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Intermediate EFL Learners' Attentional Oscillations during Writing Tasks

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ABSTRACT

Quantitative electroencephalogram (QEEG) quantitatively records brain wave oscillation changes in any brain activity. Beta waves are produced during brain consciousness when an external stimulus induces computation, reasoning, attention, and logical thinking. Accordingly, the present study tried to measure beta wave changes during writing to analyze the changes of beta oscillatory changes while performing a writing task at the intermediate level. The study followed a quantitative method with the quasi-experimental design. To meet the purpose, thirty foreign language learners (15 males and 15 females) participated in this study voluntarily. They were doing writing tasks while their brain waves were recorded in the F3, F4, and Fz brain regions by applying the QEEG technique. The results reported positive significant differences on beta oscillatory activities in these brain areas, indicating the effectiveness of writing task activities in enhancing attention. The study has implications for language teachers to manipulate creative writing tasks as compositions to enhance attention as a prerequisite of learning and beta waves activation. Moreover, it is suggested that TEFL scholars apply interdisciplinary approaches to uncover the effects of different tasks on brain oscillatory activities.

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Introduction

The close association between language functions and the brain tissue (Friederici, 2011) underscores the importance of comprehending the neural foundation of language, which in turn opens up new horizons for improving language acquisition. Language proficiency is typically divided into various skills and elements (Riad et al., 2023). Among these skills, writing is considered to be the most difficult skill for language learners as it requires a thorough understanding of various elements. These elements include having a sufficient background knowledge of the second language (L2) to ensure appropriate language usage, understanding rhetorical structures, and having a specific vocabulary that effectively communicates with the readers (Tangpermpoon, 2018). Even native speakers face challenges in generating and organizing ideas, as well as transforming them into coherent written text (Solati-Dehkordi & Salehi, 2016).

Writing can also serve as a means of self-care, providing a means of expression for emotions that might otherwise build up inside. Through the act of writing, individuals have the opportunity to work through unpleasant feelings and gain a deeper understanding of themselves. Klein and Boals (2001) found that writing can greatly enhance mental clarity. Their study revealed that individuals who engaged in a 20-minute writing exercise, expressing their opinions and emotions on a specific topic, demonstrated significantly higher levels of mental clarity compared to those who did not write. This effect was particularly pronounced among individuals who initially had lower levels of mental clarity.

The primary focus in cognitive research pertaining to text production revolves around the concept of writing dynamics (Kellogg, 1994). Writing dynamics encompass the organization of time in terms of planning ideas, transforming them into coherent sentences, and reviewing the written text (Levy & Ransdell, 1995; Piolat & Olive, 2000). Studies on writing dynamics have indicated that the processes of reviewing, translating, and planning are not strictly linear but rather recursive in nature (Hayes & Flower, 1980). This means that these cognitive functions are interdependent, as the act of translating an idea into a sentence often prompts the writer to engage in further planning for new ideas. These cognitive functions place significant demands on working memory, often leading to its overburdening (Hayes & Flower, 1980).

Attention is a crucial element in the process of writing, as indicated by Watzl (2011). Jones (2022) proposed that being consciously aware of grammar (referred to as the state of attention) is primarily engaged during the initial stages of writing rather than during the act of articulation. According to a comprehensive study on attention and the processes involved in writing, Piolat et al. (2001) emphasized the crucial role of sustained attention as a fundamental prerequisite for writing development as a cumulative outcome. The production of a written text relies on the harmonious collaboration of three complex cognitive functions: language, thinking, and memory (Piolat et al., 2001).

During logical thinking and attention-directed cognitive tasks beta waves control our normal working state. Beta oscillation is concerned with highly complex thought and attention in learning processes (Demos, 2005). The level of attention one pays is closely linked to their ability to learn and remember information (Ritter et al., 2013). Consequently, beta waves in the brain are strongly connected to the processes of learning, recalling, and retaining information.

The brain cognitive functions are hidden and sometimes unattainable to researchers, and computational neuroscience makes it possible for the scholars to reveal these underpinning variables (Soto, 2019). Computational neuroscience proposes a neural model to make it possible to search actual neural structures to underlie a particular behavior by including the neurobiological constraints (Soto, 2019). Moreover, to understand the working of the brain, nervous system, and behavior, it assigns mathematical models, computer simulations, and statistical analyses as both qualitative and quantitative data (Soto, 2019). Computational neuroscience is a novel theory in investigating brain functions applying neuroimaging devices (Soto, 2019). Today, researchers increasingly recognize brain oscillations as a useful tool to reveal substrate neuronal mechanisms involving in skill formation. Thus, the present study aimed at measuring frontal beta oscillatory activities while writing task to explore the effectiveness of creative writing on attention and enhancing frontal beta wave frequencies.

Method

Design

The current study adopted a quantitative method with a quasi-experimental design. This clinical-based project was conducted in an experimental design approach generally used in treatment studies.

Participants

The study was administered in Islamic Azad University, Mashhad Branch. Fifty-three EFL university students volunteered to take part in the study. The age of the participants ranged between 20 and 25 years old. To ensure homogeneity, the Oxford Placement Test (OPT) was administered to the sample population through which thirty intermediate learners (fifteen males and fifteen females) were selected. The participants held a range of university qualifications, were all right-handed, and spoke Persian as their first language. It is important to note that none of the participants had a history of traumatic or psychological illnesses. Also, all the participants provided their signatures and fingerprints to confirm their willingness to participate in the research. To protect the anonymity of the participants, their identities were kept confidential and substituted with a code. Besides, the study received the ethical code (IR.IAU.MSHD.REC.1401.175).

Instruments

The Standard Test of Writing

The writing test employed in this research was a standardized test adopted from the Preliminary English Test (PET) to evaluate language learners' proficiency level (Yaghchi et al., 2016). PET writing section (the Cronbach's alpha value was estimated /r=.81) consists of two parts: the first part involves learners to compose an email while the second part entails writing an article or a story. The test was administered once before the study to check its reliability and validity in the EFL context. Each section is assessed on a scale of 20, with specific criteria such as content, communicative achievement, language, and organization being marked out of 5 (Hayward, 2021).

Quantitative Electroencephalography (QEEG)

The scientific evaluation tool employed in this study was a Bioline Quantitative Electroencephalography (QEEG). This method involves the recording of brain activity over a period of time by placing electrodes on the scalp using a stretchable cap. EEG/QEEG is a noninvasive technique that allows for the detection of brain electrophysiological signals with a high level of temporal resolution, comparable to invasive recordings (Basar, 2006). The QEEG device used in the study was German Bioline 8 channels. It enabled the researcher to measure the brain activity over time using elastic cap with 8 electrodes placed on the scalp. The electrodes are connected to the recording device and can reflect thousands of simultaneously ongoing brain processes.

The EEG sampling rate in this study was 500Hz. The device employed the elimination pre-processing acquisition filter and the epochs were computed every 2 seconds. The mean of 2-second RMS signals which was artifacted was considered as the analyzed recorded signal to be investigated. The electrode impedances were kept beneath 5 kohms.

Data Collection Procedures

OPT was administered to the participants to check the homogeneity of the sample. According to Gall et al. (2003), and Wallen and Fraenkel (2009), correlational and experimental designs require a minimum sample size of at least 30 to produce accurate results (p.335). The selected sample signed and finger-printed their agreements to participate in the laboratory study. The ethical code was also acquired. There were two recording sessions of QEEG: a five minutes-session recording of Eye-closed and Eye-opened conditions as the resting state, followed by a10-minute session under task (test of writing) to check the likely changes in the brain waves. The participants were instructed to abstain from consuming coffee or taking any tablets prior to the recording sessions to avoid any unwanted disturbances. The answer sheet was positioned conveniently for them to write swiftly without having to change their positions. Following the studies by Angelidis et al. (2018); Carvalho et al. (2015); Gongora et al. (2016), Llamas-Alonso et al. (2019); and Son et al. (2019), beta oscillatory activities were recorded from frontal areas of the brain (F3, F4, and Fz) to check attentional state while doing attention-needed tasks.

Data Analysis

The gathered data were inserted into SPSS 22 for further analysis. In the first step, Cronbach's alpha reliability of the placement test (.57), besides the inter-rater reliability of writing 1 and writing 2 (.80) were estimated. To check the homogeneity of the sample, the scores on OPT were analyzed. Data recorded by the device (brain waves) were artifacted and changed through Fast Fourier Transform (FFT) to frequencies. The FFT absolute power of beta bands, on three targeted regions of F۳, F4, and Fz, were extracted. The statistical analyses followed previous studies in the field (Carvalho et al., 2015; Farrokh Alaee et al., 2020; Thomas & Viljoen, 2016). Paired sample statistics were assigned to the data acquired from the device (beta oscillatory activities) to check the changes in beta activities before and during the writing task.

Results

The current investigation conducted two essential statistical analyses using SPSS software, namely the paired sample t-test and correlation. The primary assumptions of the statistical procedures in the current study, outliers, normality, linearity, homoscedasticity, and independence of observations, were inspected. The normality of the distribution of scores was assessed using (Table 1).

Table 1

Shapiro Tests of Normality for the EFL Learners

	Shapiro-Wilk		
	Statistic	**df**	**Sig.**
Before Writing	.965	28	.463
While Writing	.957	28	.289
Writing Test Score	.909	28	.018

Note. * This is a lower bound of the true significance. A Lilliefors Significance Correction

The Sig. value for beta wave frequencies *Before Writing* (0.131), *While Writing* (0.134), and *Writing Test Score* (0.151) were estimated. Also, the results of Kolmogorov-Smirnova and Shapiro-Wilk tests proposed a normal distribution.

To summarize the large amount of data into several useful bits of information, the mean, trimmed mean, and standard deviation of the sample data were analyzed. The mean for writing score was estimated as 22.854 and the Trimmed mean was 22.734. The median was 22.295, the variance (18.747), and the standard deviation (4.329) were measured too. The acquired data indicated the descriptive statistics about the data set (Table 2).

Table 2

Descriptive Statistic for the EFL Learners

		Statistic	**Std. Error**
BeforeWriting	Mean	22.8546	.81825
	5% Trimmed Mean	22.7347	
	Median	22.2950	
	Variance	18.747	
	Std. Deviation	4.32978	
	Minimum	15.15	
	Maximum	32.27	
	Range	17.12	
	Interquartile Range	6.10	
	Skewness	.521	.441
	Kurtosis	-.111	.858
While Writing	Mean	29.7300	1.06685
	5% Trimmed Mean	29.4664	
	Median	28.5750	
	Variance	31.869	
	Std. Deviation	5.64526	
	Minimum	19.22	
	Maximum	45.71	
	Range	26.49	
	Interquartile Range	7.97	
	Skewness	.831	.441
	Kurtosis	1.189	.858
Writing Test Score	Mean	12.4464	.62326
	5% Trimmed Mean	12.4127	
	Median	12.2500	
	Variance	10.877	
	Std. Deviation	3.29798	
	Minimum	8.00	
	Maximum	17.50	
	Range	9.50	
	Interquartile Range	6.00	
	Skewness	.240	.441
	Kurtosis	-1.402	.858

Furthermore, boxplots for the beta wave frequencies *Before Writing*, and *Writing Test Score* showed no cases as outliers. However, boxplots for beta wave frequencies *While Writing* illustrated one case as an outlier, which was excluded from the subsequent statistical analysis.

Additionally, the assumption of linearity was checked through the Q-Q plot. A reasonably straight line proposes a normal distribution.The scatterplot illustrated that the residuals are roughly rectangularly distributed, with most of the cases concentrated in the center emphasizing normality and homoscedasticity. The last assumption for correlation in this study was independence of observations which indicated that observation or measurement was not influenced by other group members. Also, the paired sample statistics were used for the frontal beta frequencies on F3, F4 and Fz areas for *Before* and *While writing* task (Table 3).

Table 3
Paired Samples Statistics for Beta Wave Frequencies in Frontal Areas of the Brain (F3, F4, and FZ) Before Writing and While Writing

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	F3 Before Writing-	6.9496	28	1.25844	.23782
	While Writing	9.4636	28	1.92692	.36415
Pair 1	F4 Before Writing-	8.5857	28	2.37588	.44900
	While Writing	9.5971	28	2.21057	.41776
Pair 1	Fz Before Writing-	7.3193	28	1.67185	.31595
	While Writing	10.6693	28	2.17915	.41182

There was a statistically significant increase in beta wave frequencies in F3 (M = 6.94), F4 (M = 8.58), and Fz (M = 7.31) *Before Writing* compared to *While Writing* (F3: M = 9.46; F4: M = 9.59; Fz: M = 10.66). The mean increase in beta wave scores in F3 was 0.96 with a 95% confidence interval; the eta squared statistic (.81) indicated a large effect size. Likewise, the mean increase in beta wave scores in F4 was 1.77 with a 95% confidence interval ranging from -1.89 to .12. The eta squared statistic (.16) indicated a large effect size. In the same manner, the mean increase in beta wave scores in Fz was 1.29, with a 95% confidence interval ranging from -3.99 to -2.70. The eta squared statistic (.81) indicated a large effect size.

Following the studies in the field (e.g. Ellingson,1956; Farrokh Alaee et al., 2020; Kolayis, 2012; Mckay et al., 2022), a paired sample t-test was applied to the frontal beta frequencies on F3, F4 and Fz areas for *Before* and *While writing* task to investigate the first research question (Table 4).

Table 4
Paired Samples Test for Beta Wave Frequencies in F3, F4, and Fz Before Writing and While Writing

		Paired Differences							
		Std. Error		95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	F3 Before Wr.- While Wr.	-2.51	1.23	.23	-2.99	-2.03	10.81	27	.000
Pair 1	F4 Before Wr.- While Wr.	-1.01	2.27	.42	-1.89	.12	-2.353	27	.026
Pair 1	Fz Before Wr.- While Wr.	-3.35	1.65	.31	-3.99	-2.70	-10.739	27	.000

As shown in the Table, there are significant differences between beta wave frequencies in frontal regions of the brain (F3, F4, and Fz) Before and *While Writing* task (p<.05).

Discussion

The present study aimed to empirically investigate the frontal beta frequency changes while doing writing task in thirty EFL learners at intermediate level. The results of the paired t-test statistics showed significant differences in beta oscillatory activities in the while-state in F3, F4, and Fz brain regions in comparison to the eye-open state. Beta frequencies are the indicator of the attentional state of mind (Angelidis et al., 2018); therefore, their increase is considered as a positive sign of learning. As mentioned by Renukadevi (2014), attention is a significant factor in language learning. The results of the study are consistent with the findings of many scholars who concluded that attention is a higher-order thinking skill activated while writing (Graham et al., 2016; Kessler, 2009; Mayes & Calhoun, 2007). Reciprocally, some writing tasks activates attentional grabbers in different areas of the brain (Kayaal et al., 2022).

According to cytoarchitecture of the brain, F3 is relatively matched with Brodmann areas 8, 9, 46 (in the right hemisphere) and is associated with short-term memory-verbal episodic retrieval, planning, and problem solving; F4 (Brodmann areas 8, 9, 46 on the left hemisphere) is correlated to short-term memory-spatial/object retrieval, selective and sustained attentional areas; and Fz (Brodmann areas 8, 6, 9) corresponds to possible anterior cingulate-internal versus external attention (Garey, 1994). Localization of beta wave frequencies indicated performing higher attentional-grabbing activities in these areas.

Beta wave frequencies are ascribed to improvement in performance and learning (Marcuse et al., 2016), and the frontal regions are associated with higher memory storage and recall (Guyton & Hall, 2006) which are helpful in writing processes. Concentration and attention are attributed to beta wave increases in prefrontal and frontal brain regions (Lim et al., 2019). Applying EEG to measure brain waves changes in thirty-two college students during a focus task such as writing, Lim et al. (2019) found that beta waves increased during concentration and immersion in the frontal and occipital lobes, with a higher increase in immersion. In line with Lim et al. (2019), the data on beta wave frequencies indicated higher activity on F3 and F4 regions in this study indicated that writing task is positively and significantly associated with higher beta frequencies in frontal lobes.

Considering the result of the study, it can be deduced that the writing tasks enhanced the beta wave activities in the frontal regions of the brain. This finding corresponds to those of Klein, and Boals (2001) who believed that writing tasks can enhance attention. Prominent research reveals that the average attention span of individuals is currently estimated to be around 8 seconds. This suggests that everyone should have already stopped reading this post by now. Many individuals today possess shorter attention spans compared to those in the past. It is reported that creative writing comes to the rescue in this situation. Engaging in writing compels the brain to concentrate on a singular task. However, it is not a matter of simply performing one action. Surprisingly, many individuals are unaware that writing entails multitasking. It necessitates the simultaneous processes of composing, thinking, and reading (Klein & Boals, 2001). Consequently, this intense engagement directs attention towards the task at hand. As one phrase is completed, another thought springs to mind, eagerly awaiting to be inked onto the page. Ultimately, the more a person engages in writing, the more enhanced his/her ability to focus becomes (Klein & Boals, 2001).

Conclusion

In essence, the study goal was to use the QEEG device to scrutinize the changes occurring in the frontal beta brain oscillations while performing a writing task in intermediate groups of EFLs. The present investigation primarily centered around the examination of beta brain waves. These oscillatory activities are connected to the regulation of motor skills and cognitive functions, such as enhancing attention, maintaining cognitive sets, and exerting cognitive effort (Angelidis et al., 2018; Huster et al., 2013; Waldhauser et al., 2012). Beta waves were examined in the specific areas of the brain (F3, F4, and Fz) since, it may be possible to enhance focused attention, ultimately leading to improved scores on the subsequent writing task (Klein & Boals, 2001). The results of this study go in line with the findings by Kayaal et al. (2022), Klein and Boals (2001), and Olive (2012) who believed that some creative writing tasks as composition writings can improve attention on one hand, and with Lim et al. (2019), Angelidis et al. (2018), and many scholars who revealed that frontal beta brain waves are associated with concentration and attention on the other hand.

The results of the present inquiry pointed to the promising role of writing tasks practicing attention and, as a result, beta wave modification. This study emphasizes the need for TEFL scholars and teachers to apply interdisciplinary approaches and creative writing tasks to enhance attention. Additional work is needed to distinguish different types of writing tasks, check their relationship with the beta wave level enhancement at different levels, and include other waves involved in attentional state performance.

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