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FROM BRAINWAVES TO WELLBEING: THE PAST, PRESENT, AND FUTURE OF NEUROFEEDBACK FOR ANXIETY

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Abstract: Anxiety is one of the most widespread mental health problems globally, often causing serious emotional distress and making it hard for people to function well in daily life. Although medications and therapies like CBT can be helpful, some people experience side effects, struggle to access treatment, or do not respond well. This leads to a need for other treatment options. Neurofeedback is a non-invasive method that helps people learn to control their brain activity by showing them their brainwaves ineuro real-time feedback, potentially alleviating anxiety symptoms by promoting neural self-regulation and emotional resilience. This paper explores the use of neurofeedback as a personalized intervention for anxiety, emphasizing its theoretical basis, commonly used protocols, and the relevance of brainwave patterns such as alpha and high-beta frequencies in anxiety symptomatology. It highlights the limitations of standardized neurofeedback approaches and underscores the clinical advantages of tailoring protocols using quantitative EEG (qEEG) assessments. Based on a review of global publication trends identified from the Scopus database (1974–2024), the literature shows a significant rise in research interest, largely dominated by Western countries, with a notable research gap in non-Western regions such as Southeast Asia. The paper also discusses the potential of culturally adaptable and individualized neurofeedback protocols to bridge this gap. The findings emphasize the need for more inclusive, accessible, and personalized applications of neurofeedback to improve anxiety treatment outcomes globally. Continued research and teamwork across different fields are important to create neurofeedback treatments that work well and fit different cultural contexts.

Keywords: Neurofeedback, Anxiety, Brainwave Training, Personalized Intervention

INTRODUCTION

The most common mental health problem affecting 301 million people around the world are anxiety disorders (World Health Organization, 2022). These includes generalized anxiety disorder (GAD), social anxiety disorder, panic disorder, and specific phobias. Anxiety can really affect a person's daily life, making it difficult to maintain relationships, excel in school, and experience a good quality of life. Apart from that, anxiety disorders caused economic burdens on healthcare systems, resulting in increased medical costs, lost productivity, and decreased workforce participation (Javaid et al., 2023).

Medication is the usual treatment for anxiety disorders. The usage of antidepressants such as selective serotonin reuptake inhibitors (SSRIs) and sedative such as benzodiazepines are common. Although these medications can help reduce anxiety symptoms, they often cause side effects on some individuals. The common side effects are weight gain, sexual problems, and a risk of becoming dependent on them (Bandelow et al., 2017; Farach et al., 2012). The effectiveness of medication can significantly differ among individuals, requiring numerous trials of various drugs and dosages, hence prolong the suffering of those impacted.

Therefore, increased attention has been directed toward non-pharmacological interventions that offer effective, side-effect-free alternatives to medication. Cognitive-behavioral therapy (CBT) is acknowledged as the golden standard in psychological treatment for anxiety disorders. It aims to modify maladaptive thought patterns and behaviors (David et al., 2018). Meta-analyses revealed that CBT can reduce anxiety and improve a person daily life functions (Hofmann et al., 2012; Olatunji et al., 2010; Öst et al., 2023). However, challenges such as limited access to therapist, time commitment, and variability in individual response may reduce its overall effectiveness (Axelsson & Hedman-Lagerlöf, 2023; Wolitzky-Taylor et al., 2018).

Besides CBT, other evidence-based treatments also have shown promise in reducing anxiety symptoms such as mindfulness therapy (Ellison et al., 2024; Hofmann & Gómez, 2017; Khoury et al., 2013), exposure therapy (Parker et al., 2018; Racz et al., 2024), and relaxation techniques (Hamdani et al., 2022; Muhammad Khir et al., 2024; Toussaint et al., 2021). Each approach contributes to improving emotional regulation and reducing stress. Mindfulness-based stress reduction (MBSR) and mindfulness-based cognitive

therapy (MBCT) are among popular methods that have been widely researched. Studies show both able to reduce anxiety and improve emotional control (Ellison et al., 2024; Hofmann & Gómez, 2017; Khoury et al., 2013). On the other hand, exposure therapy has proven effective in treating specific anxiety disorders, such as phobias and social anxiety disorder (Parker et al., 2018; Racz et al., 2024). Exposure therapy involves gradual, systematic exposure to anxiety-provoking stimuli, assisting individuals desensitize to triggers and reduce their fear response. Relaxation methods such like progressive muscle relaxation and breathing exercises also have been found to lower anxiety by triggering the body's natural calming response, in turn helps reduce the physical symptoms of anxiety (Hamdani et al., 2022; Muhammad Khir et al., 2024; Toussaint et al., 2021). These alternative approaches offer evidence-based options for individuals seeking non-pharmacological methods for managing anxiety.

Traditional non-pharmacological treatments do not always provide sufficient relief for every individual experiencing anxiety. As a result, researchers have increasingly explored innovative strategies to address these unmet needs. One such approach is neurofeedback, which allows individuals to learn how to regulate their own brain activity using real-time feedback. By focusing on the brain's natural capacity for change. Neurofeedback helps individuals reshape brainwave patterns that are linked to anxiety. Over time, this can foster greater self-regulation and support the development of calmer, more adaptive mental states, particularly in those who have not responded well to standard treatments (Jubair, 2024; Krause et al., 2024; Wider et al., 2024).

Even though neurofeedback shows promise, research faces challenges such as small sample sizes, varied methods, and issues like the placebo effect, which can complicate the interpretation of its benefits. Hence, this review focuses on emerging research and potential future directions in the use of neurofeedback for treating anxiety. This review paper explores recent studies, key findings, and gaps in the research, providing an overview of current progress and suggesting directions for future studies and practice.

While neurofeedback shows significant potential, there is a continued need to further explore and refine individualized protocols tailored to individuals' specific needs in managing anxiety. Personalized neurofeedback protocols may offer a more precise and effective approach to reducing anxiety

symptoms by taking into account the complexities of anxiety disorders and the individual differences in response to treatment. Hence, the objective of this paper is to explore the potential of neurofeedback as a personalized intervention for anxiety by examining its theoretical foundations, commonly applied protocols, and emerging technological innovations. The paper also reviews global publication trends to highlight geographic research gaps and emphasizes the importance of culturally sensitive applications. By synthesizing current evidence and identifying limitations in standardized approaches, this review aims to inform more adaptive, inclusive, and effective neurofeedback strategies for clinical practice and future research.

Neurofeedback: Concept and General Application in Anxiety Disorders

Neurofeedback is founded on the principle of neuroplasticity, which refers to the brain's capacity to adapt and form new connections through learning and experience. This innovative therapy aims to train individuals to achieve healthier patterns of brain activity by providing real-time feedback on their brainwave states. By guiding individuals to shift from dysregulated brainwave patterns commonly associated with anxiety to more stable and adaptive states, neurofeedback has shown promise in alleviating anxiety symptoms (Hammond, 2011a; Holnthaner, 2008; Liu et al., 2022).

Despite the potential benefits of neurofeedback, the protocols can vary among practitioners. Many neurofeedback interventions still tend to rely on established protocols that may not fully account for the variability in symptom profiles, neurobiological underpinnings, and individual responsiveness to these interventions (Hasslinger et al., 2022). This general approach may limit the overall effectiveness of neurofeedback for certain individuals, as it may not address the unique brain patterns and experiences that characterize their anxiety. A one-size-fits-all approach does not adequately address the unique brain patterns, personal histories, and specific symptoms that can strongly influence treatment outcomes (Mayer et al., 2012).

As such, while neurofeedback can offer significant improvements in anxiety symptomatology, the reliance on more standardized protocols may restrict its efficacy and broader applicability. Recognizing these limitations underscores the importance of developing personalized neurofeedback interventions tailored to individual needs, which can ultimately enhance treatment outcomes and patient satisfaction.

The aim of this paper is to explore how neurofeedback can be used as a personalized treatment for anxiety. It examines how neurofeedback works, the common protocols used, and how these protocols can be improved by adjusting them to individual brain activity patterns. The paper also discusses current trends in global research, especially the lack of studies in Asian contexts, and highlights new technologies that can make neurofeedback more effective and accessible. This review hopes to provide useful insights for researchers and mental health professionals who are interested in applying neurofeedback in more practical and personalized ways

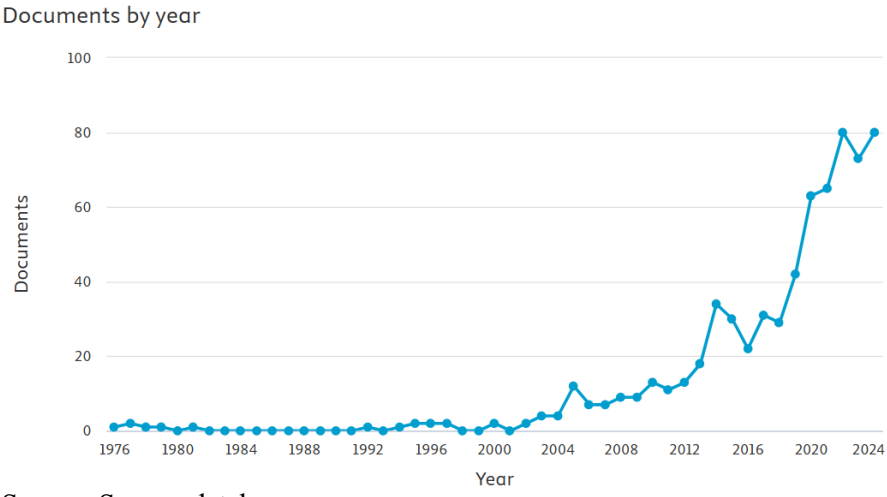
Research Trends in Neurofeedback and Anxiety

To gain insight into global research activity on neurofeedback for anxiety, a literature search was carried out using the Scopus database. Scopus was chosen because to its large coverage, data reliability, and widespread use in academic research. Scopus ranks among the most widely used and trusted abstract and citation databases, covering peer-reviewed journals, conference proceedings, and books. According to Baas et al.(2020), an independent Content Selection and Advisory Board carefully selects high-quality scholarly materials. Scopus has better article coverage and bibliometric features including advanced search tools and APIs than Web of Science and PubMed. Scopus has 84% of WoS titles, although only half of Scopus-indexed papers are in WoS, demonstrating its larger reach (Garrido-Cardenas et al., 2020). According to Dinić and Jevremov (2021), Scopus provides more precise and controlled publishing quality than open platforms like Google Scholar. It provides a solid platform for accurate and scalable bibliometric analysis in psychological and neuroscientific research (Mongeon & Paul-Hus, 2016).

The search was limited to documents published between 1974 and 2024, to capture the historical development and contemporary advancements in the field. The Boolean search term ("neurofeedback" OR "neurotherapy" OR "EEG biofeedback" OR "neurobiofeedback" OR "brainwave training" OR "neurofeedback training") AND ("anxiety" OR "anxiety disorder" OR "generalized anxiety disorder" OR "GAD" OR "social anxiety" OR "panic disorder" OR "phobia" OR "anxious symptoms") was filtered for English-language content. This search yielded 674 documents.

An analysis of publication trends from 1976 to 2024 using Scopus-indexed documents shows a clear upward trajectory in academic interest surrounding neurofeedback and anxiety. In the earlier decades, research output was minimal, with fewer than five publications annually before the mid-1990s. A gradual increase began in the early 2000s, followed by more substantial growth from 2010 onwards. This rise coincides with increasing interest in non-invasive neurotherapies, growing evidence on neuroplasticity, and technological advancements in neurofeedback tools. Figure 1 demonstrates a steady rise in academic output over the past two decades, with a notable increase from 2018 to 2023. This pattern likely reflects the growing recognition of neurofeedback as a viable intervention for anxiety-related conditions, especially amid heightened global awareness of mental health during the COVID-19 pandemic.

Figure 1: Number of Scopus-Indexed Publications Related to Neurofeedback and Anxiety (1976–2024)



Source: Scopus database

A breakdown of the 674 studies included in this review shows that most articles addressed anxiety in general terms. Smaller proportions focused on generalized anxiety disorder (GAD), social anxiety, panic disorder, PTSD, or

phobia. Neurofeedback was most often delivered as a standalone intervention, with a minority of studies combining it with CBT, medication, or other treatments. Out of 674 articles, 92 articles specifically mentioned symptom reduction or effect size, generally indicating moderate to large improvements in anxiety symptoms (Table 1). This summary provides a clear picture on the diversity and methodological scope of research included in the review.

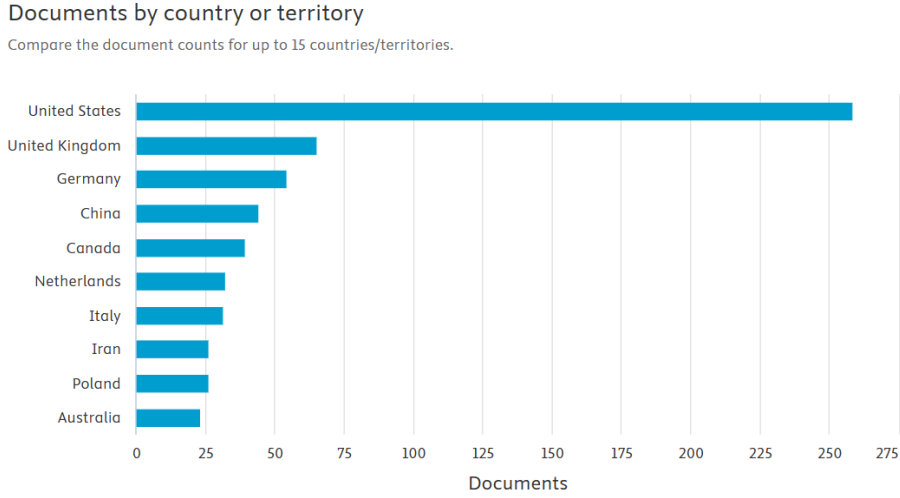
Table 1

Distribution of Studies by Anxiety Subtype and Intervention

Anxiety Subtype	Intervention		Total (n)
	Neurofeedback Only (n)	Neurofeedback + Other (n)	
GAD	19	9	28
Social Anxiety	29	2	31
Panic Disorder	11	2	13
PTSD	47	11	58
Phobia	15	2	17
Not Classified	440	87	527

Figure 2 shows country-specific publishing distribution. Most studies originate from Western countries, with the United States, United Kingdom, and Germany contributing the most. Among non-Western countries, China is the only Asian nation appearing in the top 10. This regional imbalance indicating a significant research gap in non-Western regions. This pattern indicates that there is a priority to broaden the scope of study on neurofeedback in non-Western environments. The necessity of conducting research on neurofeedback interventions throughout a variety of cultures is highlighted by the fact that there are cultural disparities in the expression of anxiety, accessibility of treatment, and neurocognitive processing (Hofmann et al., 2010) Personalised neurofeedback (Jubair, 2024; Wider et al., 2024) has the potential to be an effective and culturally appropriate therapeutic for places such as Asia, where anxiety disorders are common yet frequently go undiagnosed or untreated (Zhang et al., 2019).

Figure 2: Country-Wise Distribution of Scopus-Indexed Publications on Neurofeedback and Anxiety



Source: Scopus Database

Overview of Neurofeedback Mechanisms in Anxiety Intervention

Through real-time monitoring and feedback, neurofeedback is a biofeedback technique that enables individuals to self-regulate their brainwave activity, facilitating changes in emotional and cognitive states (Arns et al., 2016; Gruzelier et al., 2006; Marzbani et al., 2016b; Sherlin et al., 2011). With roots in operant conditioning, neurofeedback provides individuals with immediate feedback on their brain activity patterns, enabling them to adjust these patterns to achieve desired mental states, such as relaxation or concentration (Hammond, 2005a). Neurofeedback is also associated with its capacity to induce neuroplastic changes. Neuroplasticity is the brain's capacity to reshape itself by creating new neural pathways, which can be particularly useful in reducing anxiety symptoms as it allows the brain to "retrain" its response to stressful stimuli (Aday & Carlson, 2017; Månsson et al., 2016). Neurofeedback facilitates neuroplasticity by repeatedly guiding the brain toward desired states, reinforcing adaptive brainwave patterns while suppressing maladaptive ones. With consistent training, these reinforced responses can result in long-term changes in brain function due to neuroplasticity, supporting improvements in emotional and cognitive

regulation. Studies demonstrate that neurofeedback can lead to long-term reductions in anxiety by promoting stable changes in brainwave activity. For example, a study by Hammond (2005) found that patients who completed neurofeedback training not only showed immediate symptom reduction but also maintained improvements in anxiety symptoms in follow-up assessments. Similarly, Escolano and colleagues (2014) found that EEG-individualized alpha training led to significant improvements in anxiety and compliance, emphasizing the role of alpha waves in emotional regulation.

Brainwave Patterns Associated with Anxiety

Brainwaves are electrical signals produced by activity in the brain, reflecting different mental states and levels of consciousness. They are categorized by frequency, measured in Hertz (Hz), and are commonly divided into five main types: delta, theta, alpha, beta, and gamma. Each type corresponds to a unique state of mind and cognitive function (Demos, 2005; Evans, 2007). Delta waves (0.5–4 Hz), the slowest, occur during deep sleep and are linked to repair and recovery processes. Theta waves (4–8 Hz) are seen in light sleep, daydreaming, and creativity, and help in memory processing. Alpha waves (8–12 Hz) appear in relaxed yet awake states, such as during meditation, promoting stress relief and calmness. Beta waves (13–30 Hz) are linked to concentration, mental activity, and decision-making, and focus but, in excess, can increase anxiety and stress. Finally, Gamma waves (30–100 Hz), the fastest, support cognitive tasks like information processing, learning, and memory integration, especially during complex problem-solving. These waves collectively illustrate the brain's state from deep relaxation to heightened alertness.

In neurofeedback intervention for anxiety, understanding the relationship between specific brainwave patterns and anxiety is essential. Studies have shown that individuals with anxiety disorders tend to exhibit heightened high-beta activity, associated with excessive cognitive arousal and hypervigilance, and reduced alpha activity, which is typically linked to relaxation and calmness (Abhang et al., 2016; Hou et al., 2021a; Russo et al., 2022). Alpha waves are associated with relaxation, creativity, and a sense of calm. Many neurofeedback protocols for anxiety focus on increasing alpha activity in the brain, as studies have shown that enhancing alpha waves can help reduce anxiety symptoms and promote a state of relaxation (Marzbani et al., 2016a;

Price & Budzynski, 2009; Zoefel et al., 2011). Theta waves are associated with deeply relaxed, meditative states and are often targeted in neurofeedback protocols aimed at reducing anxiety by promoting introspection and emotional processing (Hammond, 2005; Moore, 2000). Sensorimotor Rhythm (SMR) training, which enhances brain activity in the 12–15 Hz frequency band, has been shown to support emotional stability and cognitive control. Inattention is a common cognitive manifestation in individuals with anxiety, and SMR activity has been closely associated with attentional processes (Blaskovits et al., 2017). It is proposed that enhancing SMR activity, which is associated with attention, may help reduce symptoms of anxiety. Recent studies also suggest that SMR neurofeedback not only reduces hyperarousal but also facilitates a calm, alert state that is ideal for managing anxiety symptoms (Gadea et al., 2020; Kavianipoor et al., 2023; Liu et al., 2022). Modulating these brainwave patterns through neurofeedback can help reduce anxiety by promoting a shift from high arousal states to more balanced and regulated brainwave activity.

Changes in these brainwave patterns through neurofeedback may help reduce anxiety by encouraging a more balanced and regulated brain state. However, in real-world practice, the choice of which protocol to use is not determined by brainwave theory alone. The selection of neurofeedback protocol usually depends on the individual's symptoms, their EEG patterns, and the goals of treatment (Hammond, 2010a, 2011b) Practitioners may also consider factors such as the presence of co-occurring conditions (e.g., ADHD), previous response to other treatments, and client preference. In some cases, neurofeedback is combined with approaches like CBT or relaxation training to improve overall results (Marzbani et al., 2016a; Micoulaud-Franchi et al., 2021a). This individualized selection process helps ensure that the neurofeedback intervention matches the client's unique clinical profile.

Neurofeedback Protocols for Anxiety

Several neurofeedback protocols are widely used to address anxiety by modulating these brainwave patterns. Common approaches include Alpha/Theta Training, Beta Down-Training and SMR Training, each tailored to specific brainwave frequencies and intended outcomes. Alpha-theta training involves increasing alpha and theta wave activity to achieve a calm, meditative state, which helps reduce anxiety symptoms. Research indicates that alpha-

theta neurofeedback may help individuals with generalized anxiety disorder (GAD) and post-traumatic stress disorder (PTSD) by reducing symptoms and promoting relaxation and enhancing emotional regulation(Hammond, 2005b; Lotnia et al., 2023; Moore, 2000; Nicholson et al., 2020). This protocol often involves training the brain to decrease high-beta activity, which is linked to hyper-arousal, while promoting alpha waves associated with a relaxed state. Since anxiety is often characterized by high levels of beta activity, especially in the high-beta range (18–30 Hz), Beta down-training protocols focus on reducing beta waves in the prefrontal cortex. This approach has been shown to reduce symptoms of worry, hypervigilance, and overthinking, as found in studies examining generalized anxiety disorder and in some cases depressive disorder (Aristizabal et al., 2024; Chen & Lin, 2020; S.-Y. Wang et al., 2019). Sensorimotor Rhythm (SMR) training targets the sensory motor rhythm, a frequency band associated with calmness and relaxation, usually in the range of 12-15 Hz. Increasing SMR has been linked to a reduction in anxiety symptoms, as well as improved focus and emotional stability, which can help individuals cope with stress and anxious thoughts (Gadea et al., 2020; Liu et al., 2022). These protocols typically aim to reduce excessive beta activity, which is associated with heightened stress and anxiety. Given that anxiety disorders are often characterized by dysregulated brainwave patterns, neurofeedback has been identified as a promising non-invasive intervention for reducing anxiety symptoms (Chen & Lin, 2020; Micoulaud-Franchi et al., 2021b).

Toward Personalized Neurofeedback: Clinical Relevance and Applications

In this paper, the term “personalized neurofeedback” is used to describe protocols that are adapted to the unique clinical and neurophysiological characteristics of each individual, in contrast to a standardized, one-size-fits-all approach. While neurofeedback has demonstrated therapeutic potential in reducing anxiety symptoms, a growing body of literature emphasizes the need to move beyond generalized protocols toward more personalized approaches. Anxiety disorders vary widely in symptom expression, neurophysiological profiles, and comorbid conditions, making a “one-size-fits-all” intervention approach insufficient. For example, people with generalized anxiety disorder (GAD) often show high levels of fast beta brainwave activity in the prefrontal cortex, whereas those with social anxiety disorder (SAD) may display uneven

alpha wave patterns in the frontal areas or increased activity on the right side of the brain (Baehr et al., 1999; Harrewijn et al., 2016; Qi et al., 2023; J. Wang et al., 2022). Applying the same neurofeedback protocol across such diverse presentations may not only be ineffective but may also lead to limited engagement or poorer long-term outcomes.

The personalization of neurofeedback is typically guided by quantitative electroencephalogram (qEEG) mapping, which enables clinicians to identify an individual's unique brainwave patterns and select protocols that address their specific dysregulations. For example, individuals with reduced alpha activity are commonly associated with poor relaxation and elevated tension, which may benefit from alpha enhancement protocols, while those with excessive high-beta activity may require beta down-training (Escolano et al., 2014; Mayer et al., 2012). This individualized matching of neurophysiological markers to training protocols reflects a broader trend in mental health care toward precision interventions, where treatments are tailored to the client's biological and psychological profile.

Clinical evidence supports the efficacy of personalized neurofeedback protocols (Garcia Pimenta et al., 2021; Mutang et al., 2021). Research by Hou et al. (2021a); Kerson et al. (2009); and Mennella et al. (2017) demonstrated that individualized alpha training was associated with greater reductions in anxiety symptoms compared to standardized treatments. Likewise, Dreis et al. (2004); Gregory et al. (2020); and Simos & Hofmann (2013) found that participants who received qEEG-guided interventions experienced more robust and sustained symptom relief. These findings suggest that individualized neurofeedback can not only enhance clinical outcomes but may also shorten treatment duration and improve patient adherence due to its relevance to the patient's lived experience.

Personalized neurofeedback also offers a promising avenue for increasing treatment inclusivity across cultural contexts. In Southeast Asia, for example, anxiety disorders may be underreported due to stigma or may manifest through somatic symptoms rather than overt psychological complaints (Dessauvagie et al., 2022; Sitaram et al., 2016; Vaishnav et al., 2023). By grounding intervention in the individual's neural activity rather than self-reported distress alone, neurofeedback provides a culturally flexible tool for diagnosis and treatment. Moreover, as clinicians in the region increasingly adopt bio-psycho-social models of care, neurofeedback's capacity to deliver

objective, data-driven insights align with the move toward integrated and personalized mental health services. In addition to these considerations, cultural beliefs and attitudes can significantly affect how clients perceive, engage with, and respond to neurofeedback interventions. Culture may influence not only the willingness to seek help, but also neurophysiological responses such as self-processing, emotion regulation, and stress perception (Hofmann et al., 2010; A. Ryder et al., 2008). To enhance client engagement and treatment effectiveness, neurofeedback protocols can be tailored to reflect the client's cultural context. For example, clinicians may use culturally familiar relaxation cues, language, or metaphors during feedback, and address specific cultural expressions of distress (A. G. Ryder & Chentsova-Dutton, 2014). Working collaboratively with clients to recognize and respect their cultural values throughout treatment planning can help reduce barriers, build trust, and make neurofeedback more accessible and acceptable. These culturally sensitive adaptations are particularly important in regions where mental health stigma is high and where anxiety often presents with physical symptoms.

In summary, moving toward a personalized neurofeedback framework not only addresses the neurobiological heterogeneity of anxiety disorders but also meets the clinical demand for more efficient, client-centered interventions. The next frontier in neurofeedback research should focus on developing standardized protocols for personalization, expanding qEEG accessibility, and validating individualized treatments across diverse populations to ensure equitable and effective outcomes.

Clinical Feasibility of Personalized Neurofeedback

Despite its promising theoretical and clinical advantages, personalized neurofeedback is not without implementation challenges. A key concern is the accessibility of qEEG assessments, which require specialized equipment and trained professionals for data acquisition and interpretation. In many clinical settings, especially those in low-resource or rural environments, such resources may be limited. This can restrict access to personalized protocols (Arns, 2012; Arns & Lyle, 2011). Additionally, there is a need for clinician training programs that emphasize protocol adjustment based on real-time patient responsiveness, rather than rigid adherence to pre-defined session templates (Hammond, 2010b; Hasslinger et al., 2022).

Nevertheless, developments in portable EEG systems, cloud-based data analysis, and AI-assisted neurofeedback platforms are beginning to reduce these barriers (Plotnikov et al., 2019; Ponce et al., 2022; Sitaram et al., 2017). These technologies allow for more flexible treatment models, including hybrid clinic-home setups and mobile monitoring. In Asia, such innovations could be particularly transformative, offering culturally relevant and accessible tools to reach populations where mental health infrastructure is still developing. As adoption increases, there is also an opportunity to establish regionally validated neurofeedback norms, improving diagnostic sensitivity and the ecological validity of treatments for anxiety in non-Western contexts.

DISCUSSION

The findings from this review reaffirm the increasing recognition of neurofeedback as a relevant psychological tool for anxiety treatment. Current evidence suggests that neurofeedback is associated with meaningful reductions in anxiety symptoms by targeting dysregulated brainwave patterns, especially through protocols such as alpha-theta training, beta down-training, and SMR training (Hammond, 2010a; Liu et al., 2022). The growing body of literature also supports the shift toward personalized neurofeedback guided by qEEG mapping, which allows clinicians to tailor protocols to individual neurophysiological profiles (Escolano et al., 2014; Hou et al., 2021a). Despite these advances, challenges remain. The accessibility of equipment, the need for standardized training, and the predominance of Western research limit the global implementation of neurofeedback. However, technological innovations like portable EEG and AI-enhanced systems offer promising solutions. Furthermore, as highlighted in recent publications, there is a clear research gap in non-Western countries where culturally adapted interventions are urgently needed (Hou et al., 2021b; Wider et al., 2024).

LIMITATIONS AND RECOMMENDATIONS

This review has a few limitations that should be noted. First, the paper uses a narrative review approach, not a systematic one. This means that some important studies might have been missed, and the results may not cover all available evidence. Second, the analysis of publication trends was based only on the Scopus database, which may not include all studies from certain

regions, especially where other indexing platforms are more common. Also, the studies reviewed used different designs, sample groups, and neurofeedback protocols, which makes it harder to draw general conclusions.

To improve future research, future reviews should broaden literature coverage by combining multiple databases, such as Google Scholar, Web of Science, PubMed, PsycINFO, and relevant indexes, to capture all relevant studies more fully. Besides that, more structured studies like randomized controlled trials and meta-analyses are recommended. These would help better measure how effective personalized neurofeedback is for anxiety. It is also important to include participants from different backgrounds, especially from non-Western countries, so that findings can be applied more widely. Researchers, mental health professionals, and technology experts should work together to develop clear guidelines, better training, and easier-to-use tools. Making neurofeedback tools more available through open-access data and flexible, hybrid models could help people in areas with fewer mental health services.

CONCLUSION

This review highlights how neurofeedback is gaining recognition as a useful, non-invasive option for anxiety management. It looked at how brainwave activity relates to anxiety and reviewed different neurofeedback protocols, emphasizing the value of tailoring treatment to each person's brain pattern. The analysis of publication trends also showed a strong research focus in Western countries, pointing to the need for more studies in Asian and other underrepresented regions.

Informed Consent Statement
Not applicable.

Conflict of Interest
The researcher declares no conflict of interest.

Ethics Statement
Not applicable.

Author Contributions

The first author conceptualized and drafted the manuscript. The second author provided critical revisions and expert guidance. Both authors approved the final version of the manuscript.

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Data Availability Statement
No new data were created or analyzed in this study. Data sharing is not applicable to this article.

REFERENCES

Abhang, P. A., Gawali, B. W., & Mehrotra, S. C. (2016). Chapter 3 - Technical Aspects of Brain Rhythms and Speech Parameters. In P. A. Abhang, B. W. Gawali, & S. C. Mehrotra (Eds.), *Introduction to EEG- and Speech-Based Emotion Recognition* (pp. 51–79). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-804490-2.00003-8

Aday, J., & Carlson, J. M. (2017). Structural MRI-based measures of neuroplasticity in an extended amygdala network as a target for attention bias modification treatment outcome. *Medical Hypotheses*, *109*, 6–16. https://doi.org/10.1016/j.mehy.2017.09.002

Aristizabal, J. P., Pereira, A., Gomes, B. D., Goulart, P. R. K., de Souza, W. C., & Rocha, F. A. (2024). Neurofeedback Beta Down Training in Women With High State-Trait Anxiety and Elevated Beta Patterns in Temporal Lobes: A Pilot Study. *NeuroRegulation*, *11*(3), 284–295. https://doi.org/10.15540/nr.11.3.284

Arns, M. (2012). EEG-Based Personalized Medicine in ADHD: Individual Alpha Peak Frequency as an Endophenotype Associated with Nonresponse. *Journal of Neurotherapy*, *16*(2), 123–141. https://doi.org/10.1080/10874208.2012.677664

Arns, M., Batail, J.-M., Bioulac, S., Congedo, M., Daudet, C., Drapier, D.,

Fovet, T., Jardri, R., Le-Van-Quyen, M., Lotte, F., Mehler, D., Micoulaud-Franchi, J.-A., Purper-Ouakil, D., & Vialatte, F. (2016). Neurofeedback: One of today's techniques in psychiatry? *L'Encéphale*, *December*. https://doi.org/10.1016/j.encep.2016.11.003

Arns, M., & Lyle, R. R. (2011). Neurofeedback and QEEG: The Space-Race. *Journal of Neurotherapy*, *15*(4), 289–291. https://doi.org/10.1080/10874208.2011.623088

Axelsson, E., & Hedman-Lagerlöf, E. (2023). Unwanted outcomes in cognitive behavior therapy for pathological health anxiety: a systematic review and a secondary original study of two randomized controlled trials. *Expert Review of Pharmacoeconomics \& Outcomes Research*, *23*(9), 1001–1015. https://doi.org/10.1080/14737167.2023.2250915

Baas, J., Schotten, M., Plume, A., Côté, G., & Karimi, R. (2020). Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies. *Quantitative Science Studies*, *1*(1), 377–386. https://doi.org/10.1162/qss_a_00019

Baehr, E., Rosenfeld, J. P., Baehr, R., & Earnest, C. (1999). Clinical Use of an Alpha Asymmetry Neurofeedback Protocol in the Treatment of Mood Disorders. *Introduction to Quantitative EEG and Neurofeedback*, *January 2015*, 181–201. https://doi.org/10.1016/b978-012243790-8/50009-2

Bandelow, B., Michaelis, S., & Wedekind, D. (2017). Treatment of anxiety disorders. *Dialogues in Clinical Neuroscience*, *19*(2), 93–106. https://doi.org/10.1007/978-3-642-40308-8_2

Blaskovits, F., Tyerman, J., & Luctkar-Flude, M. (2017). Effectiveness of neurofeedback therapy for anxiety and stress in adults living with a chronic illness. *JBI Database of Systematic Reviews and Implementation Reports*, *15*(7), 1765–1769. https://doi.org/10.11124/JBISRIR-2016-003118

Chen, T.-C., & Lin, I.-M. (2020). The learning effects and curves during high beta down-training neurofeedback for patients with major depressive disorder. *Journal of Affective Disorders*, *266*, 235–242. https://doi.org/10.1016/j.jad.2020.01.175

David, D., Cristea, I., & Hofmann, S. G. (2018). Why cognitive behavioral therapy is the current gold standard of psychotherapy. *Frontiers in Psychiatry*, *9*(JAN), 6–8. https://doi.org/10.3389/fpsyt.2018.00004

Demos, J. N. (2005). *Getting Started with Neurofeedback*. W.W Norton & Company.

Dessauvagie, A. S., Dang, H. M., Nguyen, T. A. T., & Groen, G. (2022). Mental Health of University Students in Southeastern Asia: A Systematic Review. *Asia-Pacific Journal of Public Health*, *34*(2–3), 172–181. https://doi.org/10.1177/10105395211055545

Dinić, B., & Jevremov, T. (2021). Trends in research related to the Dark Triad: A bibliometric analysis. *Current Psychology*, *40*. https://doi.org/10.1007/s12144-019-00250-9

Dreis, S. M., Gouger, A. M., Perez, E. G., Russo, G. M., Fitzsimmons, M. A., & Jones, M. S. (2004). Using Neurofeedback to Lower Anxiety Symptoms Using Individualized qEEG Protocols: A Pilot Study. *Journal of Dance Medicine and Science*, *8*(3), 78–81. https://doi.org/10.15540/nr.2.3.137

Ellison, O. K., Bullard, L. E., Lee, G. K., Vazou, S., Pfeiffer, K. A., Baez, S. E., & Pontifex, M. B. (2024). Examining efficacy and potential mechanisms of mindfulness-based cognitive therapy for anxiety and stress reduction among college students in a cluster-randomized controlled trial. *International Journal of Clinical and Health Psychology*, *24*(4), 100514. https://doi.org/https://doi.org/10.1016/j.ijchp.2024.100514

Escolano, C., Navarro-Gil, M., Garcia-Campayo, J., Congedo, M., De Ridder, D., & Minguez, J. (2014). A controlled study on the cognitive effect of alpha neurofeedback training in patients with major depressive disorder. *Frontiers in Behavioral Neuroscience*, *8*, 296. https://doi.org/10.3389/fnbeh.2014.00296

Evans, J. R. (2007). *Handbook of Neurofeedback: Dynamics and Clinical Applications*. The Haworth Medical Press.

Farach, F. J., Pruitt, L. D., Jun, J. J., Jerud, A. B., Zoellner, L. A., & Roy-Byrne, P. P. (2012). Pharmacological Treatment of Anxiety Disorders: Current Treatments and Future Directions. *Journal of Anxiety Disorders*, *26*(8), 833–843. https://doi.org/10.1016/j.janxdis.2012.07.009

Gadea, M., Aliño, M., Hidalgo, V., Espert, R., & Salvador, A. (2020). Effects of a single session of SMR neurofeedback training on anxiety and cortisol levels. *Neurophysiologie Clinique*, *50*(3), 167–173. https://doi.org/https://doi.org/10.1016/j.neucli.2020.03.001

Garcia Pimenta, M., Brown, T., Arns, M., & Enriquez-Geppert, S. (2021). Treatment Efficacy and Clinical Effectiveness of EEG Neurofeedback as a Personalized and Multimodal Treatment in ADHD: A Critical Review. *Neuropsychiatric Disease and Treatment*, *17*, 637–648. https://doi.org/10.2147/NDT.S251547

Garrido-Cardenas, J. A., de Lamo-Sevilla, C., Cabezas-Fernández, M. T., Manzano-Agugliaro, F., & Martínez-Lirola, M. (2020). Global tuberculosis research and its future prospects. *Tuberculosis (Edinburgh, Scotland)*, *121*, 101917. https://doi.org/10.1016/j.tube.2020.101917

Gregory, J. C., Romero, D. E., & Jones, M. S. (2020). Predictors of neurofeedback outcomes following qeeg individualized protocols for anxiety. *NeuroRegulation*, *7*(1), 18–25. https://doi.org/10.15540/nr.7.1.18

Gruzelier, J., Egner, T., & Vernon, D. (2006). Chapter 27 Validating the efficacy of neurofeedback for optimising performance. *Progress in Brain Research*, *159*, 421–431. https://doi.org/10.1016/S0079-6123(06)59027-2

Hamdani, S. U., Zill-e-Huma, Zafar, S. W., Suleman, N., Um-ul-Baneen, Waqas, A., & Rahman, A. (2022). Effectiveness of relaxation techniques 'as an active ingredient of psychological interventions' to reduce distress, anxiety and depression in adolescents: a systematic review and meta-analysis. *International Journal of Mental Health Systems*, *16*(1), 31. https://doi.org/10.1186/s13033-022-00541-y

Hammond, D. C. (2005a). Neurofeedback Treatment of Depression and Anxiety. *Journal of Adult Development*, *12*(2/3), 131–137. https://doi.org/10.1007/s10804-005-7029-5

Hammond, D. C. (2005b). Neurofeedback with Anxiety and Affective Disorders. In *Child and Adolescent Psychiatric Clinics of North America* (Vol. 14, pp. 105–123). https://doi.org/10.1016/j.chc.2004.07.008

Hammond, D. C. (2010a). The need for individualization in neurofeedback: Heterogeneity in QEEG patterns associated with diagnoses and symptoms. *Applied Psychophysiology Biofeedback*, *35*(1), 31–36. https://doi.org/10.1007/s10484-009-9106-1

Hammond, D. C. (2010b). The Need for Individualization in Neurofeedback: Heterogeneity in QEEG Patterns Associated with Diagnoses and Symptoms. *Applied Psychophysiology and Biofeedback*, *35*(1), 31–36. https://doi.org/10.1007/s10484-009-9106-1

Hammond, D. C. (2011a). What is Neurofeedback: An Update. *Journal of Neurotherapy*, *15*(4), 305–336. https://doi.org/10.1080/10874208.2011.623090

Harrewijn, A., Van der Molen, M. J. W., & Westenberg, P. M. (2016). Putative EEG measures of social anxiety: Comparing frontal alpha asymmetry and delta–beta cross-frequency correlation. *Cognitive,*

Affective and Behavioral Neuroscience, *16*(6), 1086–1098. https://doi.org/10.3758/s13415-016-0455-y

Hasslinger, J., Meregalli, M., & Bölte, S. (2022). How standardized are "standard protocols"? Variations in protocol and performance evaluation for slow cortical potential neurofeedback: A systematic review. In *Frontiers in human neuroscience* (Vol. 16, p. 887504). https://doi.org/10.3389/fnhum.2022.887504

Hofmann, S. G., Anu Asnaani, M. A., & Hinton, D. E. (2010). Cultural aspects in social anxiety and social anxiety disorder. *Depression and Anxiety*, *27*(12), 1117–1127. https://doi.org/https://doi.org/10.1002/da.20759

Hofmann, S. G., Asnaani, A., Vonk, I. J. J., Sawyer, A. T., & Fang, A. (2012). The Efficacy of Cognitive Behavioral Therapy: A Review of Meta-analyses. *Cognitive Therapy and Research*, *36*(5), 427–440. https://doi.org/10.1007/s10608-012-9476-1

Hofmann, S. G., & Gómez, A. F. (2017). Mindfulness-Based Interventions for Anxiety and Depression. *Psychiatric Clinics of North America*, *40*(4), 739–749. https://doi.org/10.1016/j.psc.2017.08.008

Holnthaner, R. (2008). Neurofeedback in ADHD/ADD treatment. *Psiholoska Obzorja*, *17*(1), 107–116. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85117725039&partnerID=40&md5=34fe85acd3a586d383b85784744769c2

Hou, Y., Zhang, S., Li, N., Huang, Z., Wang, L., & Wang, Y. (2021a). Neurofeedback training improves anxiety trait and depressive symptom in GAD. *Brain and Behavior*, *11*(3), 1–8. https://doi.org/10.1002/brb3.2024

Hou, Y., Zhang, S., Li, N., Huang, Z., Wang, L., & Wang, Y. (2021b). Neurofeedback training improves anxiety trait and depressive symptom in GAD. *Brain and Behavior*, *November 2020*, 1–8. https://doi.org/10.1002/brb3.2024

Javaid, S., Hashim, I., Hashim, M., Samad, M., & Ahbabi, A. (2023). Epidemiology of anxiety disorders: global burden and sociodemographic associations. *Middle East Current Psychiatry*, *30*. https://doi.org/10.1186/s43045-023-00315-3

Jubair, H. (2024). *Neurofeedback : Applications , Advancements , and Future Directions*. 1–21.

Kavianipoor, H., Farsi, A., & Bahrami, A. (2023). The Effect of Neurofeedback Training on Executive Control Network of Attention and Dart-Throwing Performance in Individuals with Trait Anxiety. *Applied*

Psychophysiology Biofeedback, *48*(3), 379–391. https://doi.org/10.1007/s10484-023-09587-1

Kerson, C., PhD, R., & Kozlowski, G. (2009). Alpha Suppression and Symmetry Training for Generalized Anxiety Symptoms. *Journal of Neurotherapy*, *13*, 146–155. https://doi.org/10.1080/10874200903107405

Khoury, B., Lecomte, T., Fortin, G., Masse, M., Therien, P., Bouchard, V., Chapleau, M.-A., Paquin, K., & Hofmann, S. G. (2013). Mindfulness-based therapy: a comprehensive meta-analysis. *Clinical Psychology Review*, *33*(6), 763–771. https://doi.org/10.1016/j.cpr.2013.05.005

Krause, F., Linden, D. E. J., & Hermans, E. J. (2024). Getting stress-related disorders under control: the untapped potential of neurofeedback. *Trends in Neurosciences*, *47*(10), 766–776. https://doi.org/10.1016/j.tins.2024.08.007

Liu, S., Hao, X., Liu, X., He, Y., Zhang, L., An, X., Song, X., & Ming, D. (2022). Sensorimotor rhythm neurofeedback training relieves anxiety in healthy people. *Cognitive Neurodynamics*, *16*(3), 531–544. https://doi.org/10.1007/s11571-021-09732-8

Lotnia, S., Shahkaram, H., Yaseri, A., Kianimoghadam, A., & Arani, A. M. (2023). *Comparing the Ecacy of Sensory Motor Rhythm and Alpha-Theta Increase Protocol of Neurofeedback Training for Generalized Anxiety Disorder*. 1–13. https://doi.org/10.21203/rs.3.rs-3197196/v1

Månsson, K. N. T., Salami, A., Frick, A., Carlbring, P., Andersson, G., Furmark, T., & Boraxbekk, C.-J. (2016). Neuroplasticity in response to cognitive behavior therapy for social anxiety disorder. *Translational Psychiatry*, *6*. https://doi.org/10.1038/tp.2015.218

Marzbani, H., Marateb, H. R., & Mansourian, M. (2016a). Neurofeedback: A Comprehensive Review on System Design, Methodology and Clinical Applications. *Basic and Clinical Neuroscience*, *7*(2), 143–158. https://doi.org/10.15412/J.BCN.03070208

Marzbani, H., Marateb, H. R., & Mansourian, M. (2016b). Neurofeedback: A Comprehensive Review on System Design, Methodology and Clinical Applications. *Basic and Clinical Neuroscience*, *7*(2), 143–158. https://doi.org/10.15412/J.BCN.03070208

Mayer, K., Wyckoff, S. N., & Strehl, U. (2012). One Size Fits All? Slow Cortical Potentials Neurofeedback: A Review. *Journal of Attention Disorders*, *17*(5), 393–409. https://doi.org/10.1177/1087054712468053

Mennella, R., Patron, E., & Palomba, D. (2017). Frontal alpha asymmetry

neurofeedback for the reduction of negative affect and anxiety. *Behaviour Research and Therapy*, *92*, 32–40. https://doi.org/10.1016/j.brat.2017.02.002

Micoulaud-Franchi, J. A., Jeunet, C., Pelissolo, A., & Ros, T. (2021a). EEG Neurofeedback for Anxiety Disorders and Post-Traumatic Stress Disorders: A Blueprint for a Promising Brain-Based Therapy. *Current Psychiatry Reports*, *23*(12). https://doi.org/10.1007/s11920-021-01299-9

Micoulaud-Franchi, J. A., Jeunet, C., Pelissolo, A., & Ros, T. (2021b). EEG Neurofeedback for Anxiety Disorders and Post-Traumatic Stress Disorders: A Blueprint for a Promising Brain-Based Therapy. *Current Psychiatry Reports*, *23*(12), 84. https://doi.org/10.1007/s11920-021-01299-9

Mongeon, P., & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics*, *106*(1), 213–228. https://doi.org/10.1007/s11192-015-1765-5

Moore, N. C. (2000). A Review of EEG Biofeedback Treatment of Anxiety Disorders. *Clinical EEG and Neuroscience*, *31*(1), 1–6. https://doi.org/10.1177/155005940003100105

Muhammad Khir, S., Wan Mohd Yunus, W. M. A., Mahmud, N., Wang, R., Panatik, S. A., Mohd Sukor, M. S., & Nordin, N. A. (2024). Efficacy of Progressive Muscle Relaxation in Adults for Stress, Anxiety, and Depression: A Systematic Review. *Psychology Research and Behavior Management*, *17*(null), 345–365. https://doi.org/10.2147/PRBM.S437277

Mutang, J. A., Seok, C. B., & Ee, G. T. (2021). Effects of Neurofeedback Training on Anxiety Symptoms Among University Students. *Proceedings of the International Conference on Psychological Studies (ICPSYCHE 2020)*, *530*(Icpsyche 2020), 82–89. https://doi.org/10.2991/assehr.k.210423.012

Nicholson, A. A., Ros, T., Densmore, M., Frewen, P. A., Neufeld, R. W. J., Théberge, J., Jetly, R., & Lanius, R. A. (2020). A randomized, controlled trial of alpha-rhythm EEG neurofeedback in posttraumatic stress disorder: A preliminary investigation showing evidence of decreased PTSD symptoms and restored default mode and salience network connectivity using fMRI. *NeuroImage. Clinical*, *28*, 102490. https://doi.org/10.1016/j.nicl.2020.102490

Olatunji, B. O., Cisler, J. M., & Deacon, B. J. (2010). Efficacy of cognitive behavioral therapy for anxiety disorders: A review of meta-analytic

findings. *Psychiatric Clinics of North America*, *33*, 557–577. https://doi.org/10.1016/j.psc.2010.04.002

Öst, L.-G., Enebrink, P., Finnes, A., Ghaderi, A., Havnen, A., Kvale, G., Salomonsson, S., & Wergeland, G. J. (2023). Cognitive Behavior Therapy for Adult Anxiety Disorders in Routine Clinical Care: A Systematic Review and Meta-Analysis. *Clinical Psychology: Science and Practice*, *30*(3), 272–290. https://doi.org/10.1037/cps0000144

Parker, Z. J., Waller, G., Duhne, P. G. S., & Dawson, J. (2018). The role of exposure in treatment of anxiety disorders: A meta-analysis. *International Journal of Psychology & Psychological Therapy*, *18*(1), 111–141.

Plotnikov, S., Lipkovich, M., Semenov, D., & Fradkov, A. (2019). Artificial intelligence based neurofeedback. *Cybernetics and Physics*, *8*, 287–291. https://doi.org/10.35470/2226-4116-2019-8-4-287-291

Ponce, H., Martínez-Villaseñor, L., & Chen, Y. (2022). Editorial: Artificial intelligence in brain-computer interfaces and neuroimaging for neuromodulation and neurofeedback. In *Frontiers in neuroscience* (Vol. 16, p. 974269). https://doi.org/10.3389/fnins.2022.974269

Price, J., & Budzynski, T. (2009). Anxiety, EEG Patterns, and Neurofeedback. In *Introduction to Quantitative EEG and Neurofeedback* (Second Edi). Elsevier Inc. https://doi.org/10.1016/B978-0-12-374534-7.00017-4

Qi, X., Xu, W., & Li, G. (2023). Neuroimaging Study of Brain Functional Differences in Generalized Anxiety Disorder and Depressive Disorder. *Brain Sciences*, *13*(9). https://doi.org/10.3390/brainsci13091282

Racz, J. I., Bialocerkowski, A., Calteaux, I., & Farrell, L. J. (2024). Determinants of Exposure Therapy Implementation in Clinical Practice for the Treatment of Anxiety, OCD, and PTSD: A Systematic Review. *Clinical Child and Family Psychology Review*, *27*(2), 317–341. https://doi.org/10.1007/s10567-024-00478-3

Russo, G. M., Balkin, R. S., & Lenz, A. S. (2022). A meta-analysis of neurofeedback for treating anxiety-spectrum disorders. *Journal of Counseling & Development*, *100*(3), 236–251. https://doi.org/https://doi.org/10.1002/jcad.12424

Ryder, A. G., & Chentsova-Dutton, Y. E. (2014). Cultural-clinical psychology: An introduction to the special issue. *Journal of Social and Clinical Psychology*, *33*(10), 847–852. https://doi.org/10.1521/jscp.2014.33.10.847

Ryder, A., Yang, J., Zhu, X., Yao, S., Yi, J., Heine, S., & Bagby, R. (2008).

The Cultural Shaping of Depression: Somatic Symptoms in China, Psychological Symptoms in North America? *Journal of Abnormal Psychology*, *117*, 300–313. https://doi.org/10.1037/0021-843X.117.2.300

Sherlin, L. H., Arns, M., Lubar, J., Heinrich, H., Kerson, C., Strehl, U., & Sterman, B. (2011). Neurofeedback and Basic Learning Theory : Implications for Research and Practice. *Journal of Neurotherapy : Investigations in Neuromodulation, Neurofeedback and Applied Neuroscience*, *15*(4), 292–304. https://doi.org/10.1080/10874208.2011.623089

Simos, G., & Hofmann, S. G. (2013). *CBT for Anxiety Disorders: A Practioner Book*. 3 John Wiley & Sons, Ltd. www.wiley.com/wiley-blackwell.

Sitaram, R., Ros, T., Stoeckel, L. E., Haller, S., Scharnowski, F., Lewis-Peacock, J., Weiskopf, N., Blefari, M., Rana, M., Oblak, E., Birbaumer, N., & Sulzer, J. (2016). Closed-loop brain training: the science of neurofeedback. *Nature Neuroscience*, *December*. https://doi.org/10.1038/nrn.2016.164

Sitaram, R., Ros, T., Stoeckel, L., Haller, S., Scharnowski, F., Lewis-Peacock, J., Weiskopf, N., Blefari, M. L., Rana, M., Oblak, E., Birbaumer, N., & Sulzer, J. (2017). Closed-loop brain training: the science of neurofeedback. *Nature Reviews Neuroscience*, *18*(2), 86–100. https://doi.org/10.1038/nrn.2016.164

Toussaint, L., Nguyen, Q. A., Roettger, C., Dixon, K., Offenbächer, M., Kohls, N., Hirsch, J., & Sirois, F. (2021). Effectiveness of Progressive Muscle Relaxation, Deep Breathing, and Guided Imagery in Promoting Psychological and Physiological States of Relaxation. *Evidence-Based Complementary and Alternative Medicine : ECAM*, *2021*, 5924040. https://doi.org/10.1155/2021/5924040

Vaishnav, M., Javed, A., Gupta, S., Kumar, V., Vaishnav, P., Kumar, A., Salih, H., Levounis, P., Ng, B., Alkhoori, S., Luguercho, C., Soghoyan, A., Moore, E., Lakra, V., Aigner, M., Wancata, J., Ismayilova, J., Islam, M. A., Da Silva, A. G., … Ashurov, Z. (2023). Stigma towards mental illness in Asian nations and low-and-middle-income countries, and comparison with high-income countries: A literature review and practice implications. *Indian Journal of Psychiatry*, *65*(10), 995–1011. https://doi.org/10.4103/indianjpsychiatry.indianjpsychiatry_667_23

Wang, J., Fang, J., Xu, Y., Zhong, H., Li, J., Li, H., & Li, G. (2022). Difference analysis of multidimensional electroencephalogram characteristics

between young and old patients with generalized anxiety disorder. *Frontiers in Human Neuroscience*, *16*, 1074587. https://doi.org/10.3389/fnhum.2022.1074587

Wang, S.-Y., Lin, I.-M., Fan, S.-Y., Tsai, Y.-C., Yen, C.-F., Yeh, Y.-C., Huang, M.-F., Lee, Y., Chiu, N.-M., Hung, C.-F., Wang, P.-W., Liu, T.-L., & Lin, H.-C. (2019). The effects of alpha asymmetry and high-beta down-training neurofeedback for patients with the major depressive disorder and anxiety symptoms. *Journal of Affective Disorders*, *257*, 287–296. https://doi.org/https://doi.org/10.1016/j.jad.2019.07.026

Wider, W., Mutang, J. A., Chua, B. S., Pang, N. T. P., Jiang, L., Fauzi, M. A., & Udang, L. N. (2024). Mapping the evolution of neurofeedback research: a bibliometric analysis of trends and future directions. *Frontiers in Human Neuroscience* , *18*(May), 1–14. https://doi.org/10.3389/fnhum.2024.1339444

Wolitzky-Taylor, K., Fenwick, K., Lengnick-Hall, R., Grossman, J., Bearman, S. K., Arch, J., Miranda, J., & Chung, B. (2018). A Preliminary Exploration of the Barriers to Delivering (and Receiving) Exposure-Based Cognitive Behavioral Therapy for Anxiety Disorders in Adult Community Mental Health Settings. *Community Mental Health Journal*, *54*(7), 899–911. https://doi.org/10.1007/s10597-018-0252-x

World Health Organization. (2022). *Ageing and Health*. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

Zhang, Z., Sun, K., Jatchavala, C., Koh, J., Chia, Y., Bose, J., Li, Z., Tan, W., Wang, S., Chu, W., Wang, J., Tran, B., & Ho, R. (2019). Overview of Stigma against Psychiatric Illnesses and Advancements of Anti-Stigma Activities in Six Asian Societies. *International Journal of Environmental Research and Public Health*, *17*(1). https://doi.org/10.3390/ijerph17010280

Zoefel, B., Huster, R. J., & Herrmann, C. S. (2011). Neurofeedback training of the upper alpha frequency band in EEG improves cognitive performance. *NeuroImage*, *54*(2), 1427–1431. https://doi.org/https://doi.org/10.1016/j.neuroimage.2010.08.078