Effects of STM Span, Syntactic Awareness, and Vocabulary Knowledge on Iranian EFL Learners' Reading Comprehension

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Abstract—The present study aimed at investigating the effects of Short-Term Memory (STM) span, syntactic awareness, and vocabulary knowledge on Iranian EFL learners' reading comprehension. The research data were collected using quantitative methods. The data collection instruments included Oxford Placement Test, a working memory span test, and reading pretests and posttests. Sixty seven female intermediate level students were randomly assigned into the three groups of control, syntactic awareness, and vocabulary knowledge. Their performances then were measured and analyzed. Not only did the results reveal that there was a significant difference between the experimental groups and the control group in reading comprehension but also a significant difference between the two experimental groups. In other words, students in the vocabulary knowledge group benefitted more than students in the syntactic awareness. In addition, findings from the study indicated that STM does not affect reading comprehension ability of the students.

Index Terms—STM span, syntactic awareness, vocabulary knowledge

I. Introduction

Reading is an active problem-solving process of attaining interpretive meaning from text. A reader employs a range of skills and processes in a reading activity to comprehend what the author or authors have been trying to imply. Unlike what was conceived of reading in the past, today theories and models of reading almost unanimously see reading as primarily an interactive process (Adams, 1990; Samuels, 1994). Naturally, approaches to the teaching of foreign language reading too have changed to mirror this development through using interactive exercises and tasks.

A. Statement of the Problem and Significance of the Study

So far, there have been lots of discrepancies in the results found by researchers about the relationship between STM and reading comprehension. Some researchers have concluded that such a relationship exists (Duvfa, Niemi, & Voeten, 2001) while others have not been able to find any remarkable relationship between them (e.g., Hanten & Martin, 2000). May be one of the reasons why such inconsistency arises is that it is difficult to differentiate between the components of STM (Engle et al., 2011). One other reason for the mixed results could be that, after all, these experiments have been done on human subjects and changes in the conditions under which a research is conducted, or change in the subjects, can lead to varied results. Actually, the inconsistency mentioned was the problem that this study attempted to address. This study was considered to be significant because it could add to our understanding of the role that STM plays in reading comprehension. Another issue that can be mentioned in relation to the significance of this study is the researchers' intention to find any possible interaction that might have existed among the three independent variables of the study, i.e. STM span, syntactic awareness, and vocabulary knowledge.

B. Reading Comprehension

Reading comprehension, according to Brimo and Apel (2011), is a complex process which is accomplished by decoding and comprehension of language. According to these authors, there are two common measurement instruments of comprehension, syntactic knowledge and/or syntactic awareness tasks and vocabulary knowledge tasks. Reading consists of integrating two complementary bottom-up and top-down processes which summarily can be referred to as word recognition and comprehension. Word recognition is the process of perceiving written symbols and matching them with one's spoken language. Comprehension is the set of processes that involves interpreting, finding out the associations, and making sense of words, sentences and connected text. For top-down processes to be effective, readers usually make use of their background, vocabulary, and grammatical knowledge in addition to their experience with text. Although it is true that comprehension is more than recognizing words and remembering their meanings, it is also true that if a reader does not know the meanings of a sufficient proportion of words in a text, comprehension will be

incomplete. Among various types of pre-reading activities is grammar pre-teaching. According to Bossers (1992), incomplete syntactic knowledge and a basic unfamiliarity with syntactic boundaries would impede the second-language reading process. Also, it is well-documented that vocabulary and L2 reading affect each other reciprocally (Pulido, 2009; Stæhr, 2008). Definitions of these two types of knowledge are as follows:

1. Syntactic awareness: Shows students' ability to internalize and use structures in English that are grammatical. (Norris, 2012).

2. Vocabulary: "A set of lexemes, including single words, compound words and idioms" (Richards, Platt & Platt, 1992, p. 400).

C. Memory and Reading Comprehension

Since reading is a complex cognitive process, it is possible that individual learner capacities, like working memory, may influence its efficiency. This may be particularly the case with second language (L2) reading, because unlike reading in L1, L2 reading involves the engagement of two languages whenever a second language learner starts reading (Cain & Oakhill, 2006; Koda, 2005). Memory and reading are in close interaction with each other. Low-capacity working memory or a long-term memory which is organized poorly can lead to difficulties both in reading and comprehension. The correlation between working memory span measures and reading comprehension ability was originally referred to by Daneman and Carpenter (1980) and it highlights the importance of working memory for understanding texts.

D. Research Questions and Hypotheses

This study specifically addressed the following four research questions:

1. Does syntactic awareness affect reading comprehension?

2. Does vocabulary knowledge affect reading comprehension?

3. Do teaching methods of reading comprehension without any particular focus, with a focus on syntactic awareness, and with a focus on vocabulary knowledge affect students' reading comprehension in the same way?

4. Will there be any significant difference among the groups' reading comprehension abilities if the effect of STM is kept constant?

The null research hypotheses driven from the above research questions were as follows:

$H0_1$: Syntactic awareness does not affect reading comprehension.

$H0_2$: Vocabulary knowledge does not affect reading comprehension.

$H0_3$: Teaching methods of reading comprehension without any particular focus, with a focus on syntactic awareness, and with a focus on vocabulary knowledge do not affect students' reading comprehension differentially.

$H0_4$: There will be no significant difference among the groups' reading comprehension abilities if the effect of STM is kept constant.

E. Design of the Study

This study enjoyed a true-experimental design in that all the participants were selected and assigned to the groups randomly. The study also involved a control group, pretests and posttests, and treatments. The dependent variable of the study was reading comprehension and the independent variables were STM span (as a moderator variable), syntactic awareness, and vocabulary knowledge.

II. REVIEW OF THE RELATED LITERATURE

High correlations have been found between vocabulary knowledge and reading comprehension of L2 learners. Gelderen et al.'s (2004) study, for example, indicated a sizeable correlation between these two variables. Like Gelderen et al., Golkar and Yamini (2007) found a high correlation between the learners' vocabulary knowledge and reading comprehension ability.

In a longitudinal study by Muter, Hulme, Snowling, and Stevenson (2004) the contribution of phonological skills, letter knowledge, syntactic awareness, and vocabulary knowledge to word-level reading and reading comprehension was confirmed. Muter et al. concluded that vocabulary, grammatical awareness, and word-level reading are important skills and they contribute to reading comprehension of students at later stages. In another study, Demont and Gombert (1996) found that top-down and bottom-up elements affect each other and their relations are conditional and vary with students' proficiency. More specifically, they demonstrated that the predictive power relations between different measures of syntactic awareness, word reading, and reading comprehension change over time. Cutting and Scarborough (2006), too, found that variance in reading comprehension is accounted for to a large extent by vocabulary and syntactic knowledge.

Working memory has also been considered as a relevant factor in reading comprehension studies. The majority of prior studies on L2 reading present evidence of a relationship between working memory and reading comprehension (Alptekin & Erçetin, 2009; Harrington & Sawyer, 1992; Lesser, 2007; Walter, 2004). Harrington and Sawyer (1992), for example, studied the relationship between L2 working memory capacity and L2 reading ability among Japanese learners of English. The participants completed three memory tests in L1 and L2 as well as L2 English reading

comprehension. Assessment of memory consisted of three tests including digit, word, and reading span tests. Reading comprehension in English comprised of a passage with gaps (cloze passage) and the grammar and reading sections of the TOEFL. Results revealed relatively high and significant correlations between working memory capacity (L2 reading span), and both TOEFL reading (r=.54) and TOEFL grammar (r=.57).

III. METHODOLOGY

A. Participants

The participants of this study were female Persian learners of English at an Institute in Rasht, a northern city in Iran. The students' ages ranged from 13 to 16. Oxford Placement Test (OPT) was given to all students in order to determine their proficiency level. Based on the results obtained on this test, 67 intermediate level students were selected and put in three groups of control, vocabulary knowledge, and syntactic awareness.

B. Procedure

Oxford Placement Test (OPT) was administered to a large group of students in a language institute and 67 intermediate level students were selected. The internal reliability of this test was calculated for this study which showed an alpha coefficient of .80. The students were randomly assigned to three groups: two experimental and one control. Since this study had a psycholinguistic aspect to it, before proceeding with other requirements of an experimental research, the STM capacities of all participants were also measured by the WM span tasks. This test included six trials with letters used to measure the participants' WM span. The number of letters increased two letters at a time. A few letters flashed on and off on the computer monitor for 3 seconds. The students' job was to write down on their data sheet as many letters as they could remember after the letters disappeared. After that, the reading pretest was administered to all groups in order to ensure that they enjoyed almost the same level of reading ability. After the initial stages were completed the treatments began. In the group with a focus on grammatical awareness, called GAG in this study, the students received a treatment of 30 minutes each session searching for as many syntactic points and structures in a given text as they could.

The vocabulary knowledge group (VKG) was provided with words which were used in their reading texts. The students were asked to review the words prior to each session as their homework and discuss the vocabulary with which they had problem in the class. The whole vocabulary teaching took around 30 minutes after which the students read the text which was intended for that session and answered the relevant questions for about an hour.

Students in the control or No-Treatment Group (NTG) received no special treatment but were asked to read the given texts and answer the comprehension questions. The classes were held for seven weeks, two sessions a week. In the final session, the reading comprehension posttest was administered to all groups. The reliability of the reading test was estimated to be .79 using Kuder-Richardson 21 formula.

C. Materials

The materials used in this study included: Oxford Placement Test (OPT), a reading comprehension test which served both at the pretest and posttest stages, reading passages for treatment sessions, and WM-span test.

IV. DATA ANALYSIS AND RESULTS

To select the most appropriate statistical procedures to compare performances of the groups in the posttest, it was necessary to make sure that the groups' scores enjoyed normal distributions and met the assumption of parametric tests used in this study. The scores were, therefore, submitted to the One-sample K-S test first (Table 4.1) which revealed deviation from normality in none of the groups (*Sig.*=.200, .060, .200, >0.05).

TABLE 4.1
NORMALITY TESTS RUN ON READING COMPREHENSION SCORES AT THE POSTTEST STAGE

	One-sample Kolmogorov-Smirnov		
	Syntactic awareness	Vocabulary knowledge	Control
N	24	22	21
Kolmogorov-Smirnov Z	.125	.181	.152
P value	.200	.060	.200

To examine the first two null hypotheses, three Paired samples T-tests were run. Descriptive statistics of the results are given in Table 4.2.

TABLE 4. 2
DESCRIPTIVE STATISTICS OF PRETEST AND POSTTEST READING SCORES IN THE GROUPS

Group	Tests	Mean	N	S.D	Std. Error Mean
Syntactic awareness	pre reading	8.6667	24	1.99274	.40677
	post reading	12.0833	24	1.97631	.40341
Vocabulary knowledge	pre reading	8.5909	22	1.86851	.39837
	post reading	15.0455	22	1.58797	.33856
Control	pre reading	9.0476	21	1.80212	.39325
	post reading	10.1429	21	1.93095	.42137

As the descriptive statistics in Table 4.2 indicate, the means for syntactic awareness, vocabulary knowledge, and control groups' reading pretest were 8.66, 8.59, and 9.04, and for reading posttest they were 12.08, 15.04, and 10.14, respectively. For the comparison of pretest and posttest results we needed to look at the T-test results presented in Table 4.3.

TABLE 4.3
PAIRED SAMPLES T-TESTS RUN ON THE PRETEST AND POSTTEST SCORES OF THE GROUPS

	Paired differences				t	df	Sig.(2-tailed)
	Mean	S.D	95% Confidence Interval of the Difference				
			Lower	Upper			
Pre syntactic awareness – Post syntactic awareness	-3.41667	1.13890	-3.89758	-2.93575	-14.697	23	.000
Pre vocabulary knowledge –Post vocabulary knowledge	-6.45455	2.30377	-7.47598	-5.43311	-13.141	21	.000
Pre control – Post control	-1.09524	1.41084	-1.73745	-.45303	-3.557	20	.002

It is clear that there had been significant differences between the pretest and posttest results of the two experimental groups (P=.000<.05) in addition to the pretest and posttest results of the control group. But increase in the posttest result of the control group was much smaller compared to the increase in the posttest results of the experimental groups.

The significant differences between the pretest and posttest reading comprehension results of the two experimental groups (syntactic awareness, and vocabulary knowledge) rejected our first two null hypotheses. To see how strong these improvements had been, the effect sizes were calculated using the formula $t^2/t^2 + (N-1)$ the results of which are given below. Both of these values are very strong effect sizes according to Cohen's (1988) taxonomy of effect sizes.

Eta-squared for grammatical awareness = 217.79/215/79 + 23 = .90
Eta-squared for vocabulary knowledge = 172.65/183.65 + 21 = .89

Still, with all these calculations, we did not know if increases in the students' gains had resulted in groups that were significantly different from each other at the posttest stage. To reach this understanding, it was necessary to run a One-way ANOVA and compare the posttest means of all groups. Result of the homogeneity test, as an assumption of parametric tests, is given in Table 4.4.

TABLE 4.4
LEVENE'S TEST OF EQUALITY OF ERROR VARIANCES AT POSTTEST

F	df1	df2	Sig.
.897	2	64	.413

As Table 4.4 shows, this assumption was met in this study because the significance value is much larger than the cut-off .05. The descriptive statistics of posttest reading for all groups are presented in Table 4.5.

TABLE 4.5
DESCRIPTIVE STATISTICS OF POSTTEST READING SCORES FOR ALL GROUPS

Groups	N	Minimum	Maximum	Mean	S. D.
Syntactic awareness	24	9.00	16.00	12.0833	1.97631
Vocabulary knowledge	22	11.00	17.00	15.0455	1.58797
Control	21	7.00	14.00	10.1429	1.93095

As can be seen in Table 4.5, the total mean values of reading comprehension test had been 12.08, 15.04, and 10.14 respectively for the syntactic awareness, vocabulary knowledge, and control groups. These differences suggested that pre-reading activities might have affected reading comprehension ability of the participants in different groups differently. In line with the above speculation, the result of One-way ANOVA (Table 4.6) revealed a statistically significant difference at .05 probability level in reading comprehension ability among the three groups (P=.000 <.05). Thus, the third null hypothesis was also rejected.

TABLE 4.6
ONE-WAY ANOVA RUN ON READING COMPREHENSION RESULTS AT POSTTEST STAGE

	Sum of square	df	Mean square	F	Sig.
Between groups	263.208	2	131.604	38.750	.000
Within groups	217.359	64	3.396		
Total	480.567	66			

Also, using the appropriate equation, the effect size of the ANOVA result was calculated which was .70. Based on Cohen's (1988) classification, the calculated Eta Squared is at the threshold of a large effect size.

$$\text{Eta Squared} = \frac{\text{Sum of squares between} - \text{groups}}{\text{Total sum of squares}} = \frac{263.208}{480.567} = 0.54$$

$$r^2 = .54 \quad r = \sqrt{0.54} = .7 = .70$$

In addition, a post hoc test was run to find out where the differences lied. The results of the Tukey HSD, run for this purpose, are presented in Table 4.7.

TABLE 4.7
MULTIPLE COMPARISONS OF THE EFFECTS OF PRE-READING ACTIVITIES ON THE GROUPS

	(I)group	(J) group	Mean differences (I-J)	Std. error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	Syntactic awareness	Vocabulary knowledge	-2.96212*	.54395	.000	-4.2673	-1.6569
		control	1.94048*	.55067	.002	.6192	3.2618
	Vocabulary knowledge	Syntactic awareness	2.96212*	.54395	.000	1.6569	4.2673
		control	4.90260*	.56223	.000	3.5536	6.2516
	Control	Syntactic awareness	-1.94048*	.55067	.002	-3.2618	-.6192
		Vocabulary knowledge	-4.90260*	.56223	.000	-6.2516	-3.5536

As Table 4.7 indicates, there has been a significant difference between the reading comprehension mean scores of the experimental groups, that is, syntactic awareness and vocabulary knowledge ($P= .000$). Also there has been a significant difference between the reading comprehension mean scores of the syntactic awareness and control groups ($P=.002$). Furthermore, the posttest reading comprehension means of the vocabulary awareness and control groups are significantly different ($Sig= .000$, $P< .05$). Thus, it can be concluded that both syntactic awareness and vocabulary knowledge have enhanced learners' performance in reading comprehension above and beyond the control group.

In order to investigate the fourth research hypothesis an ANCOVA was necessary to see whether there had been a significant difference among all groups if the effect of STM was kept constant. This test allows exploring differences between groups while statistically controlling for an additional continuous variable (STM in the case of this study) which the researcher suspects may be influencing scores on the dependent variable. However, this test has assumptions that must be met before running it. Two of the very important assumptions are linearity and homogeneity of regression slopes. But these assumptions were not met for us to run ANCOVA.

There are two ways out of this problem: to run ANCOVA anyway or to change the continuous covariate into a categorical one and run a Two-way ANOVA. Since the second procedure does not involve the violation of assumption and thus is more appropriate statistically, it was decided that this procedure be adopted. Therefore, STM, which was the covariate in this study, was broken down into a categorical variable with the two levels of small and large STM spans. The homogeneity test result, performed to check for one of the assumptions of this test, is given in Table 4.8.

TABLE 4.8
LEVENE'S TEST OF EQUALITY OF ERROR VARIANCES AT POSTTEST

F	df1	df2	Sig.
.366	5	61	.870

As Table 4.8 shows, this assumption has been met because the significance value is much larger than the cut-off .05. The descriptive statistics of posttest reading for all groups are presented in Table 4.9.

TABLE 4.9
DESCRIPTIVE STATISTICS OF POSTTEST READING SCORES FOR ALL GROUPS

Group	STM	M	SD	N
Syntactic awareness	small STM	11.1000	1.52388	10
	large STM	12.7857	2.00686	14
	Total	12.0833	1.97631	24
Vocabulary knowledge	small STM	15.0000	1.58114	9
	large STM	15.0769	1.65638	13
	Total	15.0455	1.58797	22
Control	small STM	10.5000	2.06828	10
	large STM	9.8182	1.83402	11
	Total	10.1429	1.93095	21

Differences in the mean scores of the groups, as in the posttest ANOVA above, suggested that pre-reading activities might have affected reading comprehension ability of the participants in different groups differently. In line with the above conjecture, results of the Tow-way ANOVA (Table 4.10) revealed a statistically significant difference at .05 probability level in reading comprehension ability across three groups (P=.000 <.05).

TABLE 4.10
TWO-WAY ANOVA RUN ON READING COMPREHENSION RESULTS AT POSTTEST STAGE

Source	SS	df	Mean Square	F	Sig.	Partial Eta Square
Group	258.148	2	129.074	39.702	.000	.566
STM	2.123	1	2.123	.653	.422	.011
Group*STM	16.327	2	8.164	2.511	.090	.076
Error	198.317	61	3.251			
Total	10862.000	67				

There are two additional but important pieces of information in this table. First, there is no interaction between the group and STM variables, P=.09>.05, which we could also have obtained had we run ANCOVA. Second, the effect of STM is non-significant, P=.42>.05. Both of these pieces of information tell us that we can forgo with the STM variable and attribute improvement in reading comprehension ability of students in the groups entirely to the treatments. Moreover, the effect size for the variable group is 0.566, which can be considered large taking into account Cohen's criteria.

These findings bring us to the point of rejecting our fourth null hypothesis. Because these findings suggest that controlling for the effect of STM will not affect students' gains in terms of reading comprehension ability and groups will possibly be different from each other depending on the kind of treatment they receive.

V. CONCLUSION AND DISCUSSION

To sum up, the results of this study indicated that both types of pre-reading activities, i.e. syntactic awareness and vocabulary knowledge, have positive effects on EFL learners' reading comprehension. However, the findings also illustrated that vocabulary knowledge benefits learners more. The difference between the two groups taught using these methods may be attributable to the fact that more attention is paid to lexical cues than to syntactic ones by EFL learners which makes syntactic cues less noticeable.

These results also suggest that working memory capacity is not a potential source of individual difference in explaining L2 reading ability at the intermediate level. In other words, the relationship between working memory capacity and reading ability might be most important at the beginning levels of language ability. Thus, considering the effect of working memory, findings of this study support Walter's (2004) proposal that success of higher-proficiency learners relies more on reading skills than on working memory. It seems that for higher level learners, with greater language knowledge and greater automaticity in the reading process, reading tasks present less of a burden on working memory than for lower level learners who rely more on memory capacity. The findings of the study are also in line with Demont and Gombert's (1996) and Cutting and Scarborough's (2006) studies. The former authors argue that relations between top-down and bottom up elements are conditional and vary with students' proficiency. The latter researchers state that variance in reading comprehension is accounted for to a large extent by vocabulary and syntactic knowledge.

All in all, the findings of the study showed that the experimental groups had better performance in comparison to the control group in their reading comprehension and it can be concluded that this better performance was the result of pre-reading activities that the learners received during the treatments. In other words, learners with greater language knowledge may be better readers.

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