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Iranian Prospective English Language Teachers' Perceptions of Neurocognitive Science Core Concepts: A Phenomenological Study

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Abstract

Advocating the inclusion of neurocognitive science concepts in English language teacher training curriculum is gaining more interest. However, little is known about the prospective teachers' perceptions of neurocognitive science core concepts. The purpose of this phenomenological study was to explore the prospective ELT teachers' perceptions of the neurocognitive core concepts and the applications of them through the lens of four neuro-educational models in the classroom practices. Fifteen prospective Iranian ELT teachers were interviewed and the data were analyzed using the phenomenological method. The findings revealed that the prospective ELT teachers lacked a clear understanding of the neurocognitive concepts and their implications in classroom practices. The findings support the inclusion of neurocognitive science core concepts training in language teachers' professional development.

Keywords: neurocognitive science, ELT teachers, teacher education, neurocognitive core concepts

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1. Introduction

English Language teachers' professional growth has long been recognized as a powerful and necessary means to improve educational achievements. There is a general consensus that professional development is an essential component of quality education for practicing teachers in achieving professional success in learners' achievements (Burgess-Brigham et al., 2020; Hargreaves & Fullan, 2012). Infusing latest research findings in a wide range of fields into the ELT teacher education curriculum is an integral part of teacher professional development. Due to the presence of tenable links between neurocognitive science and education, neurocognitive science may have a significant role in education reform (Zadina, 2015). Therefore, continued professional development of ELT teachers is permanently required in order to reconsider the caveats in the curriculum (Hu & Hemchua, 2023) and enrich teachers' education with relevant research-based evidence from various disciplines such as neurocognitive science. The improvement of the ELT curriculum is a dynamic and never-ending process; hence attention to the promotion of ELT curriculum is viewed as a key to enhancing the quality of teaching-learning process (Hashimoto & Van-Trao, 2018). By looking at curriculum development with a new eye toward analysis and synthesis of research findings in the fields of psycholinguistics and neurocognitive science, a unique, value-added model for teacher development can emerge (Tokuhama-Espinosa, 2017).

Neuroscience, also known as neural science as an interdisciplinary science, is the study of the way the nervous system develops, its structure, and what it does and liaises with wider scope of fields such as psychology, philosophy, mathematics, chemistry, computer science, engineering, linguistics, or medicine (Han et al., 2019). Neurocognitive science with its unique perspectives on teaching and learning can be of great support for ELT teacher professional development. The emergence of a conversation between neurocognitive science and ELT professional development through the lens of models and frameworks can improve pedagogical practices (Netten & Germain, 2012). It is important to recognize that neurocognitive science and language teaching and learning seem to work best when they remain interactive and share their findings in a mutual mode (Howard-Jones et al., 2016).

Neurocognitive science is briskly promoting our awareness and understanding of the brain anatomy and physiology and offering support, guidance, advice, and

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encouragement to educational practitioners with the intended intention of improving teaching and learning practices (Thomas et al., 2019). Data-based decision-making that facilitates interactions between neurocognitive science and language teaching and learning can bring about significant changes in the student learning outcomes (Aronsson, 2020). Despite the importance of neurocognitive science in language teaching and learning, there has been little emphasis on equipping language teachers with the latest research findings regarding the functions of the brain in the process of learning (Butterworth et al., 2011).

2. Literature review

There seems to be no exact conceptual fit between the two fields of neurocognitive science and education; therefore we need to reach a conceptual clarity in regard to the nature of knowledge and its limitations in each of the two disciplines (Willingham & Lloyd, 2007). This paves the way for the meaningful interaction between these two disciplines (Clement & Lovat, 2012). Infusing neuroscientific findings into teacher professional development, education, and research has been one of the serious concerns of researchers and educational practitioners (Aronsson, 2020; Matta, 2021; Schwartz et al., 2019). Curriculum reform movements with an eye to substantive and relevant research findings in neurocognitive science may trigger significant changes in educational practices (Sala & Gobet, 2017). However, little research has been done on the relationship between English language teaching and learning curriculum and neurocognitively informed frameworks. Implementation of efficient instructional methods can be addressed by relevant neurocognitive science findings based on their compatibility with how the brain processes information (Immordino-Yang & Gotlieb, 2017). Hence, educators should identify the relevant findings in neurocognitive science literature for the educational context.

Meaningful integration of neurocognitive science core concepts into teacher preparation and professional development requires a solid foundation supported by evidence-based models and frameworks. This study intends to draw on four neurocognitive-oriented theories and models built on the findings of studies in neurocognitive science: Society for neuroscience framework (SFNF) (2008), Netten and Germain's neurolinguistic approach (NLA) (2012), Ullman's declarative/procedural (DP) model of lexicon and grammar (2020, 2001), and

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Caine and Caine's brain-based learning framework (BBLF) (1991).

2.1. Neurocognitive Science Learning Concepts of Society for Neuroscience (2008)

SFNF is considered a framework for bridging the interdisciplinary gap between neurocognitive science and education. The core concepts of SFNF drawn on the findings of neurocognitive science discipline are significantly well-informed (Dubinsky et al., 2013) and surpass prior efforts in using neurobiology underpinning learning in educational practices. The core concepts of SFNF are shown in Table 1.

Table 1

How the Neurocognitive Science Core Concepts Inform Teaching and Learning (Society for Neuroscience, 2008)

1	The brain is the body's most complex organ. Implications**:** The complexity of an organism's nervous system dictates the range of its behaviors.	2 Neurons communicate using both electrical and chemical signals. Implications**:** The plasticity of chemical synaptic transmission provides a cellular basis for learning and memory. Communication between neurons is strengthened or weakened by patterns of use.
	3 Genetically determined circuits are the foundation of the nervous system. Implications**:** Wiring of the brain is remarkably similar among individuals within a species. Individual variations at the synaptic level account for our individuality.	4 Life experiences change the nervous system. Implications**:** Learned experiences grow new synapses and circuits and turn on nervous system genes, facilitating additional learning. An individual's regular and novel activities, such as exercise, learning, stress, and social interactions affect synaptic strength. The salience of an event, content piece, or experience will determine its retention.
	5 Intelligence arises as the brain reasons, plans, and solves problems. Implications**:** The brain is the foundation of the mind. Intelligence in all domains reflects the accumulated history of synaptic activation among the multiple brain pathways. In other words, practicing creative or deductive thinking facilitates further use of these strategies.	6 The brain makes it possible to communicate knowledge through language. Implications**:** Promoting effective communication fosters information exchange and creative thought and enhances these skills through exercising appropriate neural pathways.
	7 The human brain endows us with a natural curiosity to understand how the world works. Implications**:** The brain tries to make sense of all incoming information, recognizes conflicts, and makes predictions and expectations that guide	8 Fundamental discoveries promote healthy living and treatment of disease. Implications**:** Knowledge application acquired from research empowers students to make healthy lifestyle and social choices and prevent diseases.

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behaviors. Harnessing the natural curiosity of the learners motivates them in the process of exploring their environment.	

2.2. Neurolinguistic Approach (Netten & Germain, 2012)

Paradis's neurolinguistic theory of bilingualism (2009), rooted in cognitive psychology and neurocognitive science, underscores the relationship between L2/FL acquisition/learning and teaching strategies in the classroom to improve L2/FL learning/teaching in the school setting (Germain, 2018). NLA, developed by Netten and Germain (2012), is a new paradigm and way of conceiving the association between acquiring/learning and teaching of a second or foreign language (L2/FL). This approach embodies five fundamental principles as presented in Table 2.

Table 2

NLA's Five Fundamental Principles (Netten & Germain, 2012)

1 The absence of a direct connection between declarative memory and procedural memory Implications: Learners need to acquire/learn TWO grammars: an internal grammar in the form of an implicit competence for verbal communication and an external grammar in the form of explicit knowledge for written language.	2 The complexity of the brain and two neural mechanisms: conscious (vocabulary) and unconscious (lexicon) Implications: Verbal communication should be prioritized over other skills. Speaking should precede reading and writing. Reading should precede writing. A sentence-based pedagogy is necessary.
3 Focusing on the meaning or on the task to develop implicit competence Implications**:** Concentrating on meaning implies a gradual progression from sentence when speaking to paragraph when reading and thence to complete text when writing, leading to a final project. Emphasis is placed on the message while completing projects.	4 The importance of "transfer appropriate processing" (TAP) and the limbic system's role Implications**:** To become certain that learners are strongly motivated and have the desire to communicate, their limbic system should be activated by having them speak of what is authentic for them.
5 Intake and individual cognitive benefits of social interaction Implications**:** Social interaction is considered as an inseparable part of pedagogical activities, including a number of mini-projects leading to the completion of a relatively important project.	

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2.3. The declarative/procedural model of lexicon and grammar (Ullman, 2001)

Language is dependent on two important mental capacities: word memorization in the mental lexicon and the combination of words based on rules by the mental grammar (Ullman, 2001). One of the models addressing aspects of the lexicon/grammar distinction is the declarative/procedural (DP) model that attributes the distinction between mental lexicon and mental grammar to two distinct memory systems- declarative and procedural memory (Ullman, 2001). The declarative memory system underlying the explicit use of facts and the sounds and meanings of words appears to be specialized for associative binding. The procedural memory system underlying the implicit learning of motor and cognitive skills and grammatical rules is specialized for sequences in both syntax and morphology (Ullman, 2020).

The DP model can predict which learning and memory enhancement techniques potentially enhance language learning. Spaced repetition and retrieval practice are the two techniques that can improve second language learning (Ullman & Lovelett, 2018). According to this model, these two techniques are related to declarative and procedural memory. Learning in the procedural memory system is a gradual and slow process through repeated exposure compared to that of declarative memory system. However, processing of what is learned by procedural memory seems to be more automatic. In L2, the learning, storage, and use of idiosyncratic linguistic knowledge, including simple content words, their phonological forms and meanings, categorization knowledge, and irregular morphological forms, is dependent on the declarative memory system. It is only after the adequate experience with language that the processing of procedural memory supersedes declarative memory-based processing (Ullman & Lovelett, 2018).

2.4. Brain-Based Learning Framework (Caine and Caine, 1991)

Caine and Caine's (1991) Brain-based learning framework (BBLF) with 12 principles of natural learning or the Brain/Mind Natural Learning infuses neurocognitive science research findings into educational practices. The potential positive influence of direct integration of neuroscientific knowledge and research into education is confirmed by the accomplishments of professional development programs or workshops like *BrainU*. Such programs emphasize the fundamental principles of neurocognitive science that enrich teachers' understanding of

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learning and teaching (Dubinsky et al., 2013). The core principles of BBLF framework and their implications are presented in Table 3.

Table 3

Principles of BBLF and Their Implications in the Classroom (Caine & Caine, 1991)

1 The brain is a parallel processor. Implications**:** Thoughts, predispositions, and emotions operate simultaneously and interact with different modes of information processing.	2 Learning engages the entire physiology. Implications**:** Wide range of health facets like stress management, good nutrition, proper sleep, positive mental attitude, and exercise should be incorporated into the learning curriculum.
3 The search for meaning is innate. Implications**:** The learning curriculum should provide learners with stability and familiarity and satiate their thirst for novelty and challenge.	4 The search for meaning occurs through patterning. Implications**:** Learners should be presented with the material in a way that enables them to extract the patterns.
5 Emotions are critical to patterning. Implications**:** Learners' emotions should be embraced in a supportive atmosphere that shows respect for each learner.	6 Every brain simultaneously perceives and creates parts and wholes. Implications**:** Genuine and whole-language experiences should be incorporated into the teaching process.
7 Learning involves both focused attention and peripheral attention. Implications**:** Though peripheral stimuli are not consciously noticed, they are within the field of attention. Thus, it is necessary to organize peripherals.	8 Learning always involves conscious and unconscious processes. Implications**:** Creative elaboration of procedures through metaphors and analogies is used to engage learners in the active processing of experiences.
9 We have two types of memory: A spatial memory system and a set of systems for rote learning. Implications**:** The application of these two memory types should be balanced. Teaching practices should be meaningful and connected to the learners.	10 The brain understands and remembers best when facts and skills are embedded in natural spatial memory. Implications**:** To give meaning to specific items, teachers should use real-life activities, including classroom demonstrations, projects, and field trips.
11 Learning is enhanced by challenge and inhibited by threat. Implications**:** The learning context should offer an atmosphere of relaxed alertness that is low in threat and high in challenge.	12 Every brain is uniquely organized. Implications**:** In order to facilitate optimal brain functioning, we should understand how individuals learn and perceive the world.

The overarching purpose of this research study was to explore if and how ELT teachers are aware of any of the neurocognitive science core concepts and the extent

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to which they value those concepts. Hence, their lived experiences in the ELTE programs were scrutinized via semi-structured interviews guided by the following main research question: What are the ELT teachers' perceptions of values and practices of neurocognitive science core concepts in English language teaching?

3. Methodology

3.1. Study Design

A Hermeneutic phenomenological approach was adopted to examine ELT teachers' perceptions of the meaning, role, and salience of neurocognitive science-informed knowledge in the process of language teaching within an ELT context. Hermeneutic phenomenological approach, as Spielgelberg (1976) argues, intends to essentially bring out and make manifest what is typically hidden in human experience to bring to the fore the perceptions of individuals. This approach potentially allows unfolding the multiple layers of meaning that teachers held and experienced with the English teacher training courses within the professional development curriculum for ELT teachers.

3.2. Participants and Context

Fifteen ELT teachers from five state universities were chosen via a purposive sampling approach. They were interviewed to explore their perceptions of values and practices of neurocognitive science-informed core concepts in English language teaching and learning. The participants, of whom seven were female, were educating at five state universities in Mashhad and Sabzevar in Iran: Ferdowsi University of Mashhad, Hakim Sabzevari University, Shahid Beheshti Fahangin University, Shahid Hashmi Nejad Fahangin University, and Islamic Azad University of Mashhad. They were third and fourth year ELT student teachers at B.A. level. ELT teachers in Iran as non-native speakers of English who study English language teaching take and pass both proficiency and teacher education courses in the university. The courses are mainly aimed at the development of their English language knowledge, pedagogical knowledge, contextual, and pedagogical content knowledge.

In a phenomenological study, Creswell (1998) suggests long interviews with up to 10 individuals. These prospective teachers, aged 20-24, did not have any practical teaching experience. However, they had undergone teacher training courses, most of

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which were mainly theoretical in nature. To protect the confidentiality of all the participants, pseudonyms were used throughout the manuscript.

3.3. Instruments

This study used semi-structured interviews and an open-ended questionnaire as the main instruments. The interview questions were researcher-developed based on the constructs of the four neurocognitively informed models. In effect, two interview sessions were held with each of the 15 participants, each taking about an hour (see Appendix 1). In order to gain further insight, an open-ended questionnaire with two sections was employed. The first part included questions in relation to the demographic information, containing items asking about age, gender, academic degree, and years of experience. In the second section, the participants responded to four main questions (see Appendix 2) to explore their perceptions of the links between neurocognitive findings and ELT education. MAXQDA 12, as a computer-assisted qualitative data analysis software, was used to explore the themes.

3.4. Procedure

3.4.1. Data Collection

Data collection was done between March and June 2021 via in-depth semi-structured interviews and an open-ended questionnaire drawing on Bevan's (2014) structure of phenomenological interviewing: contextualization, apprehending the phenomenon, and clarifying the phenomenon. *Contextualization*, as the first interview structure consisting of descriptive context questions, elicited the lifeworld in natural attitude. *Apprehending* the phenomenon, as the second interview structure consisting of descriptive and structural questions, elicited modes of appearing in natural attitude. And *clarifying the phenomenon*, as the third interview structure including varying questions of structure, elicited meaning through imaginative variation. Using multiple questions guided by a primary question provides a more comprehensive perspective on the neurocognitively-informed ELT teacher preparation curriculum (see Appendix 1). One main question guided the phenomenological inquiry (Creswell, 2007) in constructing a clear description of the perceptions of ELT teachers in regard to neurocognitively informed core concepts: What are the ELT

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prospective teachers' perceptions of values and practices of neurocognitive science-informed core concepts in English language teaching?

All the interviews were audio-recorded, transcribed, and analyzed in line with principles of qualitative data analysis following Colaizzi's (1978) phenomenological method. The themes extracted from the interviews and the questionnaire revealed the extent to which teachers' perceptions were compatible with the neurocognitively informed core concepts reflected in the four models.

3.4.2. Data Analysis

The transcripts of the interviews and the responses to the questionnaire were analyzed using Colaizzi's (1978) seven-step phenomenological approach. The seven steps are as presented in Table 4:

Table 4
Colaizzi (1978) Phenomenological Analytic Method

Step analysis
1) Read all the interviews to acquire a feeling for them
2) Review each protocol and extract significant statements
3) Spell out the meaning of each significant statement
4) Organize the formulated meanings into clusters of themes
5) Integrate the results into an exhaustive description of the phenomenon
6) Formulate an exhaustive description of the phenomenon
7) Ask participants about the findings as a final validation step

Considering the notion of neurocognitive science-informed core concepts, the researchers employed the neurocognitively informed frameworks for the coding procedure of data analysis. To ensure that a rigorous and auditable process was adhered to throughout the data analysis, the analysis of the transcripts was performed by three specialists in both the fields of ELT and neurocognitive science. The interviews and the responses to the questionnaire were digitally recorded and transcribed verbatim into written English. The thematic analysis of the collected data was done based on the principles of the four models for the implementation of neurocognitive science core findings in educational settings. The research team conducting this study consisted of the researcher as a Ph.D. candidate and three faculty members specialized in both language teaching and neurocognitive science. The face-to-face tape-recorded interviews coded with

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pseudonyms were conducted by the interview tool. Each of the interview questions had several prompts for the in-depth discovery of the participants' responses (e.g., could you elaborate on that? Can you give me an example?). Final confirmatory interviews were also performed in the same way as the step seven of Colaizzi's (1978) method for data analysis. Each of the research team members read the interview transcripts, identified the meaningful statements, and then developed the themes based on the four models. The research team reviewed peers' findings in several meetings, further developed the themes, codified the meanings into clusters of themes, and then grouped the final description of the coded data.

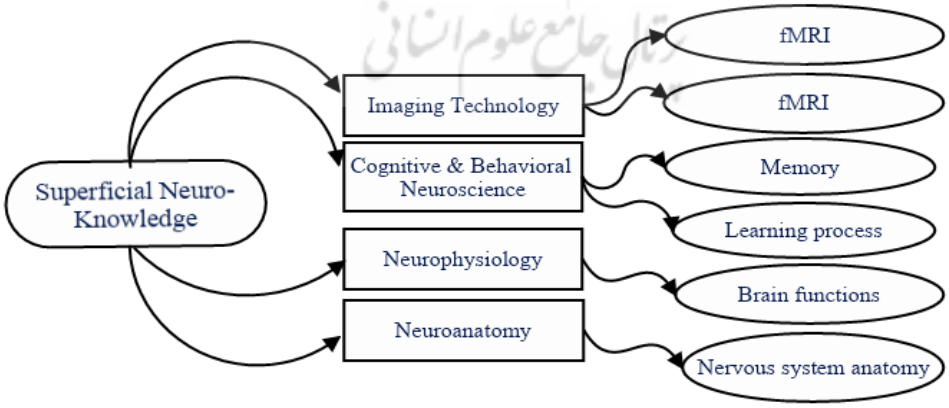
4. Results

Using Colaizzi's (1978) method of qualitative data analysis, emergent themes for each of the interview questions and also the questionnaire items were identified. The extracted themes are described in this part.

4.1. Superficial Neuro-Knowledge

In response to the first survey question (See Appendix 2) regarding their background knowledge about and attitudes toward neurocognitively informed core concepts, five main themes were extracted from the interviews, as shown in Figure 1.

Figure 1
Superficial Knowledge of Neuro-Themes



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All the participants expressed that they did not have the slightest knowledge or awareness of the neurocognitively informed core concepts; however, they assumed that the technical terms, had their origins in the field of neurocognitive science. They argued that they did not have an in-depth knowledge of the concepts and how such concepts might play a role in the process of language teaching and learning. The terms that the interviewees used were categorized on the basis of their relevance to a wide range of branches of neuroscience. The delicate analysis of the concepts indicated that they were within four main branches of neuroscience: imaging technology, cognitive and behavioral neuroscience, neurophysiology, and neuroanatomy.

Three of the participants said that they had heard technical terms such as fMRI and EEG as neuroimaging techniques to measure brain structure and activity. Though all the terms were pertinent to imaging technology, they remarked that they had no in-depth knowledge of such concepts and their relation to the language teaching profession.

Memory and learning processes were also among the terms that some of the participants mentioned that they had studied in the books and articles. As one participant mentioned, "I have a great interest in the field of neuroscience and have read some books and articles on my own. This endeavor has resulted in having some awareness of the hidden processes involved in decision making, storing information in memory, and in the learning processes; however, my effort to study in this domain was temporary and inconsistent."

Functions of the hemispheres of the nervous system were also among the concepts. Four of the participants mentioned that they had read about them in the articles or in university textbooks. As one participant mentioned, "I have studied some of the basic functions of the nervous system in some of the university courses, especially in the psychology of language teaching course, but I do not know how that knowledge can have a beneficial impact on the process of language learning and teaching."

Brain anatomy was also covered in language teaching psychology course. As one participant mentioned, "I remember my knowledge of the nervous system anatomy was formed in a course. I know that brain is composed of two hemispheres and four main lobes."

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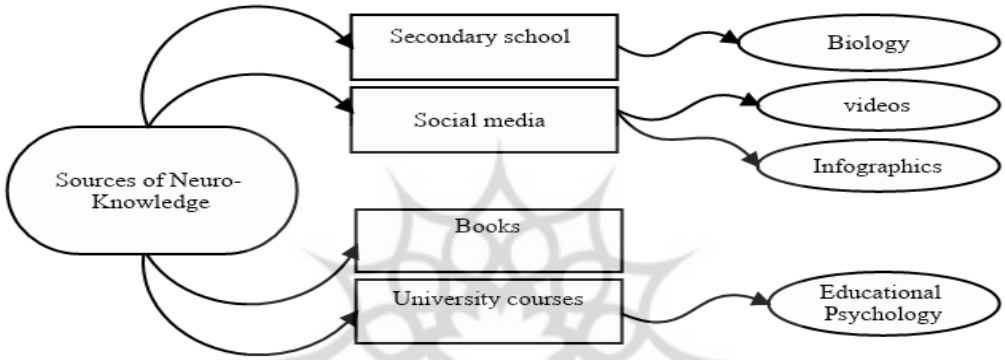
4.2. Sources of Neuro-Knowledge

In response to the second survey question (See Appendix 2) regarding the interviewees' source of knowledge, they mentioned a number of sources for their neurocognitive knowledge, including books, university courses, secondary school, and social media.

Figure 2
Sources of Neuro-Knowledge



Whilst all of the interviewees admitted that they did not have in-depth knowledge and experience in regard to the neurocognitive science core concepts and their applications in language education, they have had unplanned and unsystematic opportunities to learn about neurocognitive science of learning. Most of what they had heard, seen, and experienced related to the neurocognitive science core concepts were received via biology courses in the secondary school. As one participant mentioned, "Whatever I have learned about the brain anatomy and physiology dates back to the time when I was a student of experimental science in the senior high school."

Most of the interviewees mentioned that they learned a lot from the social media like Telegram channels, the relevant pages in Instagram, LinkedIn, Facebook, YouTube, or WhatsApp in which neuroscience-oriented topics were shared in the form of infographics and videos. As one participant mentioned, "At least most of what I have learned about neurophysiology of brain mechanisms comes from the neuroscience channels in which latest news or interesting facts about brain are posted in an irregular and disjointed manner."

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Books were also among the sources that had increased the interviewees' knowledge of neurocognitive science core concepts. However, just a very limited number of books were read; and there had been no systematic adherence to a time plan to go over the sources. As one participant said, "I remember that I have read a book in my childhood about 15 years ago which included the basics of the brain anatomy and its underlying neuronal functions."

The least expressed source of neurocognitive knowledge was the university courses. Although they have had courses in educational psychology, theories of language acquisition, and strategies of language teaching, neurocognition of learning and teaching did not have independent and distinguished status in any of the courses and in the whole educational curriculum. As one of the participants said, "The professor of educational psychology sporadically introduced some neuroscientific concepts such as neurogenesis or neuroplasticity, but those chapters that specifically included neuroanatomy and neurophysiology of the brain were not covered and were treated as unimportant sections of the book."

4.3. Neuro-Themes Application

In response to the third survey question (See Appendix 2) about the application of the knowledge of neurocognitive science core concepts, the interviewees expressed a wide range of concepts. The concepts were matched to the principles of the four neurocognitive-oriented theories and models and presented in three distinct figures- Figures 3, 4, and 5.

4.3.1. Applicable Neuro-Themes: BBLF

The neuro-themes extracted from the transcripts and also the interviews related to Caine and Caine's framework (1991) are presented in Figure 3.

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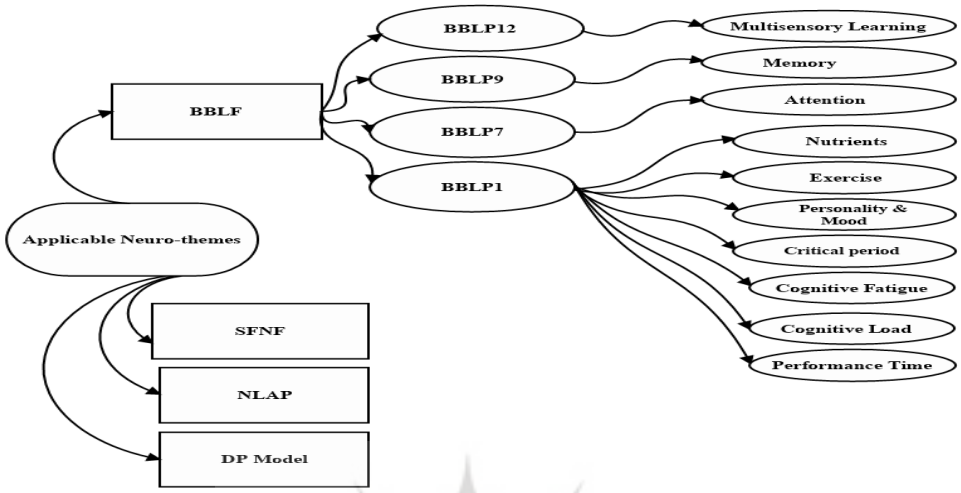
Figure 3
Applicable BBLF Neuro-Themes



Note. BBLF= brain-based learning framework; BBLP= brain-based learning principle; SFNF= society for neuroscience framework; NLAP= Neurolinguistic approach principle; DP model= declarative/procedural model of lexicon and grammar

Seven themes- performance time, cognitive load, cognitive fatigue, critical period, personality and mood, exercise, and nutrients- expressed by the interviewees about the application of the core concepts of neurocognitive science were reflected in principle 2 of BBLF, i.e., health facets such as stress management, good nutrition, proper sleep, positive mental attitude, and exercise affect the brain functions. A number of the interviewees' statements for the seven themes are presented in Table 5.

Attention as one of the themes expressed by the interviewees was reflected in principle 7 of BBLF, i.e., learning involves both focused and peripheral attention. One of the interviewees attributed the greatest achievements in the teaching process to the art of creating and maintaining learners' attention in the classroom.

Memory was another theme frequently expressed by the interviewees. Principle 9 of BBLF underscoring the balanced application of the spatial memory system and rote memory in the teaching practices is the match for this point of view.

Two of the interviewees believed that a multisensory learning approach is what makes the new words memorable since more than one sense (modality) is used in the

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teaching of the words. This is a reflection of principle 12 of BBLF, i.e., multifaceted teaching methodology caters to individuals with different learning styles.

Table 5

Interviewees' Statements Related to BBLF

BBLP1	Nutrients	"…when I am aware of the core concepts of neurocognition, I can offer nutritional suggestions that can boost learners' brain functions and memory such as drinking water while they are in the classroom."
	Exercise	"Aerobic exercises not only guarantee physical health but also facilitate basic learning mechanisms."
	Personality & mood	"We need to know how the learners' mood can affect their tendency to receive input and store it in the long term memory."
	Critical period	"As prospective teachers, we should know the cognitive and biological developments that the learners go through and the optimal time periods that teachers can use to expose learners to language."
	Cognitive fatigue	"I prefer not to assign challenging tasks or carry on teaching while learners feel exhausted and experience decreased performance level."
	Cognitive load	"Learners' potential and capacity in being exposed to the language input are key factors that should not be ignored in the language teaching process; otherwise, time and energy would be wasted."
	Performance time	"…sometimes I feel that kids' cognitive functioning draws closer to optimality in later hours in the morning." And with regard to time spacing, an interviewee said, "I think we need to know the particular amount of time that is required to be spent for any type of activity and the time lapse required after each."
BBLP7	Attention	"Knowing the how of brain functioning while attending to a particular subject not only saves a lot of time and energy, it also benefits the formation of memories."
BBLP9	Memory	"Basic principles of neural functions enable prospective teachers to employ more efficient strategies to teach the vocabulary and the grammatical points in the target language."
BBLP12	Multisensory learning	"I myself have used different modalities in learning new English words: I watch films with English subtitles, and at the same time that I listen to the words I can see them below the screen, and this enhances my ability to retain the words. Teaching words through different modalities can do wonders."

4.3.2. Applicable Neuro-Themes: SFNF

Among the concepts elicited from the interviewees via interviews and a questionnaire, six themes were closely related to the principles of SFNF (see Figure 4).

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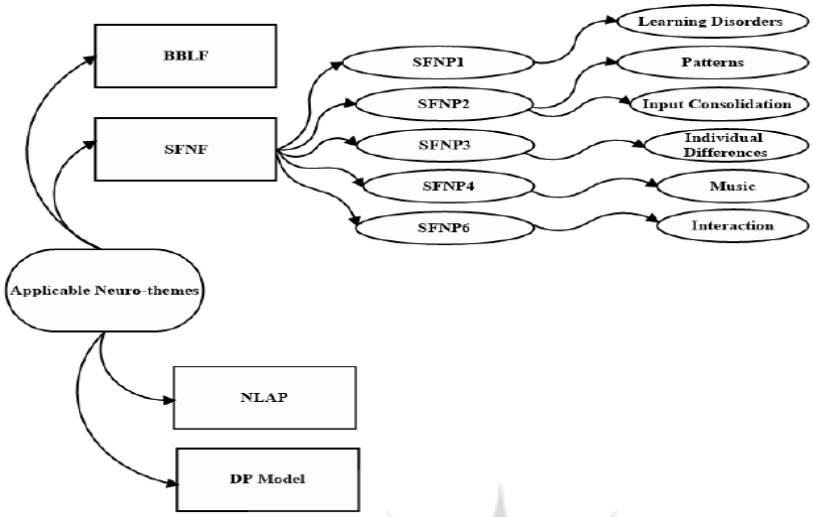
Figure 4

Applicable SFN-oriented Neuro-Themes



Note. SFNF= society for neuroscience framework; NLAP= Neurolinguistic approach principle; DP model= declarative/procedural model of lexicon and grammar

Learning disorders among other themes were pertinent to the first principle of SFNF, i.e., the organism's behavior is dictated by the complexity of its nervous system. One of the interviewees argued, "I think knowledge of brain functions can do a lot in identifying learners with cognitive and learning disorders and referring them to psychologists for psychological therapy."

Two themes, pattern of use and input consolidation, relevant to the second principle of SFNF were extracted from the interviews. The pattern of use reflects the second principle of SFNF, i.e., communication between neurons is strengthened or weakened by the patterns of use. One of the interviewees underscored the role of patterns in teaching grammatical structures. He mentioned, "For a long time, I wanted to know which one is more effective, the inductive or the deductive approach in teaching grammar. Knowledge of neurocognitive science can offer the reliable answer to such questions". Another participant pointed out that the knowledge of the basics of neurocognitive science sheds light on the how of input consolidation, "As far as I know, learning occurs as the result of neural communications. In my view, knowledge of neural connections can help me to employ more effective strategies to transmit and consolidate input in learners' memory."

Individual difference is among the factors mentioned by the interviewees and is

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relevant to the third principle of SFNF, i.e., genetically determined circuits and variations at the synaptic level account for our individuality. One of the interviewees said, "contrary to the fact that individual difference is a significant factor in language teaching, we have not yet passed any course that makes us aware of such individual differences at the level of the nervous system and the effects they may have in the learning processes."

Music, as another theme extracted from the interviews, can also have a significant impact on learners' potential for learning. As one participant said, "I believe that investing some time for learning music can exert a lot of influence on the learners' lifestyle, attitude, and potential to learn other subjects. I don't know why but some knowledge of neuroscience can unravel this mystery about the possible growth of new synapses in the brain and the subsequent influence on the whole memory network." This is to a large extent relevant to the fourth principle of SFNF, i.e., learned experiences grow and activate nervous system genes, facilitating further learning.

Interaction was also a theme extracted from the interviews as a component of the successful teaching. This component is related to the sixth principle of SFNF, i.e., the brain imparts knowledge through language. One of the interviewees was baffled about the effect of interaction on the learning experience and outcome and mentioned, "I am really interested to know how interaction as a tool for input retrieval in the context of English language teaching can optimize the learning process."

4.3.3. Applicable Neuro-theme: NLAP

Among the concepts elicited from the interviewees via interviews and questionnaire, two themes were related to the principles of the NLAP, and one theme was related to the DP model (see Figure 5). The themes for NLAP and DP model are presented in one figure, Figure 5.

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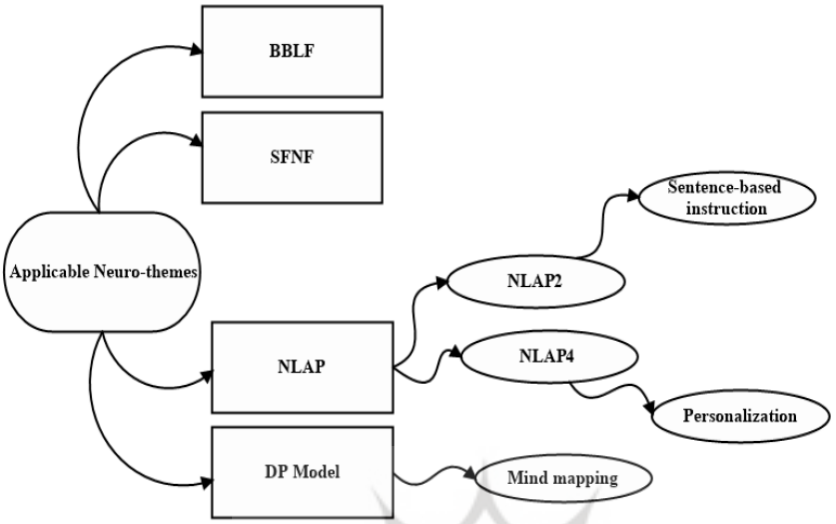
Figure 5
Applicable NLA-Oriented & DP Model



Note. NLAP= Neurolinguistic approach principle; DP model= declarative/procedural model of lexicon and grammar

Two of the interviewees thought that language teaching should concentrate on sentences as the basic unit of meaning. Sentence-based instruction is closely tied to the second principle of NLA, i.e., two neural mechanisms, conscious (vocabulary) and unconscious (lexicon), are involved in storing knowledge and skills. As one participant said, "In order to make the process of language learning as efficient as possible, I think we need to avoid relying on fragmented vocabulary or phrases and shift our efforts towards sentences even for elementary and intermediate language learners."

Three of the participants underscored the significance of personalization in improving classroom dynamics which is related to the fourth principle of NLA, i.e., the importance of "transfer-appropriate processing" (TAP) and the limbic system's role. As one of the participants said, "Language content should be personalized and activate learners' memory of their own previous experiences."

4.3.4. Applicable Neuro-Themes: DP Model

Mind mapping expressed by two of the interviewees is relevant to Ullman's model of lexicon and grammar, i.e., the search for meaning occurs through

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patterning. One of the interviewees believed, "mind mapping is among the most effective and useful learning tools to organize and memorize information and should be employed to enhance learners' ability to store English vocabulary into their long-term memory."

4.4. Prospective Change

Following the analysis of participants' responses to the questions in the interviews and the questionnaire in regard to the application of neurocognitive science core concepts, their perceptions of the main areas of change after being exposed to the neurocognitive-oriented courses in the language teaching curriculum were scrutinized. The interviewees pointed out that the ELT teacher-education curriculum should be enriched with systematic and methodical opportunities to learn about the core concepts of neurocognitive science; ELT education curriculums should incorporate relevant exclusive courses on the neurocognitive science of learning and teaching. As one participant mentioned, "Although our brain is the most active organ in the learning process, we, as prospective language teachers, do not know the basics of the underlying learning processes, the how of information storage and retrieval, or the possible impacts of environment on the brain mechanisms. Or another participant said, "Lack of courses in teacher education about memory mechanisms is one of the greatest caveats in the language teacher preparation courses and should be given the desired attention since it can jump-start a series of significant changes in the language teaching."

The changes that can possibly occur in their professional development, especially the language teaching practices, included three themes as presented in Figure 5: teaching approaches, quality of interaction, and language commercial hypes.

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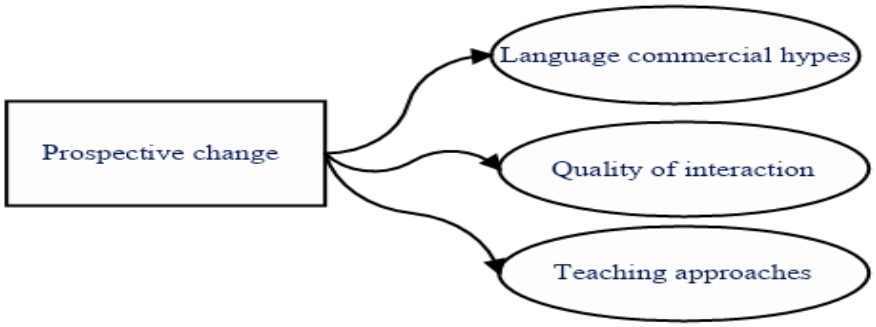
Figure 5
Neuro-Themes Prospective Change



The most frequently expressed area that the interviewees believed that knowledge of core concepts of neurocognitive science can change for the better was teaching approaches. All of the interviewees believed that incorporating relevant courses in the language teaching training curriculum can cause fundamental changes in their language teaching approaches. They emphasized that bringing about a phenomenal change in the language teaching domain requires the teachers' awareness of the brain functions, especially those related to the learning of new knowledge and skills; hence this calls for enriching language teachers' training curriculum with courses that develop teachers' agency and decision-making potential in designing and implementing classroom practices. One of the interviewees said, "We have had some courses that were related to language teaching approaches, strategies and techniques including teaching language skills, strategies of language teaching, and theories of language acquisition/learning, but they were not enlightening when it comes to raising our awareness of the underlying reasons for the effectiveness of each theory or practice. If we are given a tool to tease out the complex nature of language learning, we would be more capable in doing our best to teach the language skills and subskills."

Quality of interaction was also one of the themes extracted from the interviews. Three of the interviewees believed that teaching language skills necessitates the investment of a considerable amount of time in giving input, eliciting responses, and giving feedback to language learners via social interaction on the basis of teacher to student, student to teacher, and student to student classroom interactions. Therefore, the neuroscience of social interaction and the neurobiological underpinnings can pave the way for the establishment and maintenance of greater social bonds between the learners and the teacher. As one of the interviewees

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expressed, "I had a course of classroom management in which teachers' mediating role in the language classroom was brought to attention. However, the interface between the teacher and the learners and the context in which the teaching/learning process occurs was not highlighted, and I did not learn how to build rapport with the learners and regulate behavioral and emotional problems. Awareness of the neurobiological underpinnings of social interactions in the classroom context can have a significant impact on a range of social and affective behaviors."

The third theme for prospective change was language commercial hypes. Two of the interviewees pointed out that occasional overzealous language educational practitioners exaggerated the capacity of the particular language teaching programs and instructional designs, and many teachers rush to apply underdeveloped science for commercial and even circulate them in their classes. Lack of access to systematic and reliable knowledge of language teaching pedagogy leads to the misperceptions and naïve acceptance of claims with no scientific evidence. They believed that knowledge of the basics of brain function in the leaning process can function as a compass in identifying such unreliable claims. One of the interviewees said, "Knowledge of brain functions is an invaluable tool to distinguish research-based claims from false and misleading ones, especially vocabulary teaching programs via strange approaches that are widely disseminated on social media."

5. Discussion

This study, adopting a qualitative phenomenological approach, aimed at exploring the ELT teachers' perceptions of values and practices of neurocognitively informed core concepts in English language teaching to gain a more comprehensive insight into ELT teachers' knowledge of neurocognitive science concepts relevant to their profession. Contrary to the fact that neurocognitive science training gives rise to the application of teaching strategies associated with active learning (Dubinsky et al., 2019), the inaction to introduce the core concepts of neurocognitive science to ELT teachers in their initial training programs is contentious and summons the attention of researchers to explore the underlying causes. In the same vein, ELT teachers' perceptions of the basics of neurocognitive science and their presumable applications can possibly offer a lot of beneficial information.

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As the interviews with prospective ELT teachers revealed, ELT teachers' curriculums included not a single direct course related to the neurocognitive science of language teaching and learning, and this lack of attention can not only deprive them of the latest useful neurocognitive knowledge relevant to educational practices but also portend the emergence of neuromyths and their implementation in language teaching practices. The emergence of these neuromyths in ELT education is rooted in the absence of neurocognitive science training in teachers' education (Ching et al., 2020).

The Interviews revealed that most of the teachers had a general and shallow knowledge of brain functions based on their own claims; they did not know whether that knowledge could have any productive contributions to the teaching activities. Dekker et al. (2012) have also found that the teachers' general knowledge about brain functions is an important predictor of belief in neuromyths; those teachers who know more about the brain at a general level are more likely to believe misconceptions about the brain. Systematic inclusion of relevant neurocognitive science courses in the curriculum can hinder the emergence of myriad misrepresentations of neurocognitive science research and the negative impact of neuromyths on educational outcomes (Coch, 2018). Incorporation of neuroscience-oriented courses into teacher training programs can not only reduce the perpetuation of neuromyths (Ansari & Coch, 2006) but also results in improved pedagogical and learning outcomes (Desimone, 2009). Training in neurocognitive science, which provides the teachers with a deeper understanding of the brain and its underlying functions, can develop the quality of both teaching and learning (Privitera, 2021). Simply put, such training can offer a resourceful toolkit to benefit from active learning by using pedagogical and didactic strategies (Dubinsky et al., 2019) and also support learners with major individual differences (Walker et al., 2019).

An important point concerning the results of this study calling for further attention to the ELT scientific community was the source of the interviewees' knowledge of neurocognitive science and their effort to learn and grow professionally in this domain. All the participants acknowledged that they were mostly passive recipients of input from a wide array of sources and sometimes they did not even know whether the source was reliable or not, and they did not make any conscious, purposeful attempt to substantially enhance their understanding of neurocognitive science core concepts and the functions of brain

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underlying neural systems. Misrepresentation of neurocognitive science publications by the non-scientific media results in the generation of neuromyths which would negatively influence the quality of education (Howard-Jones et al., 2016). Put another way, deficient teacher training programs which do not incorporate neuroscience-related courses can result in teachers' inability to evaluate the purported benefits of particular educational programs; hence the adoption of ineffective programs and misallocation of limited educational resources (Coch, 2018). Though the results of some studies on the impact of neurocognitive science training on the prevalence of neuromyths have shown that the inclusion of neuroscience-related content reduced the teachers' belief in neuromyths (McMahon et al., 2019), addressing all neuromyths in a single course of neurocognitive science study is an unrealistic expectation (Macdonald et al., 2017).

As the interviews revealed, neurocognitive science training has the potential to cause dramatic changes in language teaching approaches and the choice of classroom practices. Neurocognitive science training not only reduces the perpetuation of neuromyths (Roehrig et al., 2012) but also improves teachers' choice of instructional strategies (Schwartz et al., 2019; Tan & Amiel, 2019; Tan et al., 2019). The results of one study that addressed the use of instructional practices after participation in neurocognitive science workshops showed that neurocognitive science training increased the teachers' use of learner-centered pedagogies (Anderson et al., 2018).

The Interviewees pointed out that participation in neurocognitive science training gives them new insights into teaching practice, provides more benefits to the prospective teachers, and help them to make better evaluations of instructional decisions in the classroom. This is in line with the results of similar studies on the impact of neurocognitive science training on teachers' perspectives on the adoption of more constructivist approaches and effective pedagogical and didactic strategies. Results of Tan et al.'s (2019) study investigating the impact of a neurocognitive science theory framed learning showed improvement in teachers' understanding of the association between brain functions and educational outcomes.

The interviews also revealed that prospective teachers' quality of interaction with the language learners would change for the better. Most of them believed that being exposed to neurocognitive science core concepts can not only foster the development of a growth mindset in themselves but also in their language learners. This finding is consistent with the result of studies on the impact of

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teachers' participation in mindset interventions covering the concept of neuroplasticity on their beliefs and behaviors (see Ergas et al., 2018, Yeager & Dweck, 2020). The prospective teachers thought that neuroscience-oriented courses can change their classroom discourse and their quality of interactions with the learners. A similar finding is reported in Anderson et al.'s (2018) study in which participation in a course on foundational neurocognitive science and mindset changed teacher discourse from a fixed mindset to a more growth-oriented one and revealed a shift toward learner-centered pedagogy.

Succinct and easily applicable neurocognitive science training programs for teachers have been previously used in the context of teaching and learning (see Schwartz et al., 2019). Concepts such as neuroplasticity are among the highly relevant concepts to language teaching and learning that alter teachers' beliefs and behaviors (Dubinsky et al., 2019). Though a number of studies have reported positive outcomes for the teachers' participation in neurocognitive science programs (Howard-Jones et al., 2020; McMahon et al., 2019; Schwartz et al., 2019), the duration of the training programs was different across studies since there are no specific guidelines for the ideal duration of such programs. However, adopting the neurocognitive science training for language teaching professional development should be done thoughtfully to reap maximal benefits in the shortest period of time (Desimone, 2009). Irrespective of the format of neurocognitive science training delivery and the scope and duration of the program, teacher professional development should mainly focus on the goal of empowering teachers to identify the close connection between neurocognitive science and pedagogy (Dubinsky et al., 2019).

The idea of inclusion of neurocognitive science training in professional teacher development is still in its infancy, though not by no means a new one, and as Im et al. (2018) assert, its impact on teachers' classroom practices and learners' achievements should be addressed in future research studies. Despite the fact that the participants did not have any courses in the curriculum exclusively related to neurocognitive science, they thought that they had limited knowledge of neurocognitive science. The primary reason for this limited knowledge can be the existence of overlap among neurocognitive science, cognitive psychology, and the science of learning (Privitera, 2021).

This study exclusively aimed at exploring the prospective language teachers' perceptions of values and practices of neurocognitively informed core concepts

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and the possible benefits of neurocognitive science courses in their professional development. Prospective teachers' perceptions, as the most influential agents of change in any educational system, should be given a significant priority, especially in curriculum decision-making processes for the inclusion of neurocognitive science training courses. Participation in neurocognitive science training can exert positive change on teacher- and student-level variables. A number of studies have reported the benefits of neurocognitive science training on teachers' beliefs, behaviors, and student-level measures (Anderson et al., 2018; Howard-Jones et al., 2020), specifically in regard to prospective teachers (McMahon et al., 2019). Exploring prospective language teachers' perceptions is definitely important since background beliefs and values can exert considerable influence on the benefits of professional development (Timperley et al., 2007). Though the advent of some fields such as educational neuroscience (Thomas et al., 2019) and mind, brain, and education (Fischer, 2009) shows the great interest in the construction of a bridge between neurocognitive science and education, improved understanding of the brain functions has not played a prominent role in changing the educational systems (Privitera, 2021). Therefore, considering the individuals' diverse educational beliefs about neurocognitive science core concepts in language learning and teaching and the limited time available for their professional development calls for further research studies to fill the significant void in the literature.

6. Conclusion

Despite the drawbacks in the current English language training curriculum in regard to the scarcity of neurocognitive science-related courses, the prospective teachers felt that the inclusion of courses relevant to neurocognitive science concepts at a minimum can have potentially positive effects on their beliefs and pedagogical practices and subsequently on language learners' achievements across a wide range of fields and grade levels.

Contrary to the fact that the inclusion of neurocognitive science concepts in language teacher training curriculum seems necessary (Coch, 2018; Dubinsky et al., 2019; Walker et al., 2019), this does not mean that prospective teachers are to be trained as neuroscientists. Simply put, supplementing the language teaching training curriculum with courses relevant to neurocognitive science should be

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focused on the primary objective of supporting teachers to make use of this knowledge in their pedagogical practices (Coch, 2018). Development of neurocognitive science training programs most relevant to educational practices requires a rigorous collaboration between neuroscientists and teachers (Howard-Jones et al., 2020), and also the available sources such as the Society for Neuroscience's Neuroscience Core Concepts are potentially useful in guiding teacher training programs (Society for Neuroscience, 2008). Results of the previous studies have supported the inclusion of neurocognitive science core concepts training in professional development as a worthwhile endeavor for both prospective and in-service teachers (Tan & Amiel, 2019; Tan et al., 2019). English language teacher education curriculum for prospective teachers should reconsider how to align the content of the courses in the programs with relevant research findings of educational neuroscience. The potential positive impacts of neurocognitive science education on both language teachers' instructional practices and students' achievements call for drastic reforms in the prospective language teacher training curriculum.

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Appendix 1

1. What are your perceptions on values and practices of neurocognitively informed core concepts in English language teaching?
2. What were the salient themes you learned in the ELT curriculum which seemed to be useful for your future teaching?
3. Do you have any familiarity with the neurocognitive science?
4. What are the core constructs of neurocognitive sciences that can be employed in English language teaching?
5. Does any change occur in your landscapes of practices if you become aware of neurocognitively informed core concepts in the profession of ELT?

Appendix 2

Questionnaire Survey

This questionnaire intends to obtain your perceptions about the significance of neurocognitive knowledge and its application in the process of language learning and teaching. We'd like to elicit your perceptions on the current state of the neurocognitive-oriented courses in the language teacher training curriculum. We shall collate the results of these interviews anonymously and use them for only research purposes.

Section 1: Demographic information

Age: ……. Gender: Male ☐ Female ☐

Academic degree: ……. Year of teacher education: ……

Teaching experience: …….. City: ……..

University: ……..

Section 2:

This sections includes five questions. Please answer the following questions in regard to your perception about the significance of neurocognitive knowledge in the English language teacher training curriculum in the university.

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1) To what extent are you familiar with brain functions?

2) What is the source of knowledge you have about brain function?

3) Does familiarity with neurocognitive knowledge have any application in English language learning and teaching?

4) Have you ever passed any relevant courses to brain functions in English language teacher education?

5) To what extent is the integration of neurocognitive courses into the English language teacher training curriculum necessary? Why?

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