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Rewiring Anxiety: Unveiling the Power of Neurofeedback through QEEG Analysis

Masoud Nosratabadi[1], Elnur Rustamov[1], Nader Alirezaloo[1], Narinj Rustamova[1], Ulkar Zalova Nuriyeva[1], Sayana Aliyeva[1], Sevil Abbasova[1]

Psychology Scientific Research Institute Azerbaijan[1]

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ABSTRACT

Anxiety disorders affect a significant portion of the global population, with lifetime prevalence rates estimated at 33.7% [1] which is an alarming figure for appeal for proper assistance. Nowadays, neurofeedback offers a complementary and alternative approach that may benefit those who have not found anxiety relief through conventional methods. Despite promising results, the field of neurofeedback for anxiety disorders requires more rigorous scientific investigation. Therefore, this study addresses methodological limitations of previous research by employing a larger sample size and utilizing QEEG analysis for a more comprehensive assessment of neural changes. 40 individuals diagnosed with anxiety disorders were recruited for the study. The main criterion was a primary diagnosis of an anxiety disorder, in the age range of 18-65 years. While the vast majority of neurofeedback research is focused on frontal areas, the role of posterior regions in anxiety disorders is less understood. So, there is a prospect that this study's emphasis on posterior brain activity may provide new insights into the neural mechanisms of anxiety and potential targets for intervention. At the stage of statistical analysis of results, the paired samples t-test was used to determine whether the difference of means was statistically significant. Eventually, the observed increase in alpha power of the occipital and parietal regions was confirmed by the result of the t-test ($t(39) = 4.82$, $p < .01$, $d = 4.33$). By revealing the relationship between QEEG patterns and treatment outcomes, this research contributes to the development of more personalized and targeted neurofeedback protocols for anxiety disorders.

1. Introduction

Anxiety disorders are among the most prevalent mental health conditions worldwide, affecting millions of individuals and significantly impacting their quality of life [1]. Traditional treatments, such as cognitive-behavioral therapy and pharmacological interventions, have shown varying degrees of success, but there remains a need for alternative and complementary approaches to address the complex nature of anxiety disorders [2]. In recent years, neurofeedback has emerged as a promising non-invasive technique for

treating various neuropsychiatric conditions, including anxiety disorders [4].

Neurofeedback, also known as EEG biofeedback, is a form of operant conditioning that aims to teach individuals to self-regulate their brain activity [11]. This technique involves real-time monitoring of brain electrical activity through electroencephalography (EEG) and providing feedback to the individual, allowing them to learn to modulate their neural patterns [6]. The underlying principle of neurofeedback is based on the brain's neuroplasticity, which enables the reorganization of neural networks in response to experience and training [9].

In the context of anxiety disorders, neurofeedback protocols often target specific EEG frequency bands and brain regions associated with anxiety symptoms [7]. For instance, anxiety has been linked to decreased alpha activity (8-12 Hz) in posterior regions [5]. By training individuals to modulate these specific neural patterns, neurofeedback aims to alleviate anxiety symptoms and improve overall emotional regulation [3].

Quantitative EEG (QEEG) analysis plays a crucial role in both the assessment and treatment of anxiety disorders using neurofeedback. QEEG provides a comprehensive mapping of brain electrical activity, allowing for the identification of specific neural patterns associated with anxiety symptoms [12]. This information can be used to tailor neurofeedback protocols to individual patients, potentially enhancing treatment efficacy [10].

Several studies have investigated the effectiveness of neurofeedback in treating anxiety disorders. A meta-analysis by [4] found that neurofeedback showed promise in reducing anxiety symptoms across various anxiety disorders. More recently, a randomized controlled trial by [7] demonstrated that alpha/theta neurofeedback training led to significant reductions in anxiety symptoms and improvements in emotion regulation abilities.

Despite these encouraging findings, there remains a need for more rigorous research to establish the efficacy of neurofeedback for anxiety disorders. Many existing studies have been limited by small sample sizes, lack of appropriate control groups, and inconsistent methodologies [13]. Additionally, the specific neural mechanisms underlying the effects of neurofeedback on anxiety symptoms are not fully understood, necessitating further investigation into the neurophysiological changes associated with successful treatment outcomes [9].

The present study aims to address these gaps in the literature by examining the effectiveness of neurofeedback in reducing anxiety symptoms based on brain electrical activity and QEEG analysis. By employing a pre-post design with a substantial sample size and utilizing QEEG measurements, this research seeks to provide a more comprehensive understanding of the neural changes associated with neurofeedback treatment for anxiety.

Furthermore, this study focuses on the posterior regions of the brain, which have been implicated in anxiety disorders but have received less attention in neurofeedback research compared to frontal areas [5]. By investigating the effects of neurofeedback on posterior brain regions, this study may contribute to a more nuanced understanding of the neural correlates of anxiety and the potential targets for neurofeedback interventions.

In summary, this research addresses the critical need for evidence-based, non-invasive treatments for anxiety disorders. By investigating the effectiveness of neurofeedback through rigorous QEEG analysis and

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focusing on posterior brain regions, this study has the potential to advance our understanding of anxiety disorders and contribute to the development of more targeted and effective neurofeedback protocols.

2. Methods

Subjects

The study included 40 participants diagnosed with anxiety disorders. The sample consisted of adults aged 18-65 years (mean age = 34.7, SD = 9.8), among whom, there were 22 females (55%) and 18 males (45%). All participants met the diagnostic criteria for an anxiety disorder as per the DSM-5, with generalized anxiety disorder (45%), social anxiety disorder (30%), and panic disorder (25%) being the most common diagnoses.

An inclusion criterion was a primary diagnosis of an anxiety disorder without any concurrent psychotropic medication use. An exclusion criterion was represented by comorbid neurological disorders, substance use disorders, and previous neurofeedback experience.

Ethics

The research was carried out in full compliance with the ethical guidelines outlined in the Helsinki Declaration of 1975, as updated in 2000. Before the study commenced, ethical approval was obtained from the Ethics Committee of the Psychology Scientific Research Institute in Baku, Azerbaijan.

Equipment

The study utilized a clinical-grade EEG amplifier (Neuroserve, Medinateb) and a neurofeedback system (Bioline, Medinateb) for both QEEG assessments and neurofeedback training sessions. QEEG data were analyzed using specialized software (NeuroGuide and LORETA) to assess brain wave patterns.

Data analysis

Quantitative EEG recordings were conducted before and after the neurofeedback intervention. A standardized 19-channel EEG system following the International 10-20 system was used for data collection. Participants underwent 40 sessions of neurofeedback training, with each session lasting approximately 30 minutes. The neurofeedback protocol targeted specific frequency bands in posterior regions, based on individual QEEG profiles and established protocols for anxiety reduction.

3. Results

The paired samples t-test, comparing pre- and post-intervention QEEG measures, showed statistically significant difference of means within the same group of respondents which serves as evidence of substantial changes in the posterior regions of the brain.

A significant increase in alpha power (average of all posterior sites) was observed in the occipital and parietal regions ($t(39) = 4.82$, $p < .01$, $d = 4.33$). This increase in alpha activity is consistent with previous research suggesting that enhanced alpha power in posterior regions is associated with reduced anxiety and improved relaxation [5].

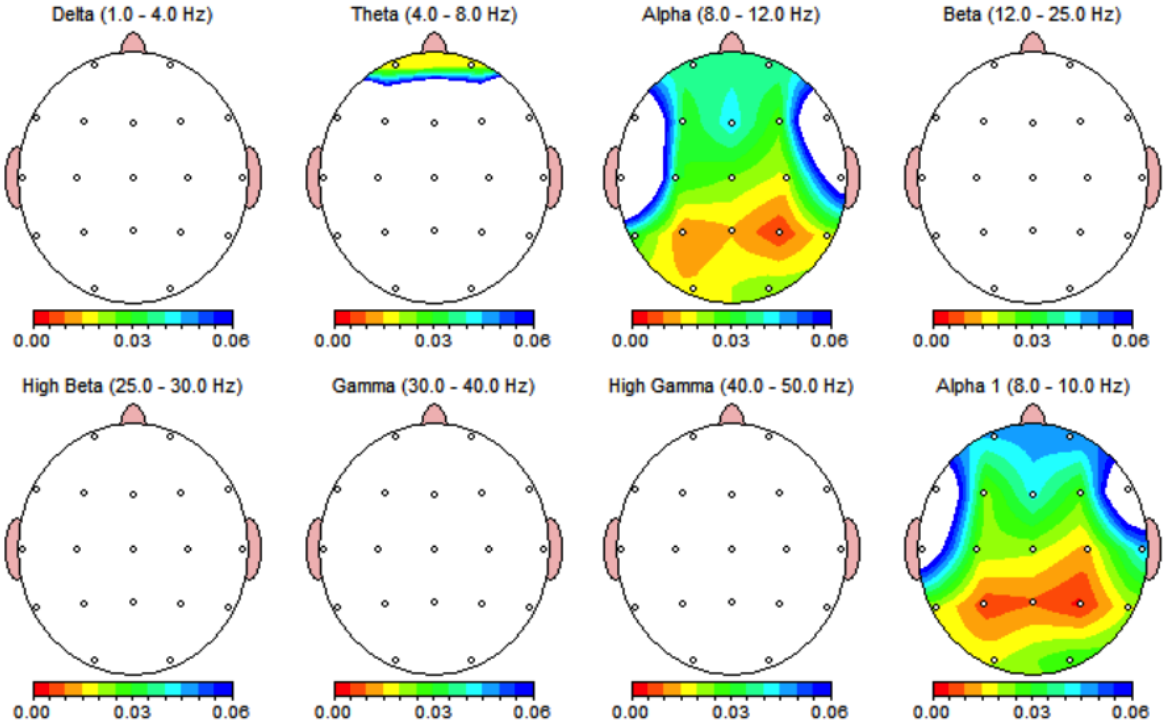

Figure 1. The color codes show the significant levels. we can see significant changes in alpha activity after treatment.

Table 1. Mean and percent differences (Pre-Post) and dependent t-test significant level

The most significant changes were observed in the alpha and high bands, with moderate changes in the theta band, suggesting that the neurofeedback protocol specifically targeted the frequency bands most relevant to anxiety reduction in posterior regions.

Loreta analysis showed that these changes are more dominant on frontal and pario-occipital regions.

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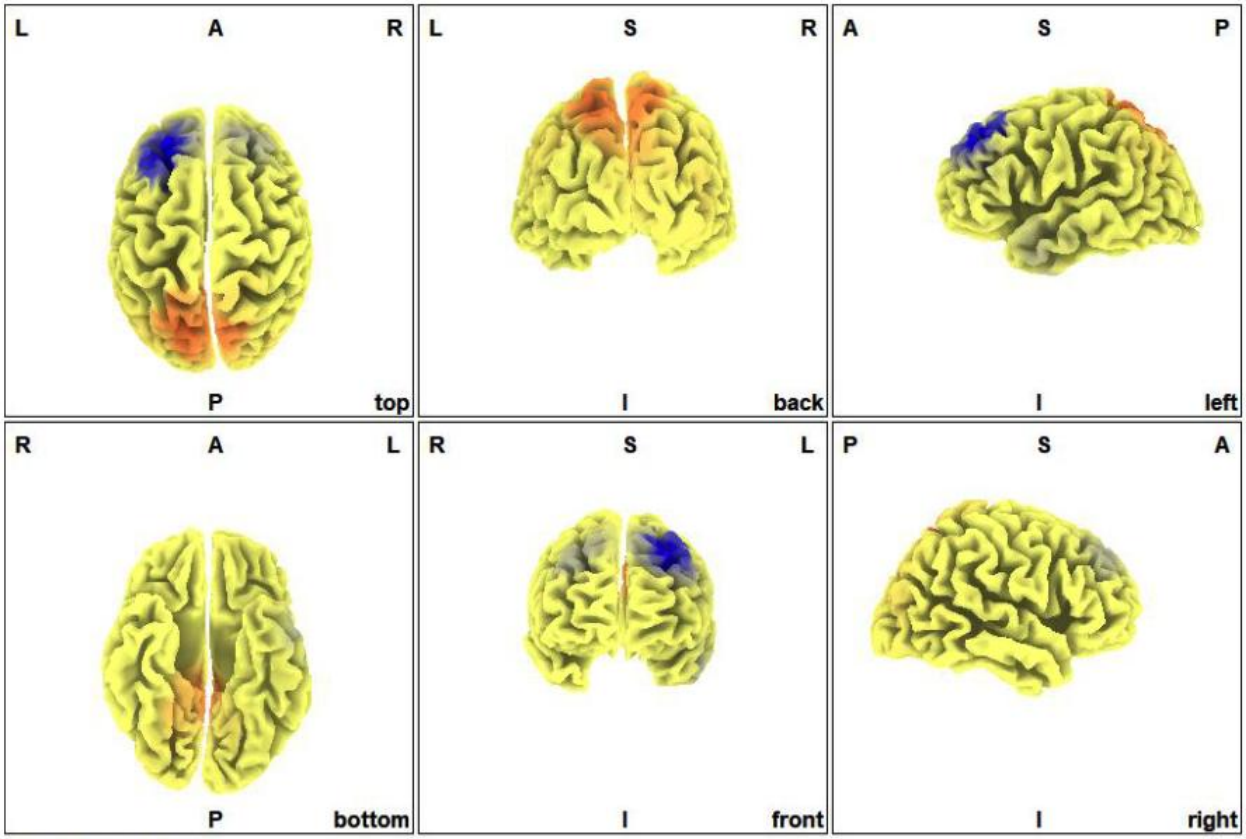

Figure 2. Loreta-Key

4. Discussion

The results of this study provide compelling evidence for the effectiveness of neurofeedback in reducing anxiety symptoms through modulation of brain electrical activity, particularly in posterior regions. The significant changes observed in QEEG patterns, specifically the increase in alpha power, decrease in high beta power, and increase in theta/beta ratio, align with theoretical models of anxiety that emphasize the role of cortical arousal and emotional regulation [7].

The strong connection between changes in QEEG patterns and reductions in anxiety symptoms support the notion that neurofeedback-induced alterations in brain activity directly reflect in clinical improvements. This finding strengthens the neurophysiological basis for neurofeedback as a treatment for anxiety disorders and provides insights into potential mechanisms of action.

The focus on posterior regions in this study highlights the importance of considering broader neural networks in anxiety disorders, beyond the traditionally emphasized frontal areas. The significant changes observed in occipital and parietal regions suggest that these areas play a crucial role in anxiety regulation and may be viable targets for neurofeedback interventions.

The individual variability in treatment response underscores the need for personalized approaches in neurofeedback therapy. Future research should aim to identify predictors of treatment response and develop tailored protocols based on individual QEEG profiles.

Limitations

However, several limitations of the study should be noted. The lack of a control group limits the ability to

definitively attribute the observed changes to the neurofeedback intervention. Future studies should employ randomized controlled designs to address this limitation. Additionally, the specific focus on posterior regions, while novel, may have overlooked important changes in other brain areas. Whole-brain analyses in future research could provide a more comprehensive understanding of the neural changes associated with neurofeedback for anxiety.

5. Conclusion

This study provides strong evidence for the efficacy of neurofeedback in reducing anxiety symptoms through modulation of brain activity in posterior regions. The findings contribute to the growing body of literature supporting neurofeedback as a viable treatment option for anxiety disorders and offer new insights into the neural mechanisms underlying its effects. Future research should build upon these results to further refine neurofeedback protocols and establish its place in the clinical treatment of anxiety disorders.

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Conflict of Interest
No conflict of interest exists for this manuscript for any of the authors.

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