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ORIGINALES

Standardization of the Semantic Memory Evaluation Battery (EMSEA) in institutionalized elderly adults of Lima

Estandarización de la batería de Evaluación de la Memoria Semántica (EMSEA) en adultos mayores institucionalizados de Lima

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ABSTRACT:

Objective: To determine if semantic memory is a factor associated with cognitive impairment in older adults in Lima.
Method: The Semantic Memory Assessment Battery for Older Adults (EMSEA), the Mini-mental State Examination (MMSE) and other instruments that were used as external criteria were applied. The sample consisted of 158 older adults from Metropolitan Lima between 60 and 95 years of age. EMSEA differentiates between a normal and clinical sample, with a sensitivity of 80% and a specificity of 100% for a cut-off point of 251. Concurrent validity is evidenced and a two-factor EMSEA model is demonstrated. Cronbach's Alpha value is .75 and Theta is .80.
Results: Descriptive data indicated a 28% prevalence of cognitive impairment and a 23% low semantic memory level. The predictive model indicates that three areas of semantic memory are associated with cognitive impairment with an R2 of 25%, leaving the model established by: Verification, naming of drawings and analogies.
Conclusion: It is concluded that the EMSEA battery presents evidence of criterion and construct validity, internal consistency and a predictive.

Keywords: semantic memory, cognitive deterioration, older adults, validity, reliability, factorial analysis.

RESUMEN:

Objetivo: Determinar si la memoria semántica es un factor asociado al deterioro cognitivo en adultos mayores de Lima.
Método: Se aplicaron la batería de Evaluación de la Memoria Semántica para Adultos Mayores (EMSEA), el Mini-mental State Examination (MMSE) y otros instrumentos que fueron utilizados como criterios externos. La muestra estuvo constituida por 158 adultos mayores de Lima Metropolitana entre

60 a 95 años de edad. La EMSEA diferencia entre una muestra normal y clínica, siendo la sensibilidad de 80% y la especificidad de 100% para un punto de corte de 251. Se evidencia validez concurrente y se demuestra un modelo EMSEA de dos factores. La confiabilidad fue adecuada con valor Alfa de Cronbach de .75 y Theta de .80.
Resultados: Los datos descriptivos señalaron un 28% de prevalencia de deterioro cognitivo y 23% de nivel de memoria semántica bajo. El modelo predictivo señala que tres áreas de la memoria semántica están asociadas al deterioro cognitivo con un R^2 de 25%, quedando el modelo establecido por: Verificación, denominación de dibujos y analogías.
Conclusión: Se concluye que la batería EMSEA presenta evidencia de validez de criterio y constructo, así como consistencia interna.

Palabras clave: memoria semántica, deterioro cognitivo, adultos mayores, validez, fiabilidad, análisis factorial.

INTRODUCTION

Memory problems are almost an early symptom of dementia [(1)]. This cognitive variable is also considered to be diminished in Mild Cognitive Impairment (MCI)[(2)]. MCI is considered an intermediate state between normal cognition and dementia. It is characterized by a deficit of cognitive functions, but especially of memory, it should not have any functional impairment in their activities of daily living or meet the criteria for dementia syndrome; as well as understanding that it is very different from normal aging as this process is progressive [(3)]. Not all people diagnosed with MCI develop dementia, but it is associated with a high probability of having that in the future compared to cognitively healthy people, hence its detection and monitoring is important to prevent or delay its onset.

The identification of cognitive impairment at an early age has become an increasingly important challenge for health professionals, estimating its prevalence between 15% and 20% in people within the 40-age group [(4)]. The annual rate at which MCI progresses to dementia is 12%, much higher than the 1 to 2% rate found in the cognitively healthy population [(5).]

In this line, cognitive impairment was detected in older adults from different regions of Colombia that were living in community, identifying that 40% of the elderly population included in the study presented a result suggesting cognitive impairment. The most affected age range was between 70 and 79 years old (46.1%), followed by individuals between 80 and 89 years old. The prevalence of cognitive impairment was 57.6% in the elderly with arterial hypertension, 48.7% in diabetes mellitus and 56% in stroke [(6)]. On the other hand, in Argentina, in the Rosario metropolitan area, it was found that 3.44% of participants between 50 and 90 years of age had mild cognitive impairment. The reached level of education appears as the main predictor of cognitive impairment, above age and gender. Among those participants with incomplete primary education, the potential prevalence reached 10.84% [(7)].

Likewise, studies carried out in 1381 people within urban Lima and in 552 within rural Lima (Cañete), showed that the prevalence of Alzheimer's disease in the first sector was of 9.3% while in the other one was of 6.5%. Additionally, the research on the prevalence of dementia in older adults in a geriatric clinic in Huancayo (central province of Peru) was estimated at 9.9% and the prevalence of mild cognitive impairment at 11% [(8)].

As human beings, we acquired information about objects and living beings that surround us storing at the same time all this information in a process called semantic knowledge, therefore the memory that sustains and allows the processing of this knowledge is the semantic memory. This amnesic aspect stores, processes and recovers information about meaning of words, objects and concepts, as well as the world and its meaning, being different from episodic memory, which stores, recovers and processes information regarding autobiographical facts, within a temporal space axis [9]. This differentiation was made by Tulving in 1972 when he proposed two subdivisions of declarative memory: semantic and episodic memory [10]. The semantic memory is a mental thesaurus of organized knowledge about words and verbal symbols, concepts and their meanings, as well as the relationships between them. This is a conceptual knowledge based on facts and free context. In contrast to the episodic memory system, semantic memories are probably less susceptible to involuntary transformation and loss of information. In this context, it is necessary to explain this cognitive process referred to as semantic cognition, understood as a collection of neurocognitive mechanisms that are distributed throughout the brain forming a semantic control network and a hub-and-spoke representational network, interacting with neural bases that include temporoparietal areas and prefrontal cortex related to semantic control [11].

Semantic memory is relatively intact in healthy older adult [12]. One study indicates that semantic memory can differentiate healthy people from those with mild cognitive impairment and from those with Alzheimer's dementia [13]. Besides that, it is reported that semantic memory deficits are frequently found in dementia and distinct patterns of semantic impairment that characterize dementia subtypes, where life course and cultural experiences significantly influence semantic memory [14]. A meta-analytic study reviewing 22 papers indicated that patients with mild cognitive impairment performed in worse conditions than matched controls, concluding that semantic deficits are a key feature of mild cognitive impairment, implying that semantic tests should be incorporated into routine clinical assessment [15].

Therefore, it is necessary to have the standardized instruments to evaluate this aspect of declarative memory, so they recommend the use of neuropsychological tests of categorical verbal fluency, naming, conceptualization, categorization, general knowledge questions and word definitions, where the batteries include a combination of tasks, which allows a more complex evaluation than the one offered by isolated tasks, thus it is proposed the Semantic Memory Battery (BAMS) [16].

In addition, it is important also to have a series of instruments to evaluate semantic memory, reviewing the main tests, starting with the description of those that require verbal responses (naming, fluency, definition of categories and semantic analogies) and then those that need a non-verbal response (pointing, drawing, association, among others), referring to individual tests and batteries [9]. Among these last two batteries stand out: the Cambridge Semantic Memory Battery [17] and the Evaluation of Semantic Memory in patients with Dementia of the Alzheimer Type (EMSDA) battery[18].

Hence, there is the necessity to evaluate the semantic memory through culturally appropriate tests, in order to help for having an accurate diagnosis of dementia and

facilitate cross-cultural collaborative research, with the need for reliable and valid screening instruments to help to identify affected individuals.

Therefore, the objective of this study was to standardize and evaluate the psychometric aspects of the battery in the Evaluation of Semantic Memory in Alzheimer's Disease (EMSEA), which will provide specialists with valid and reliable instruments.

MATERIAL Y METHOD

Participants

Sample 1:
It was taken a sample of 100 older adults for the standardization of the instruments, which was distributed according to educational level, age and sex. The sample was taken from health centers and an institutionalized center of Lima. The older adults had an average age of 78.40 years, with a minimum age of 58 years and a maximum age of 95 years. According to sex, 49% were male and 51% female, distributed between primary (24.5%), high school (52.1%) and college (23.5%).

Sample 2:
The clinic sample consisted of 30 older adults of both sexes between 55 and 86 years old, with a mean of 71.3 and a standard deviation of 7.85 years.

Sample 3:
The normal sample consisted of 30 older adults of both sexes between 60 and 89 years old, with a mean of 75.8 and a standard deviation of 10.24 years.

Data Collection Techniques

Evaluation of Semantic Memory in Alzheimer's Disease (EMSEA). It evaluates the impairment of the lexical-conceptual system that is affected by neurodegenerative diseases. The battery was created by Peraita, Gonzales, Galeote & Sánchez in 2000 in the city of Madrid. This includes 7 tests: Verbal Fluency, Definition of Semantic Categories, Attributes Recognition, Picture Naming, Word Matching, Verification of True or False Statements and Semantic Analogies. The internal consistency reliability obtained adequate reliability coefficients, having a Cronbach's Alpha of .73 for the total scale. Regarding the validity analysis, values under the ROC curve of .98 were reported for Buenos Aires [(19)].

Pfeiffer mental status questionnaire. It evaluates the presence of cognitive impairment and the determination of its degree. It was created by Pfeiffer in 1975. It consists of 10 items with the objectives of evaluating orientation, information, short and long-term memory and calculation capacity. This is a rapid screening test and can be administered to illiterate people. Spanish psychometric validation studies report that this screening test has a sensitivity of 85.9% and a specificity of 78.9% for a cut-off point of 3 or more errors [(20)].

Minimental State Examination (MMSE). This test was originally developed by Folstein & McHugh in English language, for a screening of general cognitive function in

approximately 5 to 10 minutes. It consists of 30 items grouped into seven categories: temporal and spatial orientation, immediate and fixation memory, attention, computing language and visual construction. In addition, it founds an optimal cut-off point of 23/24 points with adequate values in sensitivity (94%) and specificity (91%) [21]. Robles also indicates that the reliability of internal consistency determined for this screening test a Cronbach's Alpha of .62 [22].

Memory Alteration Test (M@T). It is a cognitive test with high discriminatory value for amnestic mild cognitive impairment and Mild Alzheimer's disease, which evaluates temporal orientation (5 points), immediate memory (10 points), semantic memory (15), free recall (10) and facilitated recall (10 points). It is a screening test of global memory, using as a cut-off point a score of 37 [23]. The maximum score is 50 and lasts approximately four to six minutes [24].

Activities of Daily Living Index. Published in 1969 by Lawton & Brody and developed in Philadelphia Geriatric Center to evaluate the physical autonomy and instrumental activities of daily living. It is applied in geriatric population. This allows the evaluation of independence-dependence in personal and instrumental activities. It has 18 items, which refers to personal hygiene, dressing, going to the toilet, sphincter control, eating, moving, picking up objects from the floor, getting in and out of bed, going up and down the stairs. Also referring about performing the housework, preparing meals, taking medication, handling money, using the telephone, shopping, using means of transport, leaving the house and walking in the street, the validity was evidenced by external evidence by criterion [25].

Barthel Index. Designed in 1965 by Mahoney & Barthel to measure the evolution of people with neuromuscular and musculoskeletal processes. It evaluates the ability of the person to perform activities in a dependent or independent manner, having 10 basic activities of daily living such as: eating, personal hygiene, dressing, grooming, bowel movements, urination, toilet use, transfers, ambulation and stair climbing. The total score is assigned according to the time required to perform them and the need for help to carry them out, having a range from 0 to 100. The independent maximum total score is of 100 and the maximum dependence is 0. The score is expressed with the following criteria; the dependence is mild with 91-99 points, moderate with 61 to 90, severe with 21 to 60 and the total if it is less than 20 [26]. They also report an adequate correlation with clinical judgment [27].

Procedure

The evaluations were taken individually and followed the protocol for administering test battery designed for the present study. The investigators trained five evaluators who were placed in the health centers. Two members of the research team reviewed and validated the response protocols. To recollect the data, an authorization was requested from the management of each center, respecting the ethic codes of the Peruvian College of Psychologist and the ones of the university, also obtaining the informed consent from the older adults who participated in the research.

The Statistical Package for Social Sciences (SPSS-25) and AMOS-24 were used. The data analysis first considered a psychometric study through the criterion validity comparing the means of a clinical and normal sample of each sub-test of the EMSEA, evaluating the sensitivity and specificity, as well as the ROC curves. Likewise,

Pearson's correlation coefficient in order to quantify convergent validity and a confirmatory factor analysis with their respective tests of adjustment, were applied. The reliability was evaluated by the internal consistency of the score through the Cronbach's Alpha coefficient.

RESULTS

In order to evaluate the evidences to identify cases of cognitive impairment, it was examining the discriminative capacity of the EMSEA, showing that all sub-tests and the total score separate cases and non-cases, with significant differences, as shown in Table 1.

Similarly, it is observed in areas of verbal fluency and picture naming that present greater standard deviation in the normal sample, unlike the sub-tests of word hearing/drawing matching, definition of semantic categories, attribute recognition, verification of the truth of statements and semantic analogies where the highest standard deviation is presented in the clinical sample.

Table 1. Comparison of clinical and normal sample in older adults with EMSEA battery.

Areas	Sample	Mean	Standard deviation	*t*	(bilateral) Sig.
Fluency	Normal	61.7	16.2	7.288	.000
	Clinics	35.6	11.0		
Naming	Normal	68.1	15.1	11.385	.000
	Clinics	30.5	10.0		
Matching	Normal	31.6	4.7	4.563	.000
	Clinics	23.9	8.0		
Definition	Normal	84.9	12.3	7.952	.000
	Clinics	55.6	16.0		
Recognition	Normal	27.3	3.3	2.982	.004
	Clinics	24.6	3.7		
Verification	Normal	45.7	2.5	3.863	.000
	Clinics	36.1	13.4		
Analogies	Normal	12.9	4.1	3.387	.001
	Clinics	7.5	7.6		
Total, battery	Normal	331.6	29.9	11.407	.000
	Clinics	212.3	48.9		

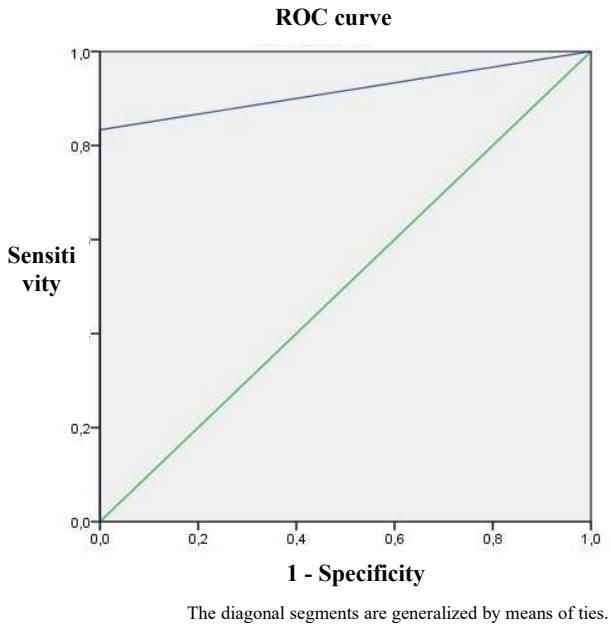
Notes: Normal sample= 30; Clinic sample=30; Mean; Standard deviation

The effect size was also calculated for the comparison of the total of EMSEA battery, resulting in a d = 2.94 which indicates that the magnitude of the effect is large and verifies the differences between the clinical and normal groups.

On the other hand, the diagnostic capacity was evaluated through sensitivity and specificity. A cut-off points of 251 was assumed for the total score, showing a

sensitivity of 80% and a specificity of 100%, with an area under the ROC curve of 91.7% shown in Image 1.

Image 1. ROC Curve for the total of EMSEA



Regarding the criterion validity in table 2, it is observed positive and significant correlations with the memory impairment test (TAM) (*r* =.52, *p* =.00); with the mental state examination (MMSE) (*r* =.38, p =.00); Lawton and Brody's Activities of Daily Living Index (*r* =.33, *p* =.00); Barthel's Functionality Index (*r* =.22, *p* =.00). It is achieved a negative correlation using the Pfeiffer Brief Mental Status Questionnaire since the instrument is scored in terms of errors (*r* =-.49, *p*=.00). Likewise, the effect sizes are high. These aspects show concurrent validity.

Table 2. Correlation between EMSEA total score and tests of cognitive impairment and daily living functionality

Tests	***r***	***d***
Memory and Attention Test (MAT)	.528	.72
Pfeiffer Brief Mental State Questionnaire MMSE	-.494	.70
	.384	.51
Barthel Functionality Index	.229	.47
Lawton's Activities of Daily Living Index	.332	.57

Notes: *d* =.10 low, .30 mean, .50 high

In addition, a correlation matrix was established between the sub-tests and the total score, being the lowest coefficient with Semantic Analogies and the highest with Verbal Fluency, showing positive and significant coefficients (*r* =.37 a *r* =.88) indicating that these areas are part of the same construct (see Table 3).

Table 3. Correlation matrix of the sub-tests and the EMSEA total score

Sub-test	Verbal Fluency	Definition of Semantic Categories	Naming	Recognition	Matching	Verification	Analogies	Total score
Verbal fluency	1	.763**	.495**	.487**	.304**	.506**	.329**	.884**
Semantic Categories	.763**	1	.353**	.482**	.332**	.457**	.278**	.852**
Naming	.495**	.353**	1	.133	.264**	.543**	.316**	.566**
Recognition	.487**	.482**	.133	1	.149	.423**	.167	.713**
Matching	.304**	.332**	.264**	.149	1	.485**	.209*	.435**
Verification	.506**	.457**	.543**	.423**	.485**	1	.269**	.702**
Semantic Analogies	.329**	.278**	.316**	.167	.209*	.269**	1	.370**
Total score	.884**	.852**	.566**	.713**	.435**	.702**	.370**	1

Notes: **. The correlation is significant at the 0.01 level (2-tailed).

*. The correlation is significant at the 0.05 level (2-tailed).

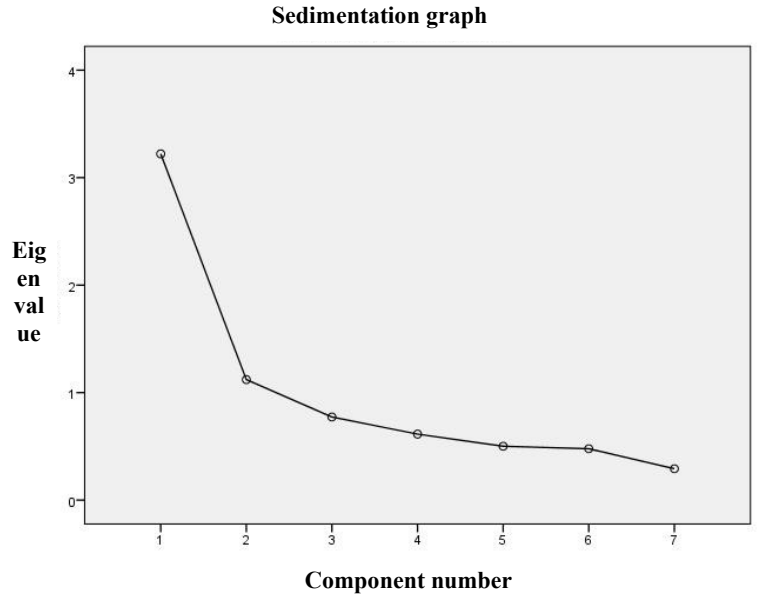
In order to identify evidences of the structure of the semantic memory construct, an exploratory factor analysis was carried out based on the sub-tests of the EMSEA battery. The KMO index had a value of .79 (IC95% =0.744-0.835), Bartlett's test of sphericity showed a Chi-square result of 343.50, p =.00, these aspects indicate the viability of the factor analysis. The eigenvalues greater than 1 would establish two factors giving an accumulated percentage between both of them of 62%, as shown in Table 4, an aspect that is complemented by the sedimentation graph, which can be seen diagrammed in Image 2.

Table 4. Eigenvalues and cumulative variance of the exploratory factor analysis of the sub-tests of EMSEA.

	Initial Eigenvalues		
Component	Total	Variance %	cumulative %
1	3.221	46.021	46.021
2	1.121	16.015	62.036
3	.773	11.042	73.078
4	.614	8.771	81.848
5	.501	7.158	89.007
6	.478	6.823	95.830
7	.292	4.170	100.000

Notes: Initial Eigenvalues of Total; Initial Eigenvalues of the % of variance; Initial Eigenvalues of the % of cumulative

Image 2. Sedimentation graph for EMSEA sub-tests



Regarding the components in table 5, it shows that the Varimax rotation established two factors with factorial weights greater than .30; the first one formed by Definition of semantic categories, Recognition of attributes and Verbal Fluency, and the second one formed by Matching word heard drawing, Semantic analogies, Verification of the veracity of statements and Naming of drawings.

Table 5. Semantic Memory Battery Configuration Matrix – EMSEA by means of Principal Axis Analysis with Varimax Rotation

	Component	
Sub-test	**1**	**2**
EMSEA-2. Definition of semantic categories	.846	
EMSEA-4. Attribute recognition	.778	
EMSEA-1. Verbal fluency	.766	
EMSEA-5. Matching word heard drawing		.783
EMSEA-7. Semantic analogies		.738
EMSEA-6. Verification of the veracity of sentences		.681
EMSEA-3. Drawing naming		.597

Notes: Extraction method: principal component analysis
Rotation method: Varimax with Kaiser normalization.
a. The rotation has converged in 3 iterations.

To confirm the model, it was evaluated the fit indexes observing that all of them meet the criteria, with the Relative Fit Index (RFI) standing out with a value of 0.86, as shown in Table 6.

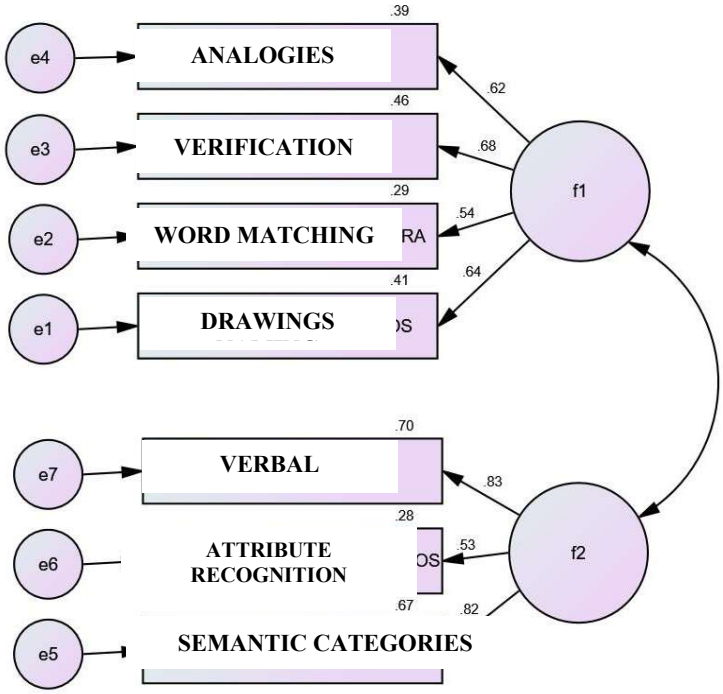
Table 6. EMSEA battery goodness-of-fit indices

Statistic	Index	Expected value	Expected value	Conclusion
Chi-square	X^2	*p* >.05	*p*<.05	Unfulfilled
Chi-square ratio/degrees of freedom	X^2/g.l.	<3	.009	Fulfilled
Normalized adjustment index	NFI	≥.90	.914	Fulfilled
Tucker-Lewis index	TLI	≥.90	.92	Fulfilled
Comparative goodness-of-fit index	CFI	≥.90	.95	Fulfilled
Incremental adjustment index	IFI	≥.90	.95	Fulfilled
Relative adjustment index	RFI	≥.90	.86	Unfulfilled
Root mean squared residual approximation	RMSEA	<.08	.08	Fulfilled

Notes: X^2: Chi-square, Degrees of freedom in Chi-square; Normalized adjustment index; Tucker-Lewis index; Comparative goodness-of-fit index; Incremental adjustment index; Relative adjustment index; Root mean squared residual approximation.

The goodness-of-fit indices validate the model shown in Image 2, where it is established that the seven sub-tests that are grouped into two factors, as seen diagrammed in Image 3.

Image 3. SEM model of the EMSEA battery



Regarding reliability, the Cronbach's Alpha Coefficient was .75, and the Theta coefficient was .80. It is also observed that all sub-tests contribute to measure the construct, giving positive coefficients between .33 and .69, as shown in table 7.

Table 7. Total correlation of EMSEA sub-tests

Sub-test	Scale mean if the element has been suppressed	Scale variance if the element has been suppressed	Total correlation of corrected elements	Cronbach's alpha if the item has been deleted
Verbal fluency	227.6582	1924.675	.690	.666
Semantic categories	228.4172	1971.509	.697	.662
Drawings naming	249.1530	3031.914	.512	.731
Attributes recognition	203.3751	2299.788	.493	.727
Word matching	250.7937	3375.298	.332	.763
Verification	235.0600	2979.590	.518	.727
Analogies	265.9618	3108.001	.430	.741

Notes: Scale mean if the element has been suppressed; Scale variance if the element has been suppressed; Total correlation of corrected elements; Cronbach's alpha if the item has been deleted.

DISCUSSION

For this reason, the standardization process and the evaluation of its psychometric properties were planned. The results showed that the EMSEA presents the ability to distinguish between a clinical and a normal sample, for the seven sub-tests that compose it. In this regard, the choice of a reliable and valid criterion (sufficient, objective and representative of the behavior of interest) is a critical aspect that determines the goodness of the validation process, so it was taken as a strategy to evaluate whether the test is able to differentiate between a clinical and normal sample, establishing if the test extent is able to differentiate between the two groups [28].

The validity of a test can also be evaluated by analyzing its sensitivity and specificity, an aspect which is called decision making validity, specifically indicating that they are associated with the potential of the test to correctly identify cases when they must be assigned to one of the two categories [29]. In this sense, the EMSEA presents a specificity of 93.1% and a sensitivity of 92.9%, with an area under the curve of 98%. The result found in the present work established a sensitivity of 80% and a specificity of 100% with an area under the ROC curve of 91.7%, these differences are probably due to the characteristics of the clinical sample, since the previous one included not only patients with Mild Cognitive Impairment, but also a sample of patients with Alzheimer's Disease who present greater involvement of semantic memory [19].

Within the context of criterion validity, three tests related to evaluation of cognitive impairment were taken as a reference: Pfeiffer's Brief Mental State Questionnaire (examines several cognitive areas, mainly memory and orientation indicating the level of impairment), Mini Mental State Examination (evaluates temporal orientation, spatial orientation, fixation memory, evocation memory, attention, calculation and language) and the Memory Impairment Test (examines immediate memory, temporal orientation memory, semantic remote memory, free recall memory and recall memory with clues [23].

The results indicated a positive and significant correlation with each one of the instruments, being evident the highest correlation with the TAM. Also, it was linked the functional ability, represented as a criterion, by the Barthel Index and the Lawton Scale, since "The loss of functionality, being this a component of dementia, constitutes in clinical practice the fundamental difference between the concept of physiological or

benign cognitive impairment and dementia itself or pathological cognitive impairment "(p.324). Additionally, positive correlations can be observed, these are logically lower than the impairment tests, indicating the evidences of criterion validity [30].

Another important aspect was to establish the construct validity of the EMSEA, which is the main type of validity being an integrating concept, conceptualized in terms of a scientific process of contrasting hypotheses where empirical and rational judgments are combine and the statistical technique used to a greater extent is factor analysis. Likewise, it is established that construct validity seeks to highlight the degree and relation between the items and test components seeing how it configures the construct to be measured and on which the interpretations will be based, seeking to evaluate the dimensionality of the test, with the aim of determining the number of factors of the instruments.

As a result of the exploratory and confirmatory factor analysis, two factors were found: the first one was composed of Semantic Analogies, Verification of Statements, Word Hearing-Drawing Matching and Picture Naming, while the second factor was composed of Verbal Fluency, Attribute Recognition and Definition of Semantic Categories. The first accounted for 46% of the variance and the second for 16%, exceeding the 60% recommended for social sciences. As explained before, the psychometric properties of the battery of EMSEA are evident, and there is no risk of affecting the internal validity of this research. As established, the EMSEA meets the necessary psychometric conditions to evaluate semantic memory.

CONCLUSIONS

The evaluation of the semantic memory in the Alzheimer's Disease differentiates between cases and non-cases, with the sensitivity of 80% and specificity of 100%, with a ROC curve of 91.7% for a cut-off point of 251 of the total score.

The concurrent criterion validity established significant correlations and high effect sizes.

The factor analysis was organized into two components for the 7 sub-tests with adequate fit indices.

The consistency of the Cronbach's Alpha score was 0.75 and a Theta coefficient of 0.80 where all sub-tests contribute to measure the construct.

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