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Decoding Collocational Disputes: An ERP Approach to Understanding Proficiency Variations

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Abstract This study was an attempt to compare the neural processes of two proficiency levels through employing a stroop-like multi-word units task. The participants were selected based on purposive sampling through a test of language proficiency. Analysis of the data revealed no significant differences in the reaction times. There was a significant difference between two levels of proficiency and Plausible Target Distractor (PTD) condition in F3, F4, C3, C4, Fz, Fp1 and P3 channels and PDT in Fz, F8 and O2 channels and Implausible Target Distractor (ITD) in F8, Fz, C4 and T4 channels. A greater recruitment of the frontal lobes was observed as the participants needed to make judgments. The findings provide insights for the understanding of processing mechanisms related to multi-word units such as collocations in the brain. They also reveal the different areas of the brain involved in terms of cognitive variances.

Keywords: *Event Related Potentials, Language Proficiency Level, Multi-word Units, Conflict Detection, Collocations*

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1. Introduction

The complexity of language and its widespread display in the brain is not surprising because it involves different linguistic processes. However, through time, it has mainly been the knowledge of neuroscience that has promoted the researchers' understanding of language processing in the brain. In fact, drawing upon neuroscience, researchers have understood the functions of the brain and how it works in this regard (Pfaff et al., 2022). The human brain consists of a complicated network of nerve cells that keep communicating with one another through impulses which are electrical signals (Akram et al., 2025). Cognitive neuroscience is a subfield of neuroscience and introduces tools and methodologies that can be used in research in the field of learning and instruction. It can equip researchers to investigate precise cognitive processes comprehensively (De Smedt, 2014).

Different neuroimaging methods have helped researchers understand learning processes, including Event-Related Potentials (ERP) or functional Magnetic Resonance Imaging (fMRI) (De Smedt, 2014). It has been noted that while the brain produces electrical voltage potentials because of cellular activities, it is possible to record those voltages in order to understand cognitive events including the different aspects of the language processing nature and language acquisition and such patterns are called event-related potentials (ERPs) (Morgan-Short, 2014). In recent years, scholars including language education scholars have tended to employ ERP studies (Esfandiari et al., 2020; Farani et al., 2023; Karipidis et al., 2018; Lee, et al., 2019; Pelzl et al., 2019; Wu et al., 2022) to have evidence and complete and extend their knowledge of learning and instruction in relation to language (De Smedt, 2014). ERP studies are advantageous in investigating various language components and language comprehension (Elgort et al., 2022) as well as production (Kaan, 2007).

ERP studies are also a worthy choice and solution for the study of semantic processing in language; thus, recent research studies at global and national levels are conducted on semantic processing and the brain (DiStefano et al., 2019; Khaleghi et al., 2020; Morgan et al., 2022; Safavi et al., 2012; Yu et al., 2016). One of the semantic processing forms that researchers have studied includes multi-word units (Kessler et al., 2022; Morgan et al., 2020; Onnis & Huettig, 2021). According to Wolter and Yamashita (2018), multi-word units contain idioms, collocations, phrasal verbs, binominals, and lexical bundles. In many of the recent studies (Jung et al., 2022; Sabanashvili & Garibashvili, 2022; Van Vu & Peters, 2022), collocations are considered as an essential element in language teaching and learning. That is why a collocational proficiency has been defined, which can distinguish native and non-native speakers (Hsu, 2007). One other area of research in neurolinguistics has been the study of the relationship between lexical proficiency and lexical semantic processing in the brain, where lexical proficiency has a basic role in this relationship (Elgort, 2022).

A large number of studies have focused on the relationship between collocations and proficiency level (Goulart, 2019; Uchihara et al., 2022); however, they have used behavioral performance or their focus has been on monolinguals or bilinguals rather than foreign language learners of English and in varied proficiency levels. While ERP studies have contributed to the understanding of the brain processes for different language components and word classes (De Smedt, 2014; Kaan, 2007), they can be used in investigating collocations which are a fundamental part of learning the vocabulary of a language (McCarthy & O'Dell, 2017). Hughes (2018) focused on the psychological validity of collocations to be evaluated through a direct measure. Jung et al. (2022) used ERPs to find the effect of textual enhancement as well as frequency manipulation on collocation acquisition through reading. Siyanova-Chanturia et al. (2019) employed ERPs to compare the processing of non-literal language forms by monolinguals and bilinguals. Accordingly, in recent years, ERPs have been used as an effective measure to study collocations as far as language processing in the brain is concerned.

ERP stroop-like tasks can provide the conflicts, and through analyzing these conflict detections, the neural processes involved can be detected and analyzed. While the processing of collocations can be different in learners of varied proficiency levels, it is possible to compare such neural processing in terms of learners' proficiency levels. The present study thus sought to use a stroop-like event-related potential (ERP) technique to analyze the neural processes involved in the detection of the conflict as well as resolution (when there is no conflict) in collocations based on the learners' proficiency levels.

A large number of studies have focused on the relationship between collocations and proficiency level (Goulart, 2019; Uchihara et al., 2022); however, they have either used behavioral performance or their focus has been on mono or bilinguals rather than foreign language learners of English and at varied proficiency levels. However, using the ERP technique of analyzing brainwave data is surprisingly lacking. ERP studies are highly informative, and their advantages outweigh other techniques specially that they are non-invasive. Thus, ERPs can provide a unique set of data that can greatly increase our understanding of cognition, including our understanding of how languages are processed" (Morgan-Short, 2014, p. 17). In this paper, the researchers employed the ERP technique to investigate the possible differences in the processing of conflict in terms of collocations based on Iranian English as a foreign language learners' proficiency level. Accordingly, the present paper sought to answer the following two main and related sub-questions:

1. Is there any significant difference in reaction time while processing collocations in terms of Iranian EFL learners' proficiency level?
2. Is there any significant difference in the processing of collocations in terms of Iranian EFL learners' proficiency level?
    - 2a. Is there any significant difference in the processing of PTD in terms of Iranian EFL learners' proficiency level?
    - 2b. Is there any significant difference in the processing of PDT in terms of Iranian EFL learners' proficiency level?
    - 2c. Is there any significant difference in the processing of ITD in terms of Iranian EFL learners' proficiency level?
    - 2d. Is there any significant difference in the processing of IDT in terms of Iranian EFL learners' proficiency level?

2. Literature Review

2.1. Importance of collocations in language proficiency

One critical aspect in learning the second language vocabulary is the knowledge of collocations, which can allow learners to improve to a high level of language proficiency (Bui, 2021; Nation, 2013; Nizonkiza, 2015). While mastering collocations is a difficult task for learners (McCarthy & O'Dell, 2017; Zaabalawi & Gould, 2017), it has been argued that with the increase in proficiency level of EFL learners, collocation use is extended (Laufer & waldman, 2011; Goulart, 2019).

Concerning their form rather than meaning, collocations are classified into two main categories of grammatical and lexical (Benson et al., 1986). "Verb + noun" collocations, which are the focus of this study, fit in the lexical group. Gyllstad (2009) argues from the reviewed studies that "verb + noun" collocations are more difficult for learners. Moreover, it has been stressed by Siepmann (2005) that, as dual units, "verb + noun" collocations are more frequently used.

Knowledge of collocations and proficiency levels have proven to have a significant relationship (Boers et al., 2006; Nizonkiza, 2015). Many studies have demonstrated that the knowledge of collocations influences the characteristics of EFL learners' proficiency as well (Du et al., 2022; Granger & Meunier 2008; Gyllstad, 2009; Keshavarz & Salimi, 2007; Nesselhauf 2003; Nizonkiza, 2015; Ordulj & Sokolić, 2019; Saito & Liu, 2022). Shi et al. (2023) also maintain that figurative collocations require more cognitive effort than do literal collocations. Besides, it is highlighted by Harati Mokhtari et al. (2016) that the cognitive processes involved in recognizing collocations can differ based on the participants' proficiency level. Siyanova-Chanturia et al. (2019) maintain that the language proficiency of learners can be a determining factor in the processing of non-literal language. It has been noted that language learners also have more difficulty understanding incongruent collocations than congruent collocations. The speed of processing for incongruent collocations is also an issue and it is stressed that responding to incongruent collocations is not only slow but also includes errors among low-proficiency level learners (Yamashita & Jiang, 2010).

Thus, the use of collocations and the errors the students make may depend on the proficiency level of the target language they have (Boonraksa & Naisena, 2022). As Sonbul and El-Dakhs (2020, p. 1) state, "congruency (the availability of a direct first language translation) and level of proficiency have been reported among the most important determinants of second language collocation processing". Other studies have also found relationships between learners' collocation knowledge and language writing proficiency level (Abdi & Ariffin, 2020; Kim & Bae, 2012; Yazdandoost et al., 2014).

One of the major variables that has been considered for observing the changes in brain mapping in individuals and participants has been proficiency (Rastelli, 2018). In one recent study, Di Liberto et al. (2021) compared high proficiency level learners with native listeners in listening through a neuroimaging study. They found out that language proficiency could be decoded with high accuracy. They also maintained that such a result advances our understanding of the cortical processing of linguistic information in second-language learners and provides an objective measure of language proficiency.

Language proficiency and semantic processing of language have been studied, and it is concluded that a higher proficiency makes it possible to process both L1 and L2 semantics similarly (Vandenberghe et al., 2019). Thus, it can be assumed that the processing of collocations as language units can be different in learners with varying levels of proficiency if situations of conflict are provided. According to the reviewed literature, there seems to be a difference in the use, knowledge, and processing of collocations among learners in terms of their proficiency levels.

2.2. Event-related potentials

The electroencephalogram (EEG) is a record of the brain oscillations related to the electric potential from electrodes on the human scalp (Nunez & Srinivasan, 2006). EEG measurements are recorded from the scalp surface and are non-invasive. The majority of neurocognitive studies that record EEG signals have employed average evoked or event-related potentials (Schomer & Da Silva, 2012), which cause voltage alterations.

Such voltage changes that relate to the time because of some event in the brain are event-related potentials, which can provide important information about how the human brain normally processes information (Picton et al., 2000). In EEG recording, when the researcher creates a stimulus, this stimulus makes variations in the EEG activity, and some neural responses can be observed accordingly. To extract the responses from the EEG recording, researchers use “a simple averaging technique or more sophisticated techniques, such as single-trial analysis and time-frequency analysis” (Lu & Hu, 2019, p. 24). The average of the responses, which is extracted from the EEG is called event-related potentials (ERPs) and relates to that specific stimulus (Hu & Zhang, 2019). Steinhauer (2014) highlights that ERPs illustrate brain waves without delay from the participants' scalp (including any age or patients) in a millisecond temporal.

2.2.1. Conflict detection through a stroop-like task

The Stroop-like task has been extensively used for clinical as well as experimental reasons. The test measures the ability to hinder cognitive interference, which is the effect of processing a stimulus feature at the expense of another stimulus attribute (Scarpina & Tagini, 2017). In its common version, the participants need to read the three different tables presented to them as fast as possible. Two of the tables represent a "congruous condition" in which "to read names of colors (henceforth referred to as color-words) printed in black ink (W) and name different color patches (C)". In the third table, which includes the color-word condition, there is an inconsistency between the word and the ink color. For example, the word blue is printed in pink color, and following this incongruent situation, the participant has to say the color of the ink rather than read the word. This difficulty, which inhibits the automated process of naming, is called the Stroop effect (Pickering, et al., 2022). The task has been used ever since the 1930s to develop other research ideas in different fields to measure working memory (Finn, et al., 2022), cognitive flexibility (Rastelli, 2018), semantic interference and attention (Scaltritti, et al., 2022) as well as language components (Pathak & Pathak, 2022; Semushina & Mayberry, 2022; Simi et al., 2022).

In a stroop task, the provision of conflict detection and resolution is essential (Coderre, et al., 2011). Based on this conflict detection, other researchers (Kałamała, et al., 2022; Pulido & Dussias, 2019; Šaban & Schmidt, 2022) have done studies in the field of language. For example, Pulido and Dussias (2019) provided high and low conflict situations where the participants had to choose between lexical candidates when one of them was implausible and when the candidate items were both plausible. In another study, Zurrón et al. (2009) employed ERPs to find the semantic conflict in terms of congruent or incongruent stimuli. Accordingly, stroop task and its effect is an accepted technique to provide conflict in language studies.

In ERP studies, while presenting collocations (V + N) to the participants and while they are asked to choose the correct verb between the proposed candidates, the lexical selection between the verbs and the single noun in each collocation could lead to conflict (Pulido & Dussias, 2019). Accordingly, as

Pulido and Dussias (2019) discuss, “because lexical selection involves detecting conflict between candidates concurrently available for selection, understanding the process of lexical selection requires investigating the conflict detection and resolution mechanisms involved” (p.1). Consequently, in the selection between congruent and incongruent verbs in collocations (multi-word units) before the display of the noun, conflict arises and the time of conflict detection may be varied (Pulido & Dussias, 2019). Conflict is a crucial characteristic of the human cognitive system, and stroop-like tasks are a fundamental tool to measure cognitive conflict. Many of the language studies have adapted this color-naming stroop task (Botvinick et al., 2004; Coderre et al., 2011; Larson et al., 2014; Šaban & Schmidt, 2022).

3. Method

3.1. Participants and setting

The sample of the study included 30 Iranian EFL students studying at university level whose native language was Persian. However, at the onset of the study three participants who were left-handed and five participants who reported taking psychoactive medication were excluded. Accordingly, the participants of the study included 22 healthy (based on the self-report questionnaire) right-handed language learner volunteers in the age range of 19 to 30. The participants included both male and female students (12 females, 10 males). They were all BA and MA students of the language-teaching major. A2 level participants included 11 (5 males and 6 females) and B1 level participants included 11 (5 males and 6 females). Authorization from the ethics committee at the Biomedical Engineering Laboratory at Islamic Azad University of Mashhad to conduct this research was received (IR.IAU.MSHD.REC.1401.166). All the participants were right-handed with normal vision. The sampling procedure included purposive sampling in which the researchers selected the participants based on the research study purposes (Etikan et al., 2016). They had proficiency levels of A2 and B1 based on the Common European Framework of Reference for languages (CEFR) as an international standard. Data were collected at the biomedical engineering laboratory of the Islamic Azad University of Mashhad.

3.2. Instrumentation

The following instruments were used to conduct the present study.

3.2.1. Test of proficiency

To determine the English proficiency level of the students, the researchers used the Oxford University Press quick placement test and all the 30 participants were tested for their language proficiency as a reliable and time-saving method for the assessment of the proficiency level (Syndicate, 2001). It included multiple-choice items for which 30 minutes were allocated. Based on the score gained, the subjects were placed in different levels.

3.2.2. Four lists of collocations

Two lists of multi-word units were created, named targets and foils adopting the procedure from Pulido and Dussias (2019) focusing on lexical collocations. The term foil refers to an alternative that serves as a contrast or distractor to the target and main items. It is an incorrect or incongruent choice included in experimental tasks to help researchers understand how well participants can distinguish the correct target item from plausible or implausible alternatives.

The first list contained eight target verb-noun multi-word units (e.g., cancel [a] trip, eat breakfast) and the second list included eight verb-noun sets used as foils (e.g., schedule [a] time, skip school). To study the effect of conflict during the experiment, the researchers selected two additional lists of plausible distractors and implausible distractors list. The plausible distractors list contained foil-verb + target-noun that were plausible (e.g., schedule [a] trip, skip breakfast). The implausible distractors' list consisted of "foil-verb + target-noun" (e.g., break [a] trip, shoot breakfast). All verb-noun units used as targets were checked by 6 experts (PhD holders in teaching and translation of English) for the target list to be congruent (could be translated literally) between two languages (Persian and English), and the foil list had to be incongruent concerning the two languages. Examining both languages can allow for assessing and controlling how the learners' native language (Persian) affects their processing of English multi-word units. Only two of the VN sets were modified (disturb [the] neighbors was changed to disturb [the] view/fail [a] test was changed to develop [a] test). All lists are presented in Table 1.

Table 1. List of verb-noun phrases per condition

Target List	Foil List	Plausible Distractors	Implausible Distractor
cancel [a] trip	schedule [a] time	schedule [a] trip	break [a] trip
eat breakfast	skip school	skip breakfast	shoot breakfast
finish [a] story	break [the] news	break [a] story	disturb [a] story
promote peace	disturb [the] view	disturb [the] peace	schedule peace
rent [a] movie	shoot photos	shoot [a] movie	launder [a] movie
save money	launder clothes	launder money	skip money
teach [a] class	develop [a] test	develop [a] class	cash [a] class
write [a] check	cash [a] prize	cash [a] check	develop [a] check

3.2.3. The familiarization phase task

In order to familiarize the participants with the target verbs, a familiarization task was created. The rationale for the familiarization phase was to train participants on what responses to select. Since the manipulation in the study involved plausible vs. implausible distractors, without the familiarization phase, it would not have been possible for the participants to know what verb to select in the plausible distractor trials (e.g., cancel-schedule-trip). That is, some participants could have chosen "cancel" and others "schedule" and both responses are technically plausible and correct. Therefore, participants would have (a) been uncertain as to whether their response was correct, and (b) the researchers would not have been able to measure accuracy in their responses.

To do the familiarization phase, for each target list the researchers created a sentence which contained the target V-NP phrase in the middle of it as follows. Participants read the sentences at their own pace on the paper before the EEG recording started. The task was adopted from Pulido and Dussias (2019). A sample is presented below.

> Carrier sentence: On Sundays, I usually get up later and eat breakfast in my pajamas.
>
> Target multi-word unit: *eat breakfast*

To avoid the participants' overlooking the target verbs, a gap-filler task displayed the sentences they had just read and the participants had to choose the right multi-word unit from two options. The participants had to choose the best answer from the options on the paper before EEG recording started as shown below in the second example. The participants had to pay attention to the target verbs before the trials started.

On Sundays, I usually get up later and **……………..** in my pajamas.

eat breakfast skip school

3.2.4. Multi-word-based lexical selection task

Each multi-word unit in Table 1 (e.g., cancel [a] trip) was presented with a plausible distractor multi-word unit (e.g., schedule [a] trip) and an implausible distractor multi-word unit (e.g., break [a] trip).

Relying on the familiarization phase and the task, and based on the phrases presented in that stage, the noun was presented for which the participants had to select the suitable verb. A counterbalanced order was taken to present the target and the distractor. This means that once for half of the trials, the order was as CANCEL-schedule-trip and for the other half of the trials it was schedule-CANCEL-trip. In order to monitor the processing and activation order, the two forms of targets and distractors related to each set were presented sequentially.

3.3. Research procedure

Initially, consent was obtained from all participants to participate in this study. The study was divided into two stages. In stage one, participants answered the quick placement test items to determine their level of English proficiency, and based on the results, they were divided into two groups of A2 and B1 proficiency levels. A2 level participants' minimum score was 30, and the maximum score was 39. The B1 level participants' minimum score was 20, and the maximum score was 29. Moreover, the participants who were left-handed were disqualified to be in the study.

In stage two, the participants were requested to take part in the experiment in the lab and completed the familiarization phase as described previously before recording started. The researchers were aware of artifacts and made an attempt to control them (Picton et al., 2000). The recorded electrical activity must always be contaminated with artifacts which may affect the analysis of EEG signal" (Jiang et al., 2019).

To display the words on the screen, the font size of Times New Roman 30 was used. For designing and running the tasks of the experiment, PSYTASK software was employed. To start the task (Figure 1), first, a fixation cross appeared on the screen for 400ms. One of the verbs appeared to the left side of the fixation cross. After leaving it for 400ms, the second verb was presented to the right side of the cross. As the next stage, both verbs remained on the screen together with the cross for another 500ms. Then, the left verb was removed from the screen while the right verb remained for another 400ms. After presenting the two verbs, the noun was presented on the screen for 500ms. As the final stage, the blue fixation cross appeared on the screen for 1500ms to the point that a response was made. Overall, 3250ms were allocated to the task. Using the button box, the participants had to press either the left or the right button in order to choose the correct response. This was done based on the side of the correct verb presented on the screen. In this research, one independent categorical variable (A2 & B1) and four (more than one) continuous dependent variables (PTD, PDT, ITD, IDT) were included. Thus, the study entailed an ERP experiment using a Stroop-like paradigm with multi-word lexical collocations as stimuli to investigate the neural correlates of conflict processing across two proficiency levels.

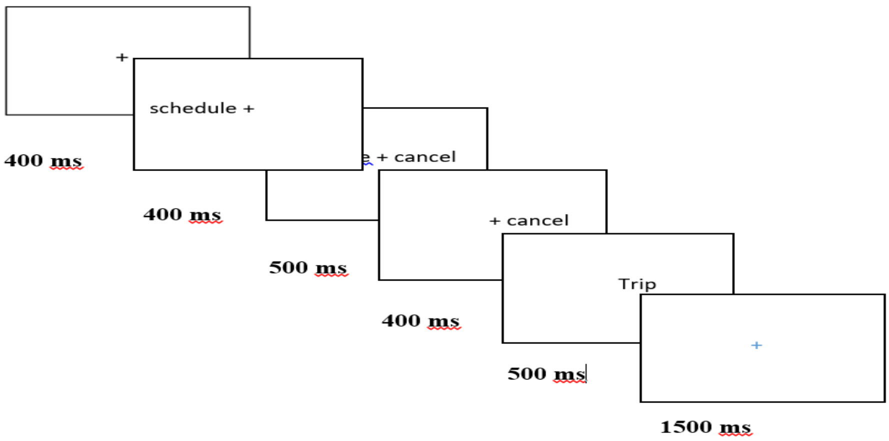

Figure 1. Sample trial of the lexical selection task

4. Results

For ERP data analysis, MATLAB software was used as it provides a flexible and powerful environment for processing and visualizing neuroscientific data. It enables precise signal processing, artifact rejection, and plotting of multi-channel ERP waveforms. These are all essential for analyzing brain activity across conditions and proficiency levels. Table 2 shows the means, standard deviations, variances, minimum, and maximum for each of the variables in the study.

Table 2. Descriptive Statistics for the Tests Used in the Study

	PTD	PDT	ITD	IDT	PTDreaction*	PDTreaction*	ITDreaction*	IDTreaction*
Mean	58.86	62.09	59.41	63.00	3139.86	3061.73	3144.59	3037.59
Median	63.50	67.00	66.00	67.00	3124.00	3107.50	3180.00	3074.50
Mode	63a	68	70	73	2826a	2725a	2895a	3111
Std. Deviation	16.08	13.28	17.22	13.14	134.17	160.05	148.63	158.20
Variance	258.79	176.37	296.53	172.85	18002.40	25618.01	22091.30	25027.39
Range	66	49	68	50	595	585	573	590
Minimum	9	30	10	28	2826	2725	2895	2728
Maximum	75	79	78	78	3421	3310	3468	3318

*PTDreaction: PTD reaction time PDTreaction: PDT reaction time ITDreaction: ITD reaction time IDTreaction: IDT reaction time

The normality of the distributions of all the tests used in the study was checked. Skewness and Kurtosis values of zero indicate the data are perfectly normally distributed. However, values between ±1 are considered "very good" and values between ±2 are considered acceptable (West, Finch, & Curran, 1995).

As Table 3 shows, values for the tests are within the "good" and "very good" excluding Kurtosis for PTD, which is above the range (3.59) (West et al., 1995). Therefore, normality can be assumed for the distributions for almost all the tests in the study.

Table 3. Test of normality for the measures used in the study

	PTD	**PDT**	**ITD**	**IDT**	**PTD reaction**	**PDT reaction**	**ITD reaction**	**IDT reaction**
Skewness	-1.86	-1.07	-1.51	-1.29	.120	-.35	.01	-.26
Std. Error of Skewness	.49	.49	.49	.49	.49	.49	.49	.49
Kurtosis	3.60	.59	1.98	1.28	.71	-.44	-.32	-.52
Std. Error of Kurtosis	.95	.95	.95	.95	.95	.95	.95	.95

As Table 4 shows, values for the tests are "very good" for PTD. Therefore, normality can be assumed for the distributions for almost all the tests for PTD in the study.

Table 4. Test of normality for the measures used in the study (PTD)

Row	Skewness	Standard Error of Skewness	Kurtosis	Standard Error of Kurtosis
Fp1	0.055	0.065524476	0.814	0.086273942
Fp2	0.710	0.04780286	0.559	0.101512171
F3	0.551	0.075473648	0.812	0.090710196
F4	0.711	0.094181109	0.432	0.150322964
C3	0.778	0.09989469	0.458	0.09417106
C4	0.282	0.140265037	0.852	0.106325203
P3	0.393	0.128169478	0.961	0.185658608
P4	0.753	0.117818557	0.151	0.154579874
O1	0.359	0.108627375	0.492	0.114673076
O2	0.555	0.157748196	0.739	0.158037496
F7	0.336	0.096394716	0.827	0.147417422
F8	0.541	0.09376816	0.634	0.080156898
T3	0.970	0.067062264	0.411	0.076724448
T4	0.324	0.059317392	0.772	0.140427218
T5	0.411	0.083001615	0.630	0.122686143
T6	0.757	0.132472894	0.655	0.179759618
Fz	0.560	0.089691636	0.981	0.120519192
Cz	0.559	0.111035099	0.698	0.133869108
Pz	0.269	0.11674812	0.605	0.166690933

As Table 5 shows, values for the tests are "very good" for PDT. Therefore, normality can be assumed for the distributions for almost all the tests for PDT in the study.

Table 5. Test of normality for the measures used in the study (PDT)

Row	Skewness	Standard Error of Skewness	Kurtosis	Standard Error of Kurtosis
Fp1	0.615	0.087554208	0.557	0.106493932
Fp2	0.137	0.09179922	0.136	0.169542648
F3	0.476	0.061438562	0.730	0.096139073
F4	0.901	0.111430213	0.669	0.162843264
C3	0.243	0.104361771	0.426	0.107744875
C4	0.525	0.117037883	0.449	0.154554953
P3	0.166	0.129191925	0.541	0.148449038
P4	0.548	0.122912471	0.837	0.141536985
O1	0.267	0.083127108	0.693	0.096001912
O2	0.033	0.114578402	0.456	0.129054941
F7	0.328	0.062830556	0.469	0.066273006
F8	0.945	0.080592353	0.002	0.190203064
T3	0.271	0.061977146	0.846	0.09372682
T4	0.528	0.081581975	0.356	0.104942542

T5	0.846	0.115063312	0.883	0.147286549
T6	0.930	0.149100716	0.395	0.159830946
Fz	0.838	0.070984332	0.319	0.149195279
Cz	0.672	0.078181248	0.322	0.127542109
Pz	0.868	0.093730036	0.949	0.134118533

As Table 6 shows, values for the tests are "very good" for ITD. Therefore, normality can be assumed for the distributions for almost all the tests for ITD in the study.

Table 6. Test of normality for the measures used in the study (ITD)

Row	Skewness	Standard Error of Skewness	Kurtosis	Standard Error of Kurtosis
Fp1	0.386	0.112839582	0.428	0.112472014
Fp2	0.113	0.090971895	0.901	0.147946342
F3	0.101	0.088856917	0.109	0.117623479
F4	0.178	0.096580227	0.586	0.133486123
C3	0.146	0.101783853	0.503	0.157460958
C4	0.044	0.13654965	0.019	0.150202885
P3	0.281	0.107310269	0.628	0.163574366
P4	0.886	0.122660502	0.438	0.157164782
O1	0.407	0.073377632	0.490	0.124145722
O2	0.523	0.120094419	0.473	0.136387235
F7	0.793	0.061954574	0.283	0.059159087
F8	0.037	0.115281251	0.397	0.112072756
T3	0.942	0.072864535	0.206	0.0692568
T4	0.023	0.066386211	0.190	0.110747686
T5	0.912	0.064279797	0.865	0.179798971
T6	0.390	0.130549663	0.974	0.158491686
Fz	0.033	0.105345823	0.663	0.145088521
Cz	0.523	0.114983727	0.287	0.163888441
Pz	0.683	0.09204252	0.222	0.151541763

As Table 7 shows, values for the tests are "very good" for IDT. Therefore, normality can be assumed for the distributions for almost all the tests for IDT in the study.

Table 7. Test of normality for the measures used in the study (IDT)

Row	**Skewness**	**Standard Error of Skewness**	**Kurtosis**	**Standard Error of Kurtosis**

Fp1	0.340	0.117016151	0.316	0.143097553
Fp2	0.651	0.121990871	0.518	0.179108263
F3	0.284	0.0850604	0.661	0.064520649
F4	0.164	0.135677017	0.507	0.13455136
C3	0.508	0.122676015	0.889	0.104628127
C4	0.802	0.134629525	0.846	0.117550997
P3	0.448	0.113024911	0.302	0.114565884
P4	0.547	0.126226099	0.496	0.111915911
O1	0.521	0.069094524	0.118	0.099911006
O2	0.380	0.119287821	0.992	0.146689596
F7	0.255	0.089725646	0.358	0.079155223
F8	0.369	0.079971699	0.492	0.051525473
T3	0.302	0.096353077	0.321	0.077616937
T4	0.606	0.083514577	0.198	0.109526866
T5	0.538	0.096482833	0.336	0.095365157
T6	0.897	0.15010977	0.322	0.11048846
Fz	0.108	0.14051385	0.260	0.137427955
Cz	0.546	0.140569927	0.313	0.103364596
Pz	0.368	0.111945428	0.697	0.107473385

After importing data to MATLAB software, the ERP analysis focused on one-time window: (400-500ms) from 19 channels. In MATLAB software, the plot of two proficiency levels of the participants (A2 Level, B1 Level) was drawn. Figures, 2, 3, 4, 5, 6, 7, and 8 show the plots of ERP signals in Fz, F3, F4, F7, Fp1, Fp2, and C3 channels in 4 conditions (PTD, PDT, ITD, IDT).

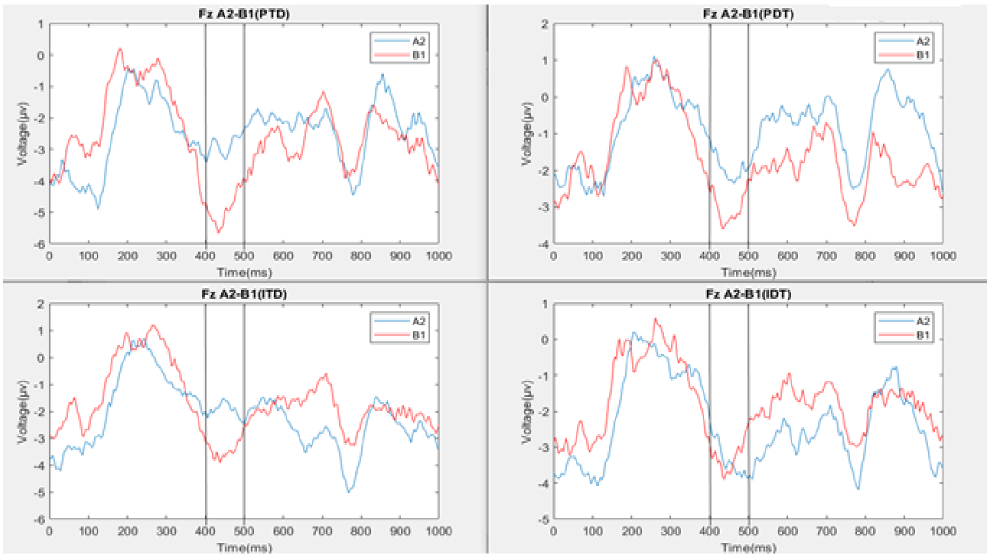

Figure 2. ERP signals plots in Fz channel in four conditions

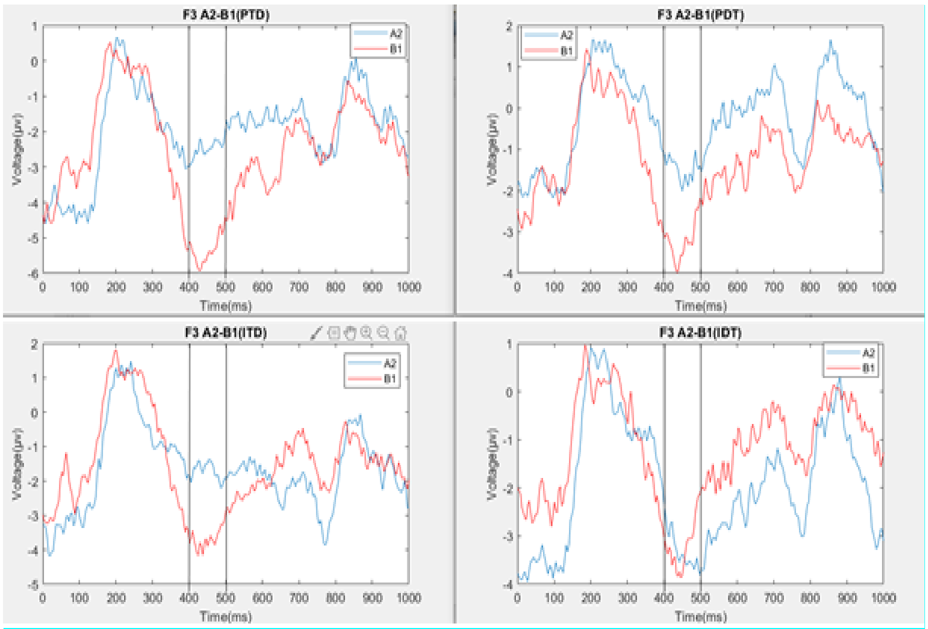

Figure 3. ERP signals plots in F3 channel in four conditions

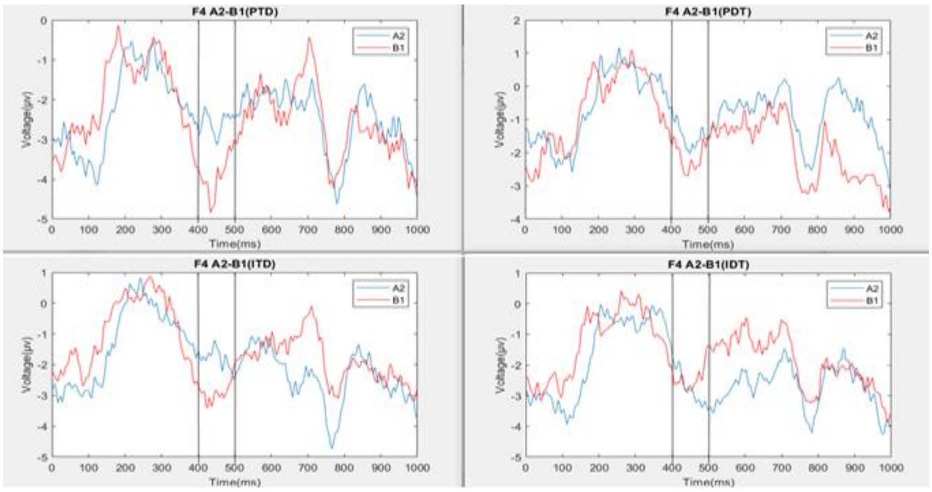

Figure 4. ERP signals plots in F4 channel in four conditions

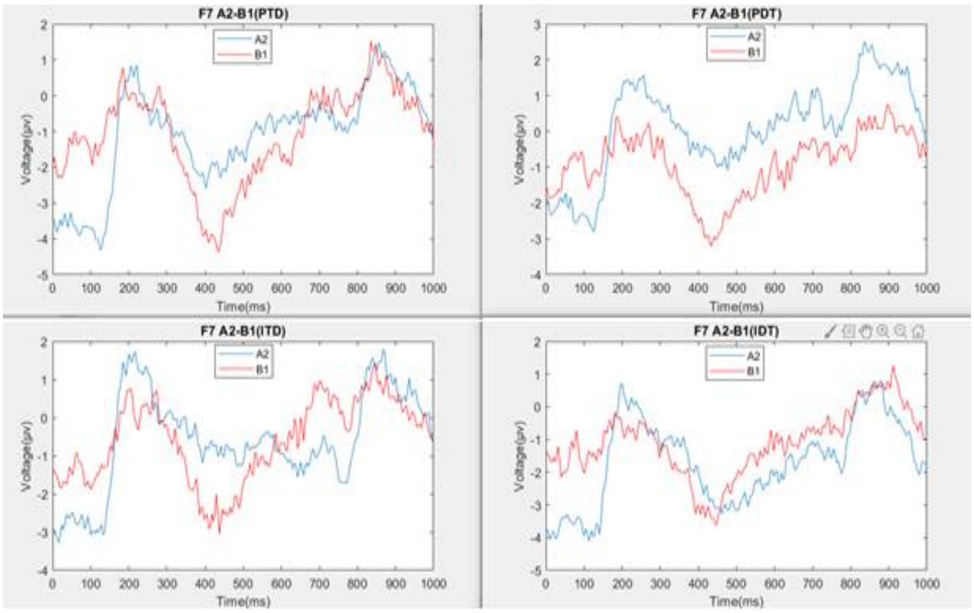

Figure 5. ERP signals plots in F7 channel in four conditions

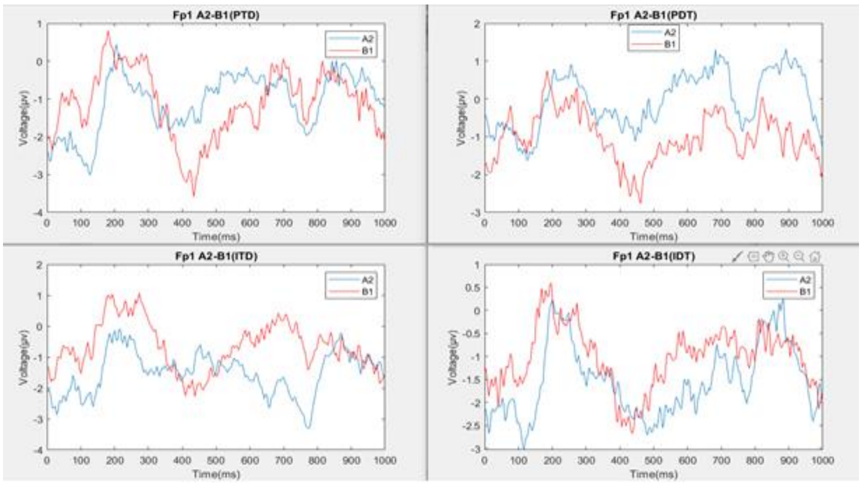

Figure 6. ERP Signals Plots in Fp1 Channel in 4 Conditions

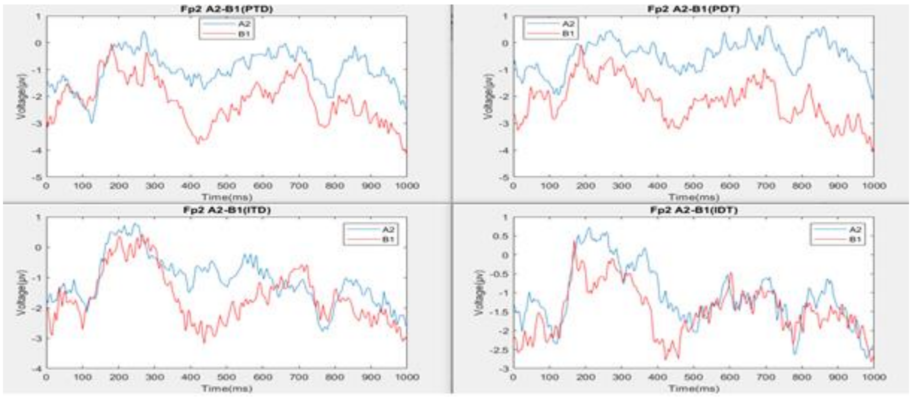

Figure 7. ERP Signals Plots in Fp2 Channel in 4 Conditions

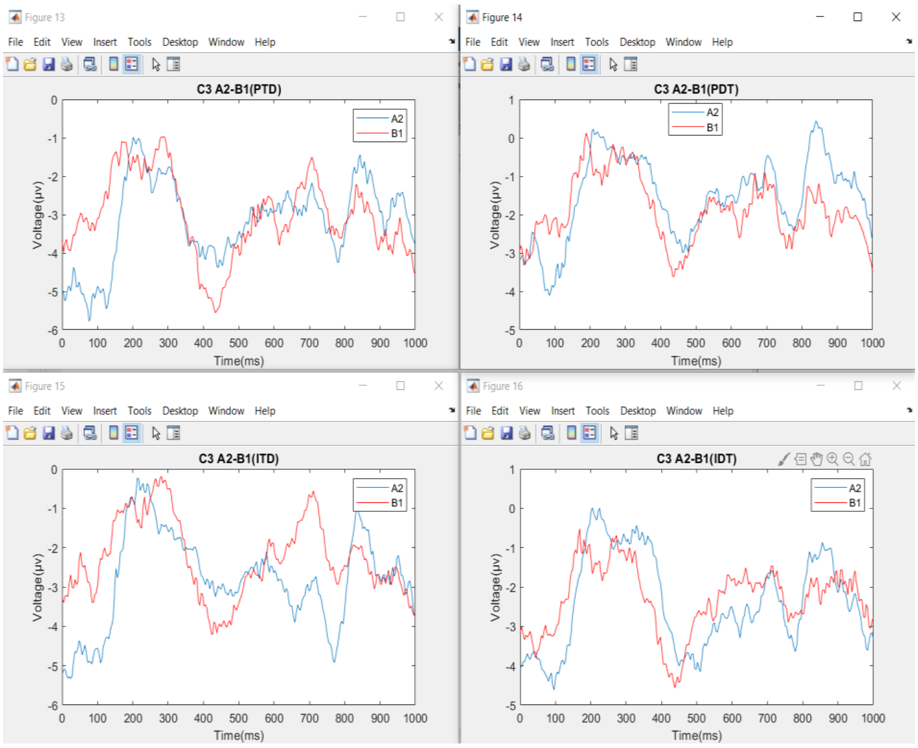

Figure 8. ERP Signals Plots in C3 Channel in four Conditions

Independent-samples t-test was run to compare the scores of A2 and B1 level students in their reaction times. Table 8 shows the descriptive statistics for A2 and B1 level of proficiency.

Table 8. Descriptive statistics for the proficiency levels in reaction time

	level	N	Mean	Std. Deviation	Std. Error Mean
PTD reaction	A2	11	3155.55	129.933	39.176
	B1	11	3124.18	142.763	43.045
PDT reaction	A2	11	3107.27	177.048	53.382
	B1	11	3016.18	133.747	40.326
ITD reaction	A2	11	3174.36	151.504	45.680
	B1	11	3114.82	146.588	44.198
IDT reaction	A2	11	3041.09	172.685	52.066
	B1	11	3034.09	150.700	45.438

According to Table 9, as all the significant values for reaction times are above .05 the hypothesis is confirmed (research question one); thus, based on research one related hypothesis, there is no significant difference in the mean scores of A2 and B1 students in reaction times.

Table 9. T-test for comparing proficiency levels in reaction time

		t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**
PTD reaction	Equal variances assumed	.539	20	.596	31.364	58.203
	Equal variances not assumed	.539	19.825	.596	31.364	58.203
PDT reaction	Equal variances assumed	1.362	20	.188	91.091	66.902
	Equal variances not assumed	1.362	18.610	.190	91.091	66.902
ITD reaction	Equal variances assumed	.937	20	.360	59.545	63.562
	Equal variances not assumed	.937	19.978	.360	59.545	63.562
IDT reaction	Equal variances assumed	.101	20	.920	7.000	69.105
	Equal variances not assumed	.101	19.640	.920	7.000	69.105

In order to answer the second research question, which aims to find the differences in processing of 4 conditions of collocations (PTD, PDT, ITD, IDT), based on proficiency levels, the research question was categorized into four sub-questions.

Processing of PTD in terms of EFL learners' proficiency level was analyzed. In Table 10, a t-test was run to compare the results of means, skewness, kurtosis, standard deviations, variances, minimums, maximums, and summations analysis of PTD condition (ERP data) and 2 levels of proficiency (400-500ms time window of ERPs).

Table 10. SEGMENTED (400-500ms)-T test-PTD

Row	Fp1	Fp2	F3	F4	C3	C4	P3	P4	O1	O2	F7	F8	T3	T4	T5	T6	Fz	Cz	Pz

Mean	0.202	0.106	0.058	0.283	0.481	0.877	0.773	0.382	0.330	0.256	0.119	0.730	0.247	0.494	0.564	0.655	0.106	0.793	0.387
Skewness	0.055	0.710	0.551	0.711	0.778	0.282	0.393	0.753	0.359	0.555	0.336	0.541	0.970	0.324	0.411	0.757	0.560	0.559	0.269
Kurtosis	0.814	0.559	0.812	0.432	0.458	0.852	0.961	0.151	0.492	0.739	0.827	0.634	0.411	0.772	0.630	0.655	0.981	0.698	0.605
SD	0.485	0.146	0.315	0.047	0.098	0.023	0.053	0.170	0.468	0.367	0.276	0.352	0.523	0.397	0.630	0.788	0.185	0.179	0.152
Variance	0.337	0.122	0.213	0.049	0.057	0.038	0.040	0.114	0.469	0.258	0.275	0.439	0.385	0.468	0.475	0.767	0.116	0.091	0.096
Median	0.241	0.109	0.064	0.308	0.471	0.824	0.780	0.384	0.307	0.289	0.129	0.755	0.263	0.513	0.526	0.680	0.107	0.835	0.360
Minimum	0.119	0.072	0.046	0.109	0.276	0.488	0.770	0.700	0.432	0.488	0.066	0.560	0.203	0.380	0.542	0.791	0.052	0.465	0.773
Maximum	0.246	0.159	0.146	0.719	0.890	0.411	0.350	0.130	0.260	0.126	0.158	0.968	0.278	0.826	0.649	0.555	0.325	0.668	0.120
Summation	0.202	0.106	0.058	0.283	0.481	0.877	0.773	0.382	0.330	0.256	0.119	0.730	0.247	0.494	0.564	0.655	0.106	0.793	0.387

As Table 10 shows, in F3, there is a significant difference in mean (p = .058) and minimum (p = .046) and summation (p = .058) in PTD condition. Moreover, in F4, there is a positive significant difference in SD (p = .047) and in variance (p = .049). In addition, there is a significant difference (p = .057) in variance in C3. Table 12 also presents significant differences in C4 (SD (P = .023), in variance (p = .038)), and in Fz (minimum (p = .052). Finally, there is a significant difference in Fp1 channel in skewness (p = .055), in P3 channel in standard deviation (SD (p = .053), and in variance (p = .040))

Processing of PDT in terms of EFL learners' proficiency level was analyzed. In Table 11, a t-test was run to compare the results of means, skewness, kurtosis, standard deviations, variances, minimums, maximums and summations analysis in PDT condition (400-500ms time window of ERPs).

Table 11. SEGMENTED (400-500ms)-T test-PDT

Row	Fp1	Fp2	F3	F4	C3	C4	P3	P4	O1	O2	F7	F8	T3	T4	T5	T6	Fz	Cz	Pz
Mean	0.161	0.124	0.208	0.605	0.655	0.832	0.661	0.536	0.682	0.726	0.114	0.222	0.291	0.215	0.863	0.624	0.387	0.798	0.802
Skewness	0.615	0.137	0.476	0.901	0.243	0.525	0.166	0.548	0.267	0.033	0.328	0.945	0.271	0.528	0.846	0.930	0.838	0.672	0.868
Kurtosis	0.557	0.136	0.730	0.669	0.426	0.449	0.541	0.837	0.693	0.456	0.469	0.002	0.846	0.356	0.883	0.395	0.319	0.322	0.949
SD	0.830	0.164	0.315	0.638	0.524	0.643	0.806	0.659	0.285	0.352	0.051	0.146	0.462	0.769	0.275	0.866	0.637	0.513	0.758
Variance	0.925	0.194	0.269	0.579	0.362	0.527	0.976	0.979	0.410	0.255	0.062	0.296	0.350	0.849	0.346	0.744	0.596	0.349	0.491
Median	0.184	0.115	0.209	0.648	0.605	0.852	0.812	0.639	0.744	0.878	0.105	0.245	0.262	0.208	0.744	0.580	0.438	0.807	0.841
Minimum	0.115	0.067	0.119	0.556	0.703	0.682	0.519	0.460	0.420	0.448	0.057	0.117	0.306	0.189	0.797	0.693	0.336	0.675	0.879
Maximum	0.246	0.269	0.311	0.744	0.984	0.989	0.516	0.695	0.812	0.909	0.345	0.411	0.586	0.393	0.606	0.686	0.464	0.900	0.712
Summation	0.161	0.124	0.208	0.605	0.655	0.832	0.661	0.536	0.682	0.726	0.114	0.222	0.291	0.215	0.863	0.624	0.387	0.798	0.802

As Table 11 presents, in F7 channel there is a significant difference in standard deviation (p = .051) and minimum (p = .057). Moreover, in F8 channel, there is a positive significant difference in kurtosis (p = .002). Also, there is a significant difference (p = .033) in skewness in O2 channel.

Processing of ITD in terms of EFL learners' proficiency level was analyzed. In Table 12, a t-test was run to compare the results of means, skewness, kurtosis, standard deviations, variances, minimums, maximums and summations analysis for ITD condition (400-500ms time window of ERPs).

Table 12. SEGMENTED (400-500ms)-T test-ITD

Row	Fp1	Fp2	F3	F4	C3	C4	P3	P4	O1	O2	F7	F8	T3	T4	T5	T6	Fz	Cz	Pz
Mean	0.562	0.126	0.126	0.444	0.484	0.785	0.626	0.537	0.150	0.346	0.201	0.542	0.937	0.877	0.606	0.831	0.262	0.836	0.540
Skewness	0.386	0.113	0.101	0.178	0.461	0.044	0.281	0.886	0.407	0.523	0.793	0.037	0.942	0.023	0.912	0.390	0.033	0.523	0.683
Kurtosis	0.428	0.901	0.109	0.586	0.503	0.019	0.628	0.438	0.490	0.473	0.283	0.397	0.206	0.190	0.865	0.974	0.663	0.287	0.222
SD	0.873	0.214	0.565	0.388	0.119	0.082	0.124	0.149	0.627	0.630	0.231	0.210	0.629	0.419	0.972	0.526	0.512	0.272	0.181
Variance	0.962	0.188	0.436	0.333	0.133	0.093	0.173	0.182	0.542	0.647	0.234	0.192	0.519	0.521	0.739	0.597	0.417	0.256	0.170
Median	0.563	0.122	0.115	0.403	0.466	0.889	0.645	0.612	0.210	0.497	0.207	0.478	0.970	0.830	0.578	0.826	0.231	0.827	0.558
Minimum	0.581	0.085	0.111	0.392	0.345	1.000	0.989	0.797	0.176	0.393	0.126	0.569	0.713	0.897	0.673	0.982	0.267	0.604	0.796
Maximum	0.628	0.316	0.268	0.696	0.932	0.247	0.288	0.248	0.098	0.208	0.352	0.944	0.944	0.644	0.602	0.638	0.513	0.705	0.232
Summation	0.562	0.126	0.126	0.444	0.484	0.785	0.626	0.537	0.150	0.346	0.201	0.542	0.937	0.877	0.606	0.831	0.262	0.836	0.540

In C4 channel there is a significant difference in skewness (p = .044) and kurtosis (p = .019). Moreover, in F8 channel, there is a positive significant difference in skewness (p = .037). Also, there is a significant difference (p = .033) in skewness in Fz channel. In T4 channel also there is a significant difference in skewness (P = .023).

Processing of IDT in terms of EFL learners' proficiency level was analyzed. In Table 13, a t-test was run to compare the results of means, skewness, kurtosis, standard deviations, variances, minimums, maximums and summations (400-500ms time window of ERPs). As table 13 presents, there is not any positive significant difference in IDT condition.

Table 13. SEGMENTED (400-500ms)-T test-IDT

ow	p 1	p 2	3	4	3	4	3	4	1	2	7	8	3	4	5	6	z	z	z

ean	.930	.267	.953	.775	.706	.418	.370	.422	.292	.354	.888	.517	.696	.520	.230	.663	.987	.885	.573
kewness	.340	.651	.284	.164	.508	.802	.448	.547	.521	.380	.255	.369	.302	.606	.538	.897	.108	.546	.368
urtosis	.316	.518	.661	.507	.889	.846	.302	.496	.118	.992	.358	.492	.321	.198	.336	.322	.260	.313	.697
D	.768	.851	.273	.551	.608	.192	.322	.538	.848	.758	.271	.421	.754	.768	.111	.252	.507	.472	.947
ariance	.616	.702	.320	.607	.815	.467	.569	.362	.869	.472	.327	.433	.869	.675	.090	.200	.471	.485	.999
edian	.869	.237	.976	.817	.697	.486	.390	.460	.298	.311	.810	.447	.667	.412	.193	.635	.926	.980	.688
inimum	.943	.349	.856	.877	.646	.695	.542	.360	.292	.364	.689	.866	.938	.807	.137	.551	.863	.811	.595
aximum	.783	.226	.872	.527	.840	.223	.322	.560	.335	.491	.839	.376	.684	.447	.425	.881	.773	.638	.511
ummation	.930	.267	.953	.775	.706	.418	.370	.422	.292	.354	.888	.517	.696	.520	.230	.663	.987	.885	.573

5. Discussion and Conclusion

The present study was conducted to find any significant differences in the processing of collocations in four conditions (PTD, PDT, ITD, IDT) in terms of EFL learners' proficiency level. In addition, the study aimed at finding behavioral results of the reaction time in both proficiency groups' responding. As for the reaction times, there were no significant differences between the two proficiency level groups. This finding was not in line with Pulido and Dussias's (2019) study. However, it needs to be noted that in their study, the participants were monolingual and bilinguals whose proficiency levels must have been different from the participants in this study. Moreover, the participants were in levels A2 and B1 which are very close in their proficiency level.

The results of t-tests in different channels revealed that there is a significant difference in PTD condition in F3, F4, C3, C4, Fz, Fp1 and P3 channels and there is a significant difference in PDT condition in F7, F8 and O2 channels. Moreover, there is a significant difference in ITD condition in F8, Fz, C4, and T4 channels, and there is no significant difference in IDT condition.

The results of the present study revealed important connections between two vital factors in language teaching, including the proficiency level and collocation processing. This finding is in line with other studies conducted in the field of language teaching, such as the study conducted by Nizonkiza (2015), which supported the relationship between the receptive collocation competence and EFL learners' proficiency, and Gitsaki's (1999) study on the relationships between proficiency level and two types of collocations. The interpretation of these results suggests that higher levels of proficiency enable better processing of collocations, indicating that learners who are more advanced may utilize more efficient cognitive mechanisms during language comprehension.

The results show a significant difference in the N400 component (400-500ms) between two levels of proficiency in PTD, PDT, and ITD conditions of collocations. This finding aligns with the study conducted by Pulido and Dussias (2019), which showed that the processing of the noun with target verb and distractors in collocations (PTD, PDT, ITD, IDT) had significant differences in monolingual and bilingual speakers in the N400 component (400-500ms). The emphasis on the N400 component is significant as it is widely regarded as an indicator of lexical retrieval and semantic processing difficulties, particularly in the context of collocations.

Observing and analyzing the qualitative data related to the plots of ERP signals reveals that in Fz, F3, F4, F7, F8, Fp1, Fp2, C3, C4, T4, and P3 channels related to the N400 component, a significant difference in N400 (PTD: F3, F4, C3, C4, Fz, Fp1, P3), (PDT: F7, F8, O2), and (ITD: F8, Fz, C4, T4) was observed. Moreover, a stronger negativity (N400 component) can be clearly seen in B1 level of proficiency plots. This finding is indicative of how different brain regions engage in collocation processing, which has been substantiated in previous research, such as the work of Kutas and Hillyard (1980), who demonstrated the significance of the N400 component in language comprehension tasks.

Additionally, the N400 responses recorded in these particular channels offer valuable perspectives on how language processing varies with different levels of proficiency and cognitive skill. Research by van Petten and Luka (2006) highlights the significance of choosing the right channels when analyzing ERPs, especially concerning tasks involving semantic processing. Therefore, concentrating on the N400 component and the specified channels is essential for linking the effects of proficiency to the fundamental cognitive mechanisms involved in language comprehension.

Based on the findings of the present study, several conclusions can be made. As for the reaction time, it was observed that it could not be a dependent variable to distinguish differences. In this study, no significant differences were observed in the reaction times of the different proficiency groups. However, it needs to be highlighted that the proficiency levels of A2 and B1 are very close. Perhaps other proficiency levels with greater differences could show differences in reaction times as well. This suggests that while proficiency does impact collocation processing, reaction time may not be as effective a measure in distinguishing between nuanced proficiency levels. Further investigation into this relationship could provide deeper insights into how various proficiency levels might exhibit different patterns in cognitive processing, as suggested by studies focusing on learners across a wider proficiency spectrum. However, based on the analyses of the data, it is possible to investigate the differences in proficiency level among language learners, in this case, Persian learners of the English language, through processing collocations. This can be done through the provision of resolution as well as conflict detection by presenting event-related tasks to the students and by recording their brain waves. In fact, the conflict is provided through the presentation of a plausible distractor in a multi-unit collocation. The PTD and PDT conditions triggered more differences as compared to the implausible condition that only triggered N400 in the ITD condition.

Many of the differences were found in the frontal lobes of the brain which is responsible for judgment (Funayama et al., 2019) and there seems to be a greater recruitment of the frontal lobes in processing collocations, including sets which have plausible pairs, as the participants needed to make judgments.

Another finding related to the P3 channel, where a difference was found in the parietal lobe. It has been noted by Coslett and Schwartz (2018) that though most of the language processing has been attributed to frontal and temporal lobes (as was found in the current study as well), “the parietal lobe plays a major role in semantic processing, particularly for ‘thematic’ relationships” (p.1). In the same vein, other researchers, including Jiao et al. (2020), Numssen et al. (2021), and Blackett et al. (2022), mention and highlight the language processing and semantic function of the parietal lobe.

The observation of N400 is also evidence of semantic processing in the study. As Kutas and Federmeier (2011) maintain, N400 can be observed in cases where language processing in the semantic aspect is done in written formats as was conducted and the words were presented in the present study on the screen.

Thus, the study revealed that learners with diverse proficiency levels processed the different conditions in various ways, especially for the PTD condition that included ambiguity, as there was a plausible distractor. In fact, in this condition, the plausible item was presented first and this should have led to confusion for the learners. Moreover, based on the qualitative data related to the plots extracted based on EEG and later ERP recordings, it was concluded that a clear stronger negativity, which relates to N400, could be found in the time span of 400 to 500, reflecting the cognitive processing challenges faced by different learners.

The findings provide new insight into the processing of collocations through conflict detection and resolution. These findings are critical for language education, as they suggest that instructors can adapt their teaching strategies and develop tailored materials that address the specific needs of learners based on their proficiency. One group of scholars who can reliably benefit from the results includes linguists. This study presents findings on the extent to which a learners’ underlying grammatical knowledge can have an influence on the processing of different sets of words, including plausible and non-plausible collocations. Moreover, the differences in channels can help linguists to understand the processing mechanisms of collocations with and without plausible distractors in the brain and the different areas of the brain involved in it in terms of cognitive variances. This study can also be used by assessment researchers to create more convenient items using ERPs evidence for effective testing. Unlike pen and paper tests that require a lot of time and effort on the part of both testers and testees as well as administrators, ERPs can be effectively used to understand cognitive processing differences of the linguistic items in language learners across various levels of proficiency, including the language structures in the brain accurately. Moreover, testing in broad terms and implemented in large groups can have negative consequences; thus, more accurate testing systems are required (Kiani, 2016; Shakibaee & Jamhidof, 2022).

A replication of the current study may be possible through a larger sample size in order to increase the generalizability of the findings as the sample size was limited. Besides, as the participants were selected based on their language proficiency levels of B1 and A2, other researchers are recommended to conduct a similar study through selecting participants based on other language proficiency levels. In addition, the present study focused on the "verb-noun" combination of collocations. Other research studies may concentrate on other types of colocations. Gender differences in the processing through conflict detection and resolution tasks can be another line of research.

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