91 ± .288
	Middle (5-9)	2.76 ± 1.078	3.16 ± .943	2.81 ± 1.685	3.90 ± 1.445	4.57 ± 1.192	5.81 ± .552
	High (10-12)	3.00 ± 1.020	3.46 ± .761	2.58 ± 1.447	4.00 ± 1.766	5.08 ± .935	5.88 ± .431

	University (>12)	3.52 ± .730	3.43 ± .843	2.43 ± 1.409	4.17 ± 1.527	5.35 ± .573	5.96 ± .209
≥80	Primary (1-4)	1.46 ± .989	2.04 ± 1.038	2.19 ± 1.721	3.62 ± 1.299	3.62 ± 1.329	5.69 ± .736
	Middle (5-9)	2.75 ± .707	3.87 ± .354	3.63 ± 1.768	4.88 ± .835	3.75 ± .886	5.88 ± .354
	High (10-12)	3.50 ± .707	3.00 ± 1.414	1.00 ± .000	3.00 ± 2.828	4.00 ± 1.141	6.00 ± .000
	University (>12)	3.50 ± .577	3.25 ± .500	3.00 ± 1.826	4.75 ± .957	4.75 ± 1.500	6.00 ± .000

Discussion

Over the years, MoCA demonstrated to be an important test to evaluate the most tenuous forms of cognitive decline (Freitas et al., 2013; Freitas, Simões, Alves, & Santana, 2015a; Roebuck-Spencer et al., 2017). Despite the existence of other instruments with the same objective, the good psychometric properties of MoCA, as well as its considerable sensitivity to early detect MCI cases, reveal the ability of this tool to bridge many of the failures of, for instance, the MMSE (Freitas, et al., 2010; Freitas, Simões, & Santana, 2014; Freitas, et al., 2015a). Due to these good characteristics, the MoCA had been adapted to and validated in many countries including Portugal.

After ten years since the first normative study conducted in Portugal (Freitas et al., 2011), why is it still so important to do an update of the previously stablished data? In ten years, the Portuguese population changed, both in the number of older people and in life expectancy, creating a necessity of constant updates to contribute to the improvement of the psychometric characteristics of the used assessment tools. Furthermore, in 2012 and 2015, Freitas and colleagues conducted two studies demonstrating the clinical usefulness and validity of the subscores of MoCA, which was not considered in the previous normative study (Freitas et al., 2012; Freitas et al, 2015).

The present study, similarly, to the first normative study of MoCA for the Portuguese population (Freitas et al., 2011), examines the impact of sociodemographic variables on MoCA performance and allows to determine norms for the MoCA according to age and educational level. To increase the equivalence with the target population and the confidence of the conclusions of this study, we used a representative sample stratified according to the various levels of each sociodemographic variable, with a distribution close to the Portuguese population. The results obtained corroborates the previous normative studies of MoCA (e. g. Kenny et al., 2013; Conti et al., 2016; Konstantopoulos et al., 2016; Kopecek et al., 2017; Pereiro-Rozas et al., 2018; Hayek, 2020), since they show that age and educational level are the sociodemographic variables that most significantly contribute to the prediction of MoCA scores. According to the results, these variables explain 35.6% of the variance observed, indicating that the total score obtained

on MoCA consistently decreases as age progresses and increase with the increase of the educational level. However, the previous normative study for Portuguese population (Freitas et al., 2011) shows a higher power of explanation comparatively to the current one (49%).

The normative data for the subscores of MoCA demonstrate that the cognitive domain of Orientation is the one with higher scores, despite age and education. Contrastingly, Executive Function shows the lower scores as age progresses and educational level decreases. Konstantopoulos and colleagues (2016) conducted a normative study on MoCA were they contemplated the cognitive domains. Despite of the results regarding the cognitive domain of Orientation being congruent with the current ones, unlike the present study, the cognitive domain of Language was the one with the lowest scores with the progress age and the lowering of the educational level (instead of Executive Function).

The main limitation of this study, similarly to the previous normative one, was the exclusion of the illiterate subjects. As demonstrated by the results, educational level has a significant impact on the performance of an individual on MoCA. It is possible to observe that neither the original article of Nasreddine and colleagues (2005), nor in most of the studies carried out in other countries, the illiterate are considered. To assure that individuals without an educational level could answer to this test, it seems necessary to perform an adaption of the items that requires knowledge provided during the primary level of formal education, namely reading and writing. Furthermore, the fact that the younger group showed higher levels of education when compared to the older group, represents another limitation, in spite of this revealing the profile of the Portuguese population (the obligatory years necessary for the conclusion of a certain educational level have been continuously updated by the government so that nowadays, it is mandatory to be 18 years old or to conclude high school in order to abandon the forma educational system). Lastly, another observed limitation was the lower number of participants in some subgroups and, consequently, the considerable differences existing between them.

Despite these limitations, the present study provides a reliable update of the normative data of MoCA for the Portuguese population, therefore increasing the value of the test as a screening assessment tool for MCI cases. The establishment of new age groups and more stratified norms, as well as the increase of power and clinical accuracy, gives response to the permanent and constant need for tests to evolve and adapt to the natural changes and growing diversity of the population, namely, the elderly one. Furthermore, our study introduces the possibility of considering for analyses the MoCA cognitive domains subscores, which improve the reading and comprehension of

observed performances in terms of clinical characterization and enhances the development and monitoring more suited interventions.

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Appendix

Appendix 1 - Some normative studies of MoCA

Authors/Year	Country	Population	Age (years)	Educational level	M ± SD
Freitas, Simões, Alves, & Santana (2011)	Portugal	Adults aged 25 years or older, with Portuguese native language and Portuguese schooling, absence of significant motor, visual or auditory deficit and cognitively healthy.	25-49 years	1-4 years	23.55 ± 2.56
				5-9 years	26.42 ± 2.18
				10-12 years	27.39 ± 1.86
				>12 years	28.83 ± 1.38
			50-64 years	1-4 years	21.78 ± 2.86
				5-9 years	25.58 ± 2.25
				10-12 years	26.61 ± 2.28
				>12 years	27.51 ± 2.13
			>65 years	1-4 years	21.27 ± 3.37
				5-9 years	24.60 ± 2.87
				10-12 years	25.11 ± 1.94
				>12 years	26.35 ± 1.87
Pereiro, Ramos-Lema, Lojo-Seoane,	Spain	Healthy adults who are members	50-54 years	>13 years	26.18
				≤13 years	26.01

Guàrdia-Olmos, Facal-Mayo, & Juncos-Rabadán (2017)		of a community aged 50 to 97.	55-59 years	>13 years	25.37
				≤13 years	25.19
			60-64 years	>13 years	24.55
				≤13 years	24.38
			65-69 years	>13 years	23.74
				≤13 years	23.56
			70-74 years	>13 years	22.92
				≤13 years	22.75
			75-79 years	>13 years	22.11
				≤13 years	21.93
			80- years	>13 years	21.29
				≤13 years	21.12
Conti, Bonazzi, Laiacona, Masina, & Coralli (2015)	Italy	Healthy individuals aged between 60 and 80 years, with at least 5 years of school education.	60-64 years	5 years	23.50 ± 2.27
				6-8 years	25.09 ± 2.12
				9-13 years	25.08 ± 2.60
				≥14 years	26.70 ± 1.95
			65-70 years	5 years	19.47 ± 3.54
				6-8 years	23.59 ± 2.34
				9-13 years	26.00 ± 1.54
				≥14 years	25.42 ± 1.88

			71-75 years	5 years	21.04 ± 3.07
				6-8 years	23.31 ± 2.98
				9-13 years	24.47 ± 2.53
				≥14 years	24.73 ± 1.65
			76-80 years	5 years	20.67 ± 3.09
				6-8 years	21.67 ± 2.74
				9-13 years	22.09 ± 2.88
				≥14 years	22.55 ± 2.07
Kenny, Coen, Frewen, Donoghue, Cronin, & Savva (2013)	Ireland	Irish individuals aged 50 and over, living in a private and healthy residence.	50 years	Without education or primary	24.00 ± 3.50
				Secondary education	25.40 ± 2.90
				Tertiary education or higher	27.30 ± 2.00
			55 years	Without education or primary	23.80 ± 3.60
				Secondary education	25.40 ± 2.90
				Tertiary education or higher	27.00 ± 2.10
			60 years	Without education or primary	23.50 ± 3.70
				Secondary education	25.30 ± 2.90

	Tertiary education or higher	26.70 ± 2.30
65 years	Without education or primary	23.10 ± 3.90
	Secondary education	25.10 ± 3.00
	Tertiary education or higher	26.30 ± 2.50
70 years	Without education or primary	22.50 ± 4.10
	Secondary education	24.60 ± 3.20
	Tertiary education or higher	25.80 ± 2.70
75 years	Without education or primary	21.70 ± 4.50
	Secondary education	23.80 ± 3.60
	Tertiary education or higher	25.30 ± 2.90
80 years	Without education or primary	20.70 ± 4.90
	Secondary education	22.70 ± 4.10
	Tertiary education or higher	24.70 ± 3.20

			85 years	Without education or primary	19.30 ± 5.50
				Secondary education	21.10 ± 4.70
				Tertiary education or higher	23.90 ± 3.50
Hayek, Tarabey, Abou-Mrad, Fadel, & Abou-Mrad (2020)	Lebanon	Healthy individuals aged between 60 and 87 years	60-69 years	Primary/Complementary	23..33 ± 2.977
				Secondary	25.47 ± 2.239
				University	26.25 ± 1.916
			70-79 years	Primary/Complementary	23.47 ± 2.759
				Secondary	24.24 ± 2.773
				University	24.80 ± 2.513
			Above 80	Primary/Complementary	22.40 ± 4.615
				Secondary	23.33 ± 5.033
				University	24.40 ± 3.373
Kopecek, Stepankova, Lukasky, Ripova, Nikolai, & Bezdicek (2017)	Czech Republic	Physical and mental healthy individuals aged 60 or over	60-74 years	< 12 years	24.62 ± 2.66
				≥ 12 years	26.43 ± 2.37
			> 74 years	< 12 years	22.98 ± 2.88

	≥ 12 years	24.79 ± 2.47