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The Role of Working Memory (WM) in Fluency, Accuracy and Complexity of Argumentative Texts Produced by Iranian EFL Learners

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Abstract

The present study intended to examine the relationship between working memory (WM) and writing performance of a group of Iranian EFL learners and to explore whether learners with different working memory levels perform differently on the fluency, accuracy and complexity of texts produced or not. The necessary data were collected through the argumentative essay writing prompt and a computerized Persian version of reading span test as a measure of learners' WM capacity. The correlation analysis revealed that there was a significant positive relationship between these two constructs. The results of Multivariate Analysis of Variance (MANOVA) indicated that there were significant differences between High, Mid and Low WM groups in terms of fluency and accuracy of texts produced, but not their complexity. The findings confirmed the importance of WM while working on cognitively challenging tasks such as writing which requires automation and effective management of cognitive resources while writing. On the whole, the present study confirmed the idea that learners with different learning characteristics orchestrate their mental resources in different ways to perform in different phases of writing and part of their difficulties or even capabilities in writing can be attributed to the efficiency with which they apply these resources while dealing with different writing systems (formulation, execution, or monitoring) or engaging in different writing processes (translating, planning, programming, reading, or editing).

Keywords**:** Accuracy, complexity, fluency, working memory (WM), writing performance

Introduction

Empirical evidence in cognitive psychology suggests that working memory is "one of the greatest accomplishments of human mind and a significant source of individual variation in performing cognitive tasks" (Biedroń, 2012). An all-encompassing conceptualization of WM is defined it as "those mechanisms or processes that are involved in the control, regulation, and active maintenance of task-relevant information in the service of complex cognition" (Miyake & Shah, 1999). The working memory model developed by Baddeley and Hitch (1974) and Baddeley (1986, 2003) is a multicomponent system that plays an influential role in cognitive language learning processes and consists of *central executive*, *phonological loop*, *visuospatial sketchpad* and *episodic buffer*. Many cognitive psychologists with different research perspectives have used this highly influential model as a catalyst in conceptualizing human mental functioning and as a framework for conducting active research programs in a range of disciplines in cognitive science in order to answer a wide range of questions about higher-level human cognition (Baddeley, 2007; Baddeley, Hitch, & Allen, 2009; Wen & Skehan, 2011). Since working memory coordinates attentional resources and is responsible for the initial appraisal, processing and temporary storage of the received information, it can be considered as an influential factor affecting performance on a variety of cognitive operations and abilities like language learning, comprehension, cognitive control, writing and reasoning (Engle, Kane, & Tuholski, 1999).

Due to the conceptualization of WM as "the active workspace where task-relevant processing and storage activities dynamically take place" (Miyake & Friedman, 1998, as cited in Wen, 2012, p. 4), its overall capacity is generally expressed in terms of working memory span which is operationalized and measured by instruments and procedures in which the participants are required to combine both processing and storage of information in a dynamic and

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simultaneous manner (e.g., by using reading span tasks suggested by Daneman and Carpenter, 1980) and, thus, it is considered as a strong predictor of a range of complex cognitive skills such as performance on reasoning tasks or language processing and comprehension (Dörnyei, 2005). Robinson (2003) also commented that "measures of working memory capacity, which affects the extent and efficiency of focal attention allocation, are closely and positively related to second language proficiency and skill development" (p. 660).

Among the many activities of human cognition, language learning is without any doubt the most complex and most intriguing of all (Gathercole, 2006). WM by acting as a mental workspace, whereby form and meaning are connected, plays a significant role in L1 and L2 language learning and processing (Gathercole, Alloway, Willis, & Adams, 2006; Schmidt, 1990; VanPatten, 2004). However, this role differs across individuals since human beings do not possess the same pool of attentional resources required for noticing the coming input that is a pre-requisite condition for learning (e.g., Schmidt, 1990, 2001). Both psychological and applied linguistic research confirms that in order to achieve learning outcomes, learners must be both cognitively and affectively engaged in the learning process (Tomlinson, 2011). Therefore, cognitive resources such as the learners' working memory capacity must be considered in order to account for how different individuals attempt to develop various language skills, the ways they approach the learning tasks at hand and benefit from the learning potentials of various instructional practices.

The important role of WM in SLA is self-evident (Sáfár & Kormos, 2008; Wen & Skehan, 2011). Part of the explanation for individual differences among learners for their success in acquiring an L2 is attributed to memory capacity (Juffs, 2006). By reviewing the WM research in cognitive psychology and findings of existing SLA studies, Wen (2012) proposed an integrated framework of WM for SLA in which he defines WM for SLA as "the limited capacity of multiple mechanisms and processes in the service of complex L2 activities/tasks" (p.10). Research evidence has shown that working memory can be directly involved in the acquisition and development of higher-order cognitive skills; it is also closely connected to important aspects of writing, vocabulary learning, oral fluency, listening and reading comprehension (Ellis, 2001; Gilabert & Muñoz, 2010; Kormos and Sáfár 2008; Leeser, 2007; Mizera, 2006; Sawyer & Ranta 2001; Skehan 1998; Walter, 2004). In case of writing, it is maintained that "cognitively demanding processes, such as idea generation, translation of ideas into words, sentences, and discourse structures, and editing strain the writer's WM resources" (Swanson & Berninger, 1996, p. 359).

In fact, writing is a complex cognitive activity that involves various parallel and iterative processes whose orchestration requires the integration of various cognitive processes and memory components. In writing, similar to other complex cognitive tasks, "working memory provides a means for transiently holding knowledge in an accessible form so it can be effectively used" (Kellogg, Turner, Whiteford, & Mertens, 2016). In the same regard, it is maintained that working memory accounts for an independent proportion of the variance in achievement in literacy (Alloway & Alloway, 2010). The role of working memory in L1 writing and the quality of written texts produced by both children and adults has been extensively researched (e.g., Hoskyn & Swanson, 2003; McCutchen, Covill, Hoyne & Mildes, 1994; Swanson & Berninger, 1996). The central role of working memory has also been emphasized in the models of writing processes proposed by Hayes (1996) and Kellogg (1996). The Hayes' model assumes that WM is related to the non-automated activities of the writing process. Kellogg (1996) was instrumental in describing the role of working memory in facilitating or constraining writing performance.

In the same regard, Baddeley (1986, 2000) believed that working memory resources are highly essential in any processes that are not automatized enough and require some level of conscious attention. Therefore, it can be claimed that all stages of writing processes (conceptualized as an interactive and recursive process) from the mere transcribing to the higher levels of metacognitive processing are dependent upon the capacity of working memory. For example, a writer's memory may be overloaded while simultaneously planning and organizing information for production, editing for conventional spelling and grammatical forms, keeping in mind the audience, genre, and so on (Swanson & Berninger, 1996). As a result, "individuals with different working memory spans can be expected to vary in the speed and efficiency with which they execute various writing processes" (Kormos, 2012). Moreover, McCutchen (1996), in her capacity theory of writing which explains the role of developmental and individual differences in writing, speculated that during the writing process writers must coordinate the resources within the working memory to efficiently plan their goals (e.g., plans for content, audience, overall tone, requirements of grammaticality, plan fulfillment, etc.) and generate language processes to retrieve the required words and organize them into an appropriate text. Consequently, a considerable degree of processing and storage demands are imposed upon the writers who must use their cognitive capacity to simultaneously focus upon the linguistic, discoursal and organizational aspects of writing and access the strategies and use the (long-term) memory resources to compose the text (Lu, 2010).

It is widely recognized that writing involves a variety of cognitively demanding sub-processes and actions which are sensitive to a limited working memory capacity. Accordingly, good writers may require fewer processes than poor writers in writing the same message because for them "the intermediate steps such as lexical access, syntactic packaging, and construction of discourse structures for translating ideas into written language may be easily consolidated and require fewer resource demands than is the case for poor writers" (Swanson & Berninger, 1996, p. 360). As for the role of various working memory components in writing, the research evidence has revealed that students having longer phonological short term memory can create longer and more complex phrasal and sentence structures and can organize and present their ideas in a more logical and coherent manner (e.g., Kellogg, 1999; Kellogg, Olive & Piolat, 2007; Williams & Lovatt, 2003). The visuospatial sketchpad by keeping the visual information in short term memory during the composing process can assist the learners in planning and editing stages of writing. As it is evident, learners writing in an L2 due to lack of automatized knowledge in various mechanisms and aspects of L2 production may face more difficulties in orchestrating the attentional resources to perform in different phases of writing and consequently rely more on the working memory resources (especially the central executive component) for the efficient allocation and coordination of attention to parallel writing processes and various aspects of writing like content, organization, cohesion, coherence, accuracy, appropriateness, punctuation use, etc. (Kormos, 2012). Consequently, working memory resources are highly essential in the successful completion of the writing tasks.

As for the empirical studies, few studies have investigated the role of working memory in L2 writing. Kormos and Sáfár (2008) showed that scores in the writing components of a proficiency test were not correlated with the scores of a backward digit span test as a measure of the complex working memory capacity. A rather similar finding was found in Adams and Guillot's (2008) study which somewhat downplayed the importance of working memory in composing the texts. Lu (2010) also found that working memory capacity has a slight impact as explanatory variable for L2 writing performance in the timed essay writing task. However, Swanson and Berninger (1996) found a significant relationship between working memory and writing skill and attributed this finding to the intelligent and effective use of writing strategies, the trade-off between low- and high-order writing processes and efficient allocation of working memory resources to writing tasks. Based on the assumption that "individual differences in language-related cognitive tasks are due to the total level of activation in a general working memory system" (p. 379), Swanson and Berninger supported the claim that individual differences in writing are related to individual differences in working memory capacity and operations skill specific to the type of processing and tasks being performed. Similarly, Hoskyn and Swanson (2003), in a cross-sectional study, found that WM moderated structural complexity in writing when other cognitive functions (namely, handwriting speed, spelling, word knowledge, and reading comprehension) were controlled for.

These conflicting findings on the relationship between WM and writing led Vanderberg and Swanson (2007) to speculate that some components of WM are more important than others when predicting writing. Therefore, they attempted to investigate the relationship between components of working memory (visuospatial sketchpad, the phonological loop, and the central executive) and the macrostructure (e.g., planning, writing, and revision) and microstructure (e.g., vocabulary, grammar, punctuation) of writing. They administered a battery of WM and writing measures to 160 high-school students. The results of hierarchical regression analyses indicated that the managerial component of WM (i.e., central executive) significantly predicted planning, writing, revision and the other microstructure measures. The findings of the study further confirmed the importance of WM in the writing process which is believed to be more intricately tied to the controlled attention component of WM when compared to storage of information. In a recent study, Kellogg et al., (2016) have suggested that the role of WM in written sentence production is markedly more complex than previously postulated, which confirms the view that writing process is dynamically managed during written composition depending on a large variety of specific task demands. On the whole, few studies have explored the role and significance of working memory in the context of EFL writing and the quality of texts learners produce. Accordingly, the present study intends to see whether there is any relationship between working memory and writing competence of Iranian EFL learners and whether this cognitive resource can make a difference in the fluency, complexity and accuracy of texts produced by learners or not. In fact, the present study intended to answer the following research questions:

– Is there any relationship between working memory and writing performance of Iranian EFL learners?
– Does the level of working memory make a difference in the fluency, accuracy and complexity of written texts produced by Iranian EFL learners?

Method

The present study is quantitative in nature and intended to see the possible relationship between working memory as a cognitive resource and a group of Iranian EFL learners' writing performance, in general, and, more specifically their performance in accuracy, fluency and complexity of written texts produced. This study can also be classified as a *formal classroom research* in which the researcher-teacher drawing on the established research traditions intended to contribute to theoretical understanding and developing a second language issue. As for collecting the required data, the researcher used two tests to measure the learners' level of working memory capacity and their writing ability. The collected data were also analyzed by quantitative techniques such as Correlation and Multivariate Analysis of Variance (MANOVA) which are further explicated below.

Participants

A total of 60 Iranian undergraduate (Junior and Senior) EFL learners studying Teaching English as a Foreign Language (TEFL) from a State University in Iran participated in the study. The average age of the participants was 21 and they were from both genders and a variety of ethnic and educational backgrounds. The language proficiency levels of these students were from intermediate to advance. All the participants had passed essay writing courses and were quite familiar with the principles and conventions of essay writing in English.

Instruments

Measure of writing performance

The participants of the study were required to write a three-paragraph essay (including a general introduction paragraph, one detailed body paragraph and a general conclusion paragraph) on a general argumentative topic selected from IELTS writing module Task 2. The argumentative topic was selected because it is believed that such topics could be expected to demand "more complex processing" (Grabe & Kaplan, 1996, p. 121) than other types of writing (e.g., narratives), and thus we expected to see more differences in how individuals with different cognitive and motivational profiles perform in the composing process. It is also maintained that argumentative tasks would lead to more knowledge-transforming and problem solving behavior on the part of learners (Ericsson & Simon, 1984), which in turn might provide us with more informative protocols about the learners' cognitive processes. In addition, a rather general and familiar topic was selected for this essay to enhance the learners' degree of involvement with the task. The participants were also informed that the written essays will be analytically scored and they must pay balanced attention to different features of their texts. The computed reliability index for this measure was .72 Cronbach's Alpha.

Writing rubric

In fact, an essay scoring rubric developed by Paulus (1999), which provides a detailed analysis of the designated features of the written texts, was used to analyze and score the students' performance on the writing task. This rubric analytically scored different aspects of students' performance such as content and organization, support and development, cohesion and coherence, structure, vocabulary and mechanics. The addition of these individual scores was used an index showing the students' level of writing performance.

Working memory test

A computerized Persian version of reading span test (RST) developed by Shahnazari (2011) was used to measure the participants' working memory capacity. The use of Persian reading span test was due to the fact that prior research on this construct has indicated that working memory is language independent and measuring WM in the L1 helps to avoid conflating WM and L2 proficiency (Miyake & Friedman, 1998). In this test, the students are required to read sets of sentences (a total of 64 items: 10 practice session sentences and 54 test sentences) on a computer screen and report on the semantic acceptability of each sentence (processing assessment), and then recall the final word of each sentence when prompted (storage assessment). All the sentences were in an active and affirmative form within a range of 13-16 words. Half of the sentences were constructed as 'nonsense' sentences to make sure that the participants processed sentences for meaning as well as recalling the final word of each sentence. The test was in PowerPoint format, but due to large number of participants in the study we could not afford to administer it individually and we used video projection facility to administer the test to a group of learners in the classroom sessions. The sentences in the test were arranged in three sets of 3, 4, 5, and 6 sentences and each sentence appeared on screen for 8 seconds, when the computer transitioned to the next slide. After each set, a slide appeared to prompt the students to recall the final words of each set. In the original test, the participants had to read each sentence aloud, judge whether or not it made sense and say their judgment aloud while their answer was recorded and after each set must also recall the final words of each set and verbalize them. However, in the present study the researcher designed a sheet including some instructions and examples for how to perform on the test and a set of slots to enable the students to write their responses regarding the semantic plausibility of the sentences and the recalled words for each set of the sentences. The reliability index for this test has been estimated to be .73 Cronbach's Alpha.

Procedure

In order to collect the necessary data, at first, the students in two different time intervals completed the working memory test and responded to the essay writing prompt. The students' performances on WM test were analyzed and after assigning a score for each individual they were classified into three groups of High, Mid and Low working memory. Subsequently, the students' essay writing and WM scores were correlated to see if there is any relationship between these two constructs or not. In addition, the students' written texts were analyzed to determine the level of fluency, accuracy and complexity in their written texts and compare the performance of students with different working memory levels in these three aspects of wiring. Following Wigglesworth and Storch (2009), fluency was measured in terms of the average number of words, T-units and clauses per text. To investigate the complexity, following Wolfe-Quintero et. al. (1998), the proportion of dependent clauses to clauses (DC/C), indicating the degree of embedding in the text, was estimated. To investigate the accuracy, the proportion of error-free T-units to all T-units (EFT/T) and the proportion of error-free clauses of all clauses (EFC/C) were estimated (Wigglesworth & Storch, 2009). As for the statistical procedures used for analyzing the data, the researcher made use of Correlation and Multivariate Analysis of Variance (MANOVA) procedures. MANOVA is an extension of analysis of variance which is used here because we have a dependent variable with three aspects (i.e., accuracy, fluency and complexity of writing) that are conceptually and practically related to each other. MANOVA compares the groups and tells whether the mean differences between the groups on the combination of dependent variables are likely to have occurred by chance. For this purpose, MANOVA creates a new summary dependent variable, which is a linear combination of each of the original dependent variables. It then performs an analysis of variance using this new combined dependent variable. MANOVA will tell if there is a significant difference between the groups on this composite dependent variable; it also provides the univariate results for each of the dependent variables separately (Pallant, 2007).

Findings

Preliminary analyses were conducted to ensure no violation of normality in the data; in fact, the results of Kolmogorov-Smirnov statistic yielded a non-significant result (Sig. value of more than .05) which indicates normality in the data. As for the main data analysis, initially the students' performance in writing competence and their working memory capacity were correlated. According to Table 1, there was a significant positive relationship between writing competence of the learners and their scores on WM measure ($r=.25$, $p<.05$). This finding confirms the role of working memory, as a cognitive resource, in the successful accomplishment of the complex tasks such as writing. However, the level of correlation is not that much high, which indicates the complex nature of writing and existence of a variety of cognitive, affective and social factors that account for the writing competence of learners.

Table 1.
The Results of Correlation Coefficient for Working Memory and Writing

	Writing competence	Working memory
Mean	37.43	43.15
Standard Deviation	6.13	4.15
Pearson Correlation	1	.255*
Sig. (2-tailed)		.050
N		60

*. Correlation is significant at the 0.05 level (2-tailed).

The second research question intended to see whether there are any significant differences among the individuals having different levels of working memory capacity in terms of fluency, accuracy and complexity of texts produced or not. The total score for WM measure was 54 and the students who scored 50 and above were considered as learners with High WM capacity (8 individual); those scoring between 40 to 49 were classified as Mid WM group (45 individuals) and those scoring less than 40 were treated as low WM group (7 individuals). A multivariate analysis of variance (MANOVA) was run to see the possible differences in the fluency, accuracy and complexity of written texts produced by learners with different WM capacities. Descriptive statistics for this analysis, presented in Table 2, indicated that there are some mean differences between these groups in terms of fluency (High: M=25.50; Mid: M=16.13: Low: M=16), accuracy (High: M=9.50; *Mid: M=6.24: Low: M=6.57*) and complexity (*High: M=14.87; Mid: M=12.37: Low: M=12.57*) of texts produced.

Table 2.
Descriptive Statistics for Three Different WM Groups' Writing Quality and Text Production Processes

	WM Group	Mean	Std. Deviation	N
Fluency	High	26.50	10.18	8
	Mid	16.13	6.70	45
	Low	16.00	11.23	7
	Total	17.50	8.44	60
Accuracy	High	9.50	2.32	8
	Mid	6.24	2.24	45
	Low	6.57	3.99	7
	Total	6.71	2.69	60
Complexity	High	14.87	9.07	8
	Mid	12.37	5.31	45
	Low	12.57	10.22	7
	Total	13.40	6.93	60

In order to see whether there are statistically significant differences among different WM groups on the linear combination of the dependent variables (i.e., fluency, accuracy and complexity of texts produced), the multivariate tests of significance were inspected (see Table 3).

Table 3.
Multivariate (MANOVA) Tests for Three Different WM Groups

Effect		Value	*F*	Hypothesis *df*	Error *df*	*Sig.*	Partial Eta Squared
Intercept	Pillai's Trace	.832	90.591	3.000	55.000	.000	.832
	Wilks' Lambda	.168	90.591	3.000	55.000	.000	.832
	Hotelling's Trace	4.941	90.591	3.000	55.000	.000	.832
	Roy's Largest Root	4.941	90.591	3.000	55.000	.000	.832
WM group	Pillai's Trace	.205	2.137	6.000	112.000	.055	.103
	Wilks' Lambda	.796	2.217[a]	6.000	110.000	.047	.108
	Hotelling's Trace	.047	2.294	6.000	108.000	.040	.113
	Roy's Largest Root	.047	4.640[b]	3.000	56.000	.006	.199

a. Exact statistic
b. The statistic is an upper bound on F that yields a lower bound on the significance level.
c. Design: Intercept + WM group

The results indicated that there was a statistically significant difference between the High, Mid and Low aptitude groups on the combined dependent variables, F (3, 55) =2.21, p=.047<.05; Wilks' Lambda=.79; Partial Eta Squared=.10. Moreover, Tests of Between-Subjects Effects were examined to see whether there are any significant differences among the groups for each dependent variables separately. According to the statistics presented in Table 4, the learners with different working memory scores were significantly different from each other in terms of fluency, accuracy and complexity of texts produced (F(2, 57)=6.15, p=.004<0.05, partial Eta Squared=.17).

Table 4.
Tests of Between-Subjects Effects for Three Different WM Groups

Source	Dependent Variable	Type III Sum of Squares	*df*	Mean Square	*F*	*Sig.*	Partial Eta Squared
Corrected Model	Fluency	747.800[a]	2	373.900	6.157	.004	.178
	Accuracy	72.158[c]	2	36.079	5.776	.005	.169
	Complexity	387.233[d]	2	193.616	4.510	.015	.137
Intercept	Fluency	11851.473	1	11851.473	195.173	.000	.774
	Accuracy	1716.765	1	1716.765	274.856	.000	.828
	Complexity	6926.413	1	6926.413	161.332	.000	.739
WM group	Fluency	747.800	2	373.900	6.157	.004	.178
	Accuracy	72.158	2	36.079	5.776	.005	.169
	Complexity	387.233	2	193.616	4.510	.015	.137
Error	Fluency	356.025	57	6.246			
	Accuracy	6773.653	57	42.933			
	Complexity	2447.167	57				
Total	Fluency	22584.000	60				
	Accuracy	428.183	60				
	Complexity	2834.400	60				

a. R Squared = .178 (Adjusted R Squared = .149)
b. Computed using alpha = .05
c. R Squared = .169 (Adjusted R Squared = .139)
d. R Squared = .137 (Adjusted R Squared = .106)

Moreover, the inspection of mean differences in the Estimated Marginal table indicated that High working memory group had a higher mean score compared to other groups in terms of fluency (Mean of high WM=26.50, Mean of mid WM=16.13, Mean of low WM=16.00), accuracy (Mean of high WM=9.50, Mean of mid WM=6.24, Mean of low WM=6.27) and complexity (Mean of high WM=14.87, Mean of mid WM=12.37, Mean of low WM=12.57). Since we have an independent variable with three levels, it is necessary to conduct follow-up univariate analysis to identify where the significant differences lie.

Table 5.
Estimated Marginal Means for Different Working Memory Groups

Dependent Variable	WM group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Fluency	High	26.50	2.755	20.98	32.01
	Mid	16.13	1.162	13.80	18.45
	Low	16.00	2.945	10.10	21.89
Accuracy	High	9.50	.884	7.73	11.26
	Mid	6.24	.373	5.49	6.99
	Low	6.57	.945	4.68	8.46
Complexity	High	14.87	2.317	15.23	24.51
	Mid	12.37	.977	10.42	14.33
	Low	12.57	2.477	7.61	17.53

For checking where the actual differences between the groups lie, Tukey post-hoc test was run (see Table 6). The multiple comparisons between the groups indicated that there were statistically significant differences between high and mid (*P=.003*) and high and low (*P=.031*) working memory groups in terms of fluency and between high and mid groups (*P=004*) in terms of accuracy of texts produced; however, there were no statistically significant differences between these groups in terms of complexity of sentence structures produced which can be attributed to the cognitive complexity of task (i.e., the argumentative genre they were writing in) or the inefficiency in orchestration of mental resources while writing on the part of learners.

Table 6.
The Results of Tukey Post-hoc Test for Multiple Comparisons of Fluency, Accuracy and Complexity of Texts Produced by High (1), Mid (2) and Low (3) WM Groups

Aspect	(I) WM Group	(J) WM Group	Mean Difference (IJ)	Std. Error	*Sig.*	95% Confidence Interval	
						Lower Bound	Upper Bound
Fluency	(1)	2	10.36*	2.98	.003	3.17	17.56
		3	10.50*	4.03	.031	.79	20.20
Accuracy	(2)	1	3.25*	.95	.004	.94	5.56
		3	2.92	1.29	.069	-.18	6.04
Complexity	(3)	1	7.49	2.51	.068	1.44	13.54
		2	7.30	3.39	.088	-.85	15.46

*. The mean difference is significant at the 0.05 level.

Discussion and Conclusion

The preliminary analysis of the first research question indicated that working memory has a positive low correlation with the writing competence of the learners. This finding further confirmed the role of working memory in the successful accomplishment of the complex tasks and management of various cognitive processes while writing. In fact, since the efficiency of writing is affected by expertise as certain processes become automated, learners with different WM spans are expected to perform with varying degrees of efficiency in writing tasks (Olive, Kellogg, & Piolat, 2008; Kormos, 2012). Learners' limited WM capacity can hinder their access to higher level strategies and knowledge bases and resources necessary for writing (Weigle, 2005). However, the level of this correlation was low which confirms the complex nature of writing and a variety of cognitive, affective and social factors which can account for the writing competence of learners. In fact, it is believed that cognitive and motivational explanations, despite their usefulness in accounting for many aspects of writing expertise, do not provide the complete picture of what makes a good writer (Weigle, 2005). Social and cultural factors are indispensable for a learner to become an expert writer within a certain discourse community (Wong, 2012). In other words, second language (L2) writing is conceptualized as both a cognitive process, in which a writer draws upon a set of internalized skills and knowledge to produce a text, and a situated activity that takes place in a specific context with a specific goal and for a specific audience (Polio & Friedman, 2017). These assertions further support the complexity of writing and the challenges learners might face in reaching an adequate level of competence in writing especially in EFL contexts in which, except for the academic contexts, they do not have real exposure to or enough authentic practice in this skill.

The second research question intended to investigate whether the learners with different levels of WM perform differently on the fluency, accuracy and complexity of their writings or not. The choice of these three measures is due to the fact that these three concepts have been used in investigating learners' language performance, both in oral and written forms and it is believed that second language performance could be explained through features of complexity, accuracy and fluency (CAF) (Ellis, 2003, 2008; Ellis & Barkhuizen, 2005; Larsen-Freeman, 2009; Skehan, 1998). A combination of these features determines the overall proficiency of the learner. The comparison of learners' performance with different working memory levels in fluency, accuracy and complexity aspects of their writing revealed that learners having higher levels of working memory can produce better texts with regard to these aspects. This finding confirms the important role of working memory in writing especially for the complex process of translating which makes huge demands on writers' cognitive processes since the number of things that must be dealt with simultaneously in this stage of writing is stupendous and, thus, writers face cognitive overload while composing a text and may be unable to adequately attend to any of these processes at all (Flower & Hayes, 1981; Kellogg, 2001). Such writing may be inefficient and might lead to poorly structured and/or incoherent texts (De Smet, Brand-Gruwel, Leijten, & Kirschner, 2014). Kellogg (2008) showed that the efficiency of writing is affected by expertise as certain processes become automated with expertise (i.e., they no longer require cognitive processing). In the present study, it has also been identified that the students who write better in terms of fluency, accuracy and complexity have a higher level of working memory capacity which assist them in managing various aspects of their writing more effectively.

However, based on the finding of the study there was a significant difference among the learners with different levels of WM in the fluency and accuracy of texts produced, but not in their complexity; this finding can be explained with regard to the fact that once learners pay attention to one aspect of language production (in this case each measure of CAF) some other dimensions are affected (Ahmadi & Alavi Zahed, 2017). For example, when the student pays attention to accuracy, he will present slower and less complex production, and by the same token when he pays attention to fluency, he will focus less on accuracy and complexity. Furthermore, the measures are supportive in the sense that development in any one of these dimensions of proficiency might depend on the development of another (Larsen-Freeman, 2009; Skehan, 2003). Cognitive complexity of the task in argumentative genre can also account for the variations in writers' performance since based on the assumptions of limited attentional capacity model (Foster & Skehan, 1996; Skehan, 1998), "increasing the cognitive complexity of a task will result in the prioritization of fluent language production at the expense of complex and accurate language production" (Johnson, 2017) since the writers, besides language production, might direct their attentional and working memory resources to generating their ideas, planning an appropriate organization, monitoring their performance while writing and even managing the conditions under which a task is performed. Skehan (2009) also proposed that tasks which are more familiar to the learners and whose structures are clear (e.g., presenting personal information) lead to higher accuracy and fluency than complexity.

It should be born in mind that working memory can account for only a portion of learners' resources which assist them in creating a refined text and a variety of other cognitive, affective, social and instructional factors are responsible in this regard. In fact, it has been found that learners' knowledge of writing process (Graham & Harris, 2005), the time they spend on planning, generating ideas and revising their texts (Plakans, 2008), their confidence in their L2 writing ability, their sense of purpose and awareness of audience and a commitment to the writing task enable them to attend more to content and accuracy of the texts, write longer texts, use more rhetorical strategies and exhibit more complex development (Leki, Cumming, & Silva, 2010; Sasaki & Hirose, 1996; Sasaki, 2000). Learners' strategic behavior during the writing process can also help them manage this complex task effectively because it has been identified that expert writers make use of well-developed writing strategies to enhance the efficacy of their performance while writing (e.g., Roca de Larios, Manchón, Murphy, & Marín, 2008; Sasaki, 2007). On the whole, the present study confirmed the idea that learners with different learning characteristics orchestrate their mental resources in different ways to perform in different phases of writing and part of their difficulties or even capabilities in writing can be attributed to the efficiency with which they apply these resources while dealing with different writing systems (formulation, execution, or monitoring) or engaging in different writing processes (translating, planning, programming, reading, or editing).

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