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Literal and Inferential Listening Comprehension: The Role of L1 vs. L2 Auditory Working Memory Capacity

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Abstract

Working memory capacity, especially as it relates to L1 vs. L2, has been found to play a significant role in language comprehension and processing. The majority of the related studies have, however, been focused on reading comprehension, either in L1 or L2 contexts. The present study is a further attempt to investigate the role of working memory capacity in language comprehension/processing, but in the context of L2 listening. To this end, a sample of 220 male and female foreign language learners were recruited. To collect the required data, a series of measures including a language proficiency test, two auditory working memory capacity tasks (English and Persian) and two listening comprehension passages were administered to the participants. The results showed a significant relationship between Persian and English auditory memories for storage dimension, but not for the processing component. Additionally, the findings showed that L2 auditory memory is more highly correlated with L2 listening comprehension compared with L1 auditory memory. A further finding of the study was that literal vs. inferential types of listening comprehension engage different types of working memory processes.

Key Words: Working Memory, Listening Span Task, Literal Comprehension, Inferential Comprehension

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1. Introduction

Working memory (WM) defined as "a multicomponent system responsible for active maintenance of information in the face of ongoing processing and/or distraction" (Conway, et al. 2005, p. 770) has come to secure a central place in second language acquisition studies. Part of the reason for this recognition lies in the assumption that WM is one individual differences variable which can explain interpersonal variation in cognitive tasks/activities (Bengson & Luck, 2015; Daneman & Carpenter, 1980; Just & Carpenter, 1992; Kane & Engle, 2002) including language acquisition, performance and processing (Indrarathne & Kormos, 2016; Juffs & Harrington, 2011; Rai, Loschky, Harris, Peck & Cook, 2011, among others). One of the vibrant and productive lines of research in this area has focused on the role that WMC is assumed to play in language comprehension and majority of the studies have been focused around reading comprehension (Alptekin & Ercetin, 2009; 2010, 2012; Alptekin, Erçetin, & Özemir, 2014; Foroughi, Barragán, & Boehm-Davis, 2016; Friedman & Miyake, 2004; Harrington & Sawyer, 1992; Min Jin Lee, 2014; Nevo & Breznitz, 2013; Walter, 2004). However, compared to reading "research on the relationship between working memory and L2 listening comprehension is rather sparse" (Sakai, 2018, p. 3).

A quick look the results of the studies reveals that they are, at times, mixed, unclear, and in many cases contradictory. For example, there is a general consensus that L1/L2 comprehension is specifically influenced by the capacity of working memory while there is evidence attenuating this consensus showing that the influence could be varied across L1 and L2 because of individuals' differential performance in L1 vs. L2 memory measures (e.g. Chan & Elliott, 2011; Chincotta & Underwood, 1997). A number of researchers (Mackey, Philp, Egi, Fujii, & Tatsumi, 2002; Alptekin & Ercetin; 2010, 2012; Alptekin et al., 2014, among others) argue for a positive correlation between L1 and L2 working memory capacity. Other researchers, however, adopt a more moderate view and suggest that some languages may be closer to each other in one study than other languages in other studies (Osaka & Osaka, 1992; Miyake & Friedman, 1998). There are also researchers (e.g. Gass, Roots, & Lee 2006) who argue that the degree of the relationship between L1 and L2 memory capacity may depend on the participants' bilingual proficiency.

Additionally, as a quick look through the literature reveals, studies of the relationship between WMC and comprehension have been biased more towards reading with listening attracting a lower share of investigative attention. The reason for this comparatively less investigative attention might have been associated with the more difficulty with designing implementing and assessing listening span tasks than those of reading span tasks. However, the role of WMC might not be the same across listening and reading . The input that is heared can be immediately and directly stored in the phonological loop as it is primarily phonologically coded; however, the input received through reading should be transformed into a phonological representation before being temporarily stored in the phonological loop, which happens through articulatory control process by sub-vocalizing the written input (Lewandowsky & Farrell, 2006; Tan & Ward, 2008; Tindle & Longstaff, 2015). Therefore, it is assumed that reading involves an additional step imposing more strain on WMC. On the other hand, in reading, the reader is assumed to determine the pace of information delivery and has the liberty to re-read the text and re-check understanding. In contrast, it is the speaker who determines the pace of information delivery in listening (Jiang & Farquharson, 2018). Given these differences, insights from research on reading comprehension may not necessarily be transferrable to listening comprehension which calls for more research on WMC and listening comrpehension.

Additionally, majority of the studies on WMC and comprehension have conceptualized comprehension as a unitary and global construct and have dealt much less with the "multilevel representational architecture" (Alptekin & Ercetin, 2011, p. 236) of comprehension. Comprehension is layered and includes literal and inferential levels and

> WM capacity may be differentially involved based on whether … tasks are chiefly of a literal or inferential nature, especially in view of the different degrees of cognitive load associated with literal or inferential … tasks and the different levels of cognitive activation associated with automatic or controlled processing. (p. 208)

Although Alptekin and Ercetin (2010) state this in relation to reading comprehension, the same could be said about listening comprehension as well and comprehension is listening could also be conceptualized in terms of literal and inferential comprehension and WMC contributions might be different, a point which has not been empirically investigated. Again this background, the present study aims to investigate the following research questions:

1) Is there any significant relationship between Persian and English auditory memories? If yes, does this relationship depend on language proficiency?
2) Which one of L1/L2 auditory memories is more highly correlated with L2 listening comprehension performance?
3) Is there any significant relationship between WM function (storage/processing) scores and literal and inferential comprehension tasks in listening? If yes, does this relationship vary across proficiency levels?

2. Literature Review

2.1. Working Memory

Working memory is not a new phenomenon in SLA. The term has replaced the now outdated concept of short term memory (which had only a storage function denotation) to contain also a processing function (Baddeley & Hitch, 1974; Daneman & Carpenter, 1980). The term "working memory" was first used by Miller, Galanter, and Pribram (1960). Then Atkinson and Shiffrin (1968) proposed a unitary concept for what they considered as working memory, they believed that the incoming information from various sources is processed in working memory and will continue to long term memory. This multi-store model of working memory assumed a linear relationship between working memory and long-term memory; however, there were two serious problems with this model (Baddeley, 2010). The first problem was that learning was more dependent on salience rather than frequency as was shown by other studies (Bailey, Madden & Krashen, 1974; Dulay & Burt, 1974; Larsen-Freeman, 1976) but in Atkinson and Schifrin's model it was believed that the activation of processes and connections in WM would result in learning. The second problem within this model was that it considered WM as the only pathway to learning and as a result people with problems in their WM should experience severe cognitive problems, again; however, it has been shown that individuals who suffer from WM deficits are able to live normally undetected (Baddeley, 2010). The multi-store model also neglects the levels of processes activated in working memory, and takes long term memory as a single component (Raaijmakers & Shiffrin, 2003).

A number of alternative models have been proposed to describe the working memory and its components. These models usually consider both a storage and a processing component for working memory which differ across different individuals and hence cause different performances in cognitive activities (Bengson & Luck, 2015; Fukuda & Vogel, 2015). The most cited of these models are the Baddeley and Hitch's (1974) multicomponent model with its subsequent modifications (Baddeley 1990, 1992, 1996, 1999, 2000, 2012) and the embedded model proposed by Cowan (2005), which assigns an important role to attention. In the following, we will discuss these two models briefly and try to show that despite differences between them, in fact, they have some basic similarities.

2.2. Multicomponent Model of Baddeley and Hitch

Baddeley and Hitch (1974) proposed a model that assumed working memory to be comprised of three components: the first component is the central executive which controls the attention divided between between the other two components: phonological loop and visuo-spatial sketchpad. The phonological loop is responsible for storing sounds and acoustic materials. Visuo-spatial sketchpad is responsible for storing pictures and visual materials, thus the difference between phonological loop and visuo-spatial sketchpad is modality based. In this model, the central executive is the principal component since it both allocates attention to other components and connects them to each other and also provides a link between sensory memory and long-term memory. It is not clear how central executive works but it is the component that directs the attention, and hence is of significant importance. The central executive decides what to be attended to, what to be rehearsed and what to be learned (Baddeley, 1986).

The phonological loop is the component responsible for auditory material. Salamé and Baddeley (1982) divided the phonological loop into articulatory control process and phonological store. The articulatory control process (involved in speech production) refreshes the information in phonological store (involved in speech perception). These two processes are dependent on each other, because the phonological store cannot refresh the information by itself and only has a limited auditory capacity store which is subject to decay, and people with verbal working memory deficits usually have problems in one or both of these components (Baddeley & Wilson, 1985). From the Jeamesian 'primary memory' up to now, every model attempting to describe the working model has taken into account the role of attention. Buchsbaum (2013) suggests that the model of the phonological loop is dependent on conscious experience.

The visuo-spatial sketchpad is the component responsible for visual materials; it can produce the image and shape of objects in our surrounding environment and retrieve information from long-term memory. A visual object to be remembered should have a joint spatial location and a number of features binding together, but these two are not dependent on each other (Allen, Castellà, Ueno, Hitch, & Baddeley, 2014.). A number of studies have shown that visual information is more likely to be distracted by external stimuli than auditory information (Mastroberardino & Vredeveldt, 2014). However, other studies do not show any significant difference between these two modality inputs (Westelinck, Valcke, De Craene & Kirschner, 2005).

This model of WM captured the attention of researchers across different disciplines and was highly effective in accounting for the processes involved in WM, but still, there was ambiguity in the way it worked. In his attempts to modify the model, Baddeley (2000) proposed a new component named 'episodic buffer'. This new component has a very limited storage capacity and can hold information from other parts of working memory and since it uses multi-dimensional codes it can communicate the information among them. The episodic buffer is directly controlled by the executive control and is able to retrieve information from long-term memory. After adding this component, Baddeley (2000) emphasized the coordination between the four components of working memory while stressing the multi-component nature of the construct.

2.3. Working Memory Capacity and L2 Listening

Listening is the first skill that any normal language user should learn. It is through listening that children and second language learners learn to speak (Rost, 2002). Most of the language specific features like phonotactic constraints are learned through listening (Kittredge & Dell, 2015). Generally, compared to reading, research on listening is not abundant and this scarcity becomes more evident in studies that explore the cognitive processes underlying listening and unfortunately, yet there is no theory of listening that enjoys the approval of all the scholars (Janusik, 2007). The reason for this scarcity of research on listening is "its implicit nature, the ephemeral nature of the acoustic input and the difficulty in accessing the processes" (Vandergrift, 2007, p. 191). However, as stated by Bodie, (2015, p. 10) "Reading the contemporary literature on listening suggests that scholars are taking seriously the need to integrate listening into viable theoretical frameworks". Considering the transient nature of listening and the type of input modality involved, the role of working memory becomes more complicated. The supportive role of working memory is different across different individuals with different language proficiency levels. To understand the relationship between working memory capacity and listening, first it is necessary to delve into various components and levels of listening. In listening and generally in any kind of comprehension there are various tasks that should be done by the listener:

> Listeners use metacognitive, cognitive, and socio-affective strategies to facilitate comprehension and to make their learning more effective. Metacognitive strategies, or self-management strategies, oversee, regulate, or direct the listening process. Cognitive strategies (e.g., inferencing) are the actual mental steps listeners use to understand what they hear. Socio-affective strategies describe the techniques listeners use to collaborate with others, to verify understanding or to lower anxiety. (Vandergrift, 2003, p. 427)

All these processes are carried out within the limited capacity of working memory. In fact, in listening, working memory in involved both in lower and higher levels of comprehension. The listener hears the sounds and decodes them to meaningful components then based on them builds syntax and semantics and relates the new information to the context. According to Anderson (1995, p. 379), there are three kinds of processes which should be done by listener: perception, parsing, and utilization. These processes are performed through both bottom-up and top-down pathways.

Despite the importance attached to the role of working memory in listening comprehension, there is little research conducted on the link between the two. While listening, working memory is continuously involved in the process of encoding, analyzing, storing and matching, and second, performance on various language tasks and performance is very much depended on working memory capacity. However, unfortunately, regarding the issue of working memory capacity, listening, and the cross-linguistic differences there is a severe scarcity of research in the literature, a point which motivated the current study.

3. Method

3.1. Participants

Two hundred and twenty EFL learners, selected through conveniency sampling, took part in the present study. They were invited, via email and face to face requests, to take part in the study. The participants' ages ranged from 14 to 35 and caution was exercised to include participants who were not zero beginner learners of English because it was thought that zero beginners would not yield a good distribution in the sample and would not meet the requirements of the study. Both males (N = 140) and females (N = 100) were recruited to control for the possible gender effect.

3.2. Data Collection Methods

In order to test the hypotheses of the study, a language proficiency test, two auditory working memory capacity tasks (English & Persian) and two listening comprehension passages were used, which are described below.

3.2.1. English Language Proficiency Test

To assess the participants' general language ability, a version of the widely used Oxford Placement Test (r = .85) was administered to the participants. The test has been developed by Oxford University Press and Cambridge University Local Examination Syndicate; it consisted of 60 multiple-choice items divided into two sections. The items on the test get progressively difficult. The test was administered individually in classroom settings in paper and pencil format and the total time allocated for completing the test was 30 minutes for all the participants.

3.2.2. English Auditory Working Memory Capacity Test

In order to assess the participants' working memory capacity in their L2, an auditory modification of the reading working memory capacity task developed by Daneman and Carpenter (1980) was administered. While administering the test, participants were listening to the speakers and were not allowed to look at the written text. The task consisted of sixty unrelated sentences, all at the same level of difficulty, which were divided into five sets of two, three, four, five and six sentences (each set was repeated three times with different sentences). After each sentence, the participants were presented with a letter orally to remember and having heard all the sentences of each set, the participants were required to remember the letters in correct order (Storage Function). To prevent the effect of practicing and rehearsal on the part of the participants, after listening to each sentence they were required to judge whether the sentence was well formed or not (Processing Function). Half of the sentences were well-formed and half were malformed and the length of each sentence was kept between ten to fifteen words. It should be pointed out that the total time allocated to the task varied across the participants.

3.2.3. Persian Auditory Working Memory Capacity Test

This test was used to measure Persian listening working memory capacity. The test consisted of sixty unrelated sentences of approximately equal length. The sentences were either chosen from secondary high school Persian books, short stories or were written by one of the researchers and were divided into three sets each comprising two to six sentences, since they exhibited the most distribution among participants in pilot editions. The sentences and the letters after each sentence were independent of each other and all were in the affirmative mode. Half of the sentences were well-formed and the other half were grammatically wrong. To measure the processing function of WM, upon encountering each sentence, the participants were required to decide whether it was grammatical or not and were, then, required to remember the letter presented after each sentence to measure the storage function of the auditory memory.

For the purpose of scoring both Persian and English auditory WMC tests, the researchers avoided the traditional method of absolute scoring whereby the participants should successfully remember all the target letters of a set in the same order that they appear to gain the score for that specific set. In contrast, one credit was assigned to each correctly remembered item and the criterion for correctness was based on remembering each letter. So the total possible score for each individual varied from zero to sixty on the storage part of the task. As for the processing dimension, the criterion was the participants' judgment of the grammaticality of the items (irrespective of the score that they gained for the storage part). The total score for each participant, therefore, ranged from zero to sixty on the processing part.

3.2.4. English Listening Comprehension Tests

In order to assess the L2 listening comprehension ability of the students, two listening comprehension tests were administered to the participants. The first one consisted of 774 words (about seven minutes) and was about the food and how food companies always try to seduce people (especially the kids) to buy their products which in many cases are harmful to them and to the planet. The second text, consisted of 1094 words (about ten minutes), was about the safety of smart phones and the difference between Apple and Android phones and the security advantages that the IOS system has over Android system. Both listening texts were judged to be of an intermediate level of difficulty and both were followed by ten multiple-choice questions five of which tested literal and five of which tested inferential comprehension.

3.3. Data Analysis Procedures

As discussed above, in line with the goals of the study, five instruments were used. The English language proficiency test and English listening working memory capacity test were administered to 220 participants to assess their language ability and WMC. The proficiency test was administered first and after a fifteen-minute break, they were given the English listening working memory capacity task. Based on the result of these tests, eighty of the participants were selected and divided into four groups as detailed below:

A) 20 participants with high L2 proficiency and high auditory WM capacity (Group A)
B) 20 participants with high L2 proficiency and low auditory WM capacity (Group B)
C) 20 participants with low L2 proficiency and high auditory WM capacity (Group C)
D) 20 participants with low L2 proficiency and low auditory WM capacity (Group D)

The eighty selected participants were, then, given the Persian Listening working memory capacity test and the two listening comprehension tests.

To test the validity of the grouping and in order to ensure that those participants were truly different from each other in language proficiency and working memory capacity, two independent samples t-test were run to compare the group means. The results suggested that there was a significant difference in language ability between those categorized as low (M=33.65, SD=5.15) and those categorized as high proficient participants (M=49.85, SD=4.41), $t(78) = 15.09$, $p = 0.00$. The results also indicated significant differences in working memory scores between the participants categorized as having low (M=26.78, SD=4.45) and those categorized as having high WM scores (M=44.82, SD = 8.92), $t(78) = 11.44$, $p = 0.00$.

4. Results and Discussion

As stated above, the first research question of the study aimed to explore the relationship between Persian and English auditory memories and whether this relationship depends on language proficiency. To explore this relationship, the data from the Persian and English auditory WM measures (storage, processing, and composite) were subjected to a Pearson product-moment correlation analysis, after checking for the normality of data through Kolmogorov-Smirnov. The results are presented in Table 1 and Table 2 below.

As it is clear from Table 1, participants did better in their L1 auditory memory capacity measure (Storing, Processing and Composite) compared to L2 auditory memory capacity measure. However, the results of the Pearson product-moment correlation analysis showed that there was a significant positive correlation between Persian and English auditory memories on storage (r= .50, p= 0.01) and composite scores (r= .46, p= 0.01). By contrast, the results did not indicate any significant relationship between the processing component of Persian and English auditory memory capacities.

Table 1

Descriptive Statistics for L1 and L2 Auditory Memory Tests

	M	*SD*	*Minimum*	*Maximum*	*N*
English Composite	37	9.43	12	59	80
English Processing	38.25	11.18	14	60	80
English Storage	35.80	11.47	10	60	80
Persian Composite	47.56	6.90	39	60	80
Persian Processing	48.17	7.68	25	60	80
Persian Storage	46.95	7.20	30	60	80

Table 2

Correlation between L1 and L2 Auditory Working Memory Capacity Measures

	Persian Storage	*Persian Processing*	*Persian Composite*
English Storage	.507**	-	-
English Processing	-	.201	-
English Composite	-	-	.467**

**Correlation is significant at the 0.01 level (2-tailed).

A second aim of the first question, as mentioned above, was to investigate how language proficiency mediates the relationship between L1 and L2 auditory memory capacities. Given that the relationship was found to be significant in the storage component and not the processing dimension, only the relationship between the storage function of WM between L1 and L2 was computed. To do so, a Pearson product-moment correlation was run for each group of the participants independently.

Table 3

Correlations between L1 and L2 Auditory Working Memory (Storage Function) among the Four Groups with Different Levels of Language Proficiency and WMC

	Group A	*Group B*	*Group C*	*Group D*
Group A	.563**	-	-	-
Group B	-	-.24	-	-
Group C	-	-	.31	-
Group D	-	-	-	.333

**Correlation is significant at the 0.01 level (2-tailed).

Table 3 shows the degree of correlation between Persian and English auditory working memory storage for each group independently. The results provided convincing evidence in favor of the existence of a significant positive relationship for participants with high proficiency and high working auditory memory (Group A, r= .563, p= 0.01). However, no significant relationship was found for the storage function of Persian and English auditory memories in the other three groups.

The present study, further, aimed to explore the possible relationship between L1/L2 auditory working memory capacities and L2 listening comprehension. To this end, a Pearson product-moment correlation was run. As the results, reported in Table 4, clearly indicate, L1 and L2 auditory memories are both significantly correlated with L2 listening comprehension. But the degree of correlation between L2 auditory memory score and L2 listening score (r =71) is higher than the degree of correlation between L1 WM capacity and L2 listening comprehension (r = 45).

Table 4

The Pearson Product-Moment Correlation between L1/L2 WMC and L2 Listening Comprehension

	L1 WMC	*L2 WMC*
L2 Listening Score	.453**	.712**

**. Correlation is significant at the 0.01 level (2-tailed).

The findings lend support to the view that L2 listening comprehension, to a large extent, depends on L2 auditory memory rather than L1 auditory memory.

Further, to present a fine-grained analysis of the relationship between L2 auditory WM and L2 listening comprehension, the correlations among L2 storage scores, L2 processing scores, and L2 inferential and literal listening comprehension scores were explored. The results are presented in Table 5.

Table 5

The Correlations among L2 WM Storage scores, L2 WM Processing Scores and L2 Listening (Literal & Inferential) Comprehension

	L2 Inferential Comprehension	*L2 Literal Comprehension*
L2 WM Processing Score	.799**	.415**
L2 WM Storage score	.380**	.813**

**. Correlation is significant at the 0.01 level (2 tailed).

The results clearly indicate that L2 WM processing has a significant positive relationship with both L2 inferential comprehension and L2 literal comprehension, However, its relationship with inferential comprehension (r = .79, N= 80, p= .01) is much higher than that with literal comprehension (r = .41, N= 80, p= .01). Additionally, the results indicate that L2 WM storage has a significant positive relationship with L2 inferential comprehension and L2 literal comprehension. However, the relationship between L2 WM storage and literal comprehension (r = .81, N= 80, p= .01) is higher than that between L2 WM storage and inferential comprehension (r = .38, N= 80, p= .01).

As discussed above, the results of the first research question pointed to a significant relationship between Persian and English auditory working memories on the storage component but did not yield any significant correlation for the processing component.

The current literature on WM abounds with studies on the relationship between L1/L2 working memories (e.g. Berquist, 1997; Harrington & Sawyer, 1992; Hummel, 1998; Keijzer, 2013; among others). This finding is in line with studies which point to a positive and significant relationship between L1 and L2 auditory memories. To give an illustration, Osaka and Osaka (1992) found a high correlation between the first and second language ($r = 0.84$) and concluded that reading working memory capacity is language independent. In contrast, there are other also studies suggesting that working memory capacity is language dependent. For example, Chan and Elliott (2011) demonstrated that Chinese students outperformed the Malay students in digit memory span task because the duration of Chinese names pronunciation is shorter that Malay.

The reason for the mismatches among the findings could be probably attributed to the different equipment that researchers have used and also the different interpretations of their findings. For example, Alptekin et al., (2014) were able to show that working memory scores can be interpreted differently based on a storage or processing point of view. They claimed that WM processing scores tend to yield language specific results while storage scores are completely language independent. Therefore, the researchers should exercise caution when reporting their results. The present study differentiated between storage and processing components and found a significant correlation between the L1 and L2 storage components, whereas no correlation was found between L1 and L2 processing components. The results lend support to the claim made by Alptekin et al (2014) and supports the view that unlike WM storage, the WM processes are language dependent.

As part of the third research question, it was hypothesized that the degree of correlation between L1 and L2 WM depends on the participants' language proficiency level. The results of this study provided evidence that as participant’s L2 proficiency increases, the degree of correlation between L1 and L2 WM storage increases, too. This finding is in line with Osaka and Osaka (1992) who found that for more competent participants the correlation between L1 and L2 WM was higher. The main theoretical premise behind this finding may lie in the assumption that low proficient participants, because of their non-automatized language processing, need to recruit more attentional resources to effectively carry out linguistic functions which, consequently, strains the working memory. On the other hand, more proficient participants process the language more automatically and hence, their performance in L2 WM measures becomes more L1-like.

This finding has found indirect support in some SLA theories. For example, Pienemann (2005) argues that at the beginning stages of language learning, learners may not have the sufficient capacity to hold all the syntactic information active in their memory as it is clear in his explanation of how learners acquire the ability to process the syntax:

> They need gradually to develop the psycholinguistic capacity to match grammatical information contained within and across units in the linguistic material they encounter, and they are capable of doing so gradually with more distant elements in linguistic units. (p. 90)

In a similar vein, Cook and Liddicoat (2002) found that less proficient listeners did not understand different types of requests because they did not possess sufficient working memory capacity to interpret the implications alongside with linguistic processing. The idea of the limited working memory capacity can be also traced in the underlying argument of Long's (1996) interaction hypothesis where he claimed that environmental effects on language learner is mediated by his developing processing capacity.

The second research question sought to address the relationship between L1/L2 auditory memories and L2 listening comprehension. The results of the Pearson product moment correlation demonstrated that L1 and L2 auditory memories are both significantly correlated with L2 language comprehension; however, the degree of correlation between L2 auditory memory and L2 listening is notably higher than that between L1 WM and L2 listening comprehension. The results lend support to L2 working memory as a significant factor in L2 listening comprehension. The role of WM has been proven in comprehension in other language skills. For example, this findings from Alptekin and Erçetin (2010) which suggested that L2 reading span is positively correlated with L2 reading comprehension. Unfortunately, there is insufficient research on the relationship between L2 listening comprehension and L2 working memory to draw any firm conclusion about their relation. However, part of the reason for this relation could lie in the fact that half of the listening questions were inferential in nature which demanded L2 working memory processing, not L1 processing. As reported above, there is a notable difference between L1 and L2 processing which renders it fair to claim that the processing component of WM is language specific which may be the reason for the lower degree of correlation between L1 WM and L2 listening comprehension, as the latter requires L2-dependent processing.

A more fine-grained analysis of the relationship between L2 auditory (storage and processing) working memory and L2 listening comprehension compartmentalized into literal and inferential comprehension was also conducted. The results indicated that L2 WM processing had a significant positive relationship with L2 inferential comprehension and L2 literal comprehension. However, its relationship with inferential comprehension was reported to be higher than that with literal comprehension. Conversely, L2 WM storage was also found to correlate with both L2 inferential listening comprehension and L2 literal listening comprehension. Its relationship with literal comprehension was, however, found to be higher than its relationship with inferential comprehension. The result indicates that the separate WM components are responsible for different types of linguistic processing. The processes underlying literal and inferential comprehension are different from each other and it seems that inferential comprehension places more demands on the processing components of WM but literal comprehension, as "a datadriven process" (Alptekin & Ercetin, 2010, p. 214) places more demand on the storage part of working memory.

5. Conclusion and Implications

In the little research that is available on the relationship between listening and working memory, listening has always been viewed as a product and the processes were neglected (Janusik, 2007). Like readers, the listeners approach the text both with higher and lower order processes. They have to recognize the sounds and words to come up with a text-based representation and then to anchor it to a higher-order situation-based representation to achieve an acceptable interpretation; in other words, text comprehension involves literal and inferential comprehension.

In the cognitive domain and specifically in WM studies, Alptekin and Erçetin (2010) were among the first who avoided the traditional way of looking at comprehension as a product, though in relation to reading. They operationalized reading as a phenomenon containing various levels and processes. In the present study, following Alptekin and Erçetin, the researchers operationalized listening as consisting of two types of comprehension (literal and inferential) and found that processing component of WM is mainly responsible for analyzing and decoding the massages that are not directly mentioned in listening. These kinds of decoding processes impose extra burden on the foreign language listener who at the same time is involved in lower-order processes such as word segmentation.

Word segmentation is a skill that is developed in childhood and is language specific. This process takes an enormous amount of attention, and consequently working memory space, and is known to be more problematic especially in less competent language learners (Goh, 2000; Vandergrift & Goh, 2003). It seems that a higher working memory span contributes to higher scores in inferential listening. However, in the present study, the result of Pearson product moment correlation for the degree of correlations among L2 storage scores, L2 processing score, and L2 inferential/literal listening comprehension scores for each group confirmed that, in fact, higher working memory processing scores contributes to higher inferential comprehension scores. But high working memory storage score does not necessarily contribute to high inferential scores.

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