

Original Article

The Effect of Working Memory Training on English Reading Comprehension of Adult English Learners

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Abstract

Introduction: It is assumed that working memory plays a pivotal role in carrying out all sorts of cognitive functions. The introduction of working memory software has provided researchers with an asset to investigate the differences among individuals which can be attributable to differences in working memory capacity. Following the advent of working memory software, there were also other pieces of software available to the public with the prospect of helping individuals enhance their working memory capacity and as a result enjoy any possible benefits. This study aimed at investigating the possible effects of working memory improvement on some university students' reading comprehension in English.

Methods: 30 adult university students chosen through convenience sampling approach participated in this study. They were randomly divided into an experimental and a control group. Both groups took pretest on their reading comprehension using three reading texts in English and working memory capacity carried out via the working memory software. While the control group took posttests on the same tests after five weeks, the experimental group underwent a working memory training program consisting of ten sessions before taking the posttests.

Results: The results of t-test analysis showed a significant statistical difference in the performance of the two groups on the working memory test, but their reading task performance scores did not show a significant difference.

Conclusion: The working memory training program did not seem to benefit the participants in carrying out reading comprehension in English.

Keywords: Memory training, Reading, Comprehension, Language training, Students

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Introduction

Imagine yourself in a foreign language exam session, going through the test booklet from section to section. There is a section requiring grammaticality judgement followed by another one asking to choose the best vocabulary item to fit a sentence semantically. In another section of the test you need to read a couple of texts and

answer corresponding comprehension questions. Finally you are asked to write an essay that demands stringing of your ideas together in a logical manner. Throughout the test, you have been performing cognitive tasks entailing decision making, evaluation of information, problem solution and so forth. According to the proponents of

cognitive psychology, performing all these tasks requires active participation of your working memory, which is responsible for a wide range of functions well beyond the requirements of the second language (L2) test completion. An argument predicated on this assumption might subsequently give rise to this question: will it ever improve your performance if you subject your working memory to related training regimens?

According to cognitive psychology, working memory is that part of human memory apparatus where various forms of data manipulation such as evaluation of information and problem solving take place. According to Baddeley, working memory is "the temporary storage and manipulation of information that is assumed to be necessary for a wide range of complex cognitive activities" (1). Whereas long term memory is responsible for the permanent storage of data throughout an individual's course of life, working memory performs cognitive functions on the information that is temporarily available from memory resources. For some educational psychologists, deficiencies in working memory capacity has been the main culprit for low achievements in areas like mathematics, reading, and dictation (2, 3). In the field of L2 acquisition, great importance has been attributed to working memory capacity (4), and a large number of studies have addressed the contribution of working memory to attainments in different areas of L2 learning (5). As a consequence of such claims emphasizing the critical role of working memory, training programs have been available on the market to help people improve their working memory capacity. Although this area of enquiry was very promising, at the moment there is a great deal of controversy surrounding the issue (6). This paper aims to investigate the effectiveness of working memory training in one area of L2 development, i.e. reading skill.

Among the different models proposed to capture the structure and functioning of working memory (7), the multicomponent model introduced by Baddeley & Hitch (8) and revised in Baddeley (1) has been the most popular one among researchers. Accordingly, the model consists of four components: a phonological loop, a visuospatial sketchpad, a central executive, an episodic buffer. Given its multicomponent structure, working memory training programs are available that supposedly lead to positive educational outcomes. Some of these programs provide the trainee with strings of audio/visual stimuli in increasing order of difficulty that need to be reported back either in the direct or backward direction. Others function on the basis of some other tasks. In essence, all these programs intend to foster educational aims by increasing the capacity of working memory capacity.

In terms of L2 acquisition, for people interested in the nexus between working memory capacity and L2 development, the introduction of the concept to the domain of individual differences enunciated the prospect of a brighter future by clarifying issues around diversities in L2 development. Working memory seemed to have the potential to account for what had previously constituted language aptitude (9, 4). In the last two decades, the Second Language Acquisition (SLA) literature has witnessed an increasing number of studies carried out in the following areas of L2 acquisition: vocabulary acquisition (10), grammar acquisition (11), language comprehension (12), speech production (13), corrective feedback and recast (14) and written production (15) among others. The results have pointed to a general consistency in findings indicating associations between working memory and L2 development. However, Wen (5) noticed serious shortcomings in the studies carried out by then and warned the SLA researchers with three caveats: the need to use unified theoretical taxonomies, homogenous methodology, and accurate research designs.

Once the association between working memory and different areas of L2 development is established, one might subsequently ask if intervention practices implemented to improve working memory capacity will yield positive outcomes. This is a familiar issue to researchers in educational psychology but not frequently touched by those in L2 learning. In educational psychology, the recognition of the importance of working memory for cognitive functions that underlie thinking, learning, and achievement on the part of students has been followed by attempts to improve its capacity through systematic interventions. The idea is established on the logic that gains in working memory capacity development will naturally be accompanied by an increase in the students' performance in related subject areas (16). However, studies aimed at discovering the effectiveness of such interventions have largely failed to indicate such results considered in retrospect. In a meta-analysis of the related literature, Melby-Lervåg & Hulme (17) reported effectiveness of such intervention practices on areas basically similar to the tasks rehearsed in the programs but not on other areas like verbal intelligence or arithmetic.

The impetus behind the present study is two-folded. For one thing, studies on the effectiveness of working memory training have almost invariably been carried out in the subjects' first language. It will be interesting to find out about possible gains of such interventions in the realms of L2 development. For another thing, most studies carried out so far have largely targeted school children (17). It will be contributing to our understanding of the issue if adult L2 learners are examined for the

possible effects of working memory training regimens on L2 skill development as working memory is considered as an integral part of the language aptitude (4). Reading skill is focused on in this study for its unique priority in the Iranian educational system. As Iranian English learners have few opportunities to use English for verbal communication, most of their familiarity with this L2 is due to their exposure to written texts. Therefore, the following two research questions are proposed:

1. Will the participants' working memory measures improve as a result of practicing with a working memory program?
2. Will their performance on reading comprehension on pretest and posttest show any significant changes?

Methods

This study was an interventional one with a pretest-posttest design consisting of an experimental and a control group. The participants in this study were 30 male and female university students aged 19-26 studying at Kermanshah University of Medical Sciences and other universities in Kermanshah, Iran, chosen through convenience sampling. The researcher first explained the purpose of the study to the participants, and their written consents were obtained afterwards. They were subsequently divided into an experimental group and a control one based on their enrolment list. There were 8 male and 7 female students aged 20.2 ± 0.77 in the control group, while there were 7 male and 8 female students aged 20.4 ± 1.72 in the experimental one. In addition, running a X^2 test on the group members' gender features revealed no significant difference in terms of the distribution of both genders in the groups ($P=0.715$).

Both groups took pretests on both three reading comprehension tests and their working memory capacity. The working memory software assessed the examinee's working memory in terms of its auditory and visual capabilities. The participants in the experimental group then practiced individually with the working memory training software prepared and distributed by Sina Institute for Cognitive and Behavioral Studies in Iran. This software, based on the manual, is claimed to help individuals improve their working memory capacity through presenting auditory and visual practicing drills in

increasing order of difficulty in the form of numbers, pictures, and alphabet letters. The trainees spent about thirty minutes each time practicing the preset drills for ten sessions over five weeks. Both groups then took posttests on their working memory capacity and reading comprehension. While the pretest and posts on the working memory were administered from the software, the reading comprehension ones were adopted whole from Willis & Willis (18) and analyzed and approved by three university professors of Teaching English as a Foreign Language at Tehran University.

The participants worked on the three reading comprehension tests in three different sessions. To do so, the topic of each test was first introduced, and there was a brief class discussion on the topic. A few related questions were then raised to invoke their curiosity about the topic, and the learners were invited to read the texts and answer the questions individually. Working on each text took no more than 10 minutes. Altogether there were 31 questions, consisting of a variety of forms like multiple choice, true/false, wh-format, etc. The results of the pretests and posttests on the working memory and reading comprehension were loaded onto SPSS.19 for analysis at 0.05 level of significance.

Results

This study aimed to find out if university students' working memory measurements as assessed by the working memory software improved as a result of following a working memory training regimen. Besides, it was intended to see if such a possible increase in working memory capacity would be accompanied by a corresponding rise in their reading comprehension scores. In order to detect any statistically significant differences between the performance of each group on the working memory capacity pretest and the posttest, the paired t-test analysis was carried out (Table 1).

The differences between the pretest and posttest scores on the working memory capacity in the experimental group are statistically significant ($P<0.05$). The working-memory-related figures for the control group, however, do not show significant improvement on the posttest in comparison to the pretest ($P>0.05$).

Table 1. Paired sample t-test results and statistics for both groups on the working memory measures

Group	Working memory measures	Pre-test	Post-test	Differences	P value
		Mean \pm SD	Mean \pm SD	Mean \pm SD	
Experimental	Audio span	5.87 \pm 1.125	8.53 \pm 0.640	-2.667 \pm 1.047	<0.001
	Visual span	7.20 \pm 1.656	8.80 \pm 0.414	-1.600 \pm 1.639	0.002
Control	Audio span	6.20 \pm 1.082	6.53 \pm 1.187	-0.333 \pm 0.724	0.096
	Visual span	7.13 \pm 1.187	7.60 \pm 0.986	-0.467 \pm 1.302	0.187

To compare the performance of the groups with each other, independent group t-test was run (Table 2). Comparisons of the two groups' performances on the

working memory pretest do not yield a statistically significant difference ($P>0.05$). Comparisons of the posttest results of both groups, however, show a statistically significant difference ($P<0.05$).

Table 2. Independent sample t-test results and statistics for both groups on the working memory measures

Group	Working memory measures	Pre-test	Post-test	t	P value
		Mean \pm SD	Mean \pm SD		
Experimental	Audio span	5.87 \pm 1.125	8.53 \pm 0.640	-0.827	0.415
	Visual span	7.20 \pm 1.656	8.80 \pm 0.414	0.127	0.900
Control	Audio span	6.20 \pm 1.082	6.53 \pm 1.187	5.743	<0.001
	Visual span	7.13 \pm 1.187	7.60 \pm 0.986	4.347	<0.001

To address the second research question, the participants in both the experimental and control groups also took pretests and posttests on the reading tasks (Table 3). In order to compare the performance of the groups, independent samples t-test was run.

Comparisons of the means of the reading tasks of both groups on the pretests and the posttests do not show a significant difference ($P=0.270$ and $P=0.127$ respectively).

Table 3. Independent sample t-tests results and statistics on the pretests and posttests on the reading tasks

Group	Pre-test	Post-test	t	P value
	Mean \pm SD	Mean \pm SD		
Experimental	16.73 \pm 4.11	17.93 \pm 5.14	1.12	0.270
Control	14.86 \pm 4.92	14.73 \pm 5.96	1.57	0.127

In order to compare the performance of each group on the pretest with its own performance on the posttest, paired t-test was run (Table 4).

Comparison of the performance of the experimental group on the pretest and posttest does not show a significant difference ($P=0.175$). Similarly, the difference between the performance of the control group over the pretest and posttest was not statistically significant ($P=0.918$).

Table 4. Paired sample t-test result and statistics for the reading tasks

Group	Pre-test	Post-test	Paired differences	t	P value
	Mean \pm SD	Mean \pm SD	Mean \pm SD		
Experimental	16.73 \pm 4.11	17.93 \pm 5.14	-1.20 \pm 3.25	-1.427	0.175
Control	14.86 \pm 4.92	14.73 \pm 5.96	0.13 \pm 4.89	0.105	0.918

Discussion

The results suggest that there was a significant difference in the working memory measures of the experimental group in comparison to their own performance on the posttest and also to the posttest results of the control group. Similar results are also reported in the literature on working memory studies, as indicated in the results of meta-analytic studies such as Melby-Lervåg & Hulme (17).

With so much growing interest in working memory and so many researchers advocating its significance, it is no surprise that commercially made products were soon available on the market to help people train their working memory and for researchers to carry out studies on working memory. One such example is the study by Kiany et al. on the effects of a working training program for adults (19). However, when it comes to the application of such training regimens to the real lives of people, the results were not as promising as they were supposed to be. A meta-analysis study on the working memory training programs involving children by Melby-Lervåg & Hulme (17) revealed improvements in carrying

out tasks that are basically similar to the ones in the program but no significant changes in nonverbal intelligence, verbal intelligence, reading, or arithmetic outcomes. It is worth mentioning that children with learning deficiencies have been the sole target of those programs.

Similar studies carried out in Iran on the effects of working memory training programs on children's learning deficiencies, however, report different results from those of other studies reported above. These studies have investigated the effects of working memory training on subject areas like reading skill, dictation, and math in primary school children (20, 21, 22), and almost invariably reported significant developments in the target areas as the result of improvements in working memory capacity. Azizi Nejad (23) studied the relationships between the types of memory and academic achievement among high school students with learning disabilities and reported positive, significant relationships. Asad Zadeh (24) found a positive and significant relationship between working memory capacity and school achievement among junior high school students in Tehran. Aghababaei & Amiri (25) investigated the visual-spatial component of working memory and short-term memory in students with learning disorders and in normal students. A significant difference between students with reading, mathematics and spelling learning disorders and normal students in terms of the visual-spatial component of working memory and short-term memory was consequently reported by them.

The findings of the present study, however, are in line with those of the studies being reported in the meta-analysis by Melby-Lervåg & Hulme (17) in that our findings show improvements in the working memory measures being assessed by the related software, but this change seems to have left the learners performance on reading comprehension tasks unaffected.

How can improvements in working memory measures not be correlated with the outcomes of its functions in areas like reading or arithmetic? Redick et al. (6), use two metaphors to capture such discrepancies: near transfer vs. far transfer. According to them, in near transfer, working memory tasks that are similar to the training material improve, which are basically different from the ones required to carry out academic or behavioral tasks, which demand a far transfer of the trained tasks to the target domain. In the case of the present study, there has been improvement in the working memory tasks that are similar to the tasks included in the training regimen. However, working memory encompasses a much larger number of tasks, and the trained ones fail to exert a

significant effect on the target learning area (reading comprehension).

Despite the fact that this study touches an area of inquiry which has not been explored fully yet, it can be said in truth that like any other studies conducted in a similar fashion, some limitations need to be conceded. First of all, the age range of the participants was limited. Participants with a wider age range might have performed differently. In addition, some of the participants were already multilingual. Apparently, they were not homogeneous in terms of the number of languages they knew. Last but not the least, the reported results were obtained from a limited number of participants. Other studies with a larger number of participants might come up with different results.

Future studies on other aspects of the issue are strongly recommended. The effects of mastering several languages on the working memory capacity and its relationship with different language skills have not yet received the due attention that they deserve. In addition, it is interesting to find out whether improving the working memory leads to significant gains in other language skills. Working memory capacity in multilinguals and its possible differences from monolinguals is another area of viable research.

Conclusion

This study tried to find out whether working memory measures of a group of university students as assessed by the related software would improve as a result of undergoing a working memory training program, and if any possible gains in this respect would be accompanied by any improvement in the subjects' reading comprehension. It was found out that working memory measures on tasks similar to the ones practiced during the training program did increase, but this increase was not accompanied by a significant rise in the subjects' reading comprehension. It can be said that working memory as measured and trained at present does not seem to reflect the full extent and potential of the construct. Considering the significant role that is assigned to working memory in carrying out academic and daily tasks, it is probable that the training pieces of software available at the moment to the public cover a too narrow range of tasks to be compared to that accounting for every mental activity required to carry on normal academic and daily functions.

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Modares University, Tehran, Iran. There is no conflict of interest in this study.

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