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The Rey Auditory Verbal Learning Test: Age-, Gender- and Education-Related Normative Data for The Iranian Healthy Population

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Abstract

Purpose: Memory and learning have particular importance due to their ubiquitous nature in everyday life and the high prevalence of related complaints. The present study aimed to provide normative data for one of the most widely used tests of verbal memory and learning in Iran and to assess the effect of demographic variables of age, gender, and education on its various measures.

Materials and Methods: The study was conducted as part of the Iranian Brain Imaging Database (IBID) project. The sample consisted of 300 normal individuals in the age range of 20 to 70 years, with an equal number of participants in each age decade (#60). The sample was classified by five decades, including 20-30-year-olds, 31-40-year-olds, 41-50-year-olds, 51-60-year-olds, and 61-70-year-olds. Each age decade was divided equally between the genders. The Rey Auditory Verbal Learning Test (RAVLT), which was defined in terms of 10 scores on learning, recall, and recognition, was used to assess verbal learning and memory.

Results: The correlation matrix among the variables shows that all three variables of age, gender, and education had a significant correlation with most RAVLT measures. Among the three demographic variables, age had the strongest correlation with most RAVLT scores. Three-way Analysis of Variance (ANOVA) showed that the effect of age and gender on memory and learning measures was significant. On the other hand, the effect of education on some measures was statistically significant. In addition, the mean and standard deviation of 10 RAVLT measures classified by gender and education years in the five age groups are provided.

Conclusion: The findings show that while increasing age, verbal memory, and learning performance decline, women outperform men, and education affects some indicators of learning and memory. These findings emphasize the importance of using age-, gender- and education-related normative data in clinical, educational, and research settings.

Keywords: Memory; Cognition; Memory and Learning Tests; Age Groups.

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1. Introduction

Neuropsychology aims to study brain-behavior relations and to make inferences about covert neural processes using tests and tasks designed to measure cognitive, emotional, and behavioral functioning (p. 500) [1]. Neuropsychological assessments are widely used in legal, research, and clinical settings on individuals in the normal and abnormal range to screen, identify and demarcate mental capacities; help with the diagnosis; predict the functional consequences of disorders; plan, prescribe and monitor treatment; predict the outcome of treatment (p. 8) [2]. This assessment has expanded rapidly in various settings especially in the last few decades [3], and despite the invention and development of modern imaging techniques such as Positron Emission Tomography (PET), functional Magnetic Resonance Imaging (fMRI), and Single-Photon Emission Computed Tomography (SPECT), it remains the dominant method for studying brain-behavior relations (p. 501) [1].

Among the functions evaluated in neuropsychological assessment, memory is one of particular importance due to its ubiquitous nature in everyday life and the high prevalence of related complaints [4]. Clinical findings and experiences suggest that these problems are clinically and sub-clinically present in the majority of neuropsychiatric disorders (p. 429) [2] and can cause serious disturbances in daily life and functional outcomes [5]. Memory complaints in outpatient settings are also arguably the most common reason for referral to neuropsychological testing [3]. On the other hand, considering the pivotal role of memory for all cognitive functions and possibly for the whole human behavior [5], its assessment can help to comprehensively evaluate the functionality of the brain (p. 513) [1].

One of the most widely used measures in assessing memory is the Rey Auditory Verbal Learning Test (RAVLT). In a survey conducted by the National Academy of Neuropsychology and the International Neuropsychological Society, this test ranked sixth among memory tests [6]. The purpose of this test is to measure individuals' learning and memory performance using three unrelated word lists (two lists for free recall and one list for recognition). More specifically, this test examines the ability to encode, consolidate, store, and retrieve verbal information [7]. The RAVLT has several advantages. First, it is easy and short-term to implement (p. 776) [8]. Second, it is a useful tool in screening, diagnosing, and predicting neuropsychiatric diseases [9]. For example, the RAVLT outperformed other memory tests in predicting the hemisphere of temporal lobe seizures onset [10]. Third, in a single test, it provides a variety of memory components such as immediate memory, delayed memory, recall, recognition, and types of error in memory performance (pp. 357-358) [11].

Since the invention of the RAVLT by Andre Rey in 1958, numerous kinds of research have been done on it or using it. According to the existing literature, several psychometric studies have been performed on its different versions in different countries and languages, such as Portugal [12], Czech [13], Ecuador [14], Venezuela [9], Brazil [15], Denmark [16], the Netherlands [17], Germany [3], Spanish [18], Greece [5], French [19] and Chinese [20]. Also, this test has been performed on different age groups [17, 21] and neurological diseases [7], psychiatric disorders [22], and healthy people [12]. There is currently rich research literature on it as a reliable and valid tool for measuring memory and learning performance [3, 23]. A comprehensive review of previous research found that this test was highly correlated with most validated memory tests, including the Wechsler Memory Test and the California Verbal Learning Test, and extensive evidence has supported its test-retest reliability in different age groups (pp. 796-801) [8].

Numerous studies have shown that performance in memory measurements can be affected by a variety of factors. In particular, some demographic variables such as age, gender, and education have been shown to have a strong effect on cognitive function in general and memory in particular [9, 24]. Schmidt (2004) in his comprehensive review of the RAVLT literature concluded that performance in this test is affected by these demographic variables, although this effect is more pronounced and consistent with age and years of education (p. 86) [25]. Altogether, in adults, two separate segments can be distinguished according to age: the differentiation between individuals aged 59-20 years is lower in terms of memory function in the RAVLT and is higher in ages 60-90 years [8]. A recent study of 4,428 cognitively unimpaired adults aged 30-91 years showed that, unlike previous studies [2, 8, 25], gender was also important in creating normative data for the RAVLT, and underestimating it can reduce the diagnostic accuracy of this test [26]. Overall, based on these results, it is suggested that these demographic variables be taken into account in preparing the norms of this test [2].

In Iran, little normative data has been collected for most neuropsychological measures, and Iranian researchers and clinicians often have to refer to normative data collected in other countries or cultures. However, using norms collected in other countries for various reasons, including different levels of difficulty of verbal stimuli and differences of intelligence or cognitive abilities in different parts of the world is often not a good solution to compensate for this shortcoming [16]. On the other hand, as far as we know, various neuropsychological tests have been developed in Iran, but they have not been widely used by Iranian clinicians and researchers. In such circumstances, translating or validating the widely used neuropsychological tests with robust psychometric properties and strong research literature in Persian and creating normative data for it is necessary.

The RAVLT has been translated twice separately in Iran and has been validated in two studies, the first on 250 cognitively unimpaired elderly individuals 69 to 80 years old [27] and the second on 90 normal individuals 18 to 50 years old [28]. Jafari and colleagues reported that the reliability of two Persian versions with an interval of 2 months showed a high correlation ($p < 001$). Also, its convergent validity with one of the subscales of the Wechsler Memory Scale was positive and significant [27]. In the second Iranian study, some measures of the RAVLT including the first and second trials, as well as total, immediate, and delayed recall scores, showed the best test-retest reliability [28]. Although the first study had a good sample size and recruited almost equally from both genders, it nevertheless focused on a limited age range and practically did not cover a long growth period. Although the original version of the RAVLT provides multiple scores, the above-mentioned study validated only a limited number of scores. The second study, despite taking into account more precise linguistic considerations in translating the test, analyzing derivative scores, and covering a relatively longer age range, nevertheless used a relatively small sample. In addition, the mean age of the study sample tended to be a young adult (29.75 ± 7.10) and did not accurately represent the population aged 20 to 50 years. Given the above, the present study aimed to (a) collect the normative data appropriate to the language and culture of Iran, (b) determine the effect of demographic variables on memory function, (c) cover a longer age range (ages 20 to 70), (d) have both genders equally present in the study sample, (e) recruit more samples than the previous two previous studies, and (f) unlike the previous Iranian studies [27, 28], almost all RAVLT scores are collected.

2. Materials and Methods

2.1. Data

The present study was conducted in 2017-2018 as part of the Iranian Brain Imaging Database (IBID) project in collaboration with and under the supervision of a group of international experts to prepare normative measures of typical brains for research and clinical purposes [29, 30]. In this project, in addition to functional and structural imaging, a set of cognitive, lifestyle, and mental health tests were performed, among which the RAVLT was one of the cognitive measures. The tests were performed by a trained cognitive psychologist. The order of the tests was the same for all participants, they were all performed on a single day. The study sample consisted of 300 normal individuals in the age range of 20 to 70 years, with an equal number of participants in each age decade (#60). Also, each age decade was divided equally between the genders. The sample of our study was generally highly-educated. More specifically, most of the participants in the present study had a diploma and a bachelor's or master's degree. However, the frequency of participants with under-diploma (6.6%) or doctoral (5.9%) education was lower. Therefore, according to many studies in the literature [12,13, 16], two levels of diploma/under-diploma and above-diploma were used to examine the effect of education level on memory and learning performance. In total, in addition to the two groups of diploma and doctoral education, a sum of 33.2% of participants had a diploma degree, and 54.2% had a bachelor's and master's degree. Independent and dependent variables, respectively, were age (classified by five decades including 20-30-year-olds, 31-40 year-olds, 41-50-year-olds, 51-60-year-olds, and 61-70-year-olds) and performance in the RAVLT (defined in terms of 10 scores on learning, recall, and recognition).

2.2. Procedure

Participants were recruited by advertising the research project on online social networks including

Instagram and Telegram .To exclude individuals with cognitive, medical, and mental health problems from the study, all participants were interviewed twice by a general practitioner and a trained cognitive psychologist. In addition, after entering participants in the study and gathering the data from them, if the obtained scores in cognitive and mental health tests were extreme outliers (> ±3.3 standard deviation) were excluded from the sample [29]. After cognitive, medical, and mental health screening, eligible individuals were invited to participate in the study. Part of the inclusion criteria was being in the age range of 20 to 70, fluent in Persian, and having the ability to read. Exclusion criteria were a history of neurological and/or psychiatric illness, a history of illicit drugs, a history of systemic disease, the current use of any medication that affects cognitive function, and visual or auditory impairments. Participation in the study was voluntary and written consent was received from the participants. The present study was approved by the ethics committee of the National Institute for Medical Research Development (NIMAD). (For more information on the IBID project, inclusion and exclusion criteria, and methods, see Batouli *et al*. [29]). It should be noted that due to (a) the existence of findings of the RAVLT robust reliability and validity in previous studies in Iran [27, 28], (b) the existence of multiple measures in the IBID project and the impossibility of performing other memory measures to assess its convergent validity [29], and finally (c) impossibility of re-implementing the RAVLT to measure the reliability of test-retest, in the present study, we decided not to take any other measures to re-evaluate its validity and reliability.

2.3. Measure: RAVLT

A one-trial version of the RAVLT was designed by Edouard Claparede (1907) in the early years of the twentieth century, and five decades later a recall five-trial version, followed by a recognition trial, was introduced by Andre Rey (1958) (p. 776) [8]. In the following years, some researchers made a few changes to it and created a more modern form [2, 25]. This test in its current form consists of three irrelevant word lists [2]. The first two lists (A and B, each containing 15 words) measure free recall, and the third list (containing 20 new words plus 30 words in A and B lists) measures recognition. Initially, list A is read to the subject in five consecutive trials, and they are asked to say in each trial any number of words that remain in their memory, regardless of the order in which they are presented. List B, which is designed to interfere with the recall of list A, is then read to them and they are asked to recall them regardless of the previous list. As soon as the recall of List B words is finished, without reading the words in list A, the examiner asks the subjects to recall them (short-delay recall). After 20 to 30 minutes of rest, the subjects are again asked to recall as many A-list words as possible (long-delay recall). In the end, the recognition list is also read to the subjects and they are asked to distinguish the words in list A from other words.

Several scores are obtained from the RAVLT on learning, recall and recognition, the most important of which are: First Trial Score (FTS; the number of words the subject recalls after the first presentation, as an index of immediate memory), Seventh Trial Score (STS; the number of words the subject recalls after the rest, as an index of delayed memory), Proactive Interference Score (PIS; the number of words the subjects recalls in the first trial minus the number of words they recall in list B, as an index of the degree to which old information prevents new information from being recalled), Retroactive Interference Score (RIS; the number of words the subject recalls in the fifth trial minus the number of words he /she recalls in the sixth trial, as an index of the degree to which new information prevents old information from being recalled), Forgetting Rate Score (FRS; the number of words the subjects recalls in the fifth trial minus the number of words the he/she recalls in the seventh trial, as an index of the extent of forgetting), Final Acquisition Learning Score (FALS; the maximum number of words recalled in five trials; the maximum score of 15, as an index of magnitude of learning), Total Learning Score (TLS; the total number of words recalled from first trial to fifth trial, as another index of learning; the maximum score of 75), Learning Over Trial Score (LOTS; the number of words recalled in the first trial is multiplied by 5 and then subtracted from TLS, as another index of learning), Net Positive Score (NPS; the total of correctly recognized words minus the total of incorrectly recognized words, as an index of recognition memory), and Recognition Over Recall Score (RORS; the total of correctly recognized words minus the number of words recalled in the seventh trial, as another index of recognition memory) [8, 25].

2.4. Statistical Analysis

Mean and standard deviation were used in the descriptive analysis of demographic data and the RAVLT performance. The Pearson correlation test and the Spearman correlation test were used to examine the associations between present variables (the Pearson correlation test for examining the association between age, gender, and the RAVLT measures, and the Spearman correlation test for examining the association of education with age, gender, and the RAVLT measures).

Independent-samples t-test was used to assess differences in performance between genders on the RAVLT measures. One-way and three-way Analysis of Variance (ANOVA) were used to compare the age groups in terms of gender and education categories and to evaluate the effect of each demographic factor on RAVLT scores, respectively. In addition, Tukey's post hoc test was used to examine whether different age groups differed significantly on RAVLT measures and education years. A *p* value below 0.05 was considered statistically significant.

3. Results

One-way ANOVA showed that males and females were not significantly acting differently in terms of age (F = 0/168, P > 0.5) and years of education (F = 2/06, P > 0.5). Table 1 shows the mean and standard deviations of age and education level of participants classified by five age groups.

Tukey's post hoc test was used to examine whether the different age groups differed significantly in terms of education. Tukey's test showed that 20-30 year olds differed significantly from other groups (P < 0.001) and, on average, had a higher education than all other groups. 31-40-year-olds, in addition to 20-30-year-olds, differed only from 61-70-year-olds (P < 0.01) and had higher education on average. 41-50-year-olds and 51-60-year-olds differed only from 20-30-year-olds (P < 0.0001). In the end, 61-70-year-olds differed from 20-30-year-olds (P < 0.001) and 31-40-year-olds (P < 0.01).

The Pearson correlation test was used to examine the association between age, gender, and RAVLT measures, and the Spearman correlation test was used to examine the association between education and other variables. As shown in Table 2, the correlation matrix between all study variables shows that all three variables of age, gender, and education had a significant correlation with most RAVLT scores. Among the three demographic variables, age had the strongest correlation with all RAVLT scores at the level of 0.01, except PIS. Its correlation with FTS, STS, FALS, TLS, LOTS, and NPS was negative, and with PIS, RIS, FRS, and RORS was positive, and it had the strongest correlation with TLS, NPS, FALS, and STS. Except with PIS, gender showed a significant correlation with the RAVLT scores, often at the level of 0.01. Its correlation with FALS was the strongest and was positive with most of the RAVLT scores. Spearman correlation coefficient showed that education in addition to age (-0.399) was correlated with FTS (0.346), STS (0.257), FALS (0.309), TLS (0.359), NPS (0.293), and RORS (-0.196). In other words, memory and learning performance improved as the years of education increased. Concerning education, the strongest correlation was found between it and TLS and FTS.

Three-way ANOVA showed that the effect of age was significant in all scores (FTS: F = 7.353, P < 0.001; STS: F = 14.734, P < 0.001; RIS: F = 2.479, P < 0.05; FRS: F = 4.171, P < 0.01; FALS: F = 17.091, P < 0.001; TLS: F = 18.737, P < 0.001; LOTS: F = 4.285, P < 0.01; NPS: F = 17.352, P < 0.001; RORS: F = 3.47, P < 0.01) except PIS (F = 0.567, P > 0.5). The effect of gender

Table 1. The means and standard deviations of age groups

Age groups	Age		Years of education	
	Mean	Standard deviation	Mean	Standard deviation
20-30-year-olds	25.26	2.9	16.98	1.87
31-40-year-olds	35.35	3.12	16.41	4.15
41-50-year-olds	45.64	3	14.69	3.22
51-60-year-olds	54.67	2.95	14.12	3.74
61-70-year-olds	66.03	4.06	12.95	3.39

Table 2. Correlation matrix between demographic variables and the Rey Auditory Verbal Learning Test (RAVLT) scores

	Age	Gender	Education	FTS	STS	PIS	RIS	FRS	FALS	TLS	LOTS	NPS	RORS
Age	1												
Gender	.024	1											
Education	-.399**	-.085	1										
FTS	-.341**	.135*	.346**	1									
STS	-.457**	.281**	.257**	.459**	1								
PIS	.068	-.002	.003	.461**	-.024	1							
RIS	.186**	-.138*	-.081	-.170**	-.487**	-.027	1						
FRS	.185**	-.192**	-.064	-.248**	-.685**	.008	.714**	1					
FALS	-.512**	.300**	.309**	.468**	.813**	-.009	-.199**	-.245**	1				
TLS	-.536**	.278**	.359**	.680**	.815**	.137*	-.261**	-.321**	.910**	1			
LOTS	-.238**	.158**	-.027	-.372**	.423**	-.487**	-.102	-.078	.525**	.357**	1		
NPS	-.510**	.122*	.293**	.359**	.713**	.008	-.383**	-.385**	.695**	.683**	.370**	1	
RORS	.259**	-.156**	-.196**	-.291**	-.722**	.076	.303**	.525**	-.535**	-.544**	-.296**	-.382**	1

**. Correlation is significant at the 0.01 level (2-tailed)

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

***Note*:** FTS: First Trial Score; STS: Seventh Trial Score; PIS: Proactive Interference Score; RIS: Retroactive Interference Score; FRS: Forgetting Rate Score; FALS: Final Acquisition Learning Score; TLS: Total Learning Score; LOTS: Learning Over Trial Score; NPS: Net Positive Score; RORS: Recognition Over Recall Score

was also statistically significant in all scores (FTS: $F = 4.225$, $P < 0.05$; STS: $F = 25.628$, $P < 0.001$; RIS: $F = 4.148$, $P < 0.05$; FRS: $F = 6.439$, $P < 0.05$; FALS: $F = 25.996$, $P < 0.001$; TLS: $F = 28.848$, $P < 0.001$; LOTS: $F = 7.857$, $P < 0.01$; NPS: $F = 6.191$, $P < 0.05$; RORS: $F = 5.803$, $P < 0.05$) except PIS ($F = 0.024$, $P > 0.5$). On the other hand, the effect of education on FTS ($F = 7.097$, $P < 0.01$), FALS ($F = 4.239$, $P < 0.05$), TLS ($F = 6.971$, $P < 0.01$), and NPS ($F = 4.045$, $P < 0.05$) was statistically significant. However, its effect on STS ($F = 1.521$, $P > 0.1$), PIS ($F = 0.172$, $P > 0.5$), RIS ($F = 0.003$, $P > 0.5$), FRS ($F = 0.21$, $P > 0.5$), LOTS ($F = 1.275$, $P > 0.1$), and RORS ($F = 0.121$, $P > 0.5$) was not statistically significant.

Tukey's post hoc test showed the following significant differences between age groups in RAVLT scores: (1) On FTS, 20-30 year olds differed from 41-50 year olds ($P < 0.05$) and 61-70 year olds ($P < 0.001$), 31-40 year olds from 61-70 year olds ($P < 0.001$), 41-50 year olds from 61-70 year olds ($P < 0.001$), and 51-60 year olds from 61-70 year olds ($P < 0.001$); (2) On STS, 20-30 year olds differed from all groups ($P < 0.001$) except 31-40 year olds ($P > 0.1$), 31-40 year olds from 61-70 year olds ($P < 0.001$), 41-50 year olds from 20-30 ($P < 0.001$) and 61-70 year olds ($P < 0.001$), and 51-60 year olds from 20-30 year olds ($P < 0.001$) and 61-70 year olds ($P < 0.001$); (3) On PIS and RIS, no significant differences were found between age groups; (4) On FRS, only 61-70 year olds differed from 20-30 year olds ($P < 0.01$), 31-40 year olds ($P < 0.05$), 41-50 year olds ($P < 0.01$), and 51-60 year olds ($P < 0.05$); (5) On FALS, 20-30 year olds and 31-40 year olds were not different but each differed from the other three groups ($P < 0.001$); 41-50 year olds differed from 20-30 year olds ($P < 0.001$), 31-40 year olds ($P < 0.05$), and 61-70 year olds ($P < 0.001$). 51-60 year olds and 70-61 year olds, in addition to the difference with 20-30 year olds and 31-40 year olds ($P < 0.001$), had a significant difference ($P < 0.01$); 51-60 year olds and 70-61 year olds, in addition to the difference with 20-30 year olds and 31-40 year olds ($P < 0.001$), had a significant difference ($P < 0.01$); And finally, 61-70 year olds differed from 50-41 year olds ($P < 0.001$); (6) On TLS, 20-30 year olds differed only from 41-50 year olds, 51-60 year olds, and 61-70 year olds ($P < 0.001$); 31-40 year olds differed from 41-50 year olds ($P < 0.05$), 51-60 year olds ($P < 0.001$), and 61-70 year olds ($P < 0.001$); In addition to the differences with the other three groups, 40-50 year olds differed from 61-70 year olds ($P < 0.001$); And apart from the difference with the other three groups, 51-60 year olds and 61-70 year olds differed from each other (P < 0.001); (7) On LOTS, 51-60 year olds differed from 20-30 year olds (P < 0.05) and 31-40 year olds (P < 0.05); 61-70 year olds also differed from 20-30 year olds (P < 0.05) and 31-40 year olds (P < 0.05); And finally 41-50 year olds differed not from any of the groups; (8) On NPS, 61-70 year olds differed from the three groups of 20-30, 31-40, and 41-50 year olds (P < 0.001) and 51-60 year olds (P < 0.001); 60-51 year olds, in addition to the difference with 61-70 year olds, also differed with 20-30 year olds and 31-40 year olds (P < 0.001); and 41-50 year olds differed from 20-30 year olds (P < 0.01) and 31-40 year olds (P < 0.05); (9) On RORS, 20-30 year olds differed from 41-50 year olds (P < 0.05), 51-60 year olds (P < 0.05), and 61-70 year olds (P < 0.001); There was no other significant difference between the other groups.

Regarding the interaction of age and gender, ANOVA showed that it had a significant effect only on PIS (F = 4.33, P < 0.01) and its effect on none of the other scores was statistically significant (FTS: F = 1.155, P > 0.1; STS: F = 1.274, P > 0.1; RIS: F = 1.119, P > 0.1; FRS: F = 1.145, P > 0.1; FALS: F = 0.458, P > 0.5; TLS: F = 1.153, P > 0.1; LOTS: F = 1.628, P > 0.1; NPS: F = 0.281, P > 0.5; RORS: F = 0.824, P > 0.5). The effect of age and education interaction on any of the RAVLT scores was not statistically significant (FTS: F = 1.516, P > 0.1; STS: F = 0.499, P > 0.5; PIS: F = 1.125, P > 0.1; RIS: F = 1.711, P > 0.1; FRS: F = 0.566, P > 0.5; FALS: F = 0.530, P > 0.5; TLS: F = 0.556, P > 0.5; LOTS: F = 0.605, P > 0.5; NPS: F = 0.093, P > 0.5; RORS: F = 0.6545, P > 0.5). In addition, the effect of gender and education interaction on any of the RAVLT scores was not statistically significant (FTS: F = 2.529, P > 0.1; STS: F = 0.566, P > 0.1; PIS: F = 0.246, P > 0.5; RIS: F = 0.151, P > 0.5; FRS: F = 0.091, P > 0.5; FALS: F = 0.377, P > 0.5; TLS: F = 0.216, P > 0.5; LOTS: F = 3.585, P > 0.1; NPS: F = 1.062, P > 0.1; RORS: F = 0.583, P > 0.1). The effect of the interaction of age, gender, and education on the RAVLT scores was not also statistically significant (FTS: F = 1.818, P > 0.1; STS: F = 1.315, P > 0.1; PIS: F = 2.028, P > 0.1; RIS: F = 0.27, P > 0.5; FRS: F = 0.669, P > 0.5; FALS: F = 0.174, P > 0.5; TLS: F = 0.629, P > 0.5; LOTS: F = 0752, P > 0.5; NPS: F = 0.856, P > 0.1; RORS: F = 0.811, P > 0.5).

Also, to further evaluate the memory and learning performance of the two genders, an independent-sample t-test was used to compare the differences among men and women in the RAVLT measures. As can be seen in Table 3, Levene's test showed that, except for STS, the variance of the other measures had significant equality. Also, the t-test showed that except for PIS, in the rest of the measures, there is a significant difference among the mean scores of men and women.

To provide normative data on memory and learning performance in RAVLT, Table 3 presents the mean and

Table 3. Means and standard deviations of RAVLT performance classified by age group

RAVLT scores	20-30-year-olds M (SD)	31-40-year-olds M (SD)	41-50-year-olds M (SD)	51-60-year-olds M (SD)	61-70-year-olds M (SD)
FTS	7.28 (1.38)	6.67 (1.98)	6.34 (1.84)	6.52 (2.08)	5.07 (1.65)
STS	11.49 (2.26)	10.71 (3.13)	9.69 (2.50)	9.46 (3.06)	7.22 (2.60)
PIS	.84 (1.93)	1.13 (2.07)	1.16 (2.11)	1.71 (2.17)	1.05 (1.93)
RIS	1.28 (1.81)	1.17 (1.65)	1.43 (1.76)	2.00 (2.27)	2.11 (1.99)
FRS	1.20 (1.63)	1.41 (2.00)	1.33 (1.85)	1.33 (2.36)	2.53 (1.95)
FALS	13.18 (1.38)	12.63 (1.98)	11.76 (1.65)	11.29 (1.92)	10.16 (1.91)
TLS	54.31 (5.89)	51.17 (9.10)	47.50 (7.42)	45.62 (8.55)	39.62 (8.08)
LOTS	17.93 (5.58)	17.84 (7.18)	15.69 (7.01)	13.96 (6.52)	14.20 (6.78)
NPS	13.15 (2.55)	12.87 (2.52)	11.03 (3.08)	10.15 (3.89)	7.45 (4.61)
RORS	2.41 (1.91)	3.19 (2.45)	3.67 (2.02)	3.67 (2.23)	4.27 (2.68)

***Note*:** M (SD): Mean (Standard Deviation); FTS: First Trial Score; STS: Seventh Trial Score; PIS: Proactive Interference Score; RIS: Retroactive Interference Score; FRS: Forgetting Rate Score; FALS: Final Acquisition Learning Score; TLS: Total Learning Score; LOTS: Learning Over Trial Score; NPS: Net Positive Score; RORS: Recognition Over Recall Score standard deviation of 10 RAVLT scores by five age groups of healthy participants. Due to the significant association between the RAVLT performance and variables of gender and education years in the present study, the mean and standard deviation of 10 RAVLT scores classified by gender (Table 4) and education years (Table 5) in the five age groups is shown.

4. Discussion

As far as we know from the extensive search in academic research databases, there are limited normative data about well-documented neuropsychological tests in Iran. Considering this issue, our study aimed at generating normative data for the RAVLT, in a wide age range (20 to 70 years) and the normal population. Our study showed that all three variables of age, gender, and education had a significant correlation with most RAVLT scores. Among the three demographic variables, age had the strongest correlation with all RAVLT scores. On the other hand, the results of ANOVA showed that the effect of age and gender was statistically significant in all RAVLT scores except PIS. However, the effect of education was limited to four memory and learning measures of the RAVLT and no significant effect was observed in the other six measures. Also, the t-test showed a significant difference between the scores of both genders in most of the RAVLT measures. Taken together, these results suggest that demographic variables, including age, gender, and education, affect memory and learning performance, and that it is essential to generate normative data for clinical or research use.

Our finding showed that the measures of memory and learning performance in the RAVLT are affected as people age, which is consistent with the findings of many studies of research literature [13-15, 31, 32]. In

Table 4. Means and standard deviations of RAVLT performance classified by age group and gender

RAVLT scores	20-30-year-olds M (SD)		31-40-year-olds M (SD)		41-50-year-olds M (SD)		51-60-year-olds M (SD)		61-70-year-olds M (SD)	
	M	F	M	F	M	F	M	F	M	F
FTS	7.00 (1.44)	7.55 (1.29)	6.30 (2.00)	7.00 (1.94)	6.35 (1.09)	6.34 (2.29)	5.86 (2.22)	7.04 (1.85)	4.88 (1.88)	5.24 (1.43)
STS	10.70 (2.41)	12.26 (1.84)	9.33 (3.14)	11.97 (2.57)	9.08 (2.54)	10.19 (2.39)	9.05 (3.50)	9.78 (2.69)	5.81 (2.33)	8.48 (2.16)
PIS	1.00 (2.35)	.68 (1.45)	1.43 (2.25)	.85 (1.87)	1.31 (1.67)	1.03 (2.43)	.52 (1.78)	2.63 (2.02)	1.38 (2.14)	.76 (1.70)
RIS	1.67 (1.88)	.90 (1.68)	1.43 (1.74)	.94 (1.56)	1.50 (2.02)	1.38 (1.54)	2.00 (2.05)	2.00 (2.46)	2.85 (1.91)	1.45 (1.84)
FRS	1.43 (1.83)	.97 (1.40)	2.23 (2.11)	.67 (1.59)	1.58 (2.18)	1.13 (1.54)	1.24 (2.28)	1.41 (2.47)	3.23 (1.68)	1.90 (1.99)
FALS	12.67 (1.47)	13.68 (1.11)	11.87 (1.91)	13.33 (1.80)	11.31 (1.54)	12.12 (1.66)	10.52 (2.04)	11.89 (1.62)	9.19 (1.72)	11.03 (1.66)
TLS	52.03 (5.72)	56.52 (5.24)	48.07 (8.48)	54.00 (8.82)	46.12 (6.00)	48.63 (8.33)	41.71 (8.40)	48.67 (7.47)	35.69 (7.84)	43.14 (6.62)
LOTS	17.07 (6.12)	18.77 (4.94)	16.57 (5.90)	19.00 (8.08)	14.38 (5.54)	16.75 (7.94)	14.33 (5.80)	13.67 (7.13)	11.35 (5.61)	16.76 (6.80)
NPS	12.40 (3.18)	13.87 (1.45)	12.13 (2.56)	13.55 (2.33)	10.96 (3.10)	11.09 (3.11)	9.76 (3.87)	10.44 (3.95)	6.69 (3.90)	8.14 (5.13)
RORS	2.77 (2.10)	2.06 (1.67)	4.03 (2.47)	2.42 (2.21)	3.77 (2.39)	3.59 (1.70)	3.67 (2.11)	3.67 (2.37)	4.92 (2.53)	3.69 (2.71)

Note: M: Male; F: Female; M (SD): Mean (Standard Deviation); FTS: First Trial Score; STS: Seventh Trial Score; PIS: Proactive Interference Score; RIS: Retroactive Interference Score; FRS: Forgetting Rate Score; FALS: Final Acquisition Learning Score; TLS: Total Learning Score; LOTS: Learning Over Trial Score; NPS: Net Positive Score; RORS: Recognition Over Recall Score

Table 5. Means and standard deviations of RAVLT performance classified by age group and years of education

RAVLT scores	20-30-year-olds M (SD)		31-40-year-olds M (SD)		41-50-year-olds M (SD)		51-60-year-olds M (SD)		61-70-year-olds M (SD)	
	<=12 years	>12 years	<=12 years	>12 years	<=12 years	>12 years	<=12 years	>12 years	<=12 years	>12 years
FTS	8.00 (.00)	7.24 (1.41)	5.50 (1.93)	7.38 (1.664)	5.69 (1.26)	6.87 (2.07)	6.37 (2.19)	6.71 (1.98)	4.77 (1.47)	5.60 (1.85)
STS	10.67 (2.89)	11.53 (2.25)	9.71 (3.84)	11.33 (2.45)	9.27 (2.43)	10.03 (2.55)	9.19 (2.84)	9.81 (3.36)	7.49 (2.39)	6.75 (2.94)
PIS	1.67 (1.15)	.79 (1.96)	.63 (1.58)	1.44 (2.28)	.88 (2.42)	1.37 (1.83)	1.74 (2.07)	1.67 (2.35)	1.20 (1.89)	.80 (2.01)
RIS	.67 (1.15)	1.31 (1.84)	1.46 (1.77)	1.00 (1.57)	1.15 (2.09)	1.66 (1.43)	2.48 (2.36)	1.38 (2.04)	1.89 (1.76)	2.50 (2.33)
FRS	.67 (1.15)	1.22 (1.65)	1.88 (2.40)	1.13 (1.69)	1.12 (2.27)	1.50 (1.44)	1.52 (2.59)	1.10 (2.07)	2.26 (1.75)	3.00 (2.22)
FALS	13.00 (1.73)	13.19 (1.38)	11.87 (2.47)	13.10 (1.45)	11.31 (1.74)	12.12 (1.50)	11.19 (1.88)	11.43 (2.01)	10.20 (2.07)	10.10 (1.65)
TLS	54.00 (7.55)	54.33 (5.87)	47.17 (10.73)	53.64 (6.99)	45.35 (6.89)	49.25 (7.49)	44.67 (7.83)	46.86 (9.44)	39.09 (8.15)	40.55 (8.07)
LOTS	14.00 (7.55)	18.14 (5.47)	19.67 (7.69)	16.72 (6.70)	16.88 (7.79)	14.72 (6.27)	14.67 (6.78)	13.05 (6.22)	15.14 (6.59)	12.55 (6.97)
NPS	11.67 (2.08)	13.22 (2.56)	11.96 (3.03)	13.44 (2.00)	10.77 (2.63)	11.25 (3.44)	9.59 (4.13)	10.86 (3.54)	7.14 (5.16)	8.00 (3.49)
RORS	1.33 (1.15)	2.47 (1.93)	3.96 (2.97)	2.72 (1.97)	3.81 (1.96)	3.56 (2.09)	3.96 (2.43)	3.29 (1.95)	4.29 (2.61)	4.25 (2.86)

***Note*:** M (SD): Mean (Standard Deviation); FTS: First Trial Score; STS: Seventh Trial Score; PIS: Proactive Interference Score; RIS: Retroactive Interference Score; FRS: Forgetting Rate Score; FALS: Final Acquisition Learning Score; TLS: Total Learning Score; LOTS: Learning Over Trial Score; NPS: Net Positive Score; RORS: Recognition Over Recall Score

another Iranian study, a significant effect of age was reported on most measures of the RAVLT [27]. The effect of age on the RAVLT measures is often inverse; In other words, as people age, the RAVLT scores decrease. Also, the pattern of results indicates that scores in most RAVLT measures decrease linearly with age. This decline was observed in both immediate recall, delayed learning, and recognition. This pattern of results has been documented in many other studies of the RAVLT [14, 9, 31]. The finding related to age differences in memory function is a global phenomenon. A recent study that collected normative data on episodic memory in a sample of 42,116 people from nine countries in Africa, Asia, Europe, and Latin America found that the same age had a significant effect on memory function, although the effect of gender was inconsistent [33]. Based on the results of this study, the effect of age was observed in all RAVLT measures except for the PIS. In addition to age, this finding was also observed in relation to gender. This finding indicates that PIS acts independently of demographic factors compared to retroactive interference. This pattern of results may be observed in the validation of the RAVLT in normal populations [8].

Memory performance in the RAVLT is assessed by two measures: free recall and recognition. Overall, age differences in free recall in the RAVLT are more supported by the research literature than by recognition [34]. Our study showed that one of the recognition measures in RAVLT decreases with age. This finding is in line with the findings of a recent meta-analysis of the association between aging and cognitive memory, which showed that recognition, like free recall, declines with increasing age. According to the findings of this meta-analysis, older adults are generally weaker than younger adults in recognition memory, distinguishing new items from old ones, and are more likely to judge items as old [35].

However, another meta-analysis concluded that age differences for free recall are greater than for recognition [36].

Episodic memory is believed to be a sensitive system and begins to decline relatively early in adulthood [37]. So far, various hypotheses have been given to explain the psychological mechanism of this decline in episodic memory function. According to one explanation, the associative deficit hypothesis, the ability to form new connections between stimuli or events decreases with age, and this impairs memory consolidation [38]. Another hypothesis, the irrelevant information deficit hypothesis, states that adults can hardly inhibit unrelated information in the presence of distraction as they age, resulting in difficulty in encoding [38].

The finding of the present study that women outperform many RAVLT measures more than men is consistent with the findings of many previous studies [27, 31, 39]. This finding is not specific to the RAVLT, and women often perform better on verbal tests than men. Numerous studies have shown that women outperform memory and learning measures more than men [40, 41]. Also, this advantage is not limited to older ages and this advantage is observed throughout life [42, 43]. In the Mayo normative studies, it was found that gender beyond age was able to explain a significant proportion of the variance in RAVLT performance [26]. A recent comprehensive meta-analysis of 617 studies (with a sample of 1,233,921 subjects) supported the female advantage in episodic memory. It seems that the female advantage in episodic memory depends to some extent on the type of stimuli and events. In this meta-analysis, it was found that the female advantage is for more verbal stimuli, although there is also the male advantage for more spatial stimuli [44].

Despite the recommendation of some researchers to report gender-related normative data separately for the RAVLT [32], some early studies did not report such normative data on memory and learning performance [8]. However, subsequent studies have gradually recognized the importance of the effect of gender on memory and learning, and have provided related normative data [31, 26]. Indeed, gender differences in learning and memory performance are not merely an academic issue and can be clinically significant [39], as women may be less likely to receive a diagnosis of memory impairment because of this verbal memory advantage if clinicians do not use gender-related norms [26, 45]. Some studies have shown that gender-related normative data for the RAVLT can increase the classification accuracy of patients with amnestic Mild Cognitive Impairment (MCI) [46]. According to a study by Sundermann and colleagues, Gender-related normative data can underestimate MCI in 10% of women and overestimate it in 10% of men [47].

Although the true cause or causes of the effect of gender on memory (the female advantage) are not yet known, there has been some speculation about it. This female advantage is probably not due to the superiority of general verbal skills or verbal intelligence abilities in women. Some studies have reported this difference specifically for episodic memory [39]. One explanation refers to the distinct methods of men and women in decoding and learning verbal information. According to this explanation, information organization in women is mainly semantic and in men serial, and this creates significant differences in memory and learning performance [39]. Another explanation states that this gender difference in learning and memory is due to the encoding of details of events in women and the encoding of summary of events in men [48]. It should be noted that the explanation of the female advantage has not only been done from a psychological perspective but also biological differences between the genders have been considered involved. The most important biological factor is the effects of estrogen on the performance of verbal episode memory [49]. Another important finding is that gender differences are not only observed with age but also manifest themselves during the developmental period [39].

Another finding of our study was the effect of education on the RAVLT scores. Although this effect was more limited than the effects of age and gender, it nevertheless suggests that some measures of memory and learning are influenced by education level and it is necessary to provide appropriate normative data. One of the possible reasons that can be mentioned for the pattern of results related to the effect of education in the present study is that the sample of our study, although there were major educational differences, was generally highly-educated. This may reduce the potential differences of our sample on memory and learning performance. In addition to the overrepresentation of participants with high education, the age groups showed a significant difference in terms of education. In other words, younger groups had more years of education than older groups, and this may have affected the pattern of results obtained regarding the effect of education on performance in the RAVLT measures.

The relationship between education and memory/ learning is not specific to younger ages and it is also seen in old age. In a study of 23,641 people in Europe with an average age of 70, it was found that in addition to age, which had an inverse correlation with memory performance, education had a significant positive correlation [50]. In the study of Jafari and colleagues, the level of education had a significant effect on all parts of the RAVLT [27]. However, a Danish study found that the effect of education was on the first five trials of the RAVLT but had no effect on other scores [16]. On the other hand, a recent meta-analysis reviewing longitudinal studies of the relationship between education and alterations in six cognitive functions, including episodic memory, concluded that although education is an important factor in adulthood, the findings of their relationship are still inconsistent [51].

One obvious benefit of providing normative data of this type is that it can be used to interpret individual scores. Since most neuropsychological tests are standardized on normal populations, reporting the mean and standard deviation of the normative sample often allows comparisons to be made between individual scores and normative scores. According to the commonly recommended rule in interpreting neuropsychological tests, 1.5 standard deviations below the normative mean indicate that a person's performance was worse than approximately 93.3% of the normative sample. According to this rule, -1.5, -1.7, -2.0, -2.5, and -3.0 standard deviations below the normative mean will indicate mild, mild to moderate, moderate, severe, and very severe levels of impairment, respectively [52] .

4.1. Limitations and Future Research

The present study had some limitations. The first limitation was that the participants were on average highly educated, and this may reduce the generalizability of its findings. It is recommended that in the following studies, participants who are in the lower range of education be selected. The second limitation relates to the possible bias in sampling or self-reports of the memory and learning abilities. In future studies, it is recommended to use randomized samples or behavioral and objective tasks to measure memory and learning performance. Another limitation was that the present research is a cross-sectional study. The importance of research design in memory research is because according to the research literature, episodic memory decline is reported in cross-sectional studies more than in longitudinal studies [37]. Therefore, it is recommended to conduct longitudinal studies on the effect of age on memory and learning performance, especially using the RAVLT test.

5. Conclusion

The present study tried to provide normative data for one of the most widely used tests of verbal memory and learning in Iran and to assess the effect of demographic variables of age, gender, and education on its various measures. Our findings show that overall, with increasing age, verbal memory, and learning performance decline, women outperform men in its measures, and education affects some indicators of learning and memory. These findings emphasize the importance of using age-, gender- and education-related normative data in clinical, educational, and research settings.

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