The effect of memory training on children with learning difficulty

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Background
Learning is a step by step process that relies on successful completion of individual learning activities for accumulation of knowledge. Failure of working memory (auditory and visual memory) can lead to inattentive behavior. The end result is frequently lost learning opportunities and so slow rates of educational progress.
Objective
The aim of this study is to adapt and apply the 'no-glamour memory' training program to suit the Egyptian learning disabled children to outline a program for training and test its effectiveness.
Patients and methods
This study was conducted on 20 school-age children complaining of learning difficulty and memory problems who were attending the Unit of Phoniatrics, Department of Otorhinolaryngology, Alexandria Main University Hospitals. All children were assessed using the protocol of assessment of learning difficulties and memory deficits and were reevaluated after a period of 3–6 months of training.
Results
In the present study, there was significant improvement of the studied group in the different tests such as Stanford Binet Intelligence Scale, childhood attention and adjustment survey, Arabic dyslexia assessment test, and test of memory and learning 2nd ed., after therapy.
Conclusion
Memory training can have an effect on domain-general cognitive mechanisms; thus, these results benefit multiple areas of cognition and learning.

Keywords:
auditory memory, learning difficulty, memory training, the &lsquo, no-glamour memory&rsquo, training program, working memory

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Introduction

The human memory system is responsible for processing information in the brain making them accessible for later use [1]. Memory is the process of encoding, storing, consolidating, and recovering information [2]. Functionally, human memory systems can be classified into three systems: short-term sensory storage, short-term memory, and long-term memory [3,4].

In normally developing children, performance on working memory (WM) span tasks is a crucial indicator of academic accomplishment [5]. Poor academic accomplishment is one of the key attributes of children with WM deficiencies [6].

The connection of WM to different parts of academic achievement emerges primarily from its restricted capacity. Even individuals with normal WM assets have a very confined WM capacity [7]. The WM capacity determines to a great extent the individual's ability to effective learning. Additionally, competent use of its resources is essential for all individuals, not merely those with WM deficits [8].

Three common approaches to rehabilitation have been applied for memory deficits: remedial, compensatory and a combination of the two. Remedial interventions aim at improving weaknesses and deficiencies. Making use of one's cognitive advantages and strengths, compensatory interventions attempt to overcome the deficit, hence diminishing its effect on learning, whereas combined interventions integrate both the remedial and compensatory approaches to address memory deficits. Most effective interventions reported in literature are multidimensional in nature with the potential of additive effects from different methods [9].

An effective training program aiming at improving memory skills was needed to help children with learning difficulty and memory deficits. The 'no-glamour memory' training program has straightforward, flexible materials that teach alternative approaches to learning, rely on multiple kinds of input (e.g. visual, auditory and kinesthetic), and are also fun for students [10].

The rationale of this study is to adapt and apply the 'no-glamour memory' training program to suit the Egyptian learning disabled children to outline a program for training and test its effectiveness in an attempt to help students overcome their memory deficits in a multimodality approach and improve their learning process.

Patients and methods

Pilot study

This study was conducted on 10 randomly chosen children. The 'no-glamour memory' program was applied after translation and modification to the Arabic language.

Assessment of learning difficulty

Twenty school-age children were assessed using the protocol of assessment of learning difficulties and memory deficits and were reevaluated after a period of 3–6 months of training. Assessments included the following:

(1) Psychometric evaluation:
   (a) Stanford Binet Scale 4th ed.,.
   (b) Children's attention and adjustment survey for cases with attention-deficit hyperactivity disorder (ADHD) symptoms.

(2) Test of memory and learning, 2nd ed., (TOMAL-2) [11].

(3) Arabic dyslexia assessment test [12].

The 'no-glamour memory' training program [10]

(1) The program is divided into two main sections:
   (a) Auditory memory section:
      (i) Rehearsing and subvocalizing.
      (ii) Chunking.
      (iii) Creating lists and taking notes.

Table 1 Mean age, sex, type of school, grade, and preferred hand for the studied group

Age (years)	
Mean±SD	8.67±1.92
KS test	*D*=0.184, *P*=0.075 (NS)
Sex [*n* (%)]	
Male	13 (65.0)
Female	7 (35.0)
Grade [*n* (%)]	
KG2	5 (25.0)
First primary	2 (10.0)
Second primary	2 (10.0)
Third primary	0 (0.0)
Fourth primary	8 (40.0)
Fifth primary	3 (15.0)
Sixth primary	0 (0.0)

KS, Kolmogorov–Smirnov test; $P \geq 0.05$, statistically no significant difference.

Table 2 Results of the Stanford Binet Scale before and after therapy

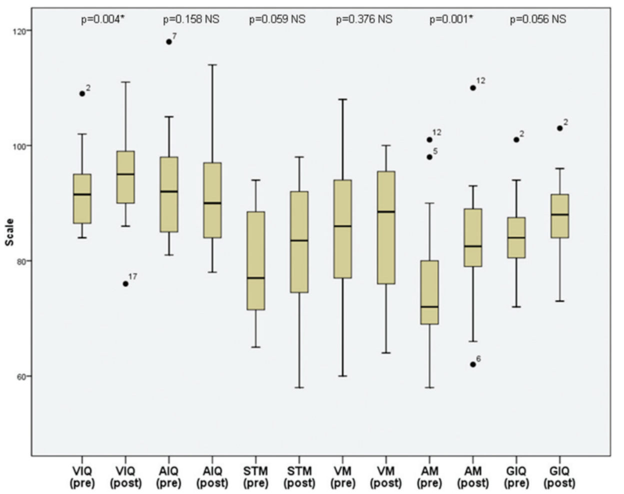
	Before therapy	After therapy	Test of significance (P value)
Verbal IQ			
Mean±SD	91.90±6.38	94.85±7.68	$Z_{(WSR)}$=2.862 (*P*=0.004*)
KS test	*D*=0.164, *P*=0.167 (NS)	*D*=0.091, *P*=0.200 (NS)	
Abstract IQ			
Mean±SD	92.85±9.44	91.55±10.22	$Z_{(WSR)}$=1.412 (*P*=0.158, NS)
KS test	*D*=0.105, *P*=0.200 (NS)	*D*=0.110, *P*=0.200 (NS)	
Short-term memory			
Mean±SD	78.55±9.94	82.20±11.71	$Z_{(WSR)}$=1.889 (*P*=0.059, NS)
KS test	*D*=0162, *P*=0.181 (NS)	*D*=0.119, *P*=0.200 (NS)	
Visual memory			
Mean±SD	84.80±11.93	86.35±11.61	$Z_{(WSR)}$=0.886 (*P*=0.376, NS)
KS test	*D*=0.127, *P*=0.200 (NS)	*D*=0.195, *P*=0.045*	
Auditory memory			
Mean±SD	74.95±11.70	82.85±10.60	$Z_{(WSR)}$=3.264 (*P*=0.001*)
KS test	*D*=0.182, *P*=0.080 (NS)	*D*=0.144, *P*=0.200 (NS)	
General IQ			
Mean±SD	84.50±6.37	87.65±7.39	$Z_{(WSR)}$=1.914 (*P*=0.056, NS)
KS test	*D*=0.119, *P*=0.200 (NS)	*D*=0.115, *P*=0.200 (NS)	

KS, Kolmogorov–Smirnov test; WSR, Word selective reminding. $P \geq 0.05$, statistically no significant difference. *$P < 0.05$, statistically significant difference.

(iv) Graphing and charting.
(v) Identifying key concepts.
(vi) Linking and associations.
(vii) Visualizing.
(viii) Paraphrasing.

(b) Visual memory section:
(i) Chunking.
(ii) Acronyms and silly sentences.
(iii) Drawing and defining.
(iv) Graphing and charting.
(v) Identifying key concepts.
(vi) Visualizing.
(vii) Paraphrasing.
(viii) Saying, tracing, writing, and drawing sounds.

Figure 1

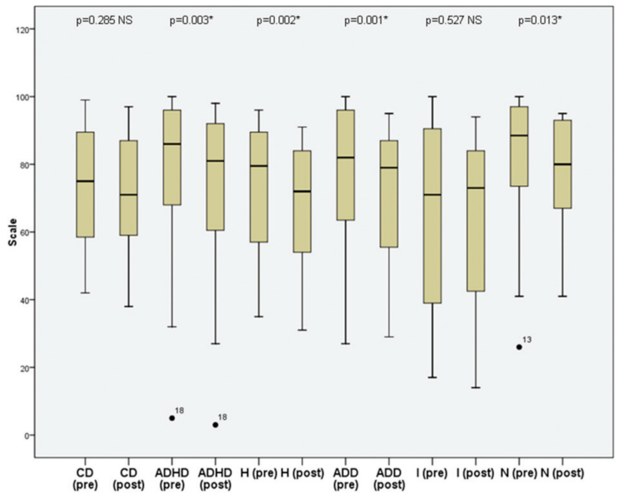


Box and whisker graph of Stanford Binet Scale scores in the studied group before (pre) and after (post) therapy. The thick line in the middle of the box represents the median, the box represents the interquartile range (from 25th to 75th percentiles), and the whiskers represent the minimum and maximum after excluding outliers (black-filled circles) (numbers indicate the serial number of the case in the master table). AIQ, abstract visual intelligence quotient; AM, auditory memory; GIQ, general intelligence quotient; STM, short term memory; VIQ, verbal intelligence quotient; VM, visual memory.

Results

Twenty school-aged children participated in this study (mean age: 8.67 years, range: 5.33–11.17 years)

Figure 2



Box and whisker graph of childhood attention and adjustment survey scores in the studied group before (pre) and after (post) therapy. The thick line in the middle of the box represents the median, the box represents the interquartile range (from 25th to 75th percentiles), and the whiskers represent the minimum and maximum after excluding outliers (black-filled circles) (numbers indicate the serial number of the case in the master table). ADD, attention deficit disorder; ADHD, attention-deficit hyperactivity disorder; CD, conduct problems; H, hyperactivity; I, impulsivity; N, inattention.

Table 3 Pretherapy and post-therapy results of childhood attention and adjustment survey

	Pretherapy results	Post-therapy results	Test of significance (*P* value)
CD (conduct problems)			
Mean±SD	73.65±18.81	71.00±17.41	$Z_{(WSR)}$=1.068 (*P*=0.285, NS)
KS test	*D*=0.129, *P*=0.200 NS	*D*=0.139, *P*=0.200 (NS)	
ADHD (attention deficit hyperactivity disorder)			
Mean±SD	77.15±26.94	70.65±26.88	$Z_{(WSR)}$=2.989 (*P*=0.003*)
KS test	*D*=0.215, *P*=0.016 (NS)	*D*=0.117, *P*=0.101 (NS)	
H (hyperactivity)			
Mean±SD	73.40±19.70	68.25±18.89	$Z_{(WSR)}$=3.122 (*P*=0.002*)
KS test	*D*=0.192, *P*=0.051 (NS)	*D*=0.166, *P*=0.151 (NS)	
ADD (attention deficit disorder)			
Mean±SD	76.45±21.98	70.20±21.42	$Z_{(WSR)}$=3.463 (*P*=0.001*)
KS test	*D*=0.156, *P*=0.200 (NS)	*D*=0.215, *P*=0.016 (NS)	
I (impulsivity)			
Mean±SD	65.75±26.31	64.40±25.38	$Z_{(WSR)}$=0.632 (*P*=0.527, NS)
KS test	*D*=0.179, *P*=0.092 (NS)	*D*=0.181, *P*=0.086 (NS)	
N (inattention)			
Mean±SD	79.85±23.09	76.70±17.88	$Z_{(WSR)}$=2.487 (*P*=0.013*)
KS test	*D*=218, *P*=0.014 (NS)	*D*=0.154, *P*=0.200 (NS)	

KS, Kolmogorov–Smirnov test; WSR, Wilcoxon signed rank test. *P<0.05, statistically significant difference.

Table 4 Comparison between the studied groups pre-and post-therapy as regards TOMAL-2

	Pretherapy results	Post-therapy results	Test of significance (*P* value)
(a) Results of TOMAL-2 core battery (verbal subsets)			
Core battery (verbal subsets)			
Memory for stories			
Mean±SD	5.60±2.85	9.55±2.11	$Z_{(WSR)}$=3.945
KS test	*D*=0.162, *P*=0.175 (NS)	*D*=0.118, *P*=0.200 (NS)	*P*=0.000*
Word selective reminding			
Mean±SD	8.95±2.89	11.80±2.65	$Z_{(WSR)}$=3.136
KS test	*D*=0.111, *P*=0.200 (NS)	*D*=0.230, *P*=0.007 (NS)	*P*=0.002*
Object recall			
Mean±SD	8.40±3.76	10.95±3.75	$Z_{(WSR)}$=3.507
KS test	*D*=0.137, *P*=0.200 (NS)	*D*=0.160, *P*=0.191 (NS)	*P*=0.000*
Paired recall			
Mean±SD	7.25±2.95	10.05±3.02	$Z_{(WSR)}$=3.612
KS test	*D*=0.214, *P*=0.017 (NS)	*D*=0.174, *P*=0.116 (NS)	*P*=0.000*
(b) Results of TOMAL-2 core battery (nonverbal subsets)			
Core battery (nonverbal subsets) align="2pt 0in 1pt"			
Facial memory			
Mean±SD	9.85±4.23	12.25±3.75	$Z_{(WSR)}$=3.642
KS test	*D*=0.169, *P*=0.137 (NS)	*D*=0.227, *P*=0008. (NS)	*P*=0.000*
Abstract visual memory			
Mean±SD	10.95±3.85	13.60±3.69	$Z_{(WSR)}$=3.302
KS test	*D*=0.148, *P*=0.200 (NS0	*D*=0.165, *P*=0.160 (NS)	*P*=0.001*
Visual sequential memory			
Mean±SD	9.65±2.94	12.30±3.08	$Z_{(WSR)}$=3.913
KS test	*D*=0.138, *P*=0.200 (NS)	*D*=0.111, *P*=0.200 (NS)	*P*=0.000*
Memory for location			
Mean±SD	8.05±2.56	9.75±2.63	$Z_{(WSR)}$=3.107
KS test	*D*=0.158, *P*=0.200 (NS)	*D*=0.212, *P*=0.019 (NS)	*P*=0.002*
(c) Results of TOMAL-2 supplementary subsets (verbal subsets)			
Supplementary (verbal subsets)			
Digits forwards			
Mean±SD	7.40±2.30	9.50±2.26	$Z_{(WSR)}$=3.436
KS test	*D*=0.219, *P*=0.013 (NS)	*D*=0.188, *P*=0.63 (NS)	*P*=0.001*
Letters forward			
Mean±SD	8.15±2.28	9.60±2.41	$Z_{(WSR)}$=3.306
KS test	*D*=0.226 *P*=0.009 (NS)	*D*=0.248, *P*=0.002 (NS)	*P*=0.001*
Digits backwards			
Mean±SD	8.25±2.34	10.35±1.84	$Z_{(WSR)}$=3.001
KS test	*D*=0.143, *P*=0.200 (NS)	*D*=0.138, *P*=0.200 (NS)	*P*=0.003*
Letters backward			
Mean±SD	7.70±1.30	9.20±1.67	$Z_{(WSR)}$=3.684
KS test	*D*=0.205, *P*=0.028 (NS)	*D*=0.198, *P*=0.040 (NS)	*P*=0.000*
(d) Results of TOMAL-2 supplementary subsets (nonverbal subsets)			
Supplementary (nonverbal subsets)			
Visual selective reminding			
Mean±SD	8.60±3.52	10.50±3.12	$Z_{(WSR)}$=3.623
KS test	*D*=0.175, *P*=0.108 (NS)	*D*=0.164, *P*=0.167 (NS)	*P*=0.000*
Manual imitation			
Mean±SD	9.40±2.76	11.35±2.16	$Z_{(WSR)}$=3.315
KS test	*D*=0.144, *P*=0.200 (NS)	*D*=0.168, *P*=0.140 (NS)	*P*=0.001*
(e) Results of TOMAL-2 (verbal delayed recall subsets)			
Verbal delayed recall			
Memory for stories delayed			
Mean±SD	5.65±2.87	9.75±1.94	$Z_{(WSR)}$=3.818
KS test	*D*=0.117, *P*=0.200 (NS)	*D*=0.201, *P*=0.033 (NS)	*P*=0.000*
Word selective reminding delayed			
Mean±SD	9.70±3.18	12.80±2.09	$Z_{(WSR)}$=3.419

(*Continued*)

Table 4 (*Continued*)

	Pretherapy results	Post-therapy results	Test of significance (*P* value)
KS test	D=0.138, P=0.200 (NS)	D=0.162, P=0.179 (NS)	P=0.001*
(f) Results of TOMAL-2 (indices)			
Indices			
Verbal memory index			
Mean±SD	85.80±15.83	98.35±19.23	$Z_{(WSR)}$=3.888
KS test	D=0.103, P=0.200 (NS)	D=0.110, P=0.200 (NS)	P=0.000*
Nonverbal memory index			
Mean±SD	96.55±16.26	108.50±14.78	$Z_{(WSR)}$=3.577
KS test	D=0.110, P=0.200 NS	D=0.140, P=0.200 (NS)	P=0.000*
Composite memory index			
Mean±SD	89.70±14.21	106.25±16.27	$Z_{(WSR)}$=3.921
KS test	D=0.108, P=0.200 NS	D=0.117, P=0.200 NS	P=0.000*
Verbal delayed recall index			
Mean±SD	83.65±15.57	98.75±10.62	$Z_{(WSR)}$=3.811
KS test	D=0.161, P=0.188 (NS)	D=0.138, P=0.200 (NS)	P=0.000*
Attention/concentration index			
Mean±SD	87.00±8.05	94.60±10.99	$Z_{(WSR)}$=3.733
KS test	D=0.155, P=0.200 (NS)	D=0.172, P=0.124 (NS)	P=0.000*
(g) Results of TOMAL-2 (indices)			
Indices			
Sequential recall index			
Mean±SD	92.40±9.13	98.75±10.78	$Z_{(WSR)}$=3.870
KS test	D=0.108, P=0.200 (NS)	D=0.097, P=0.200 (NS)	P=0.000*
Free recall index			
Mean±SD	95.20±17.24	108.10±15.98	$Z_{(WSR)}$=3.529
KS test	D=0.097, P=0.200 (NS)	D=0.172, P=0.125 (NS)	P=0.000*
Associative recall index			
Mean±SD	83.20±17.79	97.00±15.05	$Z_{(WSR)}$=3.437
KS test	D=0.204, P=0.029 (NS)	D=0.106, P=0.200 (NS)	P=0.001*
Learning index			
Mean±SD	90.05±12.68	103.65±14.73	$Z_{(WSR)}$=3.923
KS test	D=0.125, P=0.200 (NS)	D=0.129, P=0.200 (NS)	P=0.000*

KS, Kolmogorov–Smirnov test; WSR, Wilcoxon signed rank test; $P \geq 0.05$, statistically no significant difference;*$P<0.05$, statistically significant difference.

Table 5 Comparison between the studied group before therapy and after therapy regarding Arabic dyslexia assessment test

ADAT	Before therapy	After therapy	Test of significance (*P* value)
ARQ			
Mean±SD	1.65±0.71	1.23±0.61	$Z_{(WSR)}$=3.631
KS test	D=0.128, P=0.0200 (NS)	D=0.220, P=0.013 (NS)	P=0.000*

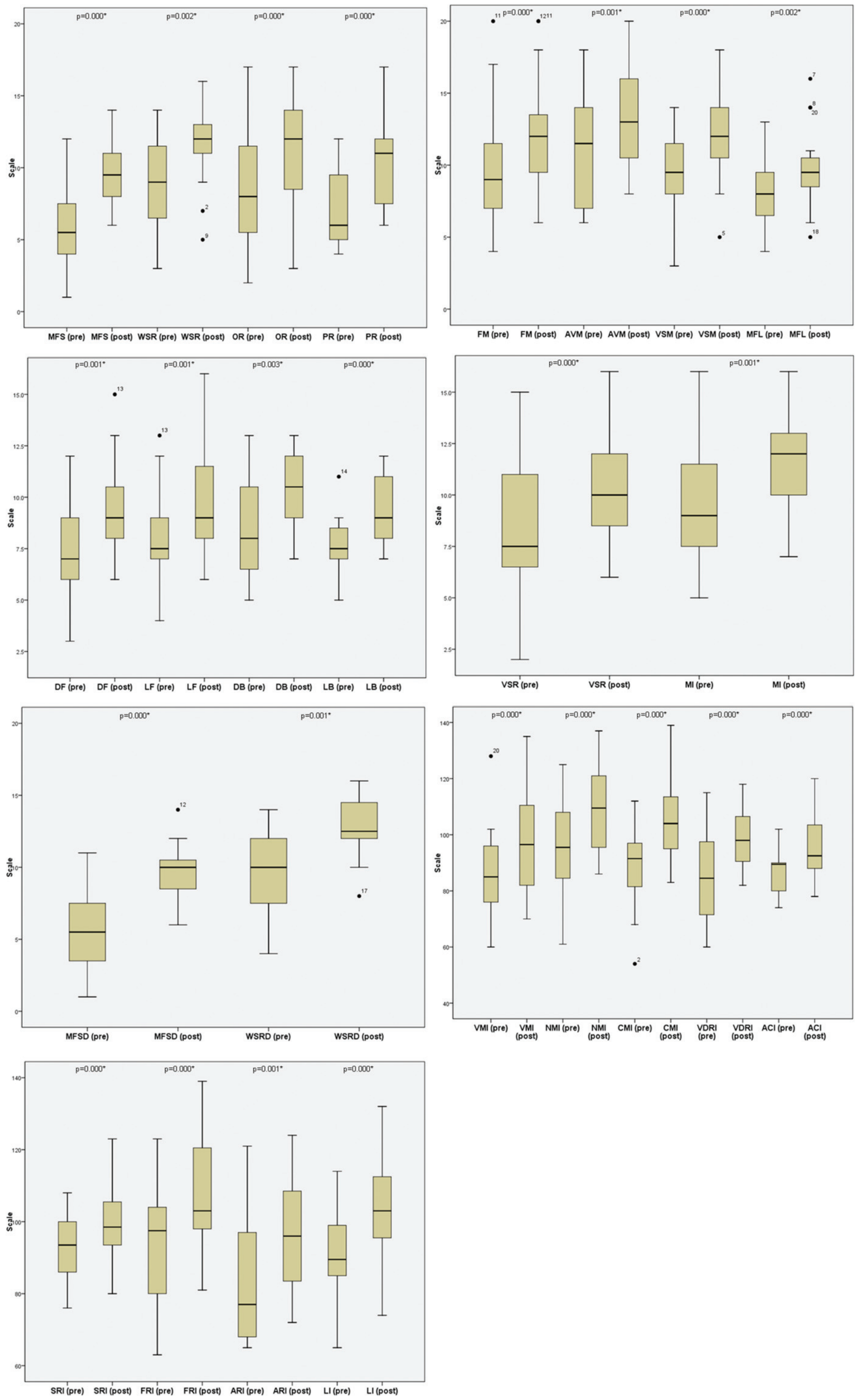
ADAT, Arabic dyslexia assessment test; ARQ, at risk quotient; KS, Kolmogorov–Smirnov test; WSR, Wilcoxon signed rank test. *$P<0.05$, statistically significant difference.

(Table 1). There was a statistically significant difference between verbal IQ in the studied group before therapy and after therapy (P=0.004). A statistically significant difference was found in the auditory memory subset of short-term memory before therapy and after therapy (P=0.001) (Table 2 and Figure 1). The studied group showed statistically significant difference regarding ADHD, H (hyperactivity), attention-deficit disorder, and N (inattention) components of the childhood attention and adjustment survey before therapy and after therapy (P=0.003, 0.002, 0.001 and 0.013, respectively). However, there was no statistically significant difference regarding CD (conduct problems) and I (impulsivity) (Table 3 and Figure 2). All items and indices of the TOMAL-2 showed statistical significant difference ($P \leq 0.01$) in the studies group before and after therapy (Table 4a–g and Fig. 3a–g). The at-risk quotient obtained from the Arabic dyslexia assessment test was significantly lower after therapy in the studied group (P=0.000) (Table 5 and Fig. 4).

Discussion

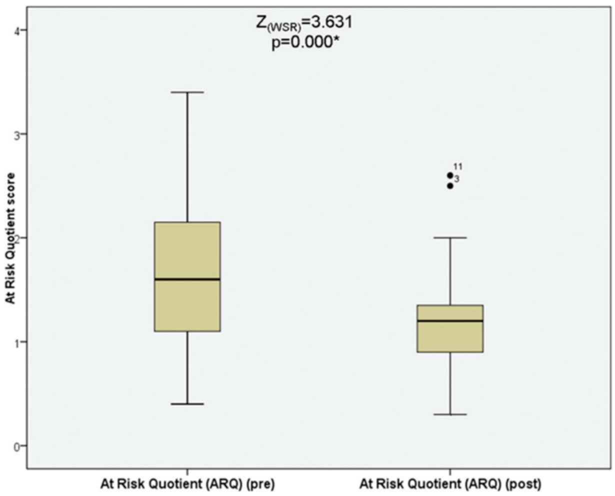
The present study showed improvement of verbal IQ in the studied group. Farquharson *et al.* [13] described

Figure 3



(a) Box and whisker graph of test of memory and learning 2nd ed. (TOMAL-2) core battery (verbal subsets) scores in the studied group before (pre) and after (post) therapy. The thick line in the middle of the box represents the median, the box represents the interquartile range (from 25th to 75th percentiles), and the whiskers represent the minimum and maximum after excluding outliers (black-filled circles) (numbers indicate the serial number of the case in the master table). (b) Box and whisker graph of TOMAL-2 core battery (nonverbal subsets) scores in the studied group before (pre) and after (post) therapy. The thick line in the middle of the box represents the median, the box represents the interquartile range (from 25th to 75th percentiles), and the whiskers represent the minimum and maximum after excluding outliers (black-filled circles) (numbers indicate the serial number of the case in the master table). (c) Box and whisker graph of TOMAL-2 supplementary (verbal subsets) scores in the studied group before (pre) and after (post) therapy. The thick line in the middle of the box represents the median, the box represents the interquartile range (from 25th to 75th percentiles), the whiskers represent the minimum and maximum after excluding outliers (black-filled circles) (numbers indicate the serial number of the case in the master table). (d) Box and whisker graph of TOMAL-2 supplementary (nonverbal subsets) scores in the studied group before (pre) and after (post) therapy. The thick line in the middle of the box represents the median, the box represents the interquartile range (from 25th to 75th percentiles), and the whiskers represent the minimum and maximum. (e) Box and whisker graph of TOMAL-2 verbal delayed recall subsets scores in the studied group before (pre) and after (post) therapy. The thick line in the middle of the box represents the median, the box represents the interquartile range (from 25th to 75th percentiles), and the whiskers represent the minimum and maximum after excluding outliers (black-filled circles) (numbers indicate the serial number of the case in the master table). (f) Box and whisker graph of TOMAL-2 Indices scores in the studied group before (pre) and after (post) therapy; the thick line in the middle of the box represents the median, the box represents the interquartile range (from 25th to 75th percentiles), and the whiskers represent the minimum and maximum after excluding outliers (black-filled circles) (numbers indicate the serial number of the case in the master table). (g) Box and whisker graph of TOMAL-2 indices scores in the studied group before (pre) and after (post) therapy; the thick line in the middle of the box represents the median, the box represents the interquartile range (from 25th to 75th percentiles), and the whiskers represent the minimum and maximum. MI, manual imitation. ACI, attention concentration index; ARI, associative recall index; AVM, abstract visual memory; CMI, composite memory index; DB, digits backwards; DF, digits forwards; FM, facial memory; FRI, free recall index; LB, letters backwards; LF, letters forwards; LI, learning index; MFS, memory for stories; MFSD, memory for stories delayed; NMI, nonverbal memory index; PR, paired recall; OR, object recall; SRI, sequential recall index; VDRI, verbal delayed recall index; VMI, verbal memory index; VSM, visual sequential memory; VSR, visual selective reminding; WSR, word selective reminding; WSRD, word selective reminding delayed.

Figure 4



Box and whisker graph of at risk quotient (ARQ) of Arabic dyslexia assessment test in the studied group before (pre) and after (post) therapy; the thick line in the middle of the box represents the median, the box represents the interquartile range (from 25th to 75th percentiles), and the whiskers represent the minimum and maximum after excluding outliers (black-filled circles) (numbers indicate the serial number of the case in the master table).

comparable outcomes in children after training for memory deficits, specifically for expressive language, nonword repetitions, and rapid automatic naming. These attainments are generated by enhanced access to stored lexical information and may be improved attention. Gill *et al.* [14] found that providing visual instructions to children as a rehearsal procedure resulted in effective and enduring change in their capability to follow these instructions.

The present study demonstrated a pattern of improvement regarding auditory memory subset of short-term memory in the studied group. This is comparable to the work of Holmes *et al.* [15] who found significant improvement in verbal short-term memory, response inhibition, and complex reasoning in their group of trainees.

Klingberg *et al.* [16] documented that trained cases manifested posttreatment advancement in visual-spatial and sound-related verbal WM, in addition to a generalization to other more complex reasoning skills. These findings indicate that intensive training of the plastic neural systems underlying these components results in augmentation of their standard function [17,19]. On the contrary, intense and prolonged rehabilitation programs may rather encourage the evolution of either WM approaches that countervail the defects in primary processes or the volitional control of attention [15].

There was no improvement of abstract IQ (nonverbal intelligence) in the studied group in the current study. Numerous research reported robust association between WM and intelligence [17,19]. Nevertheless, and in spite of the research attempts made until now, the elements underlying their robust association continue to be perplexing. Many studies could not prove such a relationship. Holmes *et al.* [15] stated that some cognitive assessments such as individual tests of fluid cognitive ability remained uninfluenced by training.

Our current study showed a consistent pattern of reduction in the severity of behavioral symptoms of ADHD (especially inattention and hyperactivity) in the studied group. Beck *et al.* [20] reported improved parent and teacher ratings after memory training. The improvements were maintained at 4-month follow-up. Klingberg and colleagues suggested that WM training may ameliorate behavioral symptoms of inattention, at least according to parents' judgments [19,21].

In the present study, the studied group showed a consistent pattern of improvement regarding all subsets and indices of the TOMAL-2 as compared with the control group. Both auditory and visual memories showed improvement in the studied group. This finding was not illustrated by the visual memory subset of short-term memory on the Stanford Binet scale. This might be because of the comprehensive and more detailed nature of the assessment using the TOMAL-2. The findings relate to the study by Holmes *et al.* [17], which detected a considerable improvement of WM scores in most children who finished a rehabilitation program. This improvement was observed both over the duration of training as well as for an additional period of 6 months after training has been concluded. Improvement extended to include some untrained WM assessments, especially those involving either the storage of visuospatial material or the simultaneous storage and manipulation of either visuospatial or verbal material.

The current study shows a consistent pattern of improvement in the at-risk quotient of the Arabic dyslexia assessment test in the studied group. Current proof suggests that memory training can generate compelling attainment on untrained WM tasks [19,22]. However, the degree to which WM learning is passed on to untrained tasks in diverse fields, such as phonological skills, is not yet confirmed [23]. Loosli *et al.* [24] suggested the presence of shared procedures among WM and reading. This is manifested by the appreciable improvement of reading skills following WM training in normally developing children. Dahlin [25] found that better reading comprehension was associated with improving WM but not with word decoding or orthographic verification. However, Holmes *et al.* [15] found no effect of memory training on word identification, yet an improvement in mathematical problem-solving skills. These findings indicate that many different processes, including encoding, covert maintenance, attention, updating, interference resolution, and controlled memory search are integrated in the compound WM span tasks. One or more of these processes may be affected by training. Consequently, transfer to different cognitive measures relies additionally on the influence of training on different processes [15].

Conclusion

The Arabic version of 'no-glamour memory' remediation program is an effective tool for children with learning difficulty.

Domain-general cognitive mechanisms are influenced by memory training; therefore, can benefit multiple areas of cognition and learning.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Sachcter DL, Tulvig E. What are the memory systems of 994?. In: Schacter DL, Tulvig E, editors. Memory systems. Cambridge, Massachusetts: MIT Press; 1994. pp. 1–38.

2 Usman Y, Shugaba A. The anatomical perspective of memory: a review article. J Sci Res Stud 2015; 2:8–15.

3 Ganong W. Review of medical physiology. New York, NY: McGraw Hill; 2003.

4 Swanson HL, Sachse-Lee C. Mathematical problem solving and working memory in children with learning disabilities: both executive and phonological processes are important. J Exp Child Psychol 2001; 79:294–321.

5 Bayliss DM, Jarrold C, Baddeley AD, Leigh E. Differential constraints on the working memory and reading abilities of individuals with learning difficulties and typically developing children. J Exp Child Psychol 2005; 92:76–99.

6 Gathercole SE, Alloway TP. Working memory and learning: a practical guide for teachers. New York, NY: SAGE 2008.

7 Cowan N. The magical number 4 in short-term memory: a reconsideration of mental storage capacity. Behav Brain Sci 2001; 24:87–114; [discussion-85].

8 Swanson HL. Are working memory deficits in readers with learning disabilities hard to change? J Learn Disabil 2000; 33:551–566.

9 Kauffman JM, Mock DR, Tankersley M, Landrum TJ. Issues related to teaching students having learning and behavioral challenges: effective service delivery models. Morris RJ, Mather N. Evidence-based interventions for students with learning and behavioral challenges. New York, NY: Routledge; 2008. pp. 359–382.

10 Rozendaal C, Gottschall C. No-glamour memory. Iowa: LinguiSystems Inc; 2007.

11 Hanafy M. Application of the adapted learning and memory test for evaluating the Egyptian children having memory problems. Thesis, MSc. Phoniatrics. Alexandria: University of Alexandria, Faculty of Medicine; 2015.

12 Aboras Y, Abdou R, Kozou H. Development of an Arabic test for assessment of dyslexia in Egyptian children. Bull Alex Fac Med 2008; 44:653–662.

13 Farquharson K, Franzluebbers CE. Comparing the effects of working memory-based interventions for children with language impairment. EBP Briefs 2014; 9:1–7.

14 Gill CB, Klecan-Aker J, Roberts T, Fredenburg KA. Following directions: Rehearsal and visualization strategies for children with specific language impairment. Child Lang Teach Ther 2003; 19:85–103.

15 Holmes J, Gathercole SE, Place M, Dunning DL, Hilton KA, Elliott JG. Working memory deficits can be overcome: impacts of training and medication on working memory in children with ADHD. Appl Cognit Psychol 2010; 24:827–836.

16 Klingberg T, Fernell E, Olesen PJ, Johnson M, Gustafsson P, Dahlstrom K, *et al.* Computerized training of working memory in children with ADHD – a randomized, controlled trial. J Am Acad Child Adolesc Psychiatry 2005; 44:177–186.

17 Colom R, Abad FJ, Rebollo I, Shih PC. Memory span and general intelligence: a latent-variable approach. Intelligence 2005; 33: 623–642.

18 Chein JM, Morrison AB. Expanding the mind's workspace: training and transfer effects with a complex working memory span task. Psychon Bull Rev 2010; 17:193–199.

19 Ackerman PL, Beier ME, Boyle MO. Working memory and intelligence: the same or different constructs? Psychol Bull 2005; 131:30–60.

20 Beck SJ, Hanson CA, Puffenberger SS, Benninger KL, Benninger WB. A controlled trial of working memory training for children and

adolescents with ADHD. J Clin Child Adolesc Psychol 2010; 39:825–836.

21 Klingberg T, Forssberg H, Westerberg H. Training of working memory in children with ADHD. J Clin Exp Neuropsychol 2002; 24:781–791.

22 McNab F, Varrone A, Farde L, Jucaite A, Bystritsky P, Forssberg H, *et al.* Changes in cortical dopamine D1 receptor binding associated with cognitive training. Science 2009; 323:800–802.

23 Westerberg H, Klingberg T. Changes in cortical activity after training of working memory – a single-subject analysis. Physiol Behav 2007; 92:186–192.

24 Loosli SV, Buschkuehl M, Perrig WJ, Jaeggi SM. Working memory training improves reading processes in typically developing children. Child Neuropsychol 2012; 18:62–78.

25 Dahlin KI. Effects of working memory training on reading in children with special needs. Read Write 2011; 24:479–491.