ORIGINAL ARTICLE

Comparison of the Rey Auditory Verbal Learning Test (RAVLT) and Digit Test among Typically Achieving and Gifted Students

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Abstract

Objective

In this study, different kinds of memory were evaluated using Rey Auditory Verbal Learning (RAVLT) test and were compared between two groups of typical and gifted students using Digit Span test. Finally, we determined if working memory interfered with scores in different Rey stages or not.

Material & Methods

This study was conducted in Tehran City, Iran in 2013. Scores on RAVLT were compared with WISC- R digit span results in a sample of 148 male students aged 12-14 yr old divided into two groups including 75 students in typical school (IQ ranging between 90 and 110) and 73 gifted students (IQs ranging between 110 and 130).

Results

Gifted students obtained higher scores than typical students in both Forward Digit Span (FDS) and Backward Digit Span (BDS) and all 9 stages of RAVLT comparing with typical students (P<0.001). There was no significant difference between different ages (P> 0.05). The 14 yr old students in both groups had the highest score. There was a high correlation between FDS and the first stage of RAVLT as well as high correlation between BDS and seventh stage of RAVLT.

Conclusion

Intelligence has effect on better score of memory and gifted subjects had better scores in memory tests, although the intelligence effect in learning was quantitative rather than qualitative. RAVLT is a comprehensive test, which evaluates short-term memory, working memory and long-term memory and besides Digit span test provides precious information about memory and learning of subjects in order to program different student's educational schedules.

Keywords: Learning; Memory; Intelligence; Rey auditory verbal learning test; Digit Span

Introduction

Learning, a change in behavior due to experience, is a key factor in language development (1). Some factors such as "intelligence" and "memory" have essential effects on learning but how they affect learning is controversial (2, 3). One unavoidable fact is that mental abilities such as intelligence and memory cannot be considered separately because they are intertwined and both of them can lead subjects to improve their academic achievement. Intelligence is a key factor for learning and in spite of the long history of studies (4, 5), there is no specific definition for it.

One common accepted definition described by Wechsler (4) is: "Intelligence is an individual's ability to adapt and constructively solve problems in the environment". Indexes in Wechsler definition are as follows: Verbal Comprehension, Perceptual Reasoning, Working Memory (WM) and Processing Speed. According to Wechsler, WM as will be described below is an important component of assessing intelligence.
On the other hand, memory is a relatively permanent recording of an experience, fundamental for learning. It is classified in several forms, e.g., based on the type of information recalled, it can be defined as verbal and nonverbal. Discrimination of these two types of memory has special importance, because they involve different brain hemispheres.
In another categorization, memory is also divided into three types, including sensory memory, short-term memory and long-term memory. Short-term memory includes WM and determining boundaries between short-term memory and WM is controversial. WM is the ability to maintain and process information simultaneously during the performance of a cognitive task. It is considered a central construction in cognitive psychology, besides plays an important role in scholastic activities like language comprehension (6). WM capacity is a predictor of performance on other cognitive tasks such as reading comprehension, reasoning, problem solving and executive function such as scheduling, organizing, strategizing, paying attention to and remembering details in daily life (6-8).
Considering the relationship between general cognitive development and proper learning process, several studies in recent years target many aspects of learning and try to find new factors and approaches effective in promoting individual learning (9-12). Both intelligence and memory have WM in common, so interaction and communication between WM and intelligence is implicated in learning. The role of intelligence as a mental ability which supports many functions of the brain in learning and academic achievement has been debated (13, 14). Intelligence is considered as the most important factor of success, but is not the only factor in success (2, 13, 15-17). On one hand the role of intelligence is overshadowed by other cognitive factors such as WM, attention, and motivation, e.g., in some studies WM is determined as an underlying factor for learning disabilities (18, 19). On the other hand, WM capacity can be improved and appropriate exercises can help increasing capacity and improving the academic situation. For example, WM training can effectively improve ADHD and other cognition and Learning Disabilities (7, 8).
WM digit span is a part of Wechsler WM test (IVth version) and includes two sub tests, Forward Digit Span (FDS) and Backward Digit Span (BDS). An easy test provides important information when evaluating working memory. One of the most popular tests used in evaluating mental abilities in Iran is the 4th edition of Wechsler intelligence test. Thereby most of the schools in Iran administer this test when registering students and record the IQ in their medical history. Subsequently students are classified into five different groups according to the Wechsler classification.
In memory evaluation, an important point is that different stimulus used varies according to the type of memory being measured. Due to the different types of memory, the form of stimulus used to evaluate the content and manner of presentation and the responses vary and can involve different parts of the brain. Rey Auditory Verbal Learning Test (RAVLT) (20) is a well-recognized measure of a person's ability to encode, combine, store and recover verbal information in different stages of immediate memory. Therefore, the effect of interference stimulus, delayed memory and recognition are evaluated with this assessment tool. It is translated and validated in multiple languages, including Finnish, Spanish, Hebrew, Chinese, German, Dutch, Greek and Persian (21). While the RAVLT in different articles among different population has been a sensitive test of verbal learning and memory, it was the tool to evaluate relationship between memory aspects and learning. It has been a sensitive instrument to measure the impact of intelligence in the learning process.
In the current study, considering students of two typical and gifted schools, evaluation of different stages of RAVLT and Digit Span was conducted to compare aspects of memory between two student groups and particularly highlight the role of WM in RAVLT stages results.

Materials & Methods

Participants

The current cross sectional comparing study by non-probability sampling, was performed on 148 male students aged 12-14 yr old divided into two groups to include 75 students in typical school with mean age± SD of 13.01 and 0.81 yr and 73 gifted students with mean age± SD as13 and 0.81 yr. This study was conducted over 4 months from February to May 2013 in Tehran, Iran

All participants were tested using the Wechsler test (based on a valid Persian version) and the results were recorded in the student's health records. The subjects were categorized into two groups using the Wechsler intelligence scale classification. The gifted students included 73 students with IQs ranging between 110 and 130. The typical students included 75 students with IQs ranging between 90 and 110 (Table 1).

All students had normal hearing, were right handed dominant, and were monolingual in the Persian language. None of the subjects had a history of recurrent ear infections, head trauma, epilepsy, use of psychotropic medications, or neuropsychological disease. After subjects were divided into groups according to the intelligence scale found in the student's health records, the Persian version of Digit Span and Rey Auditory Verbal Learning Test were performed.

This study was approved by the Ethics Committee of Shahid Beheshti University, Tehran, Iran. We utilized the index of central tendency of mean and standard deviation of the distribution to evaluate the relationship between IQ scale and the separate Rey stages using the Spearman correlation test (bidirectional). In addition, data analysis was done using statistical software SPSS 18th version (Chicago, IL, USA) in significance level of 0.05.

Materials/Procedures

Digit Span;

The digit span procedure was derived from the standardized administration of the digits forward and backward subtests of the digit span test, as described in the Wechsler Intelligence Scale for Children–Forth Edition (WISC-IV) manual. Memory performance was assessed by the experimenter reading aloud series of digits at the rate of one item per second, and the child was instructed to repeat them back immediately in the correct sequence without any discrete recall cue. Three trials were given at each list length, beginning with a list length of two items. If recall was correct on two or more of the three trials for each list length, the sequence length was increased by one item. In each span task, the change in the number of elements was signaled by the experimenter telling the child, "Now let's try it with "n" numbers" (a cue that potentially warned the child about the list length and signaled the end of a presented sequence of items). If the child failed more than one list in a list length, testing was discontinued.

Rey auditory-verbal learning test

Using the RAVL Test (a 15 noun-word list (list A) was read to the participants with a presentation rate of one word per second. The Persian version of the word list was the same as used in a previous study (21). After presentation of the 15 words the persons were requested to recall as many words as possible (participants were instructed that the order was not important). The procedure was repeated 5 times, and after each trial recall was recorded.

The five recall trials were summed into one score (trial 1–5). After 5 presentations of list A, an interference-list of 15 other nouns (list B) were read to the participants and they were asked to recall as many words as possible. Immediately after recall of list B, the participants were again asked to recall list A (short recall, A6). Delayed recall of list A was measured 30 min after the immediate recall (long recall, A7) (with no other verbal memory tests administered in this interval). Directly after long recall, A7, a recognition trial of 30 words containing the 15 words from list A and 15 distracter items were applied (10 distracter words were semantically or phonetically similar to the target words). Different versions of measuring recognition on RAVLT exist; some using 50 words, others just 30 words (22). The total scores for (trial 1–5), short recall (A6), long recall (A7) and the number of correct responses in the recognition test were analyzed.

Procedure

First, all participants completed the case history and then the examiner explained the details of the following tests. The FDS test and BDS were administered sequentially to subjects with intervals of 15 after the RAVLT was administered based on standard instruction.

Results

Participants were divided into two groups of typical and gifted students based on Wechsler classification. A Chi-square test was performed and a significant difference was found between different IQs among students in the two groups, X2(4) =116, P=0.000. While there was no significant difference between different ages. X2 (2) =0.013 ، P=0.994.

The mean, standard deviation score, number and minimum- maximum scores of students for the Digit span and first 5 stages of RAVLT are shown in Table 1. Accordingly, FDS had a greater mean score comparing with BDS and had close score to the first stage of Rey (Table 1).

The first five stages were five repetitions of the same list of words referred to as a learning curve. Figure 1 illustrates the growth in scores from the first stage up to the fifth.

There is also detailed information of the last four stages in the Table 2. Moreover, the Mean score for all tests is shown in Figure 2. As it can be seen in the Figure 1 and 2 and Tables 1 and 2 gifted students obtained higher scores than typical students in both FDS and BDS and all 9 stages of RAVLT comparing with typical students and this difference was shown significant by t-test (P<0.001). While one way ANOVA analysis did not show significant difference between different ages (P> 0.05) the 14 yr old students in both groups had the highest score.

To evaluate difference in performance of RAVLT stages, Repeated Measurement ANOVA was taken and the difference between the stages was significant (P< 0.001) and these stages were different one by one. This difference of group performance was significant at approximately the same level across test conditions. The gifted students had higher scores compared with typical students (P< 0.001). Figure 2 also shows that the Rey 6 test was substantially lower than adjacent conditions and the difference was significant (P< 0.001). The ninth stage had the highest score. This stage involves recognition of the repeated list words containing 50 written words.

Table 3 shows the two-tailed Spearman correlations between all subject's IQ and results of the FDS, BDS, and stages of the Rey tests. There was a significant positive correlation among these measures with (P<0001). Results of Pearson Product Moment correlations across subjects are shown in Table 4. There was a high correlation between FDS and the first stage of RAVLT and also the high correlation between BDS and seventh stage of RAVLT. Furthermore since the mean scores for all groups are parallel, there was not separate correlations shown for the gifted and the typical subjects and the subjects are all grouped

Table 1. Mean and SD of Digit Span and first five stages of RAVL tests in two groups of typical and gifted students in different ages.

Group	age (yr)		FDS	BDS	REY1	REY2	REY3	REY4	REY5
Gifted	12	Mean	6.4167	4.6667	6.6667	9.2917	10.9583	11.9583	12.6250
		N	24	24	24	24	24	24	24
		SD	1.10007	0.86811	1.46456	1.87615	1.48848	1.60106	1.81330
		Min -Max	5-8	3-6	4-9	6-13	8-14	9-15	9-15
	13	Mean	6.5600	4.4400	6.6800	8.4800	10.3200	11.4000	12.2800
		N	25	25	25	25	25	25	25
		SD	1.12101	0.96090	1.700984-	1.93907	1.70098	1.68325	1.81475
		Min-Max	4-8	2-6	9	5-11	7-13	8-14	8-15
	14	Mean	7.1667	5.1667	7.4167	9.1250	11.0000	12.3333	12.7500
		N	24	24	24	24	24	24	24
		SD	1.12932	1.00722	1.50121	1.65010	1.50362	1.43456	1.77544
		Min -Max	5-9	3-7	4-10	6-12	8-13	9-15	10-15
	Total	Mean	6.7123	4.7534	6.9178	8.9589	10.7534	11.8904	12.5479
		N	73	73	73	73	73	73	73
		SD	1.14842	0.98292	1.57897	1.83665	1.57921	1.60348	1.78762
		Min -Max	4-9	2-7	4-10	5-13	7-14	8-15	8-15
Typical	12	Mean	5.2500	3.8750	5.4583	7.5833	9.2083	10.2917	10.5417
		N	24	24	24	24	24	24	24
		SD	0.98907	0.79741	1.47381	1.81579	1.66757	1.54580	2.06375
		Min -Max	4-8	3-6	3-8	4-13	6-12	7-13	6-14
	13	Mean	5.4615	3.5000	5.8846	7.6538	9.2308	10.5385	11.1538
		N	26	26	26	26	26	26	26
		SD	1.24035	.0.86023	1.24344	1.49512	1.60767	1.60576	1.73649
		Min -Max	4-8	2-5	3-8	5-11	7-13	7-13	8-14
	14	Mean	5.1200	3.6000	6.2000	8.3200	9.7200	10.7600	11.1600
		N	25	25	25	25	25	25	25
		SD	1.05357	0.70711	0.95743	1.54704	1.48661	1.42244	1.43411
		Min -Max	3-7	2-5	4-8	5-11	6-12	6-12	7-13
	Total	Mean	5.2800	3.6533	5.8533	7.8533	9.3867	10.5333	10.9600
		N	75	75	75	75	75	75	75
		SD	1.09742	0.79684	1.25949	1.63321	1.58450	1.51865	1.75869
		Min -Max	3-8	2-6	3-8	4-13	6-13	6-13	6-14

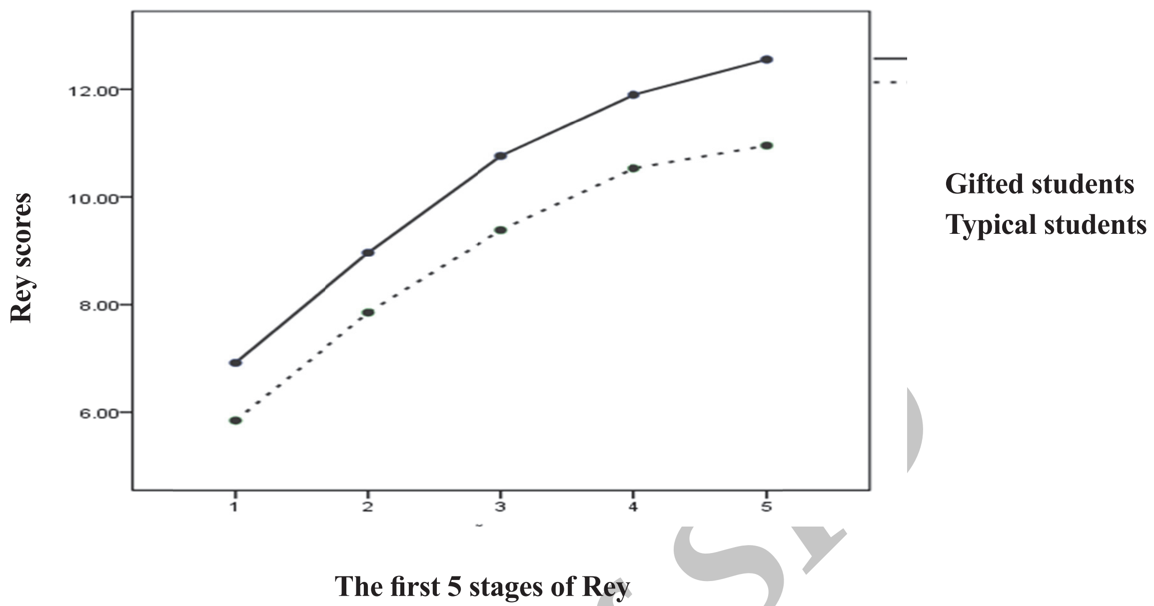

Fig 1. Comparing the results of first 5 stages of RAVLT among Typical and Gifted students

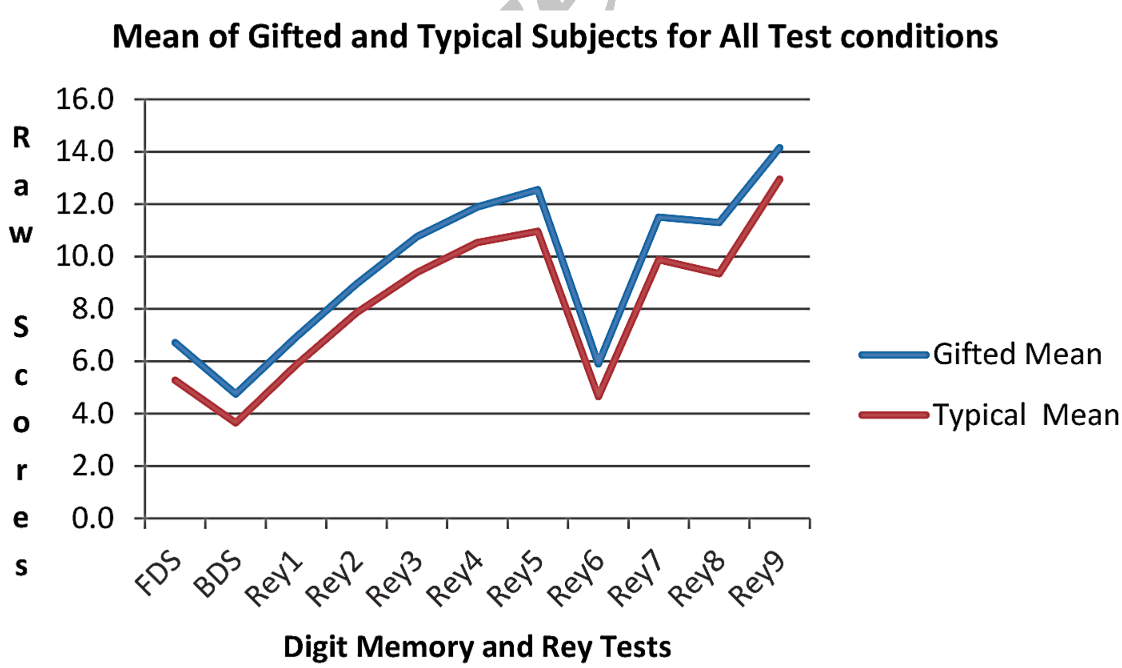

Fig 2. Comparison between Digit scores (FDS & BDS) and Rey stages scores (Rey 1 to Rey 9) among typical students and gifted students.

Table 2. Mean and SD of last 4 stages of RAVL tests in two groups of typical and gifted students in different ages.

Group	age (yr)		REY6	REY7	REY8	REY9
Gifted	12	Mean	5.8750	11.00	10.5833	14.1250
		N	24	24	24	24
		SD	1.75233	2.06419	2.24416	1.07592
		Min -Max	3-11	7-14	6-14	11-15
	13	Mean	5.8800	11.1600	11.3200	14.2000
		N	25	25	25	25
		SD	1.92180	2.19241	1.70098	0.76376
		Min -Max	3-9	7-15	8-14	13-15
	14	Mean	5.9583	12.3750	12.0000	14.1250
		N	24	24	24	24
		SD	1.19707	1.90680	2.18692	1.19100
		Min -Max	4-8	8-15	7-15	11-15
	Total	Mean	5.9041	11.5068	11.3014	14.1507
		N	73	73	73	73
		SD	1.63439	2.12213	2.10611	1.00928
		Min -Max	3-11	7-15	6-15	11-15
Typical	12	Mean	4.3333	9.8333	9.6250	12.9583
		N	24	24	24	24
		SD	1.12932	1.92617	1.81330	1.60106
		Min -Max	2-6	6-14	6-13	8-15
	13	Mean	4.9615	9.6154	8.7308	12.8462
		N	26	26	26	26
		SD	1.45549	1.69887	1.82335	1.71330
		Min -Max	2-7	6-12	5-12	7-15
	14	Mean	4.6400	10.2000	9.7200	13.0400
		N	25	25	25	25
		SD	1.28712	1.93649	1.62070	1.20692
		Min -Max	2-7	4-13	6-12	11-15
	Total	Mean	4.6533	9.8800	9.3467	12.9467
		N	75	75	75	75
		SD	1.30998	1.84508	1.78956	1.50578
		Min -Max	2-7	4-14	5-13	7-15

Table 3. Two-tailed spearman correlations between the subject's IQ and results of the FDS, BDS, and stages of the REY tests.

	FDS	BDS	Rey1	Rey2	Rey3	Rey4	Rey5	Rey6	Rey7	Rey8	Rey9
IQ Correlation Coefficient	0.630	0.596	0.472	0.478	0.527	0.533	0.561	0.458	0.495	0.559	0.595
Sig	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	148	148	148	148	148	148	148	148	148	148	148

Table 4. Results of Pearson Product Moment Correlations between Digit Span & RAVLT Stages for all subjects.

	BDS	Rey1	Rey2	Rey3	Rey4	Rey5	Rey6	Rey7	Rey8	Rey9
FDS	0.759	0.636	0.551	0.610	0.586	0.542	0.538	0.639	0.605	0.481
Sig	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BDS		0.552	0.473	0.552	0.521	0.494	0.499	0.601	0.557	0.419
Sig		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rey1			0.771	0.711	0.669	0.540	0.498	0.680	0.641	0.518
Sig			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rey2				0.765	0.765	0.655	0.486	0.664	0.582	0.619
Sig				0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rey3					0.807	0.699	0.594	0.728	0.643	0.624
Sig					0.000	0.000	0.000	0.000	0.000	0.000
Rey4						0.795	0.565	0.753	0.729	0.653
Sig						0.000	0.000	0.000	0.000	0.000
Rey5							0.564	0.783	0.749	0.678
Sig							0.000	0.000	0.000	0.000
Rey6								0.497	0.405	0.415
Sig								0.000	0.000	0.000
Rey7									0.826	0.613
Sig									0.000	0.000
Rey8										0.598
Sig										0.000

Discussion

The current study evaluated digit memory of normal hearing gifted and typical adolescent students using a WM digit span test. Gifted students obtained higher scores in both FDS and BDS compared with typical students. Furthermore, the FDS score was higher than BDS in both groups. FDS and BDS are separately interpreted; FDS evaluates Short Term Memory (STM) and BDS because of more complicated mental processing evaluates WM.

There are several studies on the relationship between memory and intelligence conducted on adults but few of them studied this relationship among children and teenagers (15). In adults, WM was the closest concept to intelligence evaluated, in some of these studies, close relationship was seen between WM and intelligence (24). In a study, 200 children aged 6 to 16 yr old used the Digit Span test of Italian version of Wechsler test. Accordingly, WM was evaluated as fourth subscale of Wechsler test, this part itself has three subscales: 1) Digit span (FDS and BDS) 2) Letter Number Sequence (LNS) and 3) Arithmetic (AR). It was indicated that the tests, which need more brain challenges in comparison with the tests, and need less challenges have the higher relationship with intelligence (15). In other studies, also the relation between different intelligence types and WM components was confirmed (8, 25-27)

WM has two essential and basic components; STS and non-storage components. Short term storage has the most important role in relation between intelligence and WM (28). On the other hand, there are some studies, which do not confirm the relation between intelligence and WM. For example, these two items as two separate and independent mental structures were reported (2, 7). Researchers found low to average correlation between intelligence and WM (29,30). Colom evaluated the effects of WM trainings on WM and intelligence, and indicated that those trains improved the WM but did not have effect on intelligence (28). The difference among these studies firstly can be attributed to the different WM tests and consequently different aspects of WM, which were evaluated. Indeed, Wechsler WM test is the best way to show that different aspects of WM have different relationship with intelligence (17). Secondly, it is due to the difference between the simple and complicated tasks, as the former is related to the simple storage capacity and the latter needs applying the cognitive control (17). Another study pointed out WM involving Central Executive System (CES) or when needed cognitive control, had the highest relation with intelligence (8). Based on Baddely binary model of WM and continuous model of Cornoldi, FDS ought to be separated from BDS and the other measurements of working memory. BDS especially in children needs more cognitive control and comparing with FDS, has more relation with intelligence (31). The probability that WM and STM have different functions or are independent and have unequal relation with intelligence has been debated among adults (16, 17, 30) and children (8, 26, 27, 31). Therefore what can be concluded is that the controversies in these studies can be attributed to the different process of WM which involve in the tasks and the tests, and possibly BDS because involves more brain challenges especially in children has higher correlation with intelligence.

RAVAL test, which has different stages and evaluates many different memory types, different stages are described separately. In the current study, gifted students compared with typical students obtained higher scores in all 1 to 5 stages. Since the first stage evaluates STM, this result confirmed the higher STM capacity in gifted students, as previously mentioned about FDS. In view of the fact that 1 to 5 stages curve shows the learning speed curve, the gifted students learning was superior to typical students, but learning curve slope was the same in both groups. This result was confirmed in other studies, which students with more intelligence got better scores in first five scores (32, 33). Another study related this result to the ways gifted students encode the information, it would be better to have the separate norm for people with different intelligence (33). The intelligence effect on I and II stages is reported (34) only, while another study reported this effect on IV and V stages (40). Possibly the reason of this variation is more limited intelligence range evaluated in these studies, the subjects were all in normal intelligence range and there was not any superior intelligence, but current study evaluated typical students with gifted students and the IQ difference was significantly higher than the others (34, 40).

Evaluating 6 and 7 stages, gifted students were superior to the typical students and this was probably because of higher resistance against interferences in first group. The considerable point is that 6 and 7 stages had lower scores than the first five stages which may be due to the negative effects of interferences in both groups' results. In fact, in 6 and 7 stages the brain involves resisting against interferences and this itself results in lower score in these stages comparing with 1 to 5 stages. This result is confirmed earlier (35-39). Therefore VI and VII stages have a closer meaning to WM rather than STM (33-40). VI stage had the lower score than I among all subjects but gifted subjects had higher score in VII stage comparing with normal subjects while Geffen accounted superior effect in VII stage among intellectual subjects (30). This paradox possibly is due to different aging group, which was evaluated.

Finally, in 7 and 9 stages also gifted students had better performance than typical students which indicates better Long Term Memory in this group. In a study, the intelligence and educational level effect on every stages of RAVLT were evaluated and concluded that the more intelligence result in higher score in RAVLT, additionally they assumed that this effect for different aging group varied (31). They relate this finding to higher processing speed and more attention and recognition ability in intellectual students. In some other studies, intelligence was effective in the VIII and IX stages. For instance in one study there was not any significant relationship in last three stages (32) or another study reported intelligence effect just in VIII stage or the other one reported no effect in 8 and 9 stages (34, 40). These conclusions might be due to limited intelligence range in those studies and the other point is that there was not any gifted subject in their studies while in current study there was intelligence that was more superior.

When comparing Digit test and Rey test subscales, some interesting results can be concluded. First it should be considered based on a study lateral premotor cortex is main central language center, although there are some differences. Indeed rostral and dorsal parts are showed significantly greater activity during the numeral task than the word task whereas its caudal part (PMdc) was similarly active during the two tasks (41). Analyzing the correlation between Digit Span subscales and the RAVLT stages, FDS and BDS had the highest correlation with I and VII stages of RAVLT respectively, and both of them had the lowest correlation with ninth stage.

There are several studies, which compared different memory tests (21-32), but only in one study, Rey and digit span are compared and the same result was seen (23), conducted among children with learning disability, which found high correlation between RAVLT stage I, and FDS and between RAVLT stage VII and BDS. As mentioned above FDS and BDS evaluate STM and WM respectively. There are evidences to assume the first stage of RAVLT as the ability of STM, so it can be rationalized that there are high correlation between FDS and first stage of RAVLT and poor relationship between BDS and first stage.

Since in VII stage comparing with the first has more challenge to resist against interferences is more close to WM and has higher correlation with BDS. Additionally BDS and Rey VII had lower score than FDS and Rey I. In a literature review study comparing STM and WM, assume WM due to higher and more complicated cognitive functions and pointed out that WM capacity is lower than STM (10). Researchers evaluated WM capacity with BDS and comparing with FDS and confirmed the previous results (25, 39).

In conclusion, there were significant relationship between intelligence and memory capacity but slope of learning with repetition was the same for two groups; moreover, it showed that FDS and BDS were inadequate to indicate all aspects of memory and capacity of learning. However, it can be used as a supplementary tool for screening subjects with learning problems.

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Author's Contribution

Dr. Robert Keith: Chief Editor. Acquisition.

Dr. Jennifer Keelor: Drafting and revision of the manuscript

Dr. Alireza Akbarzade: Analysis of Data

Elham Khosravi Fard: Study Concepts and design, Literature research. Collecting Data. Preparing manuscription.

All authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of Interest

The authors declare that there is no conflict of interests.

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