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The Impact of Brain-Based Teaching on Iranian EFL Learners' Vocabulary Retention and Recall

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Abstract

The brain-based learning (BBL) approach refers to a learning method which attends to the structural and functional properties of the brain when involved in learning. The proponents of BBL approach in language teaching have proposed a set of strategies in line with neuroscientific findings regarding the qualities of optimal language learning. Numerous studies have attested to effectiveness of these neuroeducational techniques. The present study attempted to investigate the effect of brain-based vocabulary teaching activities on EFL learners' vocabulary retention and recall. The participants were 60 high school students in the Iranian EFL context selected via convenience sampling. The experimental group received 14 sessions of instruction in accordance with the BBL strategies suggested by Caine and Caine (1994). The findings revealed that the brain-compatible approach to teaching L2 vocabulary improved learners' vocabulary retention. However, the intervention failed to have a significant effect on vocabulary recall. The divergent finding regarding the recall and retention of vocabulary is attributed to the intrinsic nature of productive vocabulary in developing in the long run as a result of deep emotional and cognitive engagement. The data collected with the perception questionnaire revealed that the majority of the participants demonstrated positive attitudes toward BBL strategies. Neuroeducational strategies facilitate vocabulary learning as a result of involving learners in deep emotional and cognitive engagement. Therefore, they should make up an integral aspect of foreign language teacher education programs. It is suggested that the synergic effects of the composure of BBL strategies for L2 teaching be investigated in relation to individual differences.

Keywords: brain-based language learning, EFL, neuroeducation, vocabulary recall, vocabulary retention

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1. Introduction

Brain-based learning (BBL), also known as neuroeducation or educational neuroscience, is an approach to education that incorporates insights from neuroscience to inform teaching practices. It involves understanding how the brain learns best and applying that knowledge to design effective learning experiences for students. This approach considers factors such as cognitive development, memory processes, attention, emotions, and motivation to optimize learning outcomes. The essence of BBL is attention to how brain functions in favor of optimal learning. This educational approach relies on those properties of the brain believed to have been designed naturally for teach (Jensen, 1996). BBL resorts to three general instructional techniques of (1) relaxed alertness, (2) orchestrated emersion, and (3) active processing to facilitate learning (Caine & Caine, 1994).

Many of the essential tenets of the educational neuroscience have also received attention on the part of language educationists as they have been underscored by a variety of language teaching methods (see below). However, a systematic integration of brain-based learning approach to language learning has not been common practice in the foreign language pedagogy. Attention to brain functioning can help language teaching methodologists develop a better understanding of how cognitive processes such as attention, perception, memory and learners' emotional states interact with the learning process. Brain-based language learning (BBLL), also known as neuroscience-informed language learning, is an approach to language acquisition and instruction that integrates insights from neuroscience to enhance learning outcomes. It focuses on understanding how the brain processes and acquires language and applies this knowledge to optimize language learning experiences. Although BBLL might not be considered pertinent to all aspects of language learning, it fits well into the requirements of those aspects of FLL that involve effective cognitive processing. Developing a lasting knowledge of vocabulary is one such area.

One of the most common challenges EFL learners face is their inability to recall and retain the words they learn. Poor vocabulary may end up in lexical poverty in learners' speaking skill as an outcome. Therefore, this study attempted to probe the efficacy of BBL techniques in facilitating the development of effective vocabulary knowledge. The specific aim of this study was to investigate the effect of brain-based learning strategies on the intermediate EFL learners' vocabulary retention and recall. Due to fostered receptive and productive vocabulary knowledge, students can communicate effectively, interact more successfully, and use language more confidently. Accordingly, the current study attempted to probe into the following research questions:

1. Do the brain-based learning techniques have any effect on Iranian intermediate EFL learners' vocabulary retention?
2. Do the brain-based bearing techniques have any effect on Iranian intermediate EFL learners' vocabulary recall?
3. What are the Iranian EFL learners' perceptions about the brain-based bearing classrooms?

2. Literature Review

Educational neuroscience as an academic discipline is a relatively recent development, emerging in the late 20th century and gaining momentum in the 21st century. In the late 20th century, new breakthroughs in neuroimaging techniques, such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG), revolutionized the field of neuroscience. Researchers began to explore the neural mechanisms underlying cognitive processes such as learning, memory, attention, and decision-making. As neuroscience research progressed, educators and psychologists started to recognize the potential implications of these findings for education. With the turn of the 20th century, such American universities as University of Southern California, Harvard University, and John Hopkins offered degree programs in educational neuroscience. The Findings of educational neuroscience have begun to inform educational policies, curriculum development, teacher training programs, and classroom practices. Educators are increasingly incorporating brain-based principles into their teaching methods, with a focus on creating more engaging, effective, and personalized learning experiences for students.

2.1. BBL and Language Teaching

Overall, the educational neuroscience reflects a growing recognition of the interplay between brain science and education, with ongoing efforts to translate neuroscientific research findings into practical strategies for improving teaching and learning (Sousa, 1995). The term *brain-based learning* has been commonly used to refer to integrating neuroscientific findings to educational settings. Jensen (1996) defines BBL as "learning in accordance with the way the brain is naturally designed to learn" (p. 6). BBL has been commonly viewed in terms of a set of educational strategies. Jenson and McConchie (2020) define brain-based education as "the engagement of strategies based on principles of how the brain learns" (p. 10). These strategies offer an operational channel for brain-based language teaching. Some of these instructions have already been underscored as the basic tenets of L2 theories. For instance, cooperative and collaborative learning make up a prominent feature of social interactionist theories, and meaning-based presentation of

language items have been highlighted in communicative methods of language teaching. A well-known set of BBL strategies involves 12 principles proposed by Caine and Caine (1994) and reviewed by Deveci (2008). In what follows, these principles are discussed in reference to L2 methodological developments.

2.1.1. Brain Is a Parallel Processor.

Since human brain is normally involved in different types of cognitive, affective, and conative activities simultaneously, it is important that the teaching method be designed so as to provide on orchestrated addressing of all brain operations. This strategy is in line with the latest findings from cognitive psychology that advocate integration between cognitive, affective, and motivational functioning of human brain (Amini, 2015; Amini & Amini, 2017; Dai & Sternberg, 2004). This integration has been highlighted in language teaching literature as well (Swain, 2011).

2.1.2. Learning Engages the Entire Physiology.

Just like other organs in human body, brain functioning rests on some physiological settings. In this sense, learning as a brain activity is subject to be influenced by nutrition, exercise and stress management. The two concerns highlighted in this principle, i.e., the integration of right brain learning by involvement of motor activities and creation of positive classroom atmosphere via stress management, made up the basic tenets of Asher's (1969) work in total physical response method of language teaching. Although Asher's emphasis might be considered an extravagant and unidimensional approach, both of its integral tenets have been integrated into the tasks suggested by commonly practiced performance-based approaches to language teaching. The role of positive affective milieu in the instructional setting has also been vehemently underpinned by advocates of positive psychology.

2.1.3. The Search for Meaning Is Innate.

According to this principle, learning takes place by recording familiar information while the curiosity for novel information is reserved. Human brain holds an innate capacity to respond to novel experiences. This underscores the significance of discovery learning. Individualization has also been highlighted in humanistic approaches to language teaching (Amini, 2014). It is also relevant that classroom activities require an optimal level of difficulty and challenges to provide optional learning condition, a point that has been considered a required condition for experiencing the state of flow (Csikszentmihalyi, 1990). Amini et al. (2016) reported a constructive role for experiencing the state of flow in acquiring second language vocabulary.

Adherence to the theory of flow is another supporting evidence for the association between BBL and positive psychology.

2.1.4 .The Search for Meaning Occurs Through Patterning.

As far as the construction of meaning is concerned, learners act not only as engineers but also as architects. That is to say, the constructed information must be organized by individual learners in a way to imply a general pattern of meaning. For instance, when students in a language class are asked to recline back on their seats and use the best of their imagination to review their past experiences, or future dreams, in relation to newly acquired words, they are actually involved in patterning. Therefore, meaningful learning cannot be ensured simply by contextualized and individualized presentation of the information of a new language. Rather, certain classroom procedures need to be designed in order to increase the chances of organized patterning. The role of imagination in dynamic cognitive and motivational process has recently been acknowledged in dynamic models of language learning (Dörnyei, 2011; Verspoor et al., 2011)

2.1.5. Emotions Are Critical to Patterning.

While the cognitive processes of attention, perception, and memory might typically present a pale drawing of an image, emotions associated with the recorded information add colorful vividness to a painting. The effect of emotional experiences on cognitive processes has been recently acknowledged by theoretical arguments attached to positive psychology. According to broaden and build theory (Fredrickson, 2001), favorable emotions not only broaden the cognitive scope of the brain in attending to the new information, but also leave learners in a better position to take advantage of learning opportunities by setting up effective social relations with teachers and other learners (Amini, 2014). The facilitation provided by emotions in the storage and recall of information is significant in terms of overall emotional support ascertained by appropriate task implementation and well-trained teachers, as well as the emotional states associated with processing new information as L2 vocabulary input.

2.1.6. The Brain Processes Parts and Wholes Simultaneously.

Encountered with a new piece of information, the human brain needs to process both the isolated details of the information and its association with context in which the information is used. Ignoring either the parts or the whole will end up with inconvenient learning. In acquiring second language vocabulary, learners need to be exposed not only to the descriptive properties of second language words including the phonological, morphological, and semantic properties as well as the syntagmatic and paradigmatic relations with

other words, but also to the instances of using target words in authentic contexts. Overlooking descriptive properties of individual words in favor of contextualized presentations as argued by strong versions of communicative language teaching, or, in reverse, resorting to practicing lexical properties in isolation without sufficient contextualization is equally deplorable.

2.1.7. Learning Involves Both Focused Attention and Peripheral Perception.

This strategy contends that all sensory data in the instructional environment can affect the learning of target items. A genuine account of this strategy has been operationalized by Lozanov's Suggestopedia (Lozanov, 1978). The parallel effect of peripheral perceptions such as classroom decor, shape, and arrangement of seats and background music was dubbed double-planeness by Lazanov. Apart from the psychotherapeutic approach adopted in Suggestopedia, the issue of peripheral perceptions has important ramifications for language classes. The details of teachers' behavior and the emotional (e.g., smile), social (e.g., posture) and behavioral (e.g., tone of voice) signals emitted by the teachers can directly influence the processing and retaining of new information. The concept of peripheral learning can be linked to the engagement element proffered by positive psychologists (Seligman, 2011). As far as second language vocabulary learning is concerned, peripheral signals including the teacher signals during the presentations and practice of new words affects the profound processing required for their long-term retaining.

2.1.8. Learning Involves both Conscious and Unconscious Learning.

The learners' awareness of their own learning plays a key role in the lasting retention of information. In this sense, learners' preferred learning style and metacognitive activities and self-regulation skills contribute to the conscious portion of learning. For example, the effectiveness of presenting lexical items within visual, or auditory, input will depend on learners' style of learning. Learners should also be encouraged to regulate their learning by resorting to their personalized vocabulary acquisition strategies.

2.1.9. There Are two Different Types of Memory.

Human brain contains a natural and spacial memory, typically involved in developing an episodic memory and a set of systems for rote learning, commonly related to learning facts and skills through rehearsal. The complementary role of the two memory systems has been underscored in L2 vocabulary teaching theories via a call on engaging learners in both implicit and explicit learning/knowledge. The explicit channel usually involves cognitive strategies, such as using flash cards, vocabulary network, mnemonics, dictionary work, etc, while the implicit channel is all about

extended, contextualized, and personalized presentation and practice of L2 words.

2.1.10. We Learn Best When the Learning Data Are Embedded in Natural, Spatial Memory.

The role of frequent exposure to vocabulary is an established theorem in the literature (Rahimpour & Amini, 2013). However, it must be ensured that multiple exposures to how L2 words are used take place in different modes (written and oral), channels (visual, auditory, kinesthetic) and contexts (various social and communicative settings). This BBL strategy has been principally acknowledged by lexical approaches to language teaching (Lewis, 1993).

2.1.11. Learning Is Enhanced by Challenge and Inhibited by Threat.

Some evidence has been introduced for an improvement in the incidental acquisition of L2 vocabulary as a result of learners' engagement in a state of flow (Amini et al., 2016). This optimal experience occurs when the vocabulary teaching tasks are adjusted to an optimal level of challenge.

2.1.12. Each Brain IS Unique.

Individual differences play a key role in neuroscience-informed vocabulary learning. Contingently, it is important that a wide range of vocabulary learning tasks and activities be available from which learners can pick their congenial techniques.

2.2. Vocabulary Acquisition in Lights of BBLL

BBLL, also known as neuroscience-informed language learning, is an approach to language acquisition and instruction that integrates insights from neuroscience to enhance learning outcomes. It focuses on understanding how the brain processes and acquires language and applies this knowledge to optimize language learning experiences. Some key principles and concepts of brain-based language learning include:

- neuroplasticity: recognizing the brain's ability to adapt and reorganize in response to language learning experiences,
- emotional engagement: acknowledging the role of emotions in language learning and promoting a positive and supportive learning environment to enhance motivation and engagement,
- input and interaction: providing rich and meaningful language input through exposure to authentic materials, interactive activities, and opportunities for communication and collaboration,

- attention and memory: incorporating techniques to enhance attention and memory retention, such as spaced repetition, mnemonics, and multisensory learning experiences,
- contextual learning: integrating language learning within meaningful contexts and real-life situations to facilitate comprehension and retention,
- feedback and error correction: Providing timely and constructive feedback to learners, encouraging risk-taking and experimentation, and addressing errors in a supportive manner to facilitate language development,
- individual differences: recognizing the diversity of learners and their unique cognitive, emotional, and linguistic profiles, and adapting instruction to meet their needs and preferences, and
- Metacognitive strategies: encouraging learners to reflect on their own language learning processes, set goals, monitor their progress, and adjust their learning strategies accordingly.

By incorporating these principles into the practice of language teaching and learning, educators aim to create effective and engaging language learning experiences that leverage the brain's natural capacity for language acquisition and retention. Although a generally-accepted system of operationalizing the principles of BBLL seems to be absent in the literature, some effective frameworks have been proposed in order to implement these principles through instructional strategies (e.g., Deveci, 2008; Haghighi, 2013; Jing, 2019; Lombardi, 2008; Radin, 2009).

In a qualitative analysis of L2 teachers and learners' beliefs, Radin (2009) reported "emotional involvement; physical systems including movement, room arrangement and homeostasis; lowered stress and threat levels; experiences in the classroom including trial and error, exploration, practice, creativity, and critical thinking; and challenge, problem-solving, and authentic work" (p. 44) as the main characteristic strategies of brain-compatible language teaching. By presenting the results of structural and functional imaging of second language acquisition, Iranmanesh et al. (2021) proposed that a systematic model of L2 instruction compatible with the patterns of language learner's brain can promote the rate and outcome of L2 learning. The constructive role of BBLL is attributed to the quality and quantity of the cognitive and affective relationship between the teacher and learner.

Through thematic analysis of language teachers and learners' opinions toward BBLL, Wagner-Heaston (2006) introduced a hybrid model of "covenant and context" framework in which BBL strategies support a synergic atmosphere for effective language learning to take place. The effect of BBL on language learners' psychological and motivational state has also been established through some experimental research. Alizadeh Oghyanous (2017),

for instance, found that a language teaching procedure inspired by BBL improved learners' self-efficacy.

The effect of BBLL in improving various aspects of second language development has been the subject of empirical research worldwide. Teaching EFL in Turkish contexts in accordance with the 12 principles of Caine and Caine (1994), and Koşar and Bedir (2018) reported an improvement in general proficiency of L2 learners after 4 months. Syahbandi (2018) reported the effectiveness of BBL, as part of a cooperative learning program, on EFL learners' speaking skill. Jampamoon (2014) investigated the effect of brain-based learning on six Thai EFL learners' speaking ability. The participants practiced through games and songs as recommended by Caine and Caine (1994). Learners' perception analysis revealed their positive attitude about learning English with BBL activities.

In the Egyptian context, Abu-Hashem (2011) demonstrated the effectiveness of a brain-compatible language teaching program in enhancing the listening and pronunciation skills of second-year university students.

Kandasamy et al. (2021) examined the impact of BBL strategies on Malaysian young EFL learners' acquisition and retention of English vocabulary and found it a successful approach in this regard. Similarly, Salem (2017) studied the effect of BBL on vocabulary retention of Egyptian ESP business students and found a moderating role for the learning style. Learners with dominant visual style of learning benefited more from BBLL in terms of L2 vocabulary retention.

3. Method

3.1 Research Design

This study used a quasi-experimental, pre/posttest design. The vocabulary retention and recall scores of the students made up the dependent variables and the vocabulary instruction plan based on Jensen's (2008) seven steps of brain-based learning was the independent variable. In addition, a questionnaire was utilized to investigate the learners' perceptions regarding the brain-based learning strategies.

3.2 Participants

The participants were 60 female high school students (aged 15-17, *M* = 15.2) found to be at 2000 level of English vocabulary knowledge, who studied at Hafez and Parvin Etesami public high schools of Sofian, East Azarbaijan, Iran. Due to limitations with school classes, the participants were selected through convenience sampling and were randomly assigned to experimental and control groups.

3.3 Instruments

The following measures and materials were utilized in the present study.

3.3.1 Pre/Posttest of Vocabulary Retention

Retention and recall are terms borrowed from cognitive psychology into L2 acquisition. They are typically measured by L1/L2 translations. Retention involves recognition of a word recently used in a meaningful context. In this research a vocabulary retention test was designed by the researchers based on the list of target words (Appendix I). The test comprised 30 multiple-choice items. The value of Cronbach's alpha coefficient showed an acceptable level of reliability ($\alpha = .78$).

3.3.2 Test of Vocabulary Recall

Vocabulary recall involves the learner's ability to retrieve an L2 word from memory when it is elicited by a verbal or non-verbal stimulus (Read, 2000). The quality of recall depends on the quality of the teaching, the interest of the learners, or the meaningfulness of the materials (Aliakbari et al., 2024; Richards & Schmidt, 2002). A vocabulary recall test was designed by the researchers in accordance with the guidelines introduced by Laufer and Nation (1999) on the design of recall tests. The test comprised 30 items in the form of incomplete missing target words, with the initials provided (Appendix II).

3.3.3 Teaching Materials

All topics and sample texts used as the teaching materials during the instructional sessions were chosen from the book *Thoughts and Notions 2* by Ackert and Lee (2005) that includes reading passages for high beginner level.

3.3.4 Learner's Perception Questionnaire

The learners' perceptions about the BBL were investigated using a questionnaire adapted from Parnell's (2018) perception questionnaire toward the BBL environment. The questionnaire comprised of 20 items on a 5-point Likert scale in English. The reliability check was satisfactory ($\alpha = .69$).

3.4 Procedure

The research was conducted during the school year 2021-2022 including 14 sessions of instruction within a 6-week period. First, a Vocabulary Levels Test (available online at www.lextutor.ca), based on West's (1953) *general service list of English words*, was applied to 82 initial participants in order to ensure the homogeneity of participants in terms of English vocabulary knowledge. Those participants who were found to be at the 2000-word level of vocabulary knowledge were selected as the final participants ($n = 60$). They were randomly assigned to the experimental and control groups. To select the

target vocabulary, the researchers administered the test of vocabulary familiarity designed according to Paribakht and Wesche's (1997) Vocabulary Knowledge Scale (VKS) to both groups of the study. The initial test consisted of all 45 target English words selected by the researchers from the VLT. The words known by at most 10% of the participants were eliminated, and the remaining 30 words were selected as the target words. Afterwards, the pretest of vocabulary retention was administrated to both groups. Because of its productive nature, the recall test was used only as the posttest to avoid the test effect.

There were 14 sessions of instruction held 3 days a week, each lasting 50 to 70 minutes for both groups. The instruction hours and materials for both groups remained identical. While the target words were instructed to the participants of the control group based on their conventional school program, the lesson plans for treating the experimental group were designed in accordance with 12 strategies of BBL (Caine & Caine, 1994) and the seven steps proposed by Jensen (2008) including (1) pre-exposure, (2) preparation, (3) initiation and acquisition, (4) elaboration, (5) incubation and memory encoding, (6) verification and confidence check, and (7) integration. The following instructions were observed by the classroom teacher in planning for presenting and practicing new words:

- active learning: Encourage active participation and engagement in the learning process through hands-on activities, discussions, debates, and collaborative projects.
- multisensory learning: Incorporate multiple senses (such as sight, hearing, touch, and movement) into learning activities to enhance comprehension and memory retention. For example, use visual aids, music, and role-playing to appeal to different learning styles.
- emotional engagement: Create a positive and supportive learning environment that fosters emotional engagement and motivation.
- chunking and spacing: Break down complex information into smaller, more manageable chunks and space out learning sessions over time to promote better encoding and retention in long-term memory.
- metacognition: Teach students metacognitive vocabulary learning strategies to help them become aware of their own thinking processes, set goals, monitor their progress, and adjust their learning strategies accordingly.
- brain-compatible environments: Design learning environments that are conducive to brain function, such as well-lit classrooms, comfortable seating, minimal distractions, and opportunities for movement.
- visualizations and analogies: Use visualizations, analogies, and metaphors to make abstract concepts more concrete and easier to understand.

- storytelling: Harness the power of storytelling to engage learners, evoke emotions, and make learning memorable.
- feedback and reflection: Provide timely and specific feedback to students to help them understand their strengths and areas for improvement. Encourage reflection on learning experiences to deepen understanding and promote continuous growth and development.

The posttest of vocabulary retention and vocabulary recall were administrated to each group in an exam session. In the meeting, Parnell's (2018) perception questionnaire was administered in order to explore the learners' perceptions toward the BBL instruction they received.

4. Results and Discussion

4.1 Results

Table 1 presents the descriptive statistics for the pretest and posttest of vocabulary retention, the means and standard deviations of the posttest of vocabulary recall. Due to the productive nature of vocabulary recall test and to avoid test effect, the recall test was not administered as a pretest.

Table 1

Descriptive Statistics for Vocabulary Retention and Recall

	Group	N	Mean Retention	SD Retention	Mean Recall	SD Recall
Pretest	Experimental group	30	9.82	1.07	-	-
	Control group	30	9.20	2.05	-	-
	Total	60	9.51	1.65	-	-
Posttest	Experimental group	30	16.33	1.78	17.03	2.07
	Control group	30	10.93	1.61	14.97	3.27
	Total	60	13.63	3.20	16.00	2.71

To address the first research question of the study, it was preliminarily needed to see if the learners had made any gain from the pretest to the posttest in terms of vocabulary retention. A one-way analysis of covariance (ANCOVA) was conducted to compare posttest results while ironing out pretest effects.

Before analyzing the data for treatment effects, the prerequisite assumptions of the ANCOVA test with regard to the normality of the data and homogeneity of variances were checked through Kolmogorov-Smirnov test of normality. The obtained data were normally distributed for each category of the independent variable; the assumption of homogeneity of variances, the assumption of linear covariate, and the assumption of homogeneity of regression slopes were also met.

According to the main results of the ANCOVA test, displayed in Table 2, the posttest scores of the experimental group and control group were

significantly different. The amount of partial eta squared indicates that 74% of variance of vocabulary retention was controlled by brain-based teaching.

Table 2

Test of Between-Subject Effect for Vocabulary Retention Scores

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared
Corrected Model	455.61[a]	2	227.80	86.38	.00	.75
Intercept	180.17	1	180.17	68.32	.00	.54
Pretest	18.21	1	18.21	6.90	.07	.01
Groups	389.59	1	389.59	147.73	.00	.72
Group * Pretest	.248	1	.248	.092	.762	.002
Error	150.31	57	2.63			
Total	11758.00	60				
Corrected Total	605.93	59				

[a] R Squared = .752 (Adjusted R Squared = .743)

Regarding the second research question, which concerned EFL learners' vocabulary recall, independent samples t-test was utilized after the prerequisite assumptions had been checked. As indicated in Table 3, the sig. (2-tailed) value was .925 and above the required cut-off of .05, which means that there was not a statistically significant difference in the mean vocabulary recall scores of control and experimental groups. Therefore, using BBL techniques had no enhancing effect on the intermediate EFL learners' vocabulary recall.

Table 3

Independent Samples Test for Comparing Vocabulary Recall Scores

		Leven's test for EV		t-test for equality of means						
									95% confidence interval of the difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	Lower	Upper
Posttest R	Equal variances assumed	5.32	.02	.09	58	.925	.06	.708	-1.350	1.484
	Equal variances not assumed			.09	49.06	.925	.06	.708	-1.356	1.489

In order to deal with the third research question which involved the participants' perceptions on BBL classrooms, the researchers first evaluated the internal consistency reliability of the questionnaire, in which the value of Cronbach's alpha coefficient obtained for the questionnaire showed a high level of reliability (α = .78). Apparently, the majority of the participants' perceptions toward the course and classroom were positive since the total mean score was 2.11 (1 = *strongly agree*, 5 = *strongly disagree*).

Three significant conclusions are worth mentioning based on the questions on which most of the students strongly agreed. First of all, the participants believed that BBL helped them use English in both classroom and real-life situations. They also reported that BBL not only let them participate

more in the classroom activities, but also its games made lots of fun. Third, they found BBL instructions easy to follow.

Table 4

Descriptive Statistics for Participants' Perceptions about BBL Classroom

	Mean	SD	Meaning
1. Brain-based learning helps me to learn English better.	2.73	1.28	Neither agree nor disagree
2. Brain-based learning uses games to make learning fun.	1.65	.89	Strongly agree
3. Brain-based learning uses songs and music to enjoy learning.	2.00	1.96	Agree
4. Brain-based learning helps me use English in real life, not only the classroom.	1.20	.68	Strongly agree
5. Brain-based learning lets me move around. I do not sit all the time.	3.95	1.26	Disagree
6. Brain-based learning is interesting.	1.85	1.16	Agree
7. Brain-based learning is not too difficult. I understand what to do.	4.43	1.01	Strongly disagree
8. Brain-based learning is a happy time.	2.15	1.00	Agree
9. Brain-based learning lets me join in the classroom activities.	1.55	.95	Strongly agree
10. Brain-based learning helps me understand even when it is difficult	2.07	1.28	Agree
11. Brain-based learning lets me use English to talk to my friends.	2.85	1.16	Neither agree nor disagree
12. Brain-based learning lets me feel relaxed.	2.13	1.34	Agree
13. Brain-based learning lets me speak English with the teacher.	1.85	1.16	Agree
14. Brain-based learning lets me share my ideas.	1.90	1.09	Agree
15. Brain-based learning lets all the students join.	2.15	1.07	Agree
16. Brain-based learning lets students be active.	2.35	1.21	Agree
17. Brain-based learning lets students help each other.	2.28	1.13	Agree
18. Brain-based learning helps me to be a better student.	2.33	.97	Agree
19. In Brain-based learning the students respect the classroom and teacher.	2.40	1.23	Agree
20. In Brain-based learning I do good work.	2.70	.93	Neither agree nor disagree
Total	2.11	1.43	Agree

4.2 Discussion

The present study attempted to examine the effect of the BBL on Iranian EFL learners' vocabulary retention and recall. It was revealed that the neuroscience-informed vocabulary teaching procedure designed in accordance with the instructions of BBL was effective in improving the students' vocabulary retention, i.e., the development of receptive lexical knowledge. This finding is in accordance with previous empirical research in different EFL contexts (Highighi, 2013; Jing, 2019; Kandasamy et al, 2021; Koşar & Bedir, 2018; Salem, 2017). One reason for reaching this result is that the BBL assists learners in overcoming the complexities of focusing on the learning process in addition to language itself. Furthermore, the BBL techniques can contribute to the creative and inventive processes of language teaching (Sousa, 1995); they provide the learners with an opportunity to practice vocabulary in multiple social contexts and roles.

Despite the effectiveness BBL in improving the retention scores of EFL learners, the brain-based procedure for teaching vocabulary had no significant effect on enhancing the learners' vocabulary recall. Performance on the recall

test depends on the learners' productive knowledge of vocabulary while retention scores rely on their receptive knowledge. Although the EFL learners in the experimental group received a higher mean score compared to the control group (M = 17.03, M = 14.93), the difference did not reach the significance level. The failure of brain-compatible treatment in this research in reaching statistical significance in affecting vocabulary recall is attributed to the productive nature of recall knowledge and the limited allocation of time for involving the students in the designed activities. The development of active and productive lexical knowledge requires the learners to engage emotionally and cognitively in the given task (Craik & Lockhart, 1972). It seems that 14 hours of treatment has not been sufficient for ensuring a deep level of engagement.

The BBL is successful in immersing the learners in appropriate experiences so that the educational environment is viewed as a small and healthy real-world community where learners take responsibility for handling various activities. The BBL also triggers the active processing in the learners. Active processing involves reflection, allowing learners to take charge of the consolidation and internalization of learning in a meaningful way. However, the development of active vocabulary knowledge demands a longitudinal process of vocabulary acquisition.

The procedures employed by the classroom teacher in the experimental treatment in compliance with Jensen's (2008) seven-step scheme for presenting and practicing lexical items seem to have played an important role in improving EFL learners' retention. The type of input and the manner of exposure to input is one aspect of dealing with the neuroplasticity of the brain (Caine & Caine 1989, 1990, 2001; Jensen, 1996, 2005). Jenson and McConchie (2020) associate the types of learning with the type of input the learners receive. In this framework, learning is formed in response to four types of input as the trigger of the learning process:

1. Preexisting input
2. Sensory input
3. Explicit/Declarative input
4. Implicit/Nondeclarative input

Preexisting input refers to the previously-stored knowledge that can be reactivated, analyzed, and recognized as a result of internal mental processes such as thinking, evaluating, and reflecting. For L2 vocabulary acquisition, the ongoing formation of versatile meanings associated with lexical items can partly result from reflecting on previous experiences of exposure to these items.

The second type of input involves not only the input through the five senses but also other stimuli such as sense of temperature, pain, balance, etc. In a traditional view, sensory learning has been associated with three types of

learning preferences, i.e., visual, auditory, and tactile styles of learning. However, educationists have recognized 71 models of learning style (Coffield et al., 2004). These findings underscore the effectiveness of multiple types of sensory input in promoting the learning experience. This can be fairly linked to the presentation modes in L2 vocabulary teaching where a multitude of channels for presenting and practicing new words generates an effective sensory learning.

The third type of input and the kind of learning associated with it involve the learning experience, mainly, located in formal instructional procedures such as teacher explanations or lectures. This explicit/declarative input can lead to the development of both episodic memories of where and how the learning is taking place, and semantic memories of facts and concepts being learned. Similarly, out-of-classroom, project-based and individualizing activities can enhance these two types of memory.

Another important vocabulary learning strategy deals with resorting to imagination. Human brain is deemed to process data and respond to them from imaginative and real sources in an identical manner (Oatley, 2011). For example, using anecdotes and stories, especially funny ones, to present and practice L2 vocabulary sets the ground for both episodic and semantic learning to take place. In addition, episodic learning involves brain's emotional activities, mainly based in amygdala.

The implicit/nondeclarative input results in unconscious and indirect learning. Some major sources of implicit learning are the teacher's beliefs, attitudes, and behavior including body language and tone. An L2 teacher's constant reference to L1 words results in the assumption on the learners' mind that there is a one-on-one correspondence between the concepts and words in the two languages. Play-embedded and game-based learning provides a congenial context for developing the desired implicit knowledge.

Finally, with regard to the third research question, concerning the learners' perceptions toward BBL, the overall results from the questionnaire suggest that the learners found the BBL more effective, useful, enjoyable, and motivating than the conational vocabulary teaching activities. This finding is in line with previous perception research on BBLL (e.g., Jampamoon, 2014; Salem, 2017). The participating EFL learners displayed a positive attitude towards most of the aspects of brain-compatible language learning activities.

To sum up, understanding how the brain learns and involves senses, emotions, physical movements, relationships and motivation can lead to better learning processes. Accordingly, getting familiar with and working on the power of the neuroplasticity of the brain can positively affect the learning of any life skill, including English language skills. Therefore, the techniques arising from the BBL approach should make up an important part of teacher education programs and should be accounted for in developing EFL materials.

5. Conclusion and Implications

The present study will give a better understanding of the brain's functioning in language learning. EFL teachers, educators, course designers, educational policy-makers, and other stakeholders are suggested to consider incorporating the principles of BBL in EFL instruction. To integrate the BBL strategies into EFL lessons successfully, teachers must be equipped with the sufficient neuroscientific knowledge of complex cognitive processing involved in L2 learning. The current study was conducted in the context of Iran and with a limited number of participants at certain proficiency level of English language. The investigation of the effect of the BBL across different cultural and educational contexts and proficiency levels may result in new findings. Further investigation is also needed to explore the long-term effect of the BBL strategies on EFL learners' development of lexical knowledge with a broader view than retention and recall.

The overall results of the present research leave brain-based language learning and teaching in positive light. The brain-based learning approach provides a package of instructional strategies which are deemed to be compatible with the natural capacity of human brain for learning. Most of these hints have been adopted and integrated sporadically into various language teaching methods. A language teaching program that adheres to the principles of BBL approach can provide a principled bundle across theoretical and methodological inferences where second language learning is facilitated as a result of the brain adaptable classroom procedures. Technology-based language teaching procures an optimal capacity for integrating the maximum number of brain-based learning strategies since BBL is made up of a conglomerate of instructional procedures advocated by a wide range of methodological options.

Furthermore, the proponents of brain-based learning approach have proposed an array of strategies as the facilitators of the learning process. These strategies target a variety of factors involved in learning such as the relationship between learning quality and physiological health, the contextual atmosphere, learning emotional state, technological engagement, the role of others, etc. There are chances that these strategies are applied to the learning situation whether in isolation or as a composure of strategies. A question that requires second language researchers' attention is how the whole set of strategies suggested by BBLL interact with each other and what the dynamics between them look like and whether there is any synergic interaction between any of the strategies when they are applied to second language instruction as a package.

Another aspect of BBL functionality which can help push the research in this area forward is the intervening role played by language learners' individual differences. How language learners with different personality traits

and learning styles react to the numerous types of instructional strategies prescribed by neuroeducational theorizers remains almost unknown. Although the brain-compatible language teaching might seem to have come short of popular theoretical justifications (Howard-Jones, 2008), the actual attainments arising from the implementation of neuroeducational instructions in language teaching leave the theory worthy of further research and practice.

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Appendices

Appendix I

Vocabulary Retention Test

1. Teaching was my chosen _____.
 A. trend B. career C. covert D. total
2. I have to _____ the manager about my matter.
 A. consult B. pay C. delete D. sell
3. I tried to_____ down to touch my toes.
 A. thank B. make C. put D. Sit
4. She in_____ her spine in a riding accident.
 A. settled B. winded C. injured D. told
5. The _____ baby was clothed with a diaper.
 A. naked B. bright C. ugly D. talkative
6. The decision was made to raise _____.
 A. wax B. tax C. vane D. lax
7. He acquired his _____ from stocks."
 A. health B. wealth C. strength D. weakness
8. I am your new teacher. Let me _____ myself.
 A. talk B. do C. introduce D. like
9. The class _____ out laughing.
 A. thought B. burst C. played D. talked
10. The company _____ the goods free of charge.
 A. deleted B. relinquish C. delivered D. focused
11. That show is very _____.
 A. compatible B. interested C. amused D. popular
12. The police _____ the evidence carefully.
 A. extracted B. rode C. drove D. practiced
13. The bedroom _____ to the kitchen.
 A. pumps B. connects C. calls D. makes
14. In 1854 a Californian company began _____ ice from Alaska.
 A. painting B. coloring C. importing D. exporting
15. The laws need to be _____.
 A. repaired B. reformed C. declined D. retailed
16. Not many people have the _____ to stand up and speak in front of a large audience.
 A. nerve B. abroad C. agenda D. aid
17. Pete was trimming the _____ around the roses.
 A. law B. lawn C. low D. lamp
18. The patient's condition is now _____.
 A. stand B. stock C. stable D. stop
19. They are being denied the _____ to grow as normal children.

A. among B. opportunity C. album D. ancient
20. The teacher threatened to kick the impudent _____ out of the room.
A. animals B. bad C. pupils D. asleep
21. I dislike him personally but I _____ his poetry.
A. adjust B. adhere C. abhor D. admire
22. Our financial position will _____due to our new loan.
A. impede B. improve C. import D. amend
23. The X-ray showed a _____ irregularity in one lung.
A. slant B. trend C. slight D. slip
24. A cordon of police _____ the building.
A. surprised B. surrounded C. supplied D. shared
25. His public utterances did not match his private _____.
A. deeds B. destiny C. decoration D. defiance
26. Her _____ was thin, and she shivered, partly from cold.
A. gut B. gown C. grown D. game
27. He defends the _____ of his cause.
A. crime B. coat C. justice D. just
28. New responsibilities _____ upon him.
A. threw B. thrusted C. thrive D. thumbed
29. He should _____ his boss into forgetting their quarrel.
A .cleared B. collapsed C. continued D. charmed
30. The criminal _____ around the court hall and got disappeared.
A. wandered B. wondered C. wore D. waged

Appendix II

Vocabulary Recall Test

1. Two players were in_____ early in the season.
2. Then he dressed the na_____ corpse, and pulled her up on the drapery cord.
3. He was accused of evading ta_____.
4. He lost his we_____because of gambling.
5. They recently intr_____ a new product for cleaning tough stains.
6. He was taken to hospital with a bu_____ appendix.
7. We promise to del_____ within 48 hours.
8. She is becoming increasingly pop_____.
9. He was ex_____ by several doctors, who found nothing wrong with him.
10. I never con_____ you with that group of people.
11. They are im_____ coal, iron and textiles.
12. The government is trying to ref_____ consumption pattern.
13. I love my ca_____, I will continue working in mine.
14. You need to co_____ your advisor for more detailed information.
15. doing more exercise will enable you to str_____ out easily.

16. She lets me do all the work, and then she has the ne_____ to criticize my cooking.
17. Passenger ships are usually sta_____.
18. The children were horsing around on the la_____.
19. This job offer is a wonderful opp_____.
20. He is a typical pu_____; he is like most of the other students.
21. I ad_____ her for her courage and her dedication to helping others.
22. They should im_____ the design of the cars.
23. I saw a sl_____ difference in car design.
24. The area is surr_____ by a labyrinth of swamps and rivers.
25. His de_____ raised doubts about his honesty.
26. I went downstairs in my dressing go_____.
27. The warden acknowledged that just_____ had not been served in my case.
28. The ch_____ of the Caribbean attract many visitors.
29. Once the jet engine was ignited, it thr_____ the rocket from the ground.
30. I always worry about my dog. It always wa_____ around the garden.