Reliability and construct validity of the Rey-Auditory Verbal Learning Test in Brazilian elders

Fidedignidade e validade de construto do Teste de Aprendizagem Auditivo-Verbal de Rey em idosos brasileiros

Jonas Jardim de Paula[1], Larissa Pacheco Cunha Melo[1], Rodrigo Nicolato[2], Edgar Nunes de Moraes[3], Maria Aparecida Bicalho[3], Amer Cavalheiro Hamdan[4], Leandro Fernandes Malloy-Diniz[2]

[1] Laboratório de Investigações Neuropsicológicas do Instituto Nacional de Ciência e Tecnologia de Medicina Molecular (INCT-MM) da Universidade Federal de Minas Gerais (UFMG).
[2] Departamento de Saúde Mental da UFMG.
[3] Departamento de Clínica Médica da UFMG.
[4] Departamento de Psicologia da Universidade Federal do Paraná (UFPR).

Abstract

Background: The Rey Auditory-Verbal Learning Test (RAVLT) is widely used for the assessment of episodic memory. However, there are few studies in Brazil assessing its psychometric properties. **Objectives:** To search for evidence of reliability and construct validity of the RAVLT, and to assess the influence of age, schooling, gender, and depressive symptoms on test performance. **Methods:** One hundred twenty-six healthy older adults (aged 60 and over) performed the RAVLT, Mini-Mental State Exam (MMSE), Clock Drawing Test (CDT) and the Geriatric Depression Scale. Reliability was assessed by analysis of internal consistency, and construct validity by factor analysis and correlations with the MMSE and CDT. The influence of age, schooling and depressive symptoms was estimated by conducting linear regression analysis, and the role of gender by comparing the performance of males and females. **Results:** The RAVLT showed a high internal consistency, weak correlations with the MMSE and CDT, and a bifactorial structure, which is related to the processes of learning and episodic memory retrieval. Only age and gender affected test performance. **Discussion:** Our results provide evidence of reliability and construct validity in the tested RAVLT version, attesting its potential for clinical and research purposes for the Brazilian elderly population.

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Keywords: Rey Auditory-Verbal Learning Test, RAVLT, validity, reliability, episodic memory, verbal learning.

Resumo

Contexto: O Teste de Aprendizagem Auditivo-Verbal de Rey (RAVLT) é amplamente utilizado para a avaliação da memória episódica. Suas propriedades psicométricas, porém, não foram bem analisadas no Brasil. **Objetivos:** Buscar evidências de fidedignidade e validade de construto do RAVLT e analisar a influência de idade, gênero, escolaridade e sintomas depressivos no desempenho. **Métodos:** Cento e vinte e seis idosos saudáveis realizaram o RAVLT, o Miniexame do Estado Mental (MEEM), o Desenho do Relógio (DR) e a Escala de Depressão Geriátrica. A fidedignidade foi avaliada pela análise de consistência interna e a validade de construto, pela estrutura fatorial e correlações com o MEEM e o DR. A influência da idade, escolaridade e sintomas depressivos foi estimada mediante regressão linear, enquanto diferenças de gênero foram avaliadas comparando o desempenho de homens e mulheres. **Resultados:** O teste apresenta alta consistência interna e estrutura bifatorial relacionada aos processos de armazenamento e evocação da memória episódica. O teste mostrou, em geral, correlações fracas com o MEEM e o DR. Apenas a idade e o gênero influenciaram o desempenho na tarefa. **Conclusão:** Nossos resultados indicam que a versão do RAVLT analisada apresenta bons indícios de fidedignidade e validade de construto, atestando sua aplicabilidade em contextos clínicos e de pesquisa para a população estudada.

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Palavras-chave: Teste de Aprendizagem Auditivo-Verbal de Rey, RAVLT, validade, fidedignidade, memória episódica, aprendizagem verbal.

Introduction

The Brazilian elderly population has increased significantly since last century and should surpass the 20 million inhabitants mark in this decade[1]. With a larger number of elderly people and higher life expectancy the prevalence of dementia increases, as well as its prodromal stage, the mild cognitive impairment, since aging is one of the main risk factors for the development of such cases. A population study in the Brazilian context[2] found a dementia prevalence of 7.1%, being the Alzheimer disease type the most commonly diagnosed (about 55% of the cases). The prevalence of mild cognitive impairment is still under debate, oscillating from 3% to 20% in elderly patients[3].

In dementia or mild cognitive impairment the cognitive assessment is fundamental for early and clinical diagnosis. The use of neuropsychological testing is one of the main tools for this assessment as it allows the patient to be compared to a group or an appropriate normative reference, leading to an objective examination of memory. This posture is essential, since patients often have significant difficulties in reporting their cognitive difficulties, as shown in a literature review of Dourado *et al.*[4], and the perception of these difficulties is influenced by different factors such as cognitive impairment and anxiety symptoms[5].

The Rey Auditory-Verbal Learning Test (RAVLT) was originally proposed as a neuropsychological tool for the assessment of the processes of learning and memory[6]. It was adapted for the Brazilian population by Malloy-Diniz *et al.*[7] with a second version published later by the same author[8], with some changes that favor its use in the elderly brazilian population, such as a change in the original list of words to a new one, containing high frequency disyllables in Brazilian Portuguese. In a recent study[9] that estimated the relationship between age, gender, educational level and test performance,

significant correlations were found between these three variables and the processes of learning and memory assessed.

In populational studies of other countries the RAVLT tends to have strong psychometric properties. Internal consistency is generally above 0.9 and it has high correlations with other instruments for episodic memory evaluation, such as the *California Verbal Learning Test*[10].

Fichman *et al.*[11] conducted the first study of the RAVLT's construct validity in the elderly population in the Brazilian context. Using convergent correlations (cognitive test instruments with positive correlations tend to measure, at some level, similar constructs) and a learning picture test that is independent from formal education, the authors correlated the components "A7", "REC", "Total" and an index compound by the total number of words mentioned in A5 minus the total of words evoked in A1 (in which the total of words memorized is considered, being short-term memory pondered). Their findings showed moderate correlations (r = 0.528 p < 0.01) in the recall component and weak ones (r = 0.197, p < 0.01) in recognition.

However, an important methodological question arises when using convergent and divergent correlations with other instruments for the analysis of construct validity: although significant, the magnitude of effect obtained by such correlations tends to be low. In Fichman *et al.*[11] study, moderate correlation of the stages of recall represents approximately 27% of the variance (r^2), while the recognition task represents only 4%. Thus, respectively 73% and 96% of common variance between the two instruments are explained by other factors rather than the latent construct to be validated. One possible explanation for the unexplained variance in that study is that the RAVLT has verbal stimuli while the other analyzed instrument has visual ones. Intercorrelation of age on these tests (the total variance explained by this variable may differ from instrument to instrument, masking the correlations) and other variables such as education, general intelligence and gender should also be considered. Given these biases, the construct validity performed using convergent correlations should be complemented by other forms of validation, seeking convergent evidence of such propriety.

When performances on several neuropsychological tests are correlated, the results are usually grouped into a single component which is responsible for most of the variance found[12]. This methodology aims to identify a latent structure, in other words, a cognitive construct related to the performed tasks that can be inferred from the association of performance in different cognitive tasks. The identification of latent structures has been historically associated with the development of the psychology of individual differences and studies about intelligence and personality. The most commonly used method in such research is the exploratory factor analysis, a multivariate statistical procedure that deals with the pattern of correlations or covariance presented by the items of a particular set of data, seeking for latent patterns of intercorrelations[13]. This methodology is one of the most appropriate ones to assess the construct validity of psychological and neuropsychological tests, since it allows the testing of hypotheses about the latent features assessed by the instruments. In a recent study[14] the latent structure of a cognitive examination protocol that consisted of several cognitive tests was evaluated in a clinical population of the Brazilian elderly population, and only one factor was responsible for more than 58% of the total variance.

The RAVLT is a test that assesses episodic memory, with components related to short-term memory, learning, immediate and delayed recall and recognition memory. Its factorial structure, however, is heterogeneous and dependent on the studied population. In clinical groups of patients with epilepsy or psychiatric disorders[15] the test tends to show a bi-factorial model, with a component related to short-term memory and the other to long-term memory. It is usually found two or three factors in the general population: short-term memory, long-term memory and recognition memory[16]. This test has been widely used in clinical and research contexts in several countries, being considered as a valid and effective measurement of episodic memory and sensitive to memory deficits found in several

clinical conditions such as Alzheimer's disease[17], Mild Cognitive Impairment[17] and major depression[18], demonstrating strong criterion validity.

This study aims to evaluate the reliability and construct validity of the RAVLT. The following hypotheses will be investigated*: 1) The items of episodic memory of the RAVLT will present high internal consistency (Cronbach's alpha > 0.8), 2) the components of the RAVLT will present weak to moderate correlations with the Mini-Mental State Exam total score and the Clock Drawing, 3) its factor structure will present a bi or tri-factorial model, with components related to learning and retrieving processes and 4) age, education, gender and depressive symptoms will significantly influence task performance.*

This study is associated with the project Depression and Dementia in the Elderly, approved by the Ethics Committee of Universidade Federal de Minas Gerais (334/06).

Method

Participants

One hundred twenty-six healthy elderly people were evaluated. They were recruited through local advertisements in the metropolitan region of Belo Horizonte, totaling 63 women and 63 men. The mean age of the sample was 71.74 (SD = 7.9, Min = 60 and Max = 89) years and the mean education of 6.74 (SD = 2.3, Min = 4 and Max = 17) years. Age showed normal distribution in the sample, confirmed by Kolmogorov-Smirnov test (Z = 1.031 p = 0.239), while education was polarized in 4 (35%) and 8 (50%) years. Inclusion criteria for the control group were: age above 60 years, at least 4 years of formal education, Mini-Mental State Exam (MMSE) total score above the cut-off proposed for education[19] (27.96, SD = 1.57), absence of functional impairment attested by the Katz *et al.*[20] and Lawton-Brody[21] inventories of daily living activities, score below the proposed cut-off for major depressive disorder on the Geriatric Depression Scale[22] (average = 3.07, SD = 2.01), no history of neuropsychiatric symptoms or neurological impairments and score 0 on the Clinical Dementia Rating Scale (CDR)[23]. The evaluations were performed by neuropsychologists of the Laboratory of Neuropsychological Investigations (LIN-UFMG). The participants filled out the term of free and informed consent of the project.

Table 1 shows the sociodemographic data of the sample and the neuropsyhcological tests performance. For better sample description the participants were segregated by age (60-69, 70-79, 80-89 years) and education (less than 8 years and more than 8 years).

Neuropsychological assessment

RAVLT: We used the adapted version for the Brazilian elderly population[8]. The fifteen words are read slowly to the subject, requesting him/her to repeat them after the reading, independently from the order they were said (A1). The same procedure is repeated in steps A2, A3, A4 and A5, pointing out that the subject must always remember all the words, including those said previously. Then a second list of words (B1) is read as a distractor, and the subject must only recall these new words. After that, the words of the first list are asked (A6), without being exposed, in a task of immediate recall from episodic memory. Twenty-five minutes after this stage the subject must again recall the words of the first list (A7) in order to assess the delayed recall of episodic memory. Finally, a recognition list (REC) containing fifty words, the fifteen ones from the first list, fifteen from the second and twenty other words phonetically or semantically related (totalling 35 distractors) are are presented, and the subject must judge whether each word belonged or not to the first list. The scores of each stage are computed according to the number of words correctly recalled, except for REC, where 35 (total of distractors) is subtracted from the total score (words correctly classified). In order to avoid negative outcomes in later analysis, the negative results were subtracted, generating a score ranging from 0 to 50 points. The Total score ($\Sigma A1-A5$) in the learning steps is also computed.

Table 1. Participants description and performance on neuropsychological assessment

	60-69 years (n = 51)		70-79 years (n = 43)		80-89 years (n = 32)	
	< 8 years n = 26, F = 12	> 8 years n = 25, F = 15	< 8 years n = 8, F = 5	> 8 years n = 35, F = 18	< 8 years n = 24, F = 14	> 8 years n = 8, F = 3
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
MEEM	29,1 (1,1)	29,1 (1,0)	27,7 (0,5)	27,4 (0,9)	26,0 (1,3)	26,5 (1,4)
CDT	4,7 (0,8)	4,8 (0,6)	4,3 (0,8)	4,0 (0,5)	3,4 (0,6)	3,3 (0,5)
GDS-15	2,0 (1,8)	1,5 (1,7)	3,3 (1,6)	3,8 (1,1)	5,2 (1,2)	4,4 (1,8)
A1	5,1 (1,1)	5,3 (0,9)	5,2 (2,6)	5,0 (0,7)	3,9 (1,7)	3,5 (0,5)
A2	7,4 (1,8)	7,8 (1,0)	6,7 (2,1)	6,7 (0,9)	5,8 (1,7)	5,5 (0,8)
A3	8,7 (2,0)	8,8 (1,6)	7,8 (2,1)	7,5 (1,4)	7,1 (1,7)	6,9 (2,2)
A4	9,9 (2,0)	10,2 (1,4)	8,7 (2,6)	9,3 (1,6)	8,0 (2,1)	8,5 (1,7)
A5	11,1 (2,0)	11,1 (1,8)	8,8 (1,3)	10,7 (1,2)	9,9 (2,5)	9,4 (2,1)
B1	4,7 (1,1)	4,5 (1,3)	4,0 (0,6)	4,0 (0,7)	2,9 (1,5)	3,5 (1,2)
A6	9,8 (2,6)	9,3 (2,3)	9,0 (1,3)	8,7 (1,1)	8,4 (1,9)	8,0 (1,8)
A7	9,1 (2,8)	9,0 (2,0)	7,7 (2,4)	8,4 (1,2)	7,0 (2,0)	7,4 (2,0)
REC	31,7 (5,8)	28,9 (9,0)	29,7 (2,8)	28,7 (4,7)	26,9 (8,2)	25,8 (8,5)
RAVLT – Total	42,2 (7,2)	43,2 (4,9)	37,2 (9,2)	39,3 (4,1)	34,6 (8,2)	33,8 (5,6)

MMSS: Mini-Mental State Exam; CDT: Clock Drawing Test; GDS-15: Geriatric Depression Scale; RAVLT: Rey Auditory-Verbal Learning Test; SD: Standard Deviations; F: female.

Mini-Mental State Exam: screening instrument commonly used for identifying cognitive impairment in the diagnosis of dementia[19]. It contains questions that assess temporal orientation, spatial orientation, calculation, short-term memory, motor praxis, naming, language and constructive praxis. The total score ranges from 0 to 30, where the cutoff points 16, 22 and 26 are used for the identification of significant cognitive impairment in illiterate, educated and college graduated, respectively.

Clock Drawing Test: used to assess the constructive praxis and executive functions. It is a test of quick and simple application and it is sensitive to cognitive impairment. In this study we used a score ranging from 0 (worst) to 5 (best)[24].

Statistical analysis

The reliability analysis is the evaluation of the stability or precision of a test measurement. One method for the analysis of this characteristic is the internal consistency, performed in this study by calculating Cronbach's Alpha (Pasquali, 2006) with the components A1, A2, A3, A4, A5, B1, A6, A7, and REC of the RAVLT. The construct validity of the RAVLT was attained through its correlations with other two neuropsychological tests (MMSE and CDT) and an exploratory factor analysis, using the principal axis factoring and oblique rotation (*direct oblimin*). These methods were selected because of the theoretical focus of this study and the probable dependence relationship between the components of the RAVLT[13]. Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) and Bartlett's test of sphericity were calculated to demonstrate the viability of the analysis in the selected sample. The proportion of observations and variables (ten to one) recommended by Hair *et al.*[13] was satisfied. Finally the relationships between the different components of the RAVLT and age, education, depressive symptoms and gender were assessed. For the first three factors we opted for stepwise linear regression models, with the components of the RAVLT as dependent variables and other variables as independent. Considering the variable gender, performance of men and women was compared by Student's t test, including the calculation of Cohen's d effect magnitude.

Results

The nine components of the RAVLT showed high level of intercorrelations, generating a Cronbach's alpha of 0.831, an evidence of good internal consistency. The correlations between the different components of the test with the MMSE and the CDT oscillated between not significant (r = 0.08 p = 405) to weak (r = 0.448, r^2 = 0.20

p < 0.001). The correlation between the MMSE and the CDT (r = 0.713, r^2 = 0.50, p < 0.001) can be considered high. Table 2 shows the correlations between tests.

KMO´s test (0.856) and Bartlett's sphericity test (χ^2 = 458.8, p < 0.001) indicate sample adequacy for exploratory factor analysis. Based on the factor extraction, rotation and interpretation of the eigenvalues and screeplot a two-factor solution was considered most appropriate (Eigenvalues: 4.411 and 1.139) to the sample, responsible for 59% of the total variance. The pattern analysis indicates factor loads predominantly on the items A1 (0.704), A2 (0.763), A3 (0.742) and A4 (0.776) for factor 1 while the second factor was related to the items A6 (0.816), A7 (0.714) and REC (0.485). A5 component exhibited substantial loads on both factors (0.393 in the first and 0.478 in the second). The factors showed a strong correlation (r = 0.752 r^2 = 0.56). These results are shown in figure 1.

The stepwise linear regression analysis, with the components of the RAVLT as dependent variables and age, education (and presence of depression symptoms (GDS-15) as independent variables led to models where only age was a predictor of performance on the RAVLT (significant in all stages), while education and depressive symptoms did not show significance. Table 2 summarizes these results. Women had higher performance levels than men in A1 (p < .001 d = 0.66), A3 (p = 0.031, d = 0.41), A5 (p = 0.015, d = 0.48), A6 (p = 0.032, d = 0.49) and total (p = 0.008, d = 0.51).

Discussion

This study investigated some psychometric properties of the RAVLT, a neuropsychological test for memory assessment commonly used in Brazil. The test of the first hypothesis proposed, which was about its internal consistency, indicates that the different items of the RAVLT present a consistent pattern of intercorrelations, an evidence of reliability. Although there is a robust evidence of such property, there are no other Brazilian studies evaluating the reliability of the RAVLT by other methodologies, such as test-retest.

The hypothesis about the construct validity of the RAVLT shows converging evidences of such characteristic for the studied population. The test had weak correlations, but generally significant, with two classical tests for global cognitive assessment of elderly patients, the MMSE and the CDT. This finding suggests that, although they share variance, the RAVLT measures distinct constructs from those assessed by the two other tests, an indication of construct validity. Accordingly, the two screening instruments showed a strong correlation, highlighting the distinction between their constructs and those measured by the RAVLT.
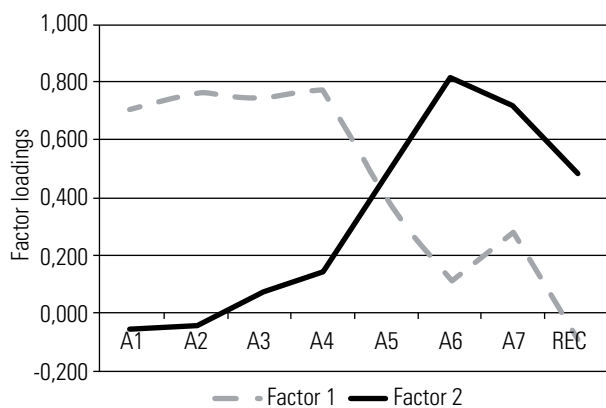
Figure 1. Factor loadings of the RAVLT.

Table 2. Linear regression analysis and correlations of the RAVLT with MMSE and CDT

RAVLT	β	Model	Sig.	Ajusted R²	Cor. MMSE	Cor. CDT
A1	-0,417	Age	p < 0,001	0,17	0,244 (p = 0,010)	0,370 (p < 0,001)
A2	-0,491	Age	p < 0,001	0,23	0,370 (p < 0,001)	0,377 (p < 0,001)
A3	-0,396	Age	p < 0,001	0,15	0,372 (p < 0,001)	0,377 (p < 0,001)
A4	-0,441	Age	p < 0,001	0,29	0,349 (p < 0,001)	0,390 (p < 0,001)
A5	-0,269	Age	p = 0,005	0,07	0,193 (p < 0,001)	0,319 (p < 0,001)
B1	-0,448	Age	p < 0,001	0,19	0,260 (p < 0,006)	0,335 (p < 0,001)
A6	-0,241	Age	p < 0,001	0,05	0,153 (p < 0,110)	0,345 (p < 0,001)
A7	-0,338	Age	p < 0,001	0,10	0,289 (p = 0,002)	0,344 (p < 0,001)
REC	-0,300	Age	p = 0,001	0,08	0,080 (p = 0,405)	0,180 (p = 0,059)
Total	-0,493	Age	p < 0,001	0,24	0,381 (p < 0,001)	0,448 (p < 0,001)

RAVLT: Rey Auditory Verbal Learning Test; Sig.: Significance; Cor.: Person Correlation; MMSE: Mini-Mental State Exam; CDT > Clock Drawing Test.

The factor structure of the RAVLT in the studied population is consistent with the one found in the literature[15,16]. In healthy elderly, with the sociodemographic profile of this study, a two-factor structure was sufficient to explain more than half of the variance presented in the test. A detailed analysis of the factor loads of each item indicates a change on the cognitive processes involved in the task: while the loads of items A1, A2, A3 and A4 on factor one suggest a process related to learning , the items A6, A7, and partly REC, suggest a search for a content already stored in the memory system. The component REC had a lower factor loading than the two components of Factor 2.We conjecture that in a larger and more heterogeneous population this task forms, by itself, an isolated factor, as pointed out by other authors[16], considering that such component differs from the structure of other components of the RAVLT.

Based on this information these results we named the two factors found, respectively, learning and retrieving. This solution is supported by A5 factor loading, the last item in the learning phase of the RAVLT, related to the two factors, as a transition between processes. The factor structure found is supported by both classical neuropsychological models of episodic memory[25] and the most recent[26,27], brain-function correlations[28] and studies with clinical populations[16,17,26]. The high correlation shown between the two factors still supports the interdependence of the episodic memory system. Huijbers *et al.*[26] demonstrated in a functional neuroimaging study that processes relatively independent from and retrieving share overlapping hippocampal activation, a structure that would act as a synthesis and transition element for different memory processes, a view shared by other authors.

The influence of sociodemographic variables on the RAVLT confirms some previous findings, such as the significant influence of age and gender[10] on test performance (the Brazilian population standards are divided by age and sex). Age, the only significant predictor in linear regression models, explained between 5% and 29% of the variance found in the different components of the RAVLT, while gender was related to components A1, A3, A5, A6 and to the total number of words stored, with better performance of women over men. The magnitudes were close to half standard deviation. The clinical relevance of these differences is significant, since in some clinical settings (such as mild cognitive impairment or mild AD) the quantitative interpretation of the neuropsychological performance is central to the diagnosis[3].

Unlike previous studies[9,11], there has not been found significant influence of formal education on test scores. This fact can be explained by the homogeneity of the participants assessed in terms of formal education, and the unequal distribution of subjects at 4 and 8 years of education, which is a limitation of this study. The study of such variable in populations with predominantly low (0-3 years) and high education (> 14 years) is essential for the proper use of the test, in order to investigate the performance at different educational levels, considering it is important for diagnostic purposes. Although the GDS score did not show influence on the various stages of the RAVLT, low scores on the scale do not indicate intensive depressive symptoms, since it was one of the inclusion criteria for this study. In a clinical group with more apparent depressive symptoms, this factor could negatively influence test performance, as evidenced studies that used the RAVLT in patients with major depression[18].

The analysis of the psychometric properties of the RAVLT conducted in this study provides significant evidence of reliability (through analysis of internal consistency), construct validity (through the use of divergent correlations and analysis of the factorial structure), besides it investigates the influence of sociodemographic variables, such as age, education and gender and the clinical variable of depressive symptoms. However, this study has the methodological limitations pointed out by Delis *et al.*[29]. The RAVLT is an instrument marked by learning processes, where each component of the the test depends crucially on the previous one, which tends to increase the variance shared by each component. These authors argue that the assessment of construct validity through correlations with other neuropsychological tests and analysis of the factorial structure is overly biased by the characteristics of the participants. In an experimental design they demonstrated that the clinical profile of episodic memory of patients with Alzheimer's disease and Huntington's disease (marked by dissociation of performance between immediate and delayed memory recall) is not supported by analysis of test correlations and factor structure in that population. However, Larrabee's[30] comment about these evidences suggests that factorial analysis can be a useful tool for construct validity when conducted in samples of adequate size and homogeneity, and preferably in combination with other similar cognitive measures (for example, using RAVLT delayed recalls together with Rey Complex Figure and CERAD battery praxis recalls).

Comparing the factorial structure of each specific clinical group can also bring important evidence about patterns of variance presented by the sample, allowing inferences about the specificity of the constructs assessed and clinical applicability. Larrabee[30] concludes that the use of these methods by itself, does not exhaust the construct validity analysis of neuropsychological tests, but along with clinical studies of well characterized populations and specific case studies it is essential for the analysis.

The present study provides evidences of validity and reliability considering the psychometric properties of the RAVLT. In favor of this, there is a multi-methodological convergence of such evidence, the homogeneity of the sample (based on a series of objective criteria for inclusion) and adequate sample size for analysis. Therefore, with the first analysis of the construct validity of the test[11], it provides convergent evidence of reliability and construct validity. However, the present results cannot be generalized to the entire elderly population, being required further studies about the influence of factors such as education and depressive symptoms in more heterogeneous samples in order to increase the external validity of these findings. In this regard, we emphasize that the growing volume of studies to obtain normative parameters and applicability of neuropsychological tests for different segments of the Brazilian population[7,8,14,19] must be accompanied by studies on the psychometric properties of these instruments. This initiative will support the refinement of the use of these instruments for both clinical practice and research.

Conclusions

The RAVLT showed strong internal consistency, weak correlations with global neuropsychological testing instruments and factorial structure composed of two components, encoding and retrieving. The analysis of sociodemographic variables suggests a significant influence of age in all the test components and gender in A1, A3, A5, A6 and total. The results showed reliability and construct validity of the test, endorsing its potential for clinical use.

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