

PERFORMANCE OF NORMAL ADULTS ON REY AUDITORY LEARNING TEST

A pilot study

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Abstract – The present study aimed to assess the performance of healthy Brazilian adults on the *Rey Auditory Verbal Learning Test* (RAVLT), a test devised for assessing memory, and to investigate the influence of the variables age, sex and education on the performance obtained, and finally to suggest scores which may be adopted for assessing memory with this instrument. The performance of 130 individuals, subdivided into groups according to age and education, was assessed. Overall performance decreased with age. Schooling presented a strong and positive relationship with scores on all subitems analyzed except learning, for which no influence was found. Mean scores of subitems analyzed did not differ significantly between men and women, except for the delayed recall subitem. This manuscript describes RAVLT scores according to age and education. In summary, this is a pilot study that presents a profile of Brazilian adults on A1, A7, recognition and LOT subitem.

KEY WORDS: memory, adult, evaluation.

Desempenho de indivíduos saudáveis no Rey Auditory Verbal Learning Test (RAVLT): estudo piloto

Resumo – O objetivo deste estudo foi avaliar o desempenho de adultos normais brasileiros no *Rey Auditory Verbal Learning Test* (RAVLT), um teste destinado à avaliação da memória, e investigar a influência das variáveis idade, sexo e escolaridade no desempenho obtido, além de sugerir escores que possam ser utilizados na avaliação da memória segundo este instrumento. Foi avaliado o desempenho de 130 indivíduos, subdivididos em grupos de acordo com a idade e escolaridade. O desempenho geral no teste diminuiu com o aumento da idade. A escolaridade apresentou relação forte e positiva com os escores em todos os subitens analisados, exceto no aprendizado, no qual não foi verificada influência. As médias dos escores dos subitens analisados não foram estatisticamente diferentes entre homens e mulheres, exceto no subitem recordação tardia. Descrevemos os escores no RAVLT de acordo com faixa etária e escolaridade neste manuscrito.

PALAVRAS-CHAVE: memória, adulto, avaliação.

Memory is defined as a group of abilities involving acquisition, storage and retrieval of different types of information¹. Long-term memory allows the storage of large quantities of information for an indefinite period of time, while short-term memory is the ability to store small quantities of information for limited periods. Models representing memory and its subsystems incorporate the concept of working memory, defined as a memory system which involves temporary storage and manipulation of information for performing a wide variety of cognitive ac-

tivities such as reasoning, comprehension, and repetitive tasks². This system is divided into three interconnecting subsystems: the articulatory loop, visuo-spatial sketchpad and central executive. The articulatory loop is responsible for processing and temporarily retaining speech knowledge, and is made up of different components: a phonological store which retains the information in phonological code, and the articulatory process, responsible for maintaining the material in this store active as well as recoding all other non-phonological material³.

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Certain variables may impact the performance on working memory tests including educational level, sex and age⁴. Although several tests to evaluate this type of memory have been described, little is known about the performance of the Brazilian population on these tests. A test frequently referred to in the international literature is the *Rey Auditory Verbal Learning Test (RAVLT)*⁵, which evaluates memory and learning. The study of this instrument is important to delineate the performance profile of the Brazilian population.

This study intends to investigate the influences of age, sex and educational level on the performance on RAVLT of normal adults, and suggest scores to assess memory according to this instrument.

METHOD

One hundred and thirty Brazilians participated in this study, divided into two different age groups (young adults: aged between 34 and 59 years; and elderly individuals: aged between 60 and 85 years) and educational levels (low: 4 to 8 years of formal education; and high: 9 or more years of education). The inclusion criteria were: age between 34 and 85 years and at least 4 years of schooling. The exclusion criteria were: uncorrected hearing impairment, severe neurological or psychiatric disorders; chronic psychotropic drug use; traumatic brain injury with loss of consciousness of 15 minutes or more; previous history of stroke or epilepsy. This study was approved by the Research Ethics Committee of UNIFESP, under protocol no. 0993/06.

The RAVLT was administered after having been translated and adapted to Brazilian Portuguese⁶. The test was administered according to its original standards⁵: fifteen translated nouns (list A) were read by the examiner, followed by subjects' free recall (A1–A5), five times consecutively. After the fifth recall, the examiner read a further list (list B) of 15 new words, followed by the subjects' free recall (B). Immediately after and 20 minutes later, another recall of list A (A6 and A7) were assessed. A recognition test, with 15 words from List A intermingled with 15 new words, was read to the subjects, who should identify which words belonged to the original list and which were new.

A method developed in MOANS (*Mayo's Older Americans Normative Studies*)⁷ was used to analyze learning, by standardizing scores: the Learning Over Trials (LOT), which is the total number of words recalled from all five trials minus five times the number of words obtained in the first trial.

We examined the scores of A1, A7, recognition and LOT to observe the performance of the subjects on immediate recall, delayed recall, recognition and learning, respectively.

Multiple linear regression was used to investigate the individual relationship between the independent (sex, age and education) and dependent (memory test results of A1, A7, recognition and LOT subitems) variables. The assumptions of these analyses were verified. A p value of <0.05 was considered to indicate statistical significance; all tests were two-tailed. All statistical analysis was performed with the Statistical Package for Social Science for Windows (Version 11.5.1).

RESULTS

One hundred and thirty patients were assessed: 65 from the young adult group and 65 from the elderly group. Of these 130 subjects, 75% were women.

The subjects aged from 34 to 85 years (mean±SD=57.4±13.4) and educational level ranged from 4 to 25 years (mean±SD=10.0±4.6).

The scores obtained in A1, A7, recognition and LOT subitems of the RAVLT are shown in Table 1.

Multiple linear regression analysis was performed to verify which factors impacted RAVLT scores. The results of A1, A7, recognition and LOT subitems were used as dependent variables whereas sex, age and education (Table 2) were used as independent variables.

Age correlated strongly with all RAVLT subitems independently of educational level and sex. Education was strongly correlated with all except with the learning RAVLT subitem. Sex was strongly correlated only with the delayed recall subitem.

Table 3 shows a descriptive analysis of the results obtained for the RAVLT subitems analyzed, with subjects divided by age and education.

DISCUSSION

The main finding of this study is that age influenced the scores of all the subitems analyzed, however, the positive and significant effect of education was not observed in learning. Sex had no influence on any subitems, except for delayed recall.

It is well described the negative effect of age on RAVLT score⁴. However, only few researchers have evaluated the sex variable.

Table 1. Descriptive analysis of subject performance on RAVLT subitems.

	Mean	Standard deviation	Median	Minimum	Maximum
A1	5.0	1.7	5	1	10
A7	7.9	3.2	8	0	15
Recognition	27.6	2.1	28	20	30
LOT	16.0	7.2	16	-4	37

A1: First attempt at List A recall A; A7: Seventh attempt at list A recall; LOT: learning over trials.

Table 2. Multiple linear regression analysis to demonstrate the relationship between the demographic data and RAVLT subitem scores. A1, A7, Recognition and LOT were used as dependent variables.

Independent variables	β	Standard-error	T	95% CI	p
A1					
Constant	5.49	0.66	–	–	–
Sex	–0.50	0.31	–1.58	–1.12 to 0.12	0.116
Educational level	0.14	0.03	4.91	0.09 to 0.20	<0.001*
Age	–0.03	0.01	–3.29	–0.05 to –0.01	0.001*
A7					
Constant	11.89	1.25	–	–	–
Sex	–1.18	0.59	–2.00	–2.35 to –0.01	0.048*
Educational level	0.19	0.06	3.49	0.08 to 0.30	0.001*
Age	–0.10	0.02	–5.27	–0.13 to –0.06	<0.001*
Recognition					
Constant	29.07	0.87	–	–	–
Sex	–0.13	0.41	–0.32	–0.95 to 0.68	0.748
Educational level	0.09	0.04	2.43	0.02 to 0.17	0.017*
Age	–0.04	0.01	–3.24	–0.07 to –0.02	0.002*
LOT					
Constant	22.84	3.07	–	–	–
Sex	–2.10	1.45	–1.44	–4.98 to 0.78	0.151
Educational level	0.15	0.14	1.08	–0.12 to 0.41	0.284
Age	–0.14	0.05	–2.98	–0.23 to –0.05	0.003*

A1: First attempt at list A recall; A7: Seventh attempt at list A recall; LOT: learning over trials.

Table 3. Means and standard deviations of number of words recalled on A1, A7, REC and LOT subitems of the RAVLT by age and educational level.

Group		A1	A7	REC	LOT
Young adults with low educational level n=26	mean	4.7	8.0	27.4	17.7
	standard deviation	1.6	2.6	2.3	8.4
Young adults with high educational level n=39	mean	6.2	10.3	28.8	17.5
	standard deviation	1.7	2.9	1.2	5.5
Elderly with low educational level n=29	mean	3.9	6.1	26.6	14.5
	standard deviation	1.2	3.0	2.0	8.0
Elderly with high educational level n=36	mean	4.8	6.7	27.2	14.3
	standard deviation	1.4	2.6	2.1	6.8

A1: First attempt at list A recall; A7: Seventh attempt at list A recall; REC: recognition; LOT: learning over trials.

The performance on A1, A7, recognition and LOT subitems revealed an increase in the number of words recalled in these two attempts (A1 and A7) This improvement could be attributed to the learning that occurred following consecutive readings of the list.

The analyses of these subitems indicated correlation between the scores, such that all the combinations were statistically significant. The mean and median scores were very close to the maximum possible score for the recognition test, which suggests a ceiling effect for normal subjects. However, individuals with impaired memory perform poorly on this test⁸.

Our results are consistent with those observed by Diniz et al.⁹: the means of A1 and A7 in the adult and elderly groups were similar to one another in both studies. However, the test version used was different from ours.

The score analysis of immediate recall (A1) indicates influence of education and age, independently, but not sex. The main component of working memory responsible for this task is the articulatory process of the articulatory loop, which function is to hold auditory information in memory using subvocal reverberation. Increase in age has a negative influence on the functions of the articulatory loop articulatory process whereby the aging process

renders this component less efficient with the stimuli rapidly reducing before being recalled. This would appear as poor performance on the immediate recall subitem. Regarding education, it is known that individuals with higher educational level present more efficient use of the articulatory component and consequently have better immediate recall performance.

All previous studies investigating the influence of age on A1 scores noted a negative effect for this variable^{8,14}.

Some studies have investigated the influence of schooling on A1 scores and also found a strong and positive relationship between schooling and A1 subitem performance^{13,14}. In contrast to our findings, several studies suggest sex influences A1 subitem performance, with women outperforming men^{8,14}. Nevertheless, this effect was not observed in a previous Brazilian study⁹.

The results on the delayed recall (A7) were influenced by sex, education and age, independently. The better performance was related to younger age, higher educational level and female sex. This task involves two components of working memory: the articulatory loop and episodic buffer¹⁵. The function of the episodic buffer is to integrate information from the articulatory and visuo-spatial loops, along with long-term memory material¹⁶. Thus, to achieve delayed recall, the subject needs to use both the articulatory loop, to store the audibly received material and maintain it active, as well as the episodic buffer. The poor performance of the elderly subjects and those with a lower educational level can be attributed to the articulatory loop and episodic buffer, based on the hypothesis that the aging process leads to impairment in mechanical components. Moreover, lower educational levels would indicate less efficient use of these components.

Concerning sex influence, our findings indicated that women, independently of age or education, presented better use of the articulatory loop and the episodic buffer.

Earlier studies that analyzed the influence of age on A7 scores have also verified the negative influence of this variable^{9,13,14}. However, the effects of education on A7 scores have been examined in a few studies found in literature^{13,14}, where all demonstrated this variable's positive influence on A7 performance.

Sex influence on A7 scores has also been examined by studies^{9,14}, where results on sex effects were contradictory.

Scores for recognition were influenced, independently, by age and education, but not by sex.

Poorer performance on recognitions tasks by elderly and less-educated subjects, as for A7 subitems, can be attributed to inefficiency of the articulatory loop and episodic buffer, which also require the participation of these two components.

The functions of these two components are also impaired with aging and go underused with lower-educational

background. However, as in recognition, the articulatory loop has a less significant role in recall. Of the two components required for the recognition task, the episodic buffer is the most jeopardized by the effects of age and education.

The present study results corroborate findings of other studies that examined the effect of age on the test scores of the cognition subitem. The negative influence of age, revealed in the present study has been reported in earlier work^{9,11,13,14,16}. However, a number of studies in the literature did not confirm the negative effect of age on the test, stating this variable had no influence^{8,12}. All the studies that examined the effects of educational level on recognition scores found this variable to have positive influence. However, this effect was not always independent of the age¹¹. Influence of sex was also absent in previous studies^{8,9}, but conflicting results exist in the literature¹⁴.

The recognition task, however, was not administered in the same manner in all the studies cited^{8,9,11,12,14,16}.

Differences in procedure for administering the recognition test hampers comparison of study results. This is the case for both test scores obtained, and how the variables age, education and sex influence the results.

Regarding the LOT subitem performance, statistical significant influence was observed for age, but not sex or education.

Learning, akin to delayed recall and recognition tasks, requires the participation of the articulatory loop and episodic buffer. During learning, the articulatory loop allows the input of more permanent information for storage in long-term memory¹⁷. The connection between working memory and long-term memory is made possible through the episodic buffer¹⁵.

This allows us to assume that younger subjects perform better on the immediate recall task due to more effective use of the articulatory process of the articulatory loop, as seen in the A1 results. This younger group was also able to considerably improve performance on subsequent recalls. Improvement occurs due to the input and storage of more permanent information in long-term memory enabled by the articulatory loop and episodic buffer. This results in a higher learning score than that obtained by older individuals who have poor immediate recall performance and worsening performance on subsequent recall trials.

The lack of influence of education on learning, although present in immediate recall, allows us to infer that subjects with higher educational levels present better results on A1 than those with lower educational levels and points to better use of the articulatory process. The articulatory loop and episodic buffer, by themselves, do not aid in recalling a sufficiently large number of words during the five trials to result in a higher learning score in in-

dividual's with greater schooling than subjects with lower educational background.

Comparing our results with literature, LOT subitem scores were negatively influenced by age, as observed in previous studies^{8,9,11,14,16}. The absence of influence of this variable on learning scores has been reported in a previous study¹². Regarding influence of education, the findings in this study differ from those found in other studies stating the positive effect that the education had on the learning score. Depending on the subject's age, this effect was not always evident¹¹. Different results were also found for influence of sex on learning score. A number of studies^{8,14} have reported the influence of sex, with females scoring higher than males, although this was not observed in the present study.

The learning measurement used in our study was not the same as that used in previous studies investigating learning over testing, which adopted different learning score parameters^{8,9,11,12,14,16}. Different methods used in the various studies limit the comparison of the results.

Analysis of our data for age and education yielded highest scores in young adults with higher education levels. Lowest scores were observed in the elderly group with lower education levels. These results reflect the tendency for age and education to impact test results negatively and positively, respectively. Several studies in the literature confirm that the younger and more schooled an individual, the better their performance on neuropsychological test^{8,9,11-14,16}.

The present study also provided scores for the A1, A7, recognition and LOT subitems of the test, which are suggested in the memory evaluation of Brazilian subjects according to age and education. Although Brazilian results are available for the test cited in the literature⁹, the differences in methodology used should be noted. These differences involved learning measurement, recognition test and sample characterization, since the age groups in the study have different educational levels. Future studies involving the application of the RAVLT in the Brazilian population should include a greater study sample size to standardize the scores obtained. In practical terms, the main contribution of this study was to highlight the influence of the variables age, sex and educational background on the test scoring process.

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