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The Effect of Working Memory Training on Vocabulary Recall and Retention of Iranian EFL Learners: The Case of Dual N-Back Task

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Abstract
Working memory plays an important role in learning since it serves as the buffer between past sensations and future behavior, making it essential to understand not only how we encode and recall sensory information in memory but also how we plan for its upcoming use. This study examined the effect of working memory training on vocabulary recall and retention of Iranian EFL learners using the dual N-back task technique. N-back requires the individual to remember an item that was presented a certain number of items previously. To this end, 50 EFL learners were randomly assigned to the experimental (n = 25) and control (n = 25) groups. The participants were taught 100 English words in 20 sessions. In each session, the experimental group also received a dual n-back task. After the treatment, immediate and delayed vocabulary posttests were administered. The obtained data were analyzed through two-way repeated-measures ANOVA and independent samples *t*-tests. The results showed that the experimental group outperformed the control group in target words' recall and retention.

Keywords:
dual n-back task, EFL learners, working memory training, vocabulary recall, vocabulary retention

INTRODUCTION

Memory is an ambiguous term. It always implies some relationship in time, some connection between a present impression and a past event. Very probably this distinction between past and present is consciously recognized only by man. The mechanism by which we recall the past is frequently a process of matching a present image with a past image. This matching can be a conscious examination of several possibilities. The successful matching of a present image with a past image involves a process of recognition. Memory, which is the process by which we acquire knowledge of the world and modify our subsequent behavior, is essential for learning (Dehn, 2011; Goo et al., 2015; Janacsek & Nemeth, 2015; Spada & Tomita, 2010; Van Abswoude et al., 2020). It has been suggested that working memory (WM) supports language learning (Baddeley, 2003, 2012; Wen, Schwieter & Benati, 2019). Working memory (WM) is important for many activities both in first and second language acquisition. According to Baddeley (2003, p. 189), WM refers to the "temporary storage and manipulation of information that is assumed to be necessary for a wide range of complex cognitive activities".

Researchers have examined the role of WM in various L2 language processes, including reading (Joh & Plakans, 2017; Walter 2006), writing (Adams & Guillot, 2008; Mavrou,2020), sentence processing (Juffs, 2004; Felser & Roberts, 2007), speaking (Kondo, 2021), vocabulary development (Ansarin & Khabbazi,2021), learning grammar (Suzuki,2019; Williams & Lovatt, 2005) and the processing of input and intake (Indrarathne & Kormos,2017; Mackey et al. 2010). WM has also been implicated as a core element in L2 aptitude (Dornyei & Skehan 2003; Grymska, 2016) and as a predictor of overall proficiency (Vallejos, 2020; Van Den Noort, Bosch & Hugdahl 2008).

The dominant theory of WM is the multicomponent Baddeley and Hitch model which was promulgated in 1974, and later revised by Baddeley (2003, 2006). This model defines WM as "a limited capacity temporary storage system that underpins complex human thought" (Baddeley, 2007, p. 7). Over the years, Baddeley has described several core central executive functions, including (a) focusing attention on relevant information while inhibiting the irrelevant information; (b) switching between concurrent cognitive activities; (c) applying strategies, such as conscious rehearsal; (d) allocating limited resources to other parts of the WM system; and (e) retrieving, holding, and manipulating temporarily activated information from LTM. According to this model, working memory is a system with several different parts that control the information being processed. This led to the development of Baddeley's Model of Working Memory. This model assumes that each component has a limited capacity and is relatively, not entirely, independent of the others. Baddeley's original model contained three components, the phonological loop, the visuo-spatial sketchpad, and the central executive. However, the current model also contains the episodic buffer. In contrast, performance decrements when two tasks are combined indicate that they share a reliance on the same component. This empirical approach has proved invaluable in fractionating WM into its constituent parts, leading to the most recent version of the WM model, advanced by Baddeley in 2000 (Baddeley, 2000) (Figure 1.1)

The concept of a phonological loop has not gone unchallenged, however. To date, the theoretical underpinnings of the phonological loop continue to be researched and have produced interesting developments in our understanding of language acquisition and processing (Baddeley, 2007). In this study, we examined the effect of WM training through using dual n-back task on vocabulary recall and retention of Iranian EFL learners.

A widely used means of measuring WM is the n-back task. The dual n-back task is a variation of memory assessment that was proposed by Jaeggi, Buschkuehl, Jonides, and Perrig, (2008). In the dual-task paradigm, two independent sequences are presented simultaneously, typically using different modalities of stimuli, such as one auditory and one visual. In the n-back task, the participant is shown a series of items (e.g., letters, words or location markers) and is asked to decide, upon presentation of each item, whether a given property of the current item matches the same property of the item N presentations back. Variations in n can be used to assess individuals' levels of processing capacity or to set a level of dual-task competition. Since its inception, the n-back task has been brought to bear on a host of issues related to WM.

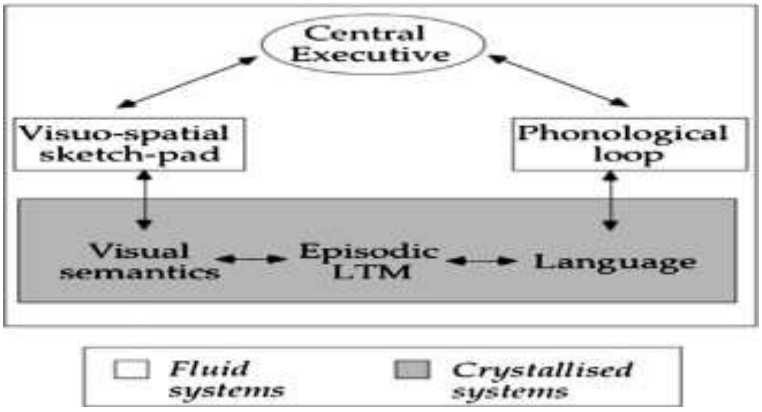

Figure 1: Multi-Component Working Memory Model (Adapted from Baddeley, 2012, p.11)

Statement of the Problem and Purpose of the Study

Nearly all cognitive and metacognitive functions are closely interrelated with WM. For example, language expression, processing speed, reasoning, phonological processing, attentional control, and executive functions have high correlations with WM. Furthermore, nearly all aspects of learning, especially academic learning, depend on adequate levels of WM Finally, performance and application of skills, as well as cognitively challenging daily activities, depend on WM. working memory (WM) has been assumed to involve two different systems of maintenance, a phonological loop and a central attentional system. Though the capacity estimate for letters of each of these systems is about 4, the maximum number of letters that individuals are able to immediately recall, a measure known as simple span, is not about 8 but 6. One of the most known problem among second language learners is memorizing the meaning of vocabularies while still want to recall it while needed. Some researchers shown that WM might predict the overall understanding of EFL learners. For EFL learners' reading comprehension, background knowledge, language skill, processing and analysis of the information (i.e., vocabulary) are related to each other processes related to WM (Gathercole, 2007). A sufficient measure of examination has been directed on L2 vocabulary obtaining and additionally on WM limit. Notwithstanding, more studies are required to research the conceivable relationship between WM limit and L2 vocabulary recall/retention. In response to this call, the study described in this article drew on a pretest-treatment–posttest-experimental-design to explore whether working memory (WM) capacity training helps the extent to which L2 learners benefit from using dual n-

back task training for partially-acquired L2 vocabulary. EFL students with higher WM capacity do better in school than students with lower WM capacity. Successful acquisition of academic skills and the performance of those skills rely heavily on WM. All things considered, it needs more investigation and examination to discover a linkage between the purported variables over the course of the current research. Since Second language researcher and L2 instructional method look to address the topic of why a few learners struggle to procure a L2 (as a rule in educated settings), specialists have been keen on seeing if WM constraints clarify contrasts in achievement in an assortment of spaces. The reason for choosing this subgroup of English vocabulary was that, despite their high frequency and importance, they are particularly difficult for nonnative speakers to learn, even at advanced levels of proficiency (Mitchell, 2018).

LITERATURE REVIEW

The studies on vocabulary can be divided into two broad types: those examining vocabulary size as the outcome variable (predictive research) and those investigating treatment effects on learning rate (experimental research). Within each category, the research can be further divided according to whether the predictor variable is phonological short-term memory (PSTM) or executive WM. Phonological short-term memory has been found to be a predictor of vocabulary size, and the finding was obtained for both adults (Hummel, 2009) and young children (Farnia & Geva, 2011; Gathercole & Masoura , 2005). Executive WM, however, has been found to be weak and unstable predictor of vocabulary size (D'Angiulli, Siegel, & Serra, 2001; Engel de Abreu & Gathercole, 2012; Jean & Geva, 2009). Experimental studies typically include one or more treatment sessions where learners were engaged in so-called "paired associate" tasks in which learners were presented with L2 words and their first language (L1) translations. This research shows that phonological short-term memory was important for learning new vocabulary at initial stages of learning (Atkins & Baddeley, 1998; Martin & Ellis, 2012; Speciale, Ellis, & Bywater, 2004). However, at more advanced stages, where learners had an extensive learning experience, phonological short-term memory stopped being a significant predictor, and previous vocabulary knowledge emerged as a more important factor (French & O'Brien, 2008; Ghazanfar & Farvardin, 2015; Verhagen & Leseman, 2016). Executive WM was also found to be predictive of learning rate in studies where learners had no background in the target language (Kempe, Brooks, & Kharkhurin, 2010; Juffs & Harrington, 2011; Perez, 2020), but because of the lack of relevant research, it remains unknown whether it is less predictive of vocabulary learning at more advanced stages of learning—as has been found for phonological short-term memory.

METHOD

Along with the previous studies in the field of WM and to extend the scope of its expansion, this experimental study was set up to compare the impact of using dual n-back task training through using memory workshop software, alongside to teaching new vocabularies, to Iranian EFL learners. To meet this objective, it was necessary to apply a pre-test and post-test in order to establish if there was a difference between the experimental and control group. The characteristics of this study fit into a quantitative type of research, in that generally starts with an experimental design in which a hypothesis is followed by the quantification of data and some sort of numerical analysis is carried out.

Participants and Setting

The participants were selected from 100 university students holding Bachelor of Arts degree in different majors at Islamic Azad University, Shoushtar Branch. The participants' first language was Farsi. The participants were male and female, aging between 25 to 40 years old. For the purpose of study, the Vocabulary Size Test (Schmitt's vocabulary size test 2001) including 2000, 3000, 5000 and 10000 level tests were applied as pre-test. Each level included 30 items and the amount of 20 minutes for each level of proficiency considered for participants. After gathering test scores, and according to existing facilities, among remaining population 50 participants selected. The participants, then divided randomly into two groups, experimental and control group. Each group consisted of 25 participants.

Materials

In order to obtain measurable data with which the results of the current study could be statically analyzed, the following instruments were utilized Schmitt's Vocabulary Size Test (2000). It is designed to measure both first language and second language learners' written receptive vocabulary size in English. The test measures largely decontextualized knowledge of the word although the tested word appears in a single non-defining context in the test.

Dual N-Back Task

The n-back task has been found to involve a number of the executive functions that have been linked to the relationship between working memory and fluid intelligence, including the processes of attentional control, updating, and the inhibition of interference. It enables subjects to improve their WM capacity and fluid intelligence. The dual n-back task involves remembering a sequence of spoken letters and a sequence of positions of a square at the same time, and identifying. It includes recalling stimuli or their location without any need to process the information, deal with distractors, or manipulate images are classified as visual-spatial STM measures. All cognitive and memory subtests measure multiple cognitive and memory abilities. This is not due only to the structure, content, and demands of the subtests themselves. Rather, it mainly reflects the integrated functioning of the brain.

Vocabulary Test

A vocabulary test consisting of twenty matching vocabulary items based on the follow up activities of each session was given (newly taught vocabulary). In order to prepare a first version of the vocabulary test; piloting this version; based on the pilot results designing the final version; and finally administering the instrument to a sample of language learners to validate. The participants of the pilot study were 50 (27 males; 23 females). The participants came from a variety of subject backgrounds such as management, business, and education. The reliability results of the final version was estimated (r=0.81). Given that the Cronbach Alpha coefficient is 0.79 we can safely conclude that the vocabulary test performed well in terms of reliability. It was to demonstrate the lexical improvement of participants in pre-test and post-test phases and to determine to what extent using Dual n-back task in teaching was effective.

Procedure

Before treatment sessions, the Vocabulary Levels Tests were conducted among 100 participants. Among 120 items, 70 items with the maximum wrong answers that most of the participants did not respond them, were selected. After excluding the highest and lowest scores, 64 subjects remained. Of these, 50 participants were selected randomly base on drawing numbers out of a hat. Then they assigned into two groups, control and experimental group. While the control group received conventional teaching, the experimental group worked with Dual-N Back software at the end of each treatment session. In order for testing the validity of the selected items for using in the treatment sessions, 60 words from the tests and 10 words from external materials were selected and used in a pilot study. The study carried out during vocabulary retention/recall measuring course consisting 12 sessions spread over about one month, three days a week, each session 75 minutes. Finally, after three weeks' interval between the posttest final vocabulary test, both experimental and control groups took a test namely a delayed test. Again, it was a vocabulary level test with slight modifications in arrangement.

RESULTS

The results of the research revealed the effectiveness of using dual n-back task training and WM capacity development and it is significant and learners benefit from using the task during their study period. Also, the findings showed that dual n-back task plays a crucial role in expanding WM of Iranian EFL learners' vocabulary recall and retention. The above-mentioned results of this study are in line with various findings in different language learning domains. As follow in accordance with Alloway, et al. (2013), development of WM capacity in the recall and retention phases was significant. Also, the results of this study are in line with L2 reading comprehension studies e.g., Adams and Shahnazari-Dorcheh, (2013). The difference between results of pretest, posttest and delayed posttest (mean score) revealed that using dual n-back task training affected significantly on the learners' vocabulary retention in a long span of time. Finally, the findings support the results of study done by Jaeggi et al (2014) and Au et al. (2015) that indicates significant correlation between using dual n-back task and memory expansion. Table 1presents the descriptive statistics for control and experimental group over time.

Table 1. Descriptive Statistics for the Control Group and the Experimental Group over Time

Group		**Time 1 (Pretest)**		**Time 2 (Im. Posttest)**		**Time 3 (Del. Posttest)**	
	N	M	SD	M	SD	M	SD
Experimental	25	29.88	7.52	50.88	8.64	47.48	8.02
Control	25	29.84	7.03	35.56	6.36	30.68	5.41

As can be seen in Table 1, the mean of pretest in experimental group is 29.88 and, in the posttest, increased to 50.88 and in delayed posttest it was 47.48, while in the control group, the mean score in pretest is 29.84, and it changes to 35.56 in posttest and finally it decreased to 30.68 in delayed posttest. The standard deviation in the experimental group was 7.52, 8.64 and 8.02 in the pretest, posttest and delayed posttest respectively. Also,

the standard deviation has changes in pretest, posttest and delayed posttests by 7.03, 6.36 and 5.41 respectively.

In order to find out the effect of treatment between control and experimental group over times, we have run two-way repeated measures ANOVA. The results are shown in Table 2 below:

Table 2 Two-Way Repeated Measures ANOVA

Source	**df**	***F***	***p***
Between Subjects			
Group	1	1222.76	<.01
Within Subjects			
Time	2	296.16	<.01
Time × Group	2	134.30	<.01

As shown in Table 2, the variance between subjects group mean (F value) is equal to 1222.76 and p value is 0.01. In the other hand, the variance within subject during test administration times is equal to 296.16 and time by group is 134.30. Table 3 shows the result of independent samples t-tests for posttests:

Table 3 *Independent Samples T-Tests for Posttests*

Posttest	T	df	p
Time 2- after 1 week	7.14	48	<.01
Time 3- after 3 weeks	8.68	48	<.01

As can be seen in table 3, t score after one week of treatment is 7.14 and after 3 weeks is 8.68. The P-value observed and degree of freedom are 0.01 and 48 for both respectively.

Finally, the Bonferroni pairwise comparisons have been implied. It can be used to correct any set of P values for multiple comparisons, and is not restricted to use as a follow-up test to ANOVA.

Table 4 Bonferroni Pairwise Comparisons for the Experimental Group

Time (I)	Time (J)	Gain (Mean Difference)	Sig.
Time 1	Time 2	- 21	.00
Time 2	Time 3	3.40	.00
Time 1	Time 3	17.60-	.00

As Table 4 shows the comparison between the results of time 1 and time 2 shows -21 in mean difference and it is 3.40 in comparison of time2 and time 3 results and finally in comparison of time 1 and time 3 mean changes to -17.60. The level of significance was 0.00 for all tests results.

DISCUSSION

In this study dual N- back task was used as treatment to see whether this kind of training has any effect. Vocabulary acquisition was assessed by an immediate posttest, where individuals attempted to recall words and attempted to answer the questions from Schmitts' vocabulary size test, that were same as the pretest with some modifications. In this test, the participants had to find correct definition among three available definitions. The mean score of the experimental group in pretest was 29.88 compared to 50.88 in posttest and in the control group it was 29.84 in pretest and 35.56 in posttest. It indicates improvements in result of the experimental group over control group. The results suggested that the application of WM training in the experimental group had an impact on their actual performance (post-test), resulting in a smaller gap between the recall of the vocabularies and WM capacity expansion. Regarding the short-term effect, the experiment group showed higher mean score of the immediate posttest than the control group while there was not any significant difference in the two groups' pre-test. The findings of the current experimental study provided empirical support of the effectiveness of applying dual n-back task on vocabulary retention of Iranian EFL learners. The difference between results of pretest, posttest and delayed posttest (mean score) revealed that using dual n-back task training affected significantly on the learners' vocabulary retention in a long span of time. Taking research outcomes into account based on the statistical analysis of results of various calculations such as Bonferroni pairwise comparisons, two-way repeated measure ANOVA and independent sample t-test of three phases of this study including pre-test, post-test and delayed posttest demonstrated that there were significant differences between the results of pre-test and post-test and delayed posttest of vocabulary retention in the experimental group. WM and long-term memory have reciprocal influences on each other that are difficult to separate. The relationship is clearly bidirectional: Long-term knowledge is used to recall and enhance short-term and WM representations; and WM facilitates the building and retrieval of long-term structures.

The results are in line with Jaeggi et al. (2008) and Klingberg et al. (2002) in that they argued that dual n-back task training can enhance WMC and other related subcomponents of WM. Also, the findings are in line with Sozler (2012) on effect of memory strategy training on vocabulary development of Austrian secondary school students, in Which it confirms the effectiveness of using memory strategies as vocabulary learning strategies. However, they are different from Marefat and Shirazi's (2003) findings in which learners who received memory strategy instruction performed better in short-term retention test than long-term retention test. This discrepancy may be due to the inappropriate combinations and use of strategies in terms of time, place, and method. Finally, as a finding of this study, the experimental group which used dual n-back task training improve their retention and ability to recall information more exactly and even after long period of time. Participants given dual n-back task training performed better than those who were given no treatment. The findings contribute to the idea that L2 vocabulary memorization and using in long periods of time can be achieved by using software like dual n-back task training and other software as medium to improve WM capacity. This result indicates that although both experimental and control group developed their scores, but experimental group that received Dual n-back task training out performed. Also, it can be said that the WM training had a positive effect on short term memory for vocabulary recall in the experimental group when compared to the control group who did not receive the training.

CONCLUSION

The findings of the current experimental study provided empirical support for the effectiveness of using dual n-back task training on vocabulary recall and retention among Iranian EFL learners. The obvious effect of usefulness of using dual n-back task training might be attributed to the fact that all participants in the experimental group who exposed to using dual n-back task after each session, performed better than the other group. They exposed to use dual n-back task training after each session for fifteen minutes. The data collected showed that exposure to using dual n-back task training has a significant effect on participants in experimental group recall and retention. Therefore, according to the findings, the participants could also expand their memory through using dual n-back task training. Individuals' WM capacity, presents a significant correlation with vocabulary acquisition in an L2 situation. (Wardlow & Heyman). This statement justifies why the great majority of the participants claimed they had learned most of the words taught during the period of data collection. It is noteworthy that some words are more difficult to learn due to their feature of being abstract, thus being less prone to being visualized and to being transferred to long-term memory. Knowing the relationships between EFL vocabulary knowledges and WM functions is valuable information that can guide assessment, interpretation of results, and diagnosis of learning disorders. Students with different WM capacity tend to demonstrate unique types of remedies in educational settings. Thus, an individual's WM profile, at least to some extent, can help to differentiate among types remedies that must be used. The results indicates that WM performance can reliably differentiate between students with high and those who are slow learners. Although recently activated LTM items contribute to WM capacity and function, there are currently no standardized instruments for assessing the number of such items and the speed with which they can be accessed. Nonetheless, the extent to which LTM is supporting WM functioning should be considered and assessed informally. N-back is very effective because it challenges executive WM by requiring continual updating, switching, and inhibiting. The only concern with n-back is that it is too challenging for younger children, especially those less than 8 years of age. For adults and those who handle n-back well, the task can be made more challenging by creating a dual n-back, such as having to remember both auditory and visual information about an item presented n-items before.

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