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What Is Left Unsaid About Semantic, Episodic and Working Memory: L2 Cognitive Control Accounts for Individual Differences and Gender Differences

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Abstract

Background: Prefrontal cortex (PFC) is believed to manipulate cognitive control and mnemonic process to overcome interference. The interaction among memory, cognitive control, and language learning is still under debate.
Objectives: This study investigated how episodic, semantic, and working memory (WM) as linguistically dependent retrieval cues can entail the interference process among EFL (English as a foreign language) individuals.
Methods: Combining the samples from five testing sectors in Shiraz, Iran, yielded data from 78 adult participants (33 males; 52 EFL independent users; 26 basic users; mean age 34.63). The participants took the test package of selection mechanism measures in resolving interference (SMMRI), including selection in semantic/episodic memory and WM/priming (backward printed reading comprehension). Both descriptive statistics (mean scores, standard deviations) and inferential statistics (Correlations, *t*-tests, interface resolution (IR)) were performed using SPSS software version 25.0.
Results: There was a downward trend in the order of magnitude from episodic (OLD-NEW) toward semantic (high-selection) toward WM/priming. Also, there was a moderate/high correlation among the aforementioned memories. There was a significant difference in IR-scores between basic and independent users.
Conclusions: Hierarchical process of compromises between L2 (Second language) memories indicated that the interactions of different cognitive sub-components played a central executive role. The difference between IR-scores revealed that training on WM tasks, which demanded higher activations in the PFC, could enhance the ability in resolving interference. Retrieval cues have limited concomitant memory capacity that integrate morphological, semantic, and syntactic features. However, men outperformed females in semantic selection, no significant gender difference was seen in episodic selection.

Keywords: L2 Cognitive Control, L2 Memory Pathways, Interference, Retrieval

1. Background

In today's world of interdisciplinary fields, neuroeducation applications have tried to make a vital contribution to how cognitive neuroscience can affect learning because teaching methodology by itself did not seem to make a major breakthrough in what should an individual learn and retrieve (1). It seems that many L2 (Second language) methodologies should consider different multidisciplinary issues such as how far L2 cognitive control encompasses the hierarchical process of compromises between L2 memory pathways? Is there any significant difference among individuals (e.g., males/females) in L2 cognitive control? Accordingly, Thompson-Schill et al. suggest researchers to assess individual differences in cognitive abilities among different developmental groups (e.g., infants, adolescents) since different stages of prefrontal maturation are coupled with different learning opportunities (2).

The interaction between cognitive control and memory is considered within the context of retrieving goal-relevant knowledge from semantic memory, working memory (WM), and priming (3). Evidence shows that semantic memory, working memory and episodic memory encompass selection mechanisms that resolve mnemonic interference (4). Cognitive control mediates semantic retrieval (3). Left mid- and posterior ventrolateral prefrontal cortex (VLPFC) regions are engaged to the extent that semantic decisions require selecting goal-relevant information in the face of competition (5). Regarding episodic memory, selection to overcome interference probably plays a role during both encoding and retrieval (6). Individuals can also facilitate learning by the use of priming sothat they can detect a stimulus based on recent experience with the same stimulus (7).

Language comprehension, problem-solving and other high-level cognitive functions rely on working memory (8). This establishes that the architecture of working memory can be an indispensable part of cognitive control mechanisms (3). Working memory is crucially involved in both native/foreign word learning as well as in the sentence and text comprehension (9). The involvement of working memory in the human language system is not restricted to word learning since working memory may be involved in the integration of individual words into coherent sentences and discourse representations (9). Daneman and Carpenter discovered that there is a correlation between working memory span measures and reading comprehension (10). The cognitive mechanism is necessary to realize complex expressions from simpler ones consisting of three levels, including form, semantics, and syntax (11). Complex meanings are assembled bottom-up from the meanings of the lexical elements by the combinatorial machinery of syntax (12). Unification operations take place at the syntactic level; furthermore, at the semantic and phonological levels, the lexical elements are integrated into larger structures (13). Three functional components of language processing i.e., memory, unification, and control (MUC) are utilized in both language production and language comprehension (13).

However syntactic and semantic features were investigated in sentence comprehension (14), perceptual priming and morphophonemic features remained recondite in L2 sentence comprehension.

2. Objectives

This study aimed to offer a comprehensive depiction of individual EFL learners' semantic/episodic memory and WM/priming.

3. Methods

3.1. Study Design and Participants

Five different universities and sectors where English is the medium or studied as a foreign language were negotiated and selected through quota sampling from Shiraz, Iran in early 2018. The participants of the study are comprised of 78 (33 males; 52 EFL independent users; 26 EFL basic users; mean age 34.63) graduate/post graduate students of universities, EFL learners and non-students, namely Agriculture College of Shiraz University (ACSU); Islamic Azad University, Shiraz Branch (IAU); South Industrial Management Institute (SIMI); Fars Regional Water Company (FRWC), and Pooräb Fars Engineering Consulting Company (PFECC). The participants were not chosen based on their academic scores, intelligence, sex, racial segregation, etc.

This project aimed at the subjects at the level of basic users (A1 & A2) and independent users (B1 & B2) based on the CEFR (common European framework of reference for languages) description (in English). Identification of the proficiency level of the participants was based on (1) IELTS (international English language testing system) test reports which include CEFR level, and (2) IELTS mock test (2018). Most of the participants had taken the test between two to four weeks before the study. The participants' overall CEFR levels fell within the scope of basic users (26 subjects) and independent users (52 subjects).

3.2. Data Collection

The package of instruments to assess selection retrievals within the domain of episodic, semantic, and working memories, is selection mechanism measures in resolving interference (SMMRI), which will be discussed below.

(1) In order to determine the participants' semantic interference, the revised version of Thompson-Schill's task (5) was utilized. The task was categorized into low-selection and high-selection tables. Task subjects were shown concrete nouns (word length ranges from 3 to 9) chosen from Davies and Gardner's frequency dictionary (15). The frequency for the lemma ranges was from 5800 to 69223 and the dispersion from 0.83 to 0.95. The participants were required to generate semantically related verbs to measure the level of semantic interference in VLPFC. Forty nouns were presented in total, which included 20 high and 20 low selection items.

(2) Within the domain of episodic memory, selection to overcome interference likely plays a role during both encoding and retrieval. The revised version of Dolan and Fletcher's PET (positron emission tomography) study was used to measure neural responses during the encoding of word pairs (16). This manipulated the extent to which prior learning interfered with the current encoding. The participants firstly studied a list of word pairs; next, two lists of word pairs (New-New/Old-Old and Old-New) were studied, containing repeated pairs and completely novel pairs (Old-Old/New-New), and the pairs that partially overlapped with previously studied pairs (Old-New).

(3) In order to determine the participants' WM-Priming memory associations (complex span paradigm), Paller and Gross's visual word-form priming test (17), Daneman and Carpenter's Reading span task (10), and Nasirpour's WM/priming RC (reading comprehension) task (18) were inspired and integrated. This test consisted of four reading comprehensions (10 RC questions; sentence length ranged from 15 to 18 words; each sentence

had an underlying phrase marker consisting of one S) which were printed backward. It should be noted that the reading comprehensions were chosen from Bagheri and Tavakoli's TOEFL actual tests (19). The participants were supposed to read the four reading comprehensions and make the choice a, b, c or d. The total time for the WM-Priming RC tasks was 10 minutes.

3.3. Ethical Considerations

However, the informed consent was obtained from all participants before the study, the nature and purpose of the research were again explained to them.

3.4. Statistical Analysis

Both descriptive statistics (mean, median, standard deviations) and inferential statistics (correlations, *t*-tests, interface resolution (IR), and error rate (ER)) were carried out to determine the magnitude of the interference. Analysis was performed using SPSS software version 25.0. A $P \leq 0.05$ was considered statistically significant.

In order to estimate the participants' interface resolution (IR), the calculation of Thompson-Schill et al. and Persson et al. were scrutinized (5, 20). IR scores can be estimated by subtracting error rates (ER) for low interface from ER's for high interface (5, 20). The tasks were categorized into the low-interface and high-interface for the two subtypes of memory (semantic/episodic memory).

4. Results

The mean scores of episodic memory, semantic memory and WM/priming RC tasks fell at different levels in SMMRI tests (Table 1). Scores were presented with percent for a better comparison. The highest memory score was semantic memory (low-selection) with a mean of 75 (SD = 21.33). The lowest memory score was WM/priming in RC, with a mean of 37.7 (SD = 2.51).

A downward trend in the order of magnitude (in mean and median) was seen from episodic (OLD-NEW) toward semantic (high-selection) toward WM/priming among basic users. Similarly, another downward trend in the order of magnitude was seen from semantic (high-selection) to WM/priming (in RC) among independent users (Table 2).

IR scores can be estimated by subtracting error rates (ER) for low-interface from ER's for high-interface. Subjects' medians were used to minimize the effect of extreme values on the distribution.

A significant tendency for episodic interference was seen among EFL basic users rather than EFL independent users (Table 2). A significant baseline difference was evident between the groups and measured by the ER difference between NEW-NEW and OLD-NEW. However, both groups showed a significant interference in pairs that partially overlapped with previously studied pairs (OLD-NEW).

(1) IR (basic users) = ER for OLD-OLD - ER for OLD-NEW = 40 - 55 = - 15

(2) IR (basic users) = ER for NEW-NEW - ER for OLD-NEW = 30 - 55 = - 25

(3) IR (independent users) = ER for OLD-OLD - ER for OLD-NEW = 50 - 50 = 0

(4) IR (independent users) = ER for NEW-NEW - ER for OLD-NEW = 30 - 50 = - 20

For semantic interference analyses, participants' medians were used to minimize the effect of extreme values on the distribution. EFL basic and independent users' performances are shown on the verb generate task in Table 2, where improvement in the speed of performance is generally evident. A significant interference was seen between EFL basic and independent users. Moreover, both groups showed a significant semantic interference (in the interference scores) in high interference condition which lacked a clear dominant response and low interference condition, which had one dominant response.

(5) IR (basic users) = ER for low-selection - ER for high-selection = 47 – 62 = - 15

(6) IR (independent users) = ER for low-selection - ER for high-selection = 15 – 32 = - 17

The results presented in Table 3 indicate that there was a moderate correlation between episodic memory (OLD-NEW) and semantic memory (high-selection) and WM/priming RC tasks (P = 0.000; P = 0.023). The correlation coefficient was significant for both episodic memory (OLD-NEW)/semantic memory and WM/priming RC tests. In this regard, there was a moderate correlation between episodic memory (OLD-NEW) and semantic memory (high-selection). Likewise, episodic memory (OLD-NEW) correlated with WM/priming RC tasks.

Table 4 illustrates that there was a moderate correlation (P = 0.023) between WM/priming (in RC) and episodic memory (OLD-NEW). More interestingly, there was a high correlation (P = 0.000) between WM/priming (in RC) and semantic memory (both low and high selections).

In order to see whether there was a significant difference between EFL basic and independent users, Independent Samples test and Descriptive Statistics were carried out (Table 5). There was a significant difference between the means of EFL basic and independent users in semantic memory (low/high selection) and WM/priming (P = 0.000). The mean scores of independent users were greater than those of basic users regarding semantic memory and WM/priming.

However, there was no significant difference between EFL basic and independent users regarding episodic interference (Table 6).

To see whether there was a significant difference between males and females in PI in cognitive control, inde-

Table 1. Median, Mean and SD of Selection Mechanism in L2 Cognitive Control

	N	Min	Max	Median	Mean ± SD (%)
Episodic memory: Old-Old	77	0	100	50	54 ± 24.06
Episodic memory: New-New	77	20	100	70	69 ± 19.57
Episodic memory: Old-New	77	0	90	50	50.5 ± 19.25
Semantic memory: Low-selection	77	15	100	80	75 ± 21.33
Semantic memory: High-selection	77	7	91	58	58.2 ± 20.10
WM/priming RC tasks	77	0	10	4	37.7 ± 2.51
Valid N (list wise)	77				

Table 2. Median, Mean and SD of Selection Mechanism in Cognitive Control Between Basic and Independent Users

	N	Min	Max	Median	Mean ± SD (%)
Episodic memory:Old-Old					
Basic users	26	20	100	60	59 ± 21.66
Independent users	52	0	100	50	52 ± 24.89
Episodic memory: New-New					
Basic users	26	20	85	70	67 ± 19.43
Independent users	52	20	100	70	70 ± 19.54
Episodic memory: Old-New					
Basic users	26	0	90	45	46 ± 22.65
Independent users	52	30	90	50	53 ± 17.00
Semantic memory: Low- selection					
Basic users	26	15	85	50	53 ± 18.81
Independent users	52	50	100	90	85 ± 12.90
Semantic memory: High- selection					
Basic users	26	7	63	40	38 ± 15.45
Independent users	52	33	91	71	68 ± 13.63
WM/priming in RC					
Basic users	26	0	6	2	16.2 ± 1.87
Independent users	52	0	10	6	48.5 ± 2.18

pendent samples test and descriptive statistics were performed for EFL basic and independent users, respectively. Firstly, information in descriptive statistics and independent samples test was combined in Table 7 for EFL basic users. The result indicated that the differences were significant between the means of males and females in semantic memory (low/high selection) (0.045 and 0.013, respectively). The mean score of male basic users was greater than that of females regarding semantic memory (low/high selection).

Secondly, information in descriptive statistics and independent samples test was combined in Table 8 for EFL independent user males and females. There was a significant difference between the means of males and females in semantic interference (high selection) (P = 0.021).

5. Discussion

5.1. Sequential Executive Functions, L2 Cognitive Processes and Individual Differences

To have a better understanding of EFL learners' cognitive control mechanisms, this study is premised on the ideas that a dynamic interaction exists between L2 cognitive control and memory pathways; in addition, a hierarchical evolutionary process exists in episodic, semantic and working memories.

As it is evident in Table 3, there was a moderate correlation between Episodic memory (OLD-NEW) and Semantic memory (High/Low-selection). In both Dolan and

Table 3. Pearson Correlations Between Episodic/Semantic Memory and WM/Priming RC Task

	Semantic Memory: Low-Selection	Semantic Memory: High-Selection	WM/Priming RC Tasks
Episodic memory: Old-Old			
Pearson correlation	0.077	- 0.039	0.084
Sig. (2-tailed)	0.506	0.738	0.469
Episodic memory: New-New			
Pearson correlation	0.222	0.168	0.054
Sig. (2-tailed)	0.052	0.145	0.642
Episodic memory: Old-New			
Pearson correlation	0.447[a]	0.486[a]	0.258[b]
Sig. (2-tailed)	0.000	0.000	0.023
N	77	77	77

[a] Correlation is significant at the 0.01 level (2-tailed).
[b] Correlation is significant at the 0.05 level (2-tailed).

Table 4. Pearson Correlations Between WM/Priming (in RC) and Episodic/Semantic Memory (SMMRI)

WM/Priming RC Tasks	Episodic Memory OLD-NEW	Semantic Memory Low Selection	Semantic Memory High Selection
Pearson correlation	0.258[a]	0.677[b]	0.649[b]
Sig. (2-tailed)	0.023	0.000	0.000
N	77	77	77

[a]Correlation is significant at the 0.05 level (2-tailed).
[b]Correlation is significant at the 0.01 level (2-tailed).

Table 5. Descriptive Statistics and *t*-Test Results Combined on Semantic and WM/Primingi Between EFL Basic and Independent Users

	N	Mean ± SD	F	Sig.	*t*	df	Sig. (2-Tailed)	Mean Difference
Semantic: Low-selection			7.27	0.009				
Basic users	25	53.40 ± 19.18			- 9.08	74	0.000	- 32.67
Independent users	51	86.08 ± 12.01			- 7.79	33	0.000	- 32.67
Semantic: High-selection			1.22	0.273				
Basic users	25	37.92 ± 15.74			- 9.11	74	0.000	- 30.78
Independent users	51	68.71 ± 12.82			- 8.49	40	0.000	- 30.78
WM/Priming RC tasks			0.425	0.516				
Basic users	25	1.68 ± 1.88			- 6.58	74	0.000	- 3.26
Independent users	51	4.94 ± 2.09			- 6.82	52	0.000	- 3.26

Abbreviations: df, degree of freedom; N, number; Sig, significant.

Fletcher's experiment (16) and this study, episodic memory (OLD-NEW) was the lowest memory score, which shows a critical emphasis on necessary semantic processing for the formation of new category-exemplar associations. Dolan and Fletcher postulated that this manipulation must elicit a degree of interference from previously encoded pairs (i.e., proactive interference) (16). Moreover, there was a correlation (P = 0.023) between WM/priming (in RC) and episodic memory (OLD-NEW). Similar to high interference attributed to semantic and working memory, PI in episodic tasks would also be engaged in selection processes for successful task execution. Jonides et al. broached the subject there might be some anatomical overlap in the neural substrates recruited by working memory and episodic memory tasks (21); and recent neuroimaging studies showed similar left inferior frontal (IFG) activations during high interference trials in both tasks (20). The findings revealed that L2 cognitive control is the hierarchical process of evo-

Table 6. *t*-Test Results: Episodic Interference Between EFL Basic and Independent Users

	F	Sig.	*t*	df	Sig. (2-Tailed)	Mean Difference
Episodic: Old-Old	0.008	0.929				
Equal variances assumed			1.23	74	0.222	7.23
Equal variances not assumed			1.28	53	0.204	7.23
Episodic:New-New	0.001	0.971				
Equal variances assumed			- 0.72	74	0.471	- 3.49
Equal variances not assumed			- 0.72	52	0.473	- 3.49
Episodic: Old-New	3.07	0.083				
Equal variances assumed			- 1.75	74	0.083	- 8.14
Equal variances not assumed			- 1.59	38	0.119	- 8.14

Abbreviations: df, degree of freedom; Sig, significant.

Table 7. Descriptive Statistics and *t*-Test Results Combined in Semantic/Episodic/WM Interference by EFL Basic User Males and Females (N = 26)

	N	Mean ± SD	F	Sig.	*t*	df	Sig. (2-Tailed)	Mean Difference
Episodic: Old-Old								
Male	10	3.00 ± 11.59	8.94	0.006	0.69	24	0.494	6.12
Female	16	56.88 ± 26.19			0.81	22.2	0.423	6.12
Episodic: New-New								
Male	10	69.50 ± 16.23	0.87	0.359	0.56	24	0.576	4.50
Female	16	65.00 ± 21.52			0.60	23	0.551	4.50
Episodic: Old-New								
Male	10	56.00 ± 20.11	0.09	0.759	1.91	24	0.068	16.62
Female	16	39.38 ± 22.35			1.96	20.8	0.063	16.62
Semantic:Low- selection								
Male	10	62.50 ± 15.50	0.34	0.562	2.11	24	0.045	15.00
Female	16	47.50 ± 18.79			2.21	22	0.038	15.00
Semantic: High- selection								
Male	10	46.90 ± 12.15	0.95	0.339	2.67	24	0.013	14.90
Female	16	32.00 ± 14.77			2.79	22	0.011	14.90
WM/priming in RC								
Male	10	2.40 ± 1.83	0.01	0.916	1.75	24	0.092	1.27
Female	16	1.13 ± 1.78			1.74	18.8	0.098	1.27

Abbreviations: df, degree of freedom; N, number; Sig, significant.

lutionary compromises because word meaning should be inculcated in the learners' minds and then it can be assembled into compound meaning.

Intensive performance of one cognitive process with other processes (e.g., in PFC) which share executive functions may cause cognitive fatigue if a selection process is involved in multiple memory domains (20, 22) or subjects are not cognitively matured to select goal-relevant representations from among competitors (e.g., basic users). This was detected in the successive memory tasks subjects carried out; in other words, a downward tendency was seen from episodic (OLD-NEW) toward semantic (high-selection) toward WM/priming (in RC) which indicated that the interactions of different cognitive subcomponents had a central executive function (Table 2). The result was in line with Van der Linden et al. (22) that multiple executive processes can result in reduced performance on the other tasks. Thus, the shared executive

Table 8. Descriptive Statistics and *t*-Test Results Combined in Semantic/Episodic/WM Interference by Independent User Males and Females (N = 52)

	N	Mean ± SD	F	Sig.	*t*	df	Sig. (2-Tailed)	Mean Difference
Episodic: Old-Old								
Male	23	50.22 ± 23.08	0.30	0.583	- 0.43	50	0.664	- 3.05
Female	29	53.28 ± 26.56			- 0.44	49.5	0.659	- 3.05
Episodic: New-New								
Male	23	75.22 ± 18.30	0.22	0.638	1.71	50	0.093	9.18
Female	29	66.03 ± 19.83			1.73	48.8	0.090	9.18
Episodic: Old-New								
Male	23	57.83 ± 14.12	2.94	0.092	1.75	50	0.085	8.17
Female	29	49.66 ± 18.41			1.81	50	0.076	8.17
Semantic: Low- selection								
Male	23	87.61 ± 10.43	3.06	0.086	1.10	50	0.273	3.98
Female	29	83.62 ± 14.51			1.15	49.6	0.255	3.98
Semantic: High- selection								
Male	23	72.87 ± 9.42	11.65	0.001	2.38	50	0.021	8.69
Female	29	64.17 ± 15.29			2.51	47.4	0.015	8.69
WM/priming in RC tasks								
Male	23	5.13 ± 1.68	3.81	0.056	0.83	50	0.408	0.51
Female	29	4.62 ± 2.51			0.87	48.8	0.387	0.51

processes can include shared cognitive processes for basic users; therefore, contribute to cognitive fatigue.

The result (Table 4) suggests that high interference conditions of the WM, semantic memory (high selections), and episodic memory OLD-NEW are mediated by a common cognitive control mechanism. This was in line with the experiments conducted by Persson et al. (20). Moreover, the difference between IR-scores, response time (RT), and error rate (ER) among basic and independent users revealed that training on WM task, which demand higher activations in the PFC, can enhance the ability to resolve interference. This was in agreement with both Szmalec et al. and Persson et al. (9, 20).

5.2. Semantic Unification and Cue-based Parsing

To manipulate the morphophonemic (perceptual priming), syntactic, and semantic properties to create interference conditions, the researchers controlled RC sentences in the form of an anti-saccade task. In this inhibition task, participants must move their eyes away from a visual routine (left alignment), decoding the words which were printed backward (i.e., high vs. low morphophonemic interference × low vs. high semantic interference × low vs. high syntactic interference). This anti-saccade study focused on L2 cognitive improvements in the ability to select between competing bootstraps, inhibit inappropriate morphophonemic shapes, rearrange the response to the previous form, retrieve the new form from memory, and monitor the performance.

The memory score was rather low in WM/priming RC tasks (Tables 1 and 2). Due to the perceptual priming challenges (in backward printed words), linguistically dependent cues could strain learners' recollection and this proved that retrieval cues might have limited concomitant memory capacity in the sentence comprehension. The mean of WM/priming in RC tasks also revealed that priming-related activation needs time to reprocess; in addition, basic users' previous exposure to the stimuli seemed to be shallow and was not strong enough to produce experience-based activation in a form of LTM. To Wagner et al., perceptual priming is not sensitive to the level of semantic elaboration during initial processing, whereas conceptual priming, which is modality-independent, is sensitive to semantic features of a stimulus during the study (3). Thus especially among basic users in this study, the tuning of semantic memory did not sharpen their conceptual representations since the initial retrieval of relevant stimulus features did not help to inhibit less relevant features. This led to high competition and interference.

There was a bottleneck with a lower processing rate in WM/priming (RC tasks) for both EFL basic and independent users. It was detected that each linguistically dependent cue had its own interference and depended on the considerable degree of overlap between the dependent memories, which were involved in perceptual priming, automatic retrieval, post-retrieval selection (in RC), and the representations generated for each processing step. Cue-based retrievals need to be processed in the semantic unification system to infer stored semantic knowledge through a top-down process. According to Oberauer and Kliegl's study, participants must alternate between encoding memory cues and processing other information in any complex span paradigm (i.e., WM paradigm) (23). Thus the binding mechanism must use synchronous firing from deciphering cues to post-retrieval selection to semantic/syntactic interaction which challenges memory demand. The results of WM/priming RC tasks, which showed a sharp downward trend in the scores, were in consistent with Oberauer and Kliegl's study (23). All in all, items did not seem to be independent in sentence comprehension, thus as Van Dyke and McElree broach, the cue-driven associative retrieval mechanism, are needed to be synthesized in sentence comprehension (24).

5.3. Gender Difference

The results of this study showed that there was no significant difference between the mean scores of males and females using episodic selection (OLD-OLD/NEW-NEW/OLD-NEW). However, the findings in another study revealed that females had a lower spatial ability (in particular, mental rotation ability) than males (25). This implies that the nature of episodic memory should be clearly defined in each study. Furthermore, there was no significant difference between the males and females in WM/priming (RC tasks); this partly disagree with the findings of Upadhayay and Guragain who observed that male cognitive functions (attentional, perceptual, and executive functions) were different in comparison to those of the female pre-ovulatory phase (26).

Unlike the present study, which experimented selection mechanisms to compare the genders in L2 semantic selection (low/high selection), Wirth et al. used event-related potentials (ERP) to compare the genders in lower and higher order semantic processing (controlled semantic analysis) during the passive reading of semantically related- and unrelated word pairs (27). Their finding indicated that the initial lexical-semantic access was similar in men and women; however, the genders differed in higher order semantic processing. The probable reasons for a better semantic selection (high selection) among males in this study can be attributed to males' priority to visual/spatial perception (28), female weakness during the pre-ovulatory phase/menstrual cycle (26), etc.

5.4. Conclusion

The findings revealed that individuals' L2 cognitive control is a hierarchical process, in which word meaning should be inculcated in their minds and thereby can be assembled into the compound meaning. The findings of independent users revealed that practice, exposure and, experience, which involve executive functions, can enhance performance on subsequent cognitive subparts. As for EFL basic users, signs of fatigue might be related to a number of factors, including the extent of practice, shallow recollection, proactive interference (PI), impaired cue-based parsing, weak semantic unification, etc. To avoid hasty conclusions, inappropriate analogies between male and female genders should not be made because a number of factors such as the nature of controlled vs. automatic process, the nature of episodic memory, sex hormone profiles (e.g., estrogen), menstrual cycle, female/male menopause, and so on can influence the results of L2 cognitive control. In delving into individual/group mental map, for upgrading any educational qualifications in L2 contexts, cognitive-minded discipline is highly recommended.

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Footnotes

Authors' Contribution: Behzad Nasirpour and Mohammad Sadegh Bagheri co-designed the study and analyzed the results; Behnam Jameie also participated in the final analysis and interpretation of the data; all authors read and modified the final version of the manuscript.

Conflict of Interests: The authors declare no conflict of interests.

Ethical Considerations: Five different universities and public/private sectors were negotiated and selected through quota sampling from Shiraz, Iran. All in all, the participants were recruited from the five sectors through posted advertisements which gave informed consent before the study began.

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