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Normative scores of the Cambridge Cognitive Examination-Revised in healthy Spanish population

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Abstract

Background: The Cambridge Cognitive Examination-Revised (CAMCOG) is widely used in clinical, epidemiological and research studies, but normative scores for age and educational level have not yet been established in the Spanish population. **Method:** The CAMCOG-R was administered to 730 adult members of the community, aged between 50-97 years, living throughout the region of Galicia. Initial screening yielded provisional identification of cognitive impairment and depressive symptoms. The final sample consisted of 643 cognitively healthy adults. The following instruments were administered: a questionnaire concerning socio-demographic and clinical data, the Charlson's Comorbidity Index, the Mini-Mental State Examination, the Montreal Cognitive Assessment (MoCA), the Lawton and Brody Index, a short version of the Geriatric Depression Scale, and the CASP-19 quality of life scale. **Results:** Internal consistency values of the CAMCOG-R were similar to those obtained for the original scale. The convergent validity between MoCA and CAMCOG-R was good, and the divergent validity between CASP-19 and CAMCOG-R was higher than the recommended value. Percentiles and inter-quartile range for age and educational level were calculated. **Conclusions:** Psychometric indexes showed that the CAMCOG-R is a reliable and valid instrument, which can generally avoid a ceiling effect. The study findings confirm the importance of specifying the normative data by age and educational level.

Keywords: CAMCOG-R, cognitive screening, neuropsychological test, aging.

Resumen

Puntuaciones normativas del Cambridge Cognitive Examination-Revised en población española sana. Antecedentes: el CAMCOG es una escala de uso frecuente para el diagnóstico y la investigación de las demencias pero hasta el momento no disponemos de puntuaciones normativas por edad y nivel educativo en población española. **Método:** se administró el CAMCOG-R a 730 adultos, de entre 50-97 años, que vivían de manera independiente en Galicia. Un cribado inicial permitió excluir a participantes con deterioro cognitivo y/o síntomas depresivos, quedando la muestra final conformada por 643 adultos. Se administraron los siguientes instrumentos: un cuestionario de datos sociodemográficos y clínicos, el índice de Comorbilidad de Charlson's, el Mini-Mental State Examination, el Montreal Cognitive Assessment, la escala Lawton-Brody, la Escala de Depresión Geriátrica y la escala de calidad de vida CASP-19. **Resultados:** los valores de consistencia interna fueron similares a los obtenidos con la escala original. La validez convergente con el MoCA fue buena y la divergente con el CASP-19 superó los valores recomendados. Se informa de percentiles y rangos inter-cuartil para cada grupo de edad y nivel educativo. **Conclusiones:** el CAMCOG-R es un instrumento fiable y válido con capacidad para evitar el efecto techo. Nuestros resultados confirman la importancia de disponer de datos normativos por edad y nivel educativo.

Palabras clave: CAMCOG-R, cribado cognitivo, test neuropsicológico, vejez.

Aging populations and the onset of neuro-degenerative diseases are increasing throughout Europe, particularly in Spain (DG ECFIN, 2012). The prevalence of dementia in Spain increases greatly with age (de Pedro-Cuesta et al., 2009), in line with the evidence reported in the world literature (Prince et al., 2013).

The availability of accurate and culturally adapted instruments that enable early identification of dementia in elderly people is critical for early diagnosis and intervention. The Cambridge Cognitive Test (CAMCOG) and its revised version (CAMCOG-R)

(Roth, Huppert, Mountjoy, & Tym, 1998) are part of the Cambridge Examination for Mental Disorders in the Elderly (CAMDEX) (Roth et al., 1986). The CAMCOG was primarily developed to detect cognitive disturbances in Alzheimer's disease (AD) and was designed to detect mild degrees of cognitive impairment even in subjects with high pre-morbid ability. It can differentiate between individuals even at high levels of cognitive performance and, in contrast to other screening instruments like the Mini-Mental State Examination (MMSE, Folstein, Folstein & McHugh, 1975), it is a sensitive measure of cognitive functioning in non-demented older adults (Spencer et al., 2013). The total score for the CAMCOG-R ranges from 0 to 105 points distributed among the following domains: orientation (10 points), language (30 points), memory (27 points), attention and calculation (9 points), praxis (12 points), abstraction (8 points) and perception (9 points). The CAMCOG-R includes an additional domain for evaluating executive function.

The CAMCOG scale has been found to have excellent internal and test-retest reliability and the total score is more normally distributed and more effective in avoiding a ceiling effect than other screening instruments such as MMSE (Huppert et al., 1996).

The CAMCOG versions have been shown to be useful for differentiating between AD, Mild Cognitive Impairment (MCI) and control groups (Aprahamian et al., 2011; Fountoulakis, Tsolaki, & Kazis, 2001; Schmand, Walstra, Lindeboom, Teunisse, & Jonker, 2000), and optimal cut-off points for discriminating healthy controls from patients with mild dementia and MCIs have been described (Huppert et al., 1996; Nunes et al., 2008). Some studies have also shown that the CAMCOG-R may be useful for predicting conversion to AD (Conde-Sala et al., 2012; Oulhaj, Wilcock, Smith, & de Jager, 2009; Gallagher et al., 2010).

Both versions of the CAMCOG have been validated for use in several languages (Bottino et al., 2001; Heinik, Werner, Mendel, Raikher, & Bleich, 1999), and they are widely used in clinical, epidemiological and research studies on AD and other mental disorders such as Parkinson disease, vascular dementia (de-Koning, Dippel, van Kooten, & Koudstaal, 2000), Levy's bodies dementia (Ballard et al., 1999) and depression (Heinik et al., 1999; Llinàs, López-Pousa, & Vilalta, 1995). A Spanish version of the CAMCOG-R (López-Pousa, 2003) has been successfully harmonised with other European adaptations (Verhey et al., 2003). Previous studies on Spanish samples have provided information about validation, cut-off points and psychometric properties (Llinàs et al., 1995; Vilalta, Llinàs, López-Pousa, Amiel, & Vidal, 1990) of the CAMCOG; all of these studies used small samples (41 and 64, respectively). Another study with a larger sample analyzed the ability of the CAMCOG to differentiate patients with dementia from healthy controls and established optimal cut-off points (Lozano-Gallego, Vilalta-Franch, Llinàs-Reglà, & López-Pousa, 1999). However, CAMCOG-R normative scores for age and educational level have not yet been established in studies of the Spanish population. As in other cognitive screening tests, CAMCOG performance is influenced by age and educational bias (Williams, Huppert, Matthews, & Nickson, 2003), and it is therefore necessary to have available normative values that take these factors into account.

The main aim of this study was to determine age- and education-related norms for the Spanish version of the CAMCOG-R in a healthy population sample comprising community dwellers aged 50 years and over. Previously, effects of age and education in the total scores of the CAMCOG-R were calculated. In addition, evidence of reliability and validity is provided through: (a) internal consistency index (Cronbach's alpha), (b) convergent validity with the Montreal Cognitive Assessment test (MoCA; Nasreddine et al., 2005) and divergent validity with the Needs Satisfaction Model CASP-19 (Hyde, Wiggins, Higgs, & Blane, 2003). Clinicians and researchers can benefit from these norms, which facilitate interpretation of the cognitive performance of individuals that takes into account age and level of education.

Method

Participants

In total, 730 adult members of the community aged between 50 and 97 years participated in the study. Seventy-seven subjects refused to participate in the study alleging reasons of lack of time

(63.6%), lack of interest (20.7%), inability (10.38%) or without reasons (5.1%). The sample originated from a community study of cognitive functioning in aging carried out in Galicia, an autonomous region in northwest Spain (total surface area, 29,430 km²; population, 2,761,970). Participants came from all (urban and rural areas) parts of the region, did not receive any incentive, and their distribution across the geographical areas (provinces) was congruent with the overall distribution of the population aged 50 years and over. In order to prevent interference with performance of the tasks, the following demographic and clinical inclusion criteria were considered in the initial selection: age 50 years and older, no previous diagnosis of neurological or psychiatric diseases, no history of alcoholism or substance abuse, no consumption of psychoactive drugs with possible impact on cognition, and free from sensory (both visual and auditory) or motor disturbance. Participants were recruited (with the help of graduate and postgraduate psychology students) from a large on-going study on cognitive aging being undertaken at the University of Santiago de Compostela. Age, sex and educational level of participants were considered in recruitment procedures to yield a balanced sample. Four age groups (50-59, 60-69, 70-79, and 80 or more years) were established and, for each group, participants were assigned to one of four levels of education considered (1-4, 5-8, 9-13 and more than 13 years of formal schooling).

From the initial sample, 87 (11.91%) participants were excluded because they fulfilled one or more of the following criteria: (a) Very low level of education compared with the standard level (National Institute Statistics, 2011) for the corresponding age groups; according to this criterion, 5 participants with 1-4 years of formal schooling in the 50-59 age group and 11 illiterate subjects in the total sample were excluded because of the negligible presence of such groups in the Spanish population. (b) Low performance of the MMSE suggesting cognitive impairment; scoring more than 1.5 SD below the mean of the corresponding age- and education-group was considered as the cut-off value for considering participants as suffering at least Mild Cognitive Impairment (Petersen et al., 2004); according to this criterion, 63 (8.63%) participants were excluded from the total sample (3 from the 50-59, 19 from the 60-69, 23 from the 70-79, and 18 from the 80+ age groups). (c) Suffering from depression, as indicated by scores of 10 points and over on the GDS test; according to this criterion, 8 (1.09%) participants were excluded (see "Materials and procedures" for the assessment tests). The final sample comprised 643 cognitively healthy adults who met all the defined inclusion criteria and who are considered representative of the Galician population. The distribution of the sample with respect to age, sex, level of education and geographical distribution is shown in Table 1.

All participants gave their written informed consent prior to participating. The research project was approved by the Galician Clinical Research Ethics Committee (Xunta de Galicia, Spain), and the study was performed in accordance with the ethical standards established in the Declaration of Helsinki, updated in Seoul 2008.

Instruments

In addition to the Spanish version of the CAMCOG-R (Roth et al., 1998; López-Pousa, 2003), the following instruments were administered to each participant: (a) a questionnaire concerning socio-demographic and clinical data, to obtain information from

the patients and/or a family member regarding age, years of formal education and medical history; (b) the Charlson's Comorbidity Index (Charlson, Pompei, Ales, & McKenzie, 1987) that has been shown to be successful in the prediction of mortality and hospitalization (Charlson et al., 1987) and has small to moderate values of convergent validity ($\rho_{x,y} = .24-.56$) (Farley, Harley, & Devine, 2006); (c) the Spanish version of the Mini-Mental State Examination (MMSE), which showed a high test-retest reliability ($\rho = .87$) and convergent validity with the Wechsler Adult Intelligence Scale ($\rho = .80$) for the 35-point version (Lobo, Ezquerro, Gómez, Sala, & Seva, 1979), and acceptable inter-rater agreement (Weighted Kappa = .62) for the 30-point version (Lobo et al., 1999); (d) the Spanish version of the Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005), validated by Lozano-Gallego et al. (2009) who reported adequate levels of internal consistency (Cronbach's $\alpha = .76$), high inter-observer ($\rho = .91$) and test-retest ($\rho = .92$) reliabilities, and concurrent validity; (e) the Lawton and Brody instrumental activities of daily living (IADL) scale (Lawton & Brody, 1969), which showed high levels of internal consistency (Cronbach's $\alpha = .90$), test-retest reliability ($\rho = .92$) and concurrent validity in a Spanish sample (Olazarán, Mouronte, & Bermejo, 2005); (f) the Spanish adaptation (Izal & Montorio, 1996) of the Geriatric Depression Scale (GDS; Sheikh & Yesavage, 1986), which showed internal consistency, high temporal stability, and high convergent validity ($\rho_{x,y} = .86$), and its 15-item abbreviated version (Martínez de la Iglesia et al., 2000) showed high internal consistency (Cronbach's alpha = .99) and intra-observer reliability (Weighted Kappa = .95), acceptable inter-observer reliability (Weighted Kappa = .65), and appropriate values for convergent ($\rho = .61$), divergent ($\rho = .23$) and concurrent validities; and (g) a translation-back-translation process on the quality of life scale CASP-19 (Hyde et al., 2003) was carried out (Kappa = .88), which, in its original version, showed moderate to high internal consistency (Cronbach's alphas = .60-.80) and acceptable convergent validity ($\rho_{x,y} = .60$).

Procedure

Assessments were carried out in the participants' homes by interviewers instructed and monitored by two psychologists with expertise in neuropsychological evaluation of adults. The instruments were administered during a 90-minute session in partially counterbalanced sequences that always started with the questionnaire on socio-demographic and clinical data. MMSE, CAMCOG-R and MoCA were scored immediately after administration, and the remaining instruments were scored daily at the end of the sessions.

Items 139 - 203 were considered in order to calculate the total CAMCOG-R score (items 177, 179, and 179b and those evaluating executive function were excluded for this calculation). The maximum possible score was 105. To calculate the total MOCA score, an additional point was added to the raw scores of participants who did not achieve maximum value (30 points) and whose schooling was less than 13 years.

Data analyses

Statistical analyses were carried out with SPSS for Windows, version 18.0 (SPSS, Chicago, IL USA).

Reliability was analyzed by calculating the internal consistency via Cronbach's alpha coefficient, and Spearman-Brown and Guttman corrections. Convergent and divergent validity evidence was analyzed by the Pearson correlation coefficient.

The enter method of Multiple linear regression analysis was performed to examine the influence of age (in years) and education (years of schooling) on the CAMCOG-R total score. Tolerance, Variance inflation factor (VIF) and Condition index statistics were calculated to test multicollinearity, and the coefficient of determination (R^2) was considered to analyze the size of the effect in the regressions.

Normative data were calculated in percentiles (inter-quartile range) because the CAMCOG-R scores were not normally distributed. Tables for age and education were constructed. Education was coded as four categories according to number years of formal education (0-4, 5-8, 9-13, and more than 13 years).

The CAMCOG-R total scores were transformed to yield a normal distribution (using $\sqrt{105}$ -CAMCOG-R total score) and to enable calculation of normalized means and ranges. The normalized means and ranges were subsequently back-transformed to the original scale.

Results

Information about the participants' health (Charlson's Comorbidity Index), depression (GDS) and general cognitive functioning (MMSE and MoCA) is provided in Table 2.

Reliability

The internal consistency of CAMCOG-R total scores, measured by both Cronbach's alpha coefficient was .81.

Elimination of any of the items of the CAMCOG-R scale never reduces the reliability to below .80. Split-half reliability with Spearman-Brown correction for equal length forms was .83. As difference between forms was observed in variance distribution, an additional Guttman split-half coefficient for reliability correction was calculated and yielded a similar value of .81.

Table 1
Socio-demographic characterization of the sample

Variable	Level	Sample N (%)	Galician population N (%)*
Age (years)	50-59	196 (30.48)	372,761 (31.76)
	60-69	161 (25.05)	328,729 (28.01)
	70-79	181 (28.14)	270,986 (23.09)
	80+	105 (16.33)	201,052 (17.13)
Sex	Female	366 (56.9)	642,173 (54.72)
	Male	277 (43.1)	531,355 (45.27)
Educational level (years of schooling)	1-4	85 (13.22)	-
	5-8	214 (33.29)	-
	9-13	153 (23.79)	-
	13+	191 (29.70)	-
Geographical region	A Coruña	301 (46.81)	1,141,286 (41.20)
	Lugo	70 (10.88)	348,067 (12.55)
	Ourense	61 (9.48)	328,697 (11.85)
	Pontevedra	211 (32.81)	954,877 (34.43)

Note: * Galician population of people aged 50 and over, according to a study by the Galician Institute of Statistics (2013)

Table 2
Descriptive values of sample according to age, sex, education, Health (Charlson's Comorbidity Index), depression (GDS) and MMSE and MoCA scores

Age group	Mean age (SD)	Sex % female	Mean years of schooling (SD)	Health Median (Mean, SD)	Depression Mean (SD)	⁽¹⁾ Lawton & Brody Mean (SD)	MMSE Mean (SD)	MoCA Mean (SD)
50-59 years	54.10 (2.95)	54.59	12.31 (4.39)	0 (.23, .59)	3.08 (2.63)	99.19 (8.03)	28.79 (1.54)	27.14 (2.70)
60-69 years	64.62 (3.10)	56.52	9.67 (4.88)	0 (.50, .94)	3.21 (2.57)	97.95 (7.22)	28.40 (1.63)	26.01 (3.01)
70-79 years	74.23 (2.75)	59.11	8.80 (5.11)	0 (.67, .82)	3.62 (2.68)	97.13 (6.47)	27.63 (2.01)	23.60 (3.82)
80+ years	83.68 (3.33)	58.09	8.73 (4.58)	0 (.59, .82)	4.35 (2.67)	92.29 (11.43)	26.04 (2.47)	21.47 (4.34)
Total	67.23 (11.02)	56.92	10.07 (4.98)	0 (.47, .81)	3.47 (2.66)	97.20 (7.43)	27.93 (2.09)	25.07 (3.94)

Note: ⁽¹⁾proportional values, adjusted according to sex (for males, a score of 5 corresponds to 100%; for females, a score of 8 corresponds to 100%)

Validity

Pearson correlations were calculated to obtain evidence about convergent and divergent validity. Convergent validity between MoCA and CAMCOG-R was estimated in .75, $p < .001$, and divergent validity between CASP-19 and CAMCOG-R was estimated in .30, $p < .001$.

Performance and normative values

The CAMCOG-R total score data was positively skewed (see Figure 1) and required transformation to produce a normal distribution that enabled calculation of reliable means and ranges.

The median CAMCOG-R total score was 91 (inter-quartile range = 14) and scores ranged from 43 to 105. Multiple linear regression analysis (enter method) showed that age and education had significant effects on the CAMCOG-R total score, $F(2,640) = 329.937$; $p < .001$. The regression model indicated that 50% of the variance in the CAMCOG-R total scores was explained by age and education, $adjusted R^2 = .506$. The standardized beta

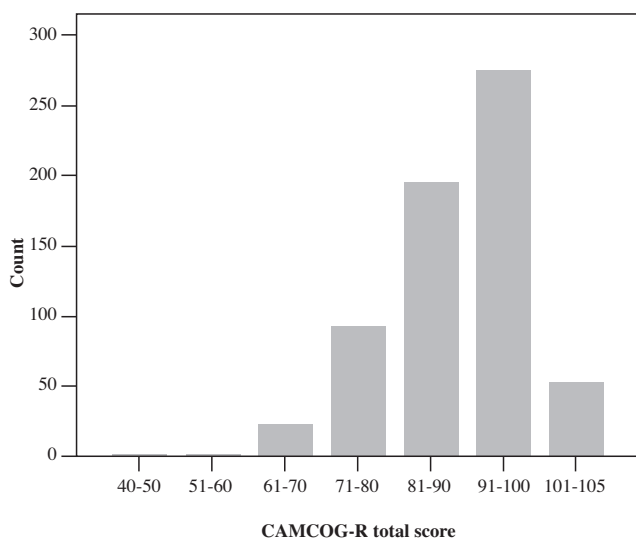


Figure 1. Distribution of CAMCOG-R total score (maximum 105 points)

weights suggest that age ($\beta = -.423$; $SE \beta = .025$; $Standardized \beta = -.492$) contributed slightly more to predicting the CAMCOG-R scores than education ($\beta = -.739$; $SE \beta = .055$; $Standardized \beta = -.389$). Multicollinearity statistics ($Tolerance = .91$, $VIF = 1.096$, and $Condition index = 16.42$) showed modest multicollinearity between age and education as predictive variables. Combined normative values for age group and educational level are shown in Table 3.

Ranges of percentile levels (1st, 5th, 10th, 25th, 50th, 75th and 90th) for educational level in each age group are plotted in Figures 2 and 3.

Lines represent performance across educational levels for each percentile in the age groups. Only participants in the younger group for higher percentiles (up to 90th percentile) obtained the maximum score (see Figure 2). Score range across percentiles was wider as educational level decreased, especially in the older age group (see Figure 3).

Discussion

The internal consistency of the CAMCOG-R total score was similar to that obtained by Huppert et al. (1996). The value was situated between the minimum and the maximum recommended (Streiner, 2003), and it was similar to those established for the use of instruments for group diagnostic purposes (Pfeiffer, Heslin, & Jones, 1976).

Convergent validity between MoCA and CAMCOG-R was good, and divergent validity between CASP-19 and CAMCOG-R was better than the level proposed as acceptable (Lévy Mangin et al., 2001).

Although total CAMCOG-R scores were positively skewed, as is usual for scores obtained from screening instruments used in healthy samples (Counsell, Cortina-Borja, Lehtonen, & Stein, 2011), very few participants from the younger age group and included in 90th percentile obtained the maximum score. This finding supports consideration of CAMCOG-R as a sensitive measure of cognitive functioning in non-demented older adults (Spencer et al., 2013), because it generally avoids a ceiling effect (Williams et al., 2003).

CAMCOG-R performance was influenced by age and educational bias, as shown in previous studies (Williams et al.,

Table 3
CAMCOG-R normative values for age group and educational level

Value	Educational level	1-4 years	5-8 years	9-13 years	13+ years
	Age group	50-59 years			
Median			92	97	99.50
5th,10th			81, 83	86.15, 87.30	88.05, 91.10
25th,75th			86, 95.25	92, 99	95, 102
90th,95th			100, 101.50	102, 103.70	104, 104
Mean *			92.17	96.50	99.20
95%Reference range			93.88-90.34	97.79-95.11	100.20-98.10
	Age group	60-69 years			
Median		85.50	89	94	96
5th,10th		73.35, 76.10	77.10, 81.80	82.40, 86.80	88.30, 90
25th,75th		81.50, 91	86, 93.50	90, 97	94, 98
90th,95th		93.30, 95.95	97.60, 98	100.20, 103	100.4, 101.7
Mean *		86.19	89.95	93.98	96.12
95%Reference range		88.64-83.58	91.53-88.27	95.92-91.86	97.18-94.99
	Age-group	70-79 years			
Median		81	84.50	86	93
5th,10th		74, 74	69, 71	75, 76.60	78.20, 80.40
25th,75th		78, 87	78.25, 87.75	79, 94	84, 98
90th,95th		91.20, 94.60	92, 94.90	98.40, 99	98, 100.80
Mean *		82.64	83.68	87.76	92.38
95%Reference range		84.59-80.61	85.54-81.73	90.44-84.85	94.36-90.23
	Age-group	80+ years			
Median		76	75	85	90
5th,10th		45, 57.60	60, 64.40	72, 74	77.40, 79.40
25th,75th		67.75, 80.50	69, 82	80, 90	84, 93
90th,95th		85.70, 85.70	88.20, 94.40	98, 98	97.40, 99
Mean *		74.25	76.67	86.38	89.36
95%Reference range		74.69-68.52	79.68-73.48	90.12-82.22	91.91-86.59

Note: * For calculation purposes, mean and range values transformed using the equation ' $\sqrt{105-CAMCOG-R}$ score' were back-transformed to the original scale

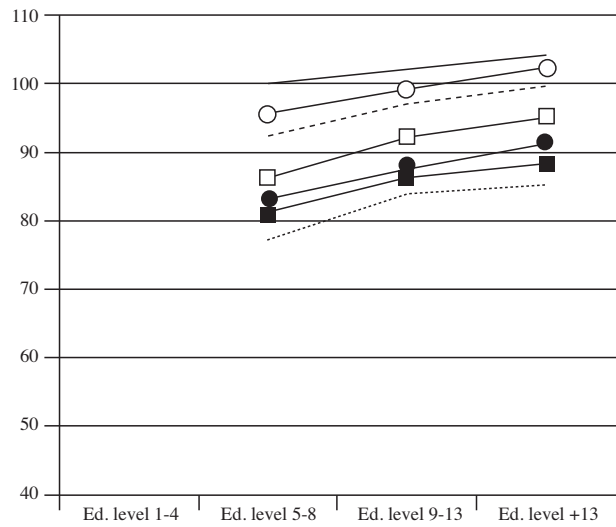
2003). Age contributed slightly more than education to predicting the CAMCOG-R total score, and only modest multicollinearity between age and education as predictive variables was observed.

As expected, the median values of CAMCOG-R total scores for all age groups and educational levels were higher than optimal cut-off points for discriminating healthy controls from patients with dementia and other psychiatric disorders (determined in other smaller Spanish samples) (Llinàs et al., 1995; Lozano-Gallego et al., 1999; Vilalta et al., 1990). A wide range of normative values was observed across percentiles and most of these, especially for younger participants and higher levels of education, were much higher than 59, which is the score established as the most reliable cut-off point for case identification regardless of the age and educational level of participants (Lozano-Gallego et al., 1999). Some normative values below this cut-off point were observed, particularly those corresponding to participants aged 80 years or more and with less than 5 years of formal schooling and who obtained scores in the lowest percentile (5-10%ile).

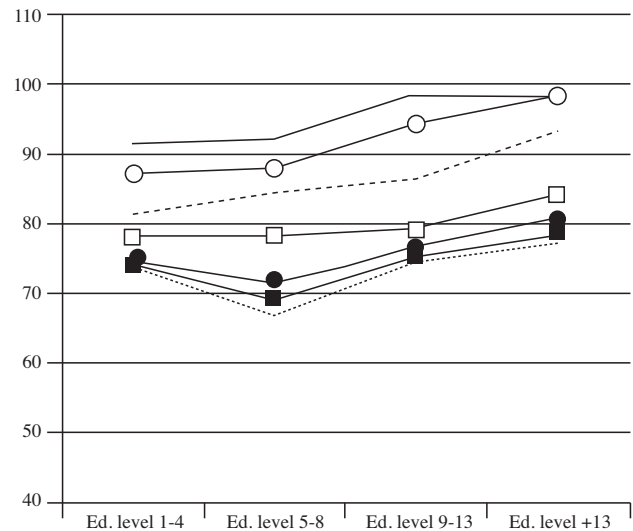
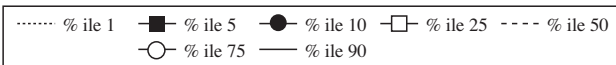
The results of the study provide normative scores of CAMCOG-R specified by age and educational level for a sample of Spanish population extracted from Galicia. Psychometric indexes showed that the CAMCOG-R is a reliable and valid instrument that generally avoids a ceiling effect and is influenced by age and educational level. Further studies should be conducted with a larger representative sample of the Spanish population to confirm the normative values proposed in this study of Galician population and to establish cut-off points for discriminating healthy controls from patients with mild cognitive impairment and/or dementia.

Acknowledgements

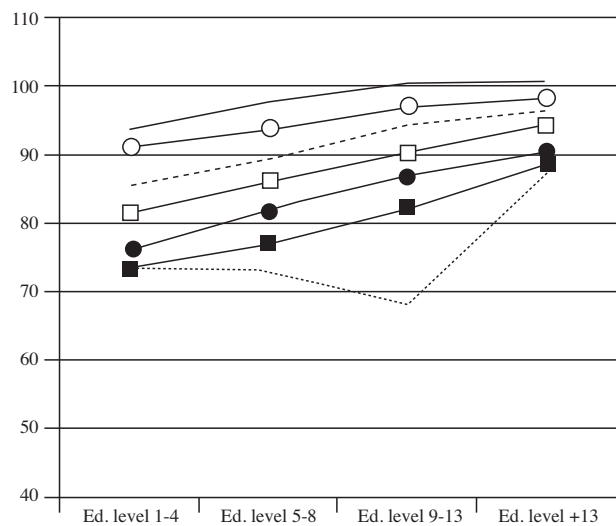
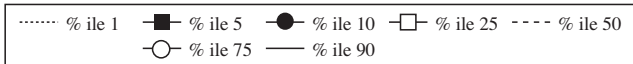
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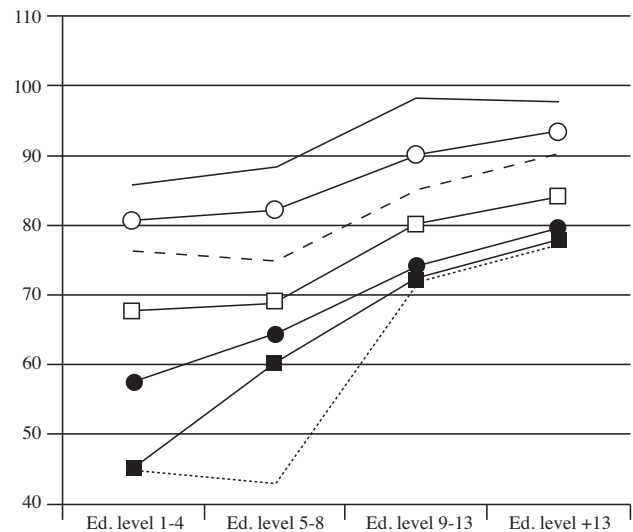
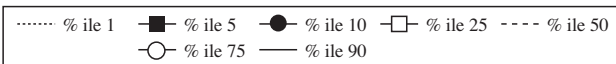
50-59 age group



70-79 age group



60-69 age group



80+ age group

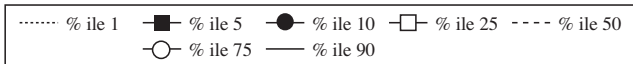


Figure 2. Normative values for CAMCOG-R score for the four educational levels in 50-59 and 60-69 year age groups across the 1st to 90th percentiles

Figure 3. Normative values for CAMCOG-R score for the four educational levels in 70-79 and 80+ year age groups across the 1st to 90th percentiles

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