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On Situating the Stance of Estrogen in the Acquisition and Recall of L2 Lexical Items: A Biological Look

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Abstract

The present study was an attempt to investigate whether the advantage of females on L2 vocabulary recall and acquisition is partly as a result of estrogen secretion. In this regard, through volunteer and convenience sampling, 15 intermediate EFL female participants aged between 23 and 31 were selected from the subject pool of 55 participants. The participants were studying at Iranian Language Center located in Bandar-e Anzali, Iran. To ensure the homogeneity among the participants, Babel English Placement test was used. In the course of study, the participants were taught two series of 42 lexical items in each phase of the menstrual cycle (i.e., follicular and luteal). The treatment period was held during six sessions at each phase. Each session took 30 minutes. To compare the performance of the participants, immediately after the sixth meeting, a piloted teacher-made vocabulary recall posttest was administered at each phase. Finally, the mean scores of participants' performance in the two phases were contrasted through a paired samples t-test. The results indicated that there was a statistically significant difference between the participants' recall scores in the follicular and luteal phases. Moreover, to investigate the impact of estrogen secretion on participants' L2 vocabulary acquisition, two months after the treatment, the participants took a piloted teacher-made vocabulary acquisition posttest at each phase of the menstrual cycle. The results of paired samples t-test indicated a significant difference between the participants' vocabulary acquisition scores in the two phases.

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There seems to be no end to the debate over sex differences in the brain. The fact that males and females have different brains is not surprising, but the implication is quite crucial because it means that not all brains think the same way (Haier & Jung, 2008). This simple fact might inspire the notion of individualism in language acquisition. That is, sexual brain investigation entails evaluating each student as an individual. Having agreed that there exist individual differences in female and male brain structures, the present researchers, then, will face an even more intense debate over what these differences involve.

In effect, the study of sex differences provides a unique opportunity to elucidate the entire trajectory from genes to behavior. Meanwhile, the scrutiny of the sexual brain will enhance our understanding of brain functioning in order to avoid the entirely abstract assumptions pioneered by numerous scholars (e.g., Chomsky, 2000). Undeniably, most of the studies conducted in the realm of second language acquisition (SLA) were mostly assumption-based. The naturalistic theory, for instance, is based on the assumption (Altenaichinger, 2003) that language acquisition is innately determined and that we are born with a specific system of language that we can call on later. Krashen's (1981) input hypothesis, though impressed by Lamendella (1977), also, merits from an assumption (Altenaichinger, 2003) that holds it is vital for the acquirers to understand the language that is a bit beyond their current level of competence.

In fact, sparse unequivocal evidence among scholars is deeply stemmed in the ideology that gender is thoroughly respected as a social construct. Nurture-based theories, per se, are keen on investigating different social norms or patterns of behavior allocated to males or females (Talbot, 1998). In reality, the scant research that has been conducted on sex differences in SLA has revealed that less interest has been paid to the biology of sex differences.

Thus, the lack of unequivocal evidence of sex differences in SLA is probably stemmed in the truism that genes and environment (nature and nurture) interact in complex ways rather than linear ways. Thus, lack of

attention to the biology of a variable (i.e., quality of it) might result in sparse empirical contrasting evidence including Farhady (1982), sticking to the nurture of SLA, found a female advantage in listening, while Boyle (1987) reported a different view that Chinese male L2 learners outperformed in listening skills.

Furthermore, it is not yet clear whether the sex differences between females and males are more or less biologically socio-cultural or socio-culturally biological, but what is clear is the fact that these two perspectives are highly interdependent. It goes without saying that language acquisition is socio-culturally bound; that is, some concepts are more acceptable in some cultures than others for males and females. Thereupon, there is so much research that has been conducted in this field, but what is felt a deficit in research is to see whether, biologically, the brain function in females and males has an advantage for them to acquire a language or not.

That males and females have a unique ability to learn more than one language is not dubious. Nevertheless, understanding the sexual brain differences central to language acquisition may present the most critical challenge to the next decade, especially if it turns out that the sexual basis of the brain is amenable to educational strategies. Whether this can be true is an empirical question yet to be answered, and there is a relatively little investigation of this issue given its critical importance. As Haier and Jung (2008) put forth, though brain study has had considerable progress in the last two decades, "it is still not known why some people learn faster than others, or why some people have better memories or longer attention spans than other people…" (p. 171).

Henceforth, "the consistent introduction of sex as a design factor in language acquisition may help to reduce the heterogeneity of findings across studies which might have varied in previous investigations partly as a result of inconsistent sex ratios among subjects" (Hartshorne & Ullman, 2006, p. 30). However, as to Hartshorne and Ullman, until now, sex has been virtually ignored in studies of the learning language. Still, one of the ways in which the study of sex differences can make a difference is to

investigate what changes and matters in brain systems make female and male language acquisition distinct. Hence, the present researchers, in line with Phillips and Sherwin (1992), who hold that the sex differences in verbal memory appear to be modulated by estrogen, endeavored to situate the role of estrogen in SLA.

Literature Review

Although sex difference is respected as an essential factor in the neurocognition of language (Hartshome & Ullman, 2006), differences in the neurobiology of females and males have not been conclusively identified (Kaiser, Haller, Schmitz, & Nitsch, 2009). In this regard, Ingalhalikar et al. (2013) claimed that although sex differences in human behavior show adaptive complementarity, studies fail to explain this complementarity in human brains. By complementarity, it is meant that males, for instance, have better motor and spatial abilities, whereas females have superior memory and social cognition skills.

To better appreciate the biology of the given complementarity, the present work contends that research in the area of hormones has followed several avenues. Early work by Kimura (1999) was mainly concerned with the role of estrogen in female's declarative memory system. Undeniably, "the female brain is so deeply affected by [estrogens] that their influence can be said to create a woman's reality" (Brizendine, 2007, p. 3).

Extant research findings on the effects of estrogen on human cognition, especially working memory allow several conclusions. Studies by Kimura (1999) and Ullman (2005) show that a higher level of estrogen can lead to an improved working memory. Working memory, as to Baddeley (1992) "refers to a brain system that provides temporary storage and manipulation of the information necessary for such complex cognitive tasks as language comprehension, learning and reasoning" (p. 556). That the level of estrogen contributes to the efficiency of working memory is deeply rooted in Estrogen Replacement Therapy (ERT) on post-menopausal females having a declining working memory because of low levels of estrogen, and their treatment with ERT showed improvement of

their working memory (Sherwin, 2012). In a sense, as to Sherwin, estrogen therapy prevents the decrease in verbal memory.

Taking the role of sex hormones into consideration, Ullman (2005), also, maintains that males and females may process lexical items differently because of different levels of estrogen, which is much higher in females and affects brain processing. Moreover, as postulated by Hartshorne and Ullman (2006), probably because of the high amount of estrogen in women, they are better at using their declarative memory. In the same line, Haist, Shimamura, and Squire (1992) claim that the high level of estrogen is conducive to recalling facts and knowledge.

Regarding the significant role of hormones, Oates, Karmiloff-Smith, and Johnson (2012) state that hormones are involved in the brain development and language acquisition. The amount of estrogen, for instance, and high rate of blood flow is among the reliable indicators of females' superiority in language-related tasks. Accordingly, Kimura (2002) maintains that "high level of estrogen is also linked to relatively depressed spatial abilities as well as to enhanced speech and manual skill-related tasks" (p. 29). Lee (2011), meanwhile, reports that females have better memories as compared with males in many areas because of "a higher rate of blood flow to certain parts of the brain including those that control language as well as higher concentrations of estrogen" (p. 283). In effect, the blood flow is considered as an essential factor because the cell bodies are fed on it (Sylwester, 1995). Regarding the connection between blood flow and brain activity, Levay (1994) holds:

> the tight coupling between neuronal activity and blood flow is a manifest that if the neurons in a small region of the brain increase their activity, blood flow to this area is expanded to allow for the extra metabolic demands of the active neurons, and so the level of radioactivity in this region increases. (p. 35)

The biological mechanisms underlying the estrogen effects have been quite well-studied. Numerous experiments have shown that estrogen strengthens the cellular and molecular correlates of long-term hippocampal learning. For example, as reported by Ullman, Miranda, and

Travers (2008), estrogen treatment of ovariectomized rats increases dendritic spine density in hippocampal pyramidal neurons and induces the formation of new synaptic connections within the hippocampus. Furthermore, higher levels of estrogen in the menstrual cycle or through hormone replacement therapy have been found to lead to improve verbal memory (Maki, Rich, & Rosenbaum, 2002) and better episodic memory for words and names (Maki & Resnick, 2000). In other words, females with Turner's syndrome who do not produce estrogen have impaired verbal memory which improves with estrogen therapy (Ross, Roeltgen, Feuillan, Kushner, & Cutler, 2000).

Kimura (2002) investigating the relationship between female brain and the neurons concluded that estrogen has an important role in the survival, growth, and multiplication of the neurons. Kimura goes on to hold that hippocampus, which is the center of verbal memory, is sensitive to estrogen. Hippocampus is responsible for the memory-related tasks, including recalling lexical items. Further, it changes short-term memories to long-term memories (Sousa, 2006). Accordingly, Gould, Woolley, Frankfurt, and McEwen (1990) state that the level of estrogen in hippocampus expands the density of dendritic spines. Therefore, estrogen, as Eberling, Wu, Tong-Turnbeaugh, and Jagust (2004) assert, is linked to the larger volume of the hippocampus.

Without a doubt, learning happens when a learner can recall words (Mombeini, Gorjian, & Pazhakh, 2013). Recall may be defined as "a process of constructing a pattern of activation that is taken by the recaller to reflect not the present input to the senses, but some pattern previously experienced" (McClleland, 1999, p. 138). Central to this view is the idea that recall is prone to a variety of influences that often helps us fill in missing details but which are not always bound to fill in correct information (McClleland, 1999). In effect, "recall refers to the ability to actively retrieve the information sought from memory stores" (Emilien, Durlach, Antoniadis, van der Linden, & Maloteaux, 2004, p. 4).

Thornbury (2002), in this regard, maintains "the learner need not only [acquire] a lot of words but also to remember them" (p. 23). The ability to

recall information is a fantastic capacity of human beings. Regarding the importance of recall in SLA, Han (1990) asserts that recall is an essential intellectual activity since it makes retrieving schemata a more straightforward process for the learner. Parallel to the same debate, Yun, Miller, Baek, and Ko (2008) assert that recall plays a vital role in transferring knowledge.

Although acquisition happens when a learner can recall words (Mombeini, Gorjian, & Pazhakh, 2013), what is remembered is not necessarily acquired. As Cook and Singleton (2014) declare vocabulary acquisition involves more than knowing the pronunciation of a word and its written form. According to Cook and Singleton, knowing a word entails "the various kinds of meanings it can convey, how it relates to and combines with other words, the effects of different contexts on its usage and impact, the extent of its use, the level of use, and its typical register" (p. 39). In other words, vocabulary acquisition entails the capacity to successfully use lexical items recalled, while recalling is concerned with the mental process of retrieving information from the past.

As stated earlier, the goal of the present work was to examine sex differences and the underlying mechanism on females' outperformance in recalling L2 vocabulary. In so doing, there is also an increasing interest in the role of steroid hormones on neuropsychological functioning, particularly concerning the possibility that estrogen may enhance memory. As proved by Yonker, Eriksson, Nilsson, and Herlitz (2003), the role of estrogen in several verbal episodic memory tasks is evident. They found out a significant relationship between estrogen level and the participants' cognitive performance in women, but not men.

Given that estrogen plays an important role in females' declarative memory, the present study aimed at investigating the role of estrogen in females' L2 vocabulary recall and acquisition. Thereupon, the following research questions are raised:

1. Is there any significant difference between intermediate females' L2 vocabulary recall in the follicular and luteal phases of the menstrual cycle?

2. Is there any significant difference between intermediate females' L2 vocabulary acquisition in the follicular and luteal phases of the menstrual cycle?

Method

Participants

In the following study, 15 participants aged between 23 and 31 were drawn from a subject pool of 55 learners. The participants were also homogenized on their language proficiency level using the Babel English Placement Test. They were found to be at intermediate level of proficiency. Of the 55 participants, 27 learners whose test scores on their language proficiency test surpassed one standard deviation above and below the mean of the whole sample were deleted, and 13 learners were also excluded for a variety of reasons including pregnancy, the use of medication, or lack of willingness to participate. To ensure whether the participants' blood sample contains a hormone called human chorionic gonadotrophin, the participants were directed to a medical laboratory located in Bandar-e Anzali. As a result, the participants were all reported not to be pregnant. It follows that the participants had announced their written consent to participate in the experiment. Due to the fluctuation of estrogen level during pregnancy, one of the delimitations of the study that had to place was based on the exclusion of the pregnant women. Besides, none of them took any hormonal pills that affect their menstrual cycle. Meanwhile, their menstrual cycle was also reported normal.

Instruments

In the current research, the following tools and materials were used:

BABEL English Language Placement test. The first device used in the study was the Babel English Language Placement test to measure the general language proficiency level of the participants and to ensure that they all belonged to the same population. The Babel English Language Placement test consists of four sections of 25 reading, grammar, and lexical items. Multiple choice formats are regarded as the format for this

test in order to ensure swift marking. This format includes those items which measure the recognition of valid responses to reading, grammatical and lexical sections. Also, this test can accurately report the general language proficiency of the learners (Maftoon & Rezaie, 2013). To verify that the test was a well-constructed one, it was administered to a sample group at different levels of language proficiency in Islamic Azad University, Rasht Branch. The test was used to clarify that all the participants belonged to the same population. The reliability estimate of the very test (r=0.79), calculated through Kuder-Richardson formula (KR-21), indicated that the test had a relatively high-reliability index and showed that there was an acceptable internal consistency among the items of the test.

Medical checklist. To obtain information regarding the participants' menstrual cycles, a medical checklist was prepared and designed by a gynecologist to ensure consistency and completeness in carrying out the study.

Nation's vocabulary level test (VLT). Nation's Vocabulary Level Test is a simple instrument for teachers to develop a suitable vocabulary teaching and learning program for their students (Read, 2000). Its utility has been proved for diagnostic purposes and is widely used and validated by different scholars (Laufer & Nation, 1999) since the 1980s. The test embodies five parts, representing five levels of word frequency in English namely, 2000, 3000, 5000, Academic and 10000. According to Nation (1990), the 2000- and 3000-word levels contain the high-frequency words that all learners need to know in order to function efficiently in English. The test involves word definition matching exercises.

Vocabulary recall achievement posttests. To investigate whether there is any statistically significant difference in the Iranian EFL learners' vocabulary recall in females' menstrual cycle (i.e., in luteal and follicular phases), the researchers designed two achievement posttests of L2 vocabulary recall, based on Nation's (1990) 3000-word level of Vocabulary Level Test. To determine the reliability of the real posttests, the Kuder-Richardson formula (KR-21), was used and acceptable

reliabilities of 0.78 and 0.81 were reported for the two tests. Each posttest consists of two halves of 15 items. In the first half, the participants were required to choose the correct letter for each meaning and write the letter of that word next to its meaning. In the second half, the participants were requested to select the right letter for each definition and write the letter of that word next to its definition.

Vocabulary acquisition achievement posttests. To measure the participants' L2 vocabulary acquisition, the present researchers also designed two achievement posttests of L2 vocabulary acquisition, administered two months after the treatment, in their respective luteal and follicular phases. The items were based on Nation's (1990) 3000-word level of Vocabulary Level Test. Before the test administration, the reliabilities of the two posttests (r=0.78, r=0.82), calculated through Kudar-Richardson formula (KR-21), indicated that the given posttests had a relatively high-reliability index and showed there was an acceptable internal consistency among the items of the two posttests. Each L2 vocabulary acquisition posttest was composed of 66 items. Three types of items were included in each test battery: (1) multiple choice, (2) matching, and (3) completion.

Procedure

Given that estrogen level in females fluctuates for various reasons (e.g., menstrual cycles, pregnancy, and ovulation), the researchers acted as follows: first, since during the pregnancy, the level of estrogen profoundly decreases, the participants were asked to take a pregnancy test in order to exclude those who were pregnant. Pregnancy tests are designed to tell if participants' urine or blood contains a hormone called human chorionic gonadotropin (HCG). As a result, the participants were all reported not to be pregnant. Moreover, each participant needed to sample their estradiol blood test twice, once in the follicular phase and the other in the luteal phase. It deserves mentioning that in the follicular phase, the level of estrogen goes down, while in the luteal phases, it rises.

Each session, the participants were taught 7 to 8 words. The reason for exposing students to 7 to 8 words each session lies in Finocchiaro and Bonomo's (1973) claim that students should not be exposed to more than eight words each session because they are not capable of managing them.

The treatment lasted one week (six sessions everyday) for each phase of the menstrual cycle, and each session took 30 minutes. Before the treatment, the researchers held a meeting to make the participants familiar with the menstrual cycle. The menstrual cycle of a healthy woman can be categorized into five phases (Riley, Robinson, Wise, & Price, 1999).

1. Menstrual Phase (Day 1-5)
2. Follicular Phase (Day 6-11)
3. Ovulation Phase (Day 12-16)
4. Luteal Phase (Day 17-23)
5. Premenstrual Phase (Day 23-28)

A regular menstrual cycle lasts about 28 days. The time from the beginning of the last menstrual period until ovulation is, on average, 14 days (Geirsson, 1991) provided that the menstrual cycle is reported normal. Recall that at the beginning of follicular phase, the level of estrogen is at the lowest, while 21 days after menstruation which occurs at the luteal phase is at its highest level. It is worth mentioning that the typical value of estrogen level ranges from 30 to 400 pg/ml. Estradiol levels during one menstrual cycle are delineated in the following figure:

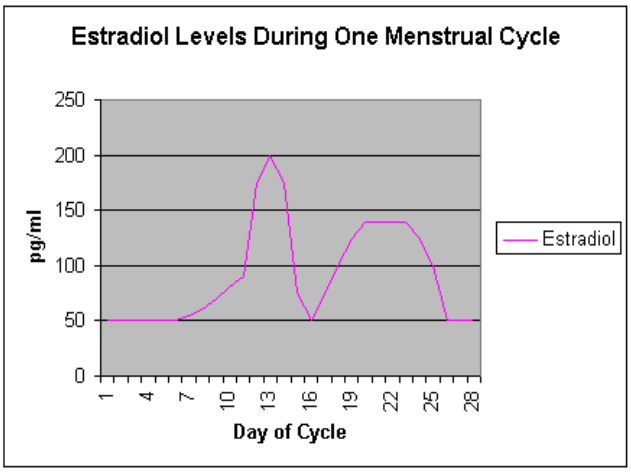

Figure 1. Menstrual cycle (Geirsson, 1991)

To conduct the experiment, initially, the exact date of menstruation for every 15 females was determined. Then, the participants were introduced to a medical laboratory located in Bandar-e Anzali, to sample their level of hormones twice: once in the follicular phase, about eight days after menstruation and, the second time, 21 days after menstruation (i.e., in the luteal phase). Among the limitations of the study is that the present researchers could not invite all the 15 participants in one session in order to begin the treatment. In fact, due to the different menstruation cycles, each of the participants, based on their time of menstruation, was taught and tested individually.

In other words, the participants, individually, were invited to take part in a training course held 6 sessions in the follicular phase; similarly, the participants were directed to another training course held 6 sessions in the luteal phase. In each phase of luteal and follicular, the participants, individually, were trained one list of 42 words. They were reminded that the primary purpose of the study was to examine the relationship between the level of estrogen secretion and L2 vocabulary recall and acquisition.

As stated earlier, the treatment period took six sessions. Each session was 30 minutes. In each session, the participants were taught 7 to 8 lexical items. Immediately after the treatment sessions in the follicular phase, the

subjects were requested to take an L2 vocabulary recall posttest, and in order to investigate the impact of estrogen level upon L2 vocabulary recall, the participants were asked to make the first estradiol blood test in order to measure the amount of estrogen secretion. The time of this blood test and the starting day of the treatment are of great importance to the researchers. Accordingly, three days after menstruation, the treatment began. The day after the sixth session, having taken an L2 vocabulary posttest, the participants were directed to the medical lab for the first estradiol test.

Similarly, in the luteal phase of the menstrual cycle which occurs after ovulation phase, the participants were trained 42 lexical items in 6 sessions. The luteal phase almost begins from the day of 16. Henceforth, 16 days after females' menstruation, the researchers began the treatment. To assure the reliability of the results, once again, the date of the second estradiol test became an important issue due to the extreme fluctuation of estrogen level. Thus, the participants took the second L2 vocabulary test and estradiol blood seven days after the beginning of treatment (that is on the day of 23).

To investigate whether the level of estrogen has any impact on L2 vocabulary acquisition, two months after the treatment, the present researchers administered two vocabulary achievement posttests. One of the vocabulary posttests was administered in the follicular phase when the level of estrogen goes down and another in the luteal phase at which the level of estrogen goes up.

Data Analysis

Two paired samples t-tests were used between different measures in line with the current research purposes. One of the central statistical assumptions of conducting t-test is to run and check the test of normality for making a sound decision regarding whether to use t-test as a parametric test or not. Therefore, the results of *the Shapiro-Wilk Normality Test* are presented and discussed before the analyses of the t-tests are taken into consideration.

Results

Checking the Normality Assumptions

Table 1 presents *The Result of the Shapiro-Wilk Normality Test* in order to check the normality assumption for different data set.

Table 1.
The Result of the Shapiro-Wilk Normality Test

	Shapiro-Wilk		
	Statistic	**df**	**Sig.**
Es_Fol	.949	15	.504
Es_Lute	.942	15	.414
Re_Fol	.978	15	.957
Re_Lute	.953	15	.572
Acq_Fol	.957	15	.633
Acq_Lute	.948	15	.500

As it can be seen in Table 1, the data are normally distributed for all sets of scores (Sig> .05). In other words, the significance level is higher than .05. Therefore, the t-test as a parametric test can be used for the mean comparison and the relationship among the variables.

The First Research Question of the Study

Is there any significant difference between females' L2 vocabulary recall in the follicular and luteal phases of the menstrual cycle?

To answer the first research question, a paired samples t-test was conducted between females' vocabulary recall scores in the follicular and luteal phases of the menstrual cycle. The results are presented in Tables 2 and 3 below.

Table 2.

Descriptive Statistics of Vocabulary Recall

		Mean	N	SD	SEM
Pair 1	Recallfol	75.1333	15	9.32636	2.40806
	Recalllut	80.2000	15	8.82529	2.27868

As it is shown in Table 2, the mean value of vocabulary recall scores in the follicular phase is 75.1333 (SD= 9.32636). In contrast, the mean value for vocabulary recall scores in the luteal phase is 80.2000 (SD=8.82529). It can be stated that the mean value of vocabulary recall scores in the luteal phase is larger than the average scores of females on the vocabulary recall measure in the follicular phase.

Table 3.

Paired Samples T-Test

		Paired Differences				
		95% Confidence Interval of the Difference				
		Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Recalfoll Recallut	-8.21653	-1.91680	-3.450	14	.004

As it is demonstrated in Table 3, the results of the paired samples t-test indicate that there is a statistically significant difference between females' vocabulary recall scores in the given phases, t (14) = 3.450, p= .004 <. 05 (two-tailed). Henceforth, females' mean value of vocabulary recall scores in the luteal phase was better than the mean value of females in the follicular phase.

To sum up, the first null hypothesis contending that there is no significant difference between females' vocabulary recall in the follicular and luteal phases of the menstrual cycle was rejected at the significance level of .05.

The Second Research Question of the Study

Is there any significant difference between females' vocabulary acquisition in the follicular and luteal phases of the menstrual cycle?

To answer this question, another paired samples t-test was also conducted between females' vocabulary acquisition scores in the follicular and luteal phases of the menstrual cycle. The results are shown in Table 4 and 5.

Table 4.
Descriptive Statistics of *Vocabulary Acquisition*

		Mean	N	SD	SEM
Pair 1	Acquifoll	48.2667	15	7.13609	1.84253
	Acquilut	51.3333	15	6.30948	1.62910

The results of Table 4 depict that the mean value of females' vocabulary acquisition scores in the follicular phase is 48.2667 with a standard deviation of 7.13609. In contrast, the mean value of the females' vocabulary acquisition scores in the luteal phase is 51.3333 (SD= 6.30948). Thus, it can be stated that the mean value of vocabulary acquisition in the luteal phase is larger than the mean value of vocabulary acquisition measure in the follicular phase.

Table 5.
Paired Samples T-Test

		Paired Differences				
		95% Confidence Interval of the Difference				
		Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Acquifoll Acquilut	-4.68075	-1.45258	-4.075	14	.001

The results of the paired samples t-test in Table 5 delineate that there exists a statistically significant difference in females' vocabulary acquisition scores in the follicular and luteal phases of the menstrual cycle, t (14) = 4.075, p= .001 <.05 (two-tailed). Therefore, females' mean value

of vocabulary acquisition scores in the luteal phase was better than the mean value of females in the follicular phase.

As a result, the second null hypothesis of the study claiming there is no significant difference between females' vocabulary acquisition in the follicular and luteal phases of the menstrual cycle was also rejected at the significance level of .05.

Discussion

While numerous studies in SLA have revealed that language acquisition is a complex phenomenon; still, the knowledge of how much the biology of sex contributes to normal cognitive function is pretty limited. Nonetheless, the scant research that has been conducted on sex differences in SLA has revealed a general trend toward higher achievement for females on most tests (Ellis, 1994, 2008).

One plausible gap in the related field is the lack of nature-based studies which led to oppositional views (e.g., Krashen, 1981; Pienemann, 1998). It seems that theories generated in the area of nurture have less compatibility compared to those who are nature-oriented. Sparse unequivocal evidence among scholars boosts the notion of contradiction rather than that of completion in seek for a comprehensive theory. Similarly, Ellis (1994) puts forth "most theories of SLA are neither comprehensive nor modular. Rather they tackle a particular area or adopt a particular perspective often derived from a parent discipline—cognitive psychology, social psychology, sociolinguistics, linguistics, neurolinguistics, education without reference to other perspectives" (p. 681).

The emergence of oppositional views, as to Beretta (1993), is a problem, since they are in an attempt to offer exclusive mutual explanations of the same facts. Nevertheless, SLA theories "are great survivors" (Ellis, 1994, p. 685). As to Ellis, they "are not usually dismissed as a result of empirical study or powerful argumentation but, instead, tend to slip slowly and gently into oblivion" (p. 685).

Until now, the story goes on; there have been successive and often contradictory views about how best to learn a language. According to Swan (2009), "progress is likely to be faster if we can remove some of the obstacles that we have allowed to stand in our way" (p. 132). In fact, progress can be achieved by making more intelligent use of all the resources we have at our disposal. In the study done by Swan, it can be claimed that we need, therefore, no so many theories in SLA, but take stock of the existing ones and integrate them into more ideologically neutral and comprehensive approaches. In fact, research, as to Griffiths (1990), has to follow the assumed methods of the hard sciences, with no room allowed for complementarity or personal preferences.

Concerning the fact that the level of estrogen in luteal phase is higher in comparison to the level of estrogen in a follicular phase, several scholars come to hold that the high level of estrogen is conducive to females' outperformance in linguistic tasks (Ellis, 2008; Kimura, 1999; Ullman, 2005). Reason for this could be that estrogen enables females to be better at communication tasks (Brizendine, 2007). As Yonker et al. (2003) assert, the role of estrogen in several verbal episodic memory tasks is evident. The authors found out a significant relationship between the level of estrogen secretion and the females' cognitive performance.

The findings of the first research questions support the early results of Ullman (2004, 2005) who reported that high level of estrogen secretion in the luteal phase increases declarative memory in females. Along the same line, Hill, Liard, and Robinson (2014) contend that the high level of estrogen secretion in luteal phase contributes to females' outpace on episodic memory tasks (e.g., recalling), especially, when the to-be-remembered items are lexical items.

Kolb and Whishaw (2008), also, argue for the reason that "the female hippocampus is far more plastic in new environments than the male hippocampus, and this plasticity depends on [the level of] estrogen" (p. 300) that is conducive to the recall of lexical items. In short, as to Kolb and Whishaw, "gonadal hormones unquestionably have significant effects on brain development" (p. 300), and, thus, it "it provides a route whereby

experiential factors (including social factors) could influence the male and female brain differently, leading to sex-related variations in brain and behavior" (p. 300). Accordingly, Kimura (cited in Saville-Troike, 2006) maintains that higher levels of articulatory and motor ability have been associated in females with higher levels of estrogen in the luteal phase.

Considering the role of declarative memory that underlies the female advantage on linguistic tasks, Ullman (2005) takes sex differences into consideration regarding the lexical retrieval patterns of males and females. Ullman found that females rely on their declarative system for recalling past-tense verb forms.

To conclude, the mechanisms of sex differences in SLA have been suggested to involve the declarative memory system. The current study indicates that sex differences on L2 vocabulary recall, like sex differences on lexical and semantic retrieval tasks, may be driven by females' reliance on the declarative memory. Maki and Resnick (2000) maintain that increase in the level of estrogen secretion has the susceptibility to improve declarative memory in females and males. As Squire (1992) puts forth declarative memory provides the basis for conscious recollections of facts and events.

The findings of the present study are also in line with Rastelli (2014), contending "higher levels of estrogen favor declarative memory" (p. 108). Accordingly, Uster (2008) asserts "since the hippocampus is larger in the female brain and fed by estrogen, girls are considered to have a higher level of retention of the learned vocabulary items" (p. 68).

Concerning the second research question, the current work is consistent with Ullman (2005). As Ullman claims "adult second language learners rely particularly heavily on declarative memory" (p. 157). Thus, "thanks to their advantage at declarative memory, females should show superior lexical abilities as compared to males" (p. 149), while males, in contrast, are expected to have "better performance at aspects of grammar that depend on the procedural system" (Ullman, 2005, p. 149). In other words, increase in the level of estrogen in the luteal phase contributes to the acquisition of lexical items, and the high level of testosterone in males

is a plausible reason for men's outperformance in the acquisition of grammar.

Regarding the effect of estrogen on the acquisition of L2 vocabulary, Herlitz and Rehnman (2008) contend that because of the high level of estrogen secretion in the luteal phase, females acquire episodically-taught lexical items faster. In the same line, Lin (2011) asserts that "females performed better than males in the tasks of comprehending the content, acquiring vocabulary immediately after video viewing, and retaining vocabulary after one week" (p. 297).

However, numerous studies (Kaufman, 2007; Speck et al., 2000) have delineated that no significant performance differences exist between males and females "during verbal working memory tasks, but there is evidence for neurofunctional differences, suggesting that the behavioral differences may still exist, but the studies could be underpowered, or males and females could be using different psychological strategies" (Hill et al., 2014, p. 19).

Nevertheless, in line with the present research findings, Ullman (2004) holds that high level of estrogen in the luteal phase has "important functions in declarative memory, likely in the learning and retrieval of new lexical knowledge" (p. 245). Kimura (1999) puts forth that the level of estrogen secretion plays a significant role in the see-saw effect in such a way that "a dysfunction of one system results in enhanced learning in the other or that learning in one system depresses the functionality of the other" (Ullman, 2005, p. 147).

All in all, across the menstrual cycle in females, when the level of estrogen decreases, performance on some of these males tasks increases (Hampson, 1990), emphasizing the view that estrogen seems to be conducive to the see-saw effect.

Conclusion

This study investigated the question claiming whether there is any statistically significant difference between intermediate females' L2 vocabulary acquisition and recall in the follicular and luteal phases of the

menstrual cycle. The results indicated that the increase in the level of estrogen contributes to L2 vocabulary recall and acquisition. However, based on the limited data generated from and analyzed in this study, one cannot make big claims regarding the generalizability of the findings. Nonetheless, the findings of the study regarding the effect of estrogen secretion on females' vocabulary acquisition and recall in L2 conform with the results obtained by several scholars (Kimura, 2002; Rastelli 2014; Ullman, 2005). Thereupon, the findings of the very study offer several pedagogical implications in EFL contexts.

The evidence linking estrogen to performance on the recall of lexical items (Hartshorne & Ullman, 2006; McEwen & Alves, 1999) suggests that the effect of sex hormones in language acquisition should be taken into account. As Hartshorne and Ullman (2006) state, sex hormone levels fluctuate not only across individuals but also within participants, over a relatively short period. Henceforth, the language-related functions, notably recall and acquisition in L2, may also vary between and within individuals, changing over the course of weeks, months and years.

Accordingly, being aware of the extent to which sex influences language acquisition provides some insights which help L2 teachers to teach more effectively. In other words, the biological fact that males and females have different brains, and so they use different pathways for the same tasks have implications about how to consider sex differences during the learning process. However, the results of the present study do not intend to make educators gain a bias for certain sexes, but it intends to encourage educators to look for ways to facilitate learning in both females and males and to help them learn with their sex-based differences.

There are also some implications to investigate in the classroom when female characteristics are considered. Teachers need to support their instruction with objects and realia. In a sense, due to the fluctuation of estrogen, females do not favor too much abstraction. Henceforth, to help female brains, there must be visual elements such as charts and written materials, and activities like puzzles must be provided in the classroom.

The present work localizes the female advantage on recalling lexical items to the level of estrogen secretion. Accordingly, increase in the level of estrogen is conducive to high attention on the part of females. Thus, the findings of the study imply that, teachers, for instance, do not have to "keep verbal instructions too long since males might lose attention since their brain is not oriented for long speech" (Uster, 2008, p. 160).

Similarly, in material developments, the course books cannot be sex-blind. Instructional materials developers should also consider sex while selecting the topics. Exciting topics provide a stimulus. Avoiding repetitive issues and considering male and female taste in materials development can trigger them to cope with the course more comfortably**.** For example, due to hormonal fluctuations in females, they are more likely to read more demanding tasks, such as fictions when the level of estrogen secretion goes up, while they become willing to read newspapers and short texts when the estrogen level rises.

To sum up, of the primary pedagogical implications of the present work strengthen sex variable as a design factor. Teachers need to provide alternative instructional materials in order to consider individual differences in the learning process. In effect, the introduction of sex as a design factor in SLA will inevitably boost the homogeneity of findings.

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