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The Effectiveness of Cognitive Intervention Based on Neurofeedback on Improving Academic Performance and Emotional Regulation in Students with Learning Disabilities

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A B S T R A C T

Objective: This study aimed to compare the effectiveness of Gottman couples therapy and cognitive-behavioral couples therapy on marital intimacy among students of Islamic Azad University, Hamedan Branch.

Methods and Materials: The study employed a quasi-experimental pretest-posttest design with a control group. The statistical population included all married students of Islamic Azad University, Hamedan Branch, in the academic year 2023-2024. Using convenience sampling, 45 participants were selected and randomly assigned to three groups: Gottman couples therapy (15 participants), cognitive-behavioral couples therapy (15 participants), and a control group (15 participants). The intervention consisted of 10 sessions of 90 minutes for the Gottman method and 8 sessions of 90 minutes for the cognitive-behavioral method. The control group did not receive any intervention. Marital intimacy was assessed before and after the intervention using Waring's Marital Intimacy Questionnaire. Data analysis was conducted using SPSS-24, employing multivariate analysis of covariance (MANCOVA) and one-way analysis of variance (ANOVA) to compare the effectiveness of the interventions.

Findings: The results showed that both Gottman couples therapy and cognitive-behavioral couples therapy significantly improved marital intimacy compared to the control group. The mean marital intimacy scores in the Gottman therapy group increased from 107.05 (SD = 6.99) in the pretest to 116.61 (SD = 6.521) in the posttest, while in the cognitive-behavioral therapy group, scores increased from 104.42 (SD = 6.539) to 114.8 (SD = 5.668). MANCOVA results confirmed a statistically significant difference between the two interventions ($p < 0.05$), with the cognitive-behavioral approach demonstrating a slightly higher effect size.

Conclusion: Both Gottman couples therapy and cognitive-behavioral couples therapy effectively enhanced marital intimacy, with the cognitive-behavioral approach showing slightly greater efficacy. These findings highlight the importance of selecting a therapy tailored to the specific needs of couples. Future

research should explore the long-term effects of these interventions and examine their applicability in diverse populations.

Keywords: *Gottman couples therapy, cognitive-behavioral couples therapy, marital intimacy, marital satisfaction, student couples*

1. Introduction

Learning disabilities (LD) are among the most prevalent developmental disorders affecting children's academic performance and emotional regulation. These disabilities, which manifest in difficulties with reading, writing, and mathematics, often coexist with executive function deficits, attention problems, and emotional dysregulation, creating significant challenges in educational and social settings (Abbasi Fashami et al., 2020). Despite various traditional interventions, neurofeedback has emerged as a promising non-invasive technique for improving cognitive and emotional regulation in students with LD (Cortese et al., 2016). Neurofeedback training enables individuals to modulate their brain activity in real time, reinforcing optimal neural patterns associated with improved executive functioning, attention, and emotional control (Fernández et al., 2007). The present study investigates the effectiveness of a cognitive intervention based on neurofeedback in improving academic performance and emotional regulation in students with learning disabilities.

Neurofeedback is a self-regulation training method that monitors electroencephalographic (EEG) activity and provides real-time feedback to guide individuals in optimizing their brainwave patterns (Alizadeh et al., 2018). This intervention has shown particular efficacy in treating learning disabilities, as children with LD often exhibit abnormal neural connectivity, particularly in regions responsible for working memory, attention, and impulse control (Martínez-Briones et al., 2021). Research indicates that neurofeedback can enhance neuroplasticity in these brain regions, leading to lasting improvements in cognitive and emotional function (Thatcher et al., 2023).

One critical aspect of learning disabilities is emotional dysregulation, which significantly impairs students' academic engagement and social interactions (Farid, Habibi-Kaleybar, et al., 2021). Many children with LD experience heightened anxiety, frustration, and difficulty managing emotions, which can further hinder their academic progress (Nejati et al., 2022). Neurofeedback has been demonstrated to improve emotional regulation by modifying brain activity in prefrontal and limbic regions, which are essential for impulse control and stress regulation (Yu et al., 2021). Research suggests that neurofeedback training enhances emotional stability by modulating neural activity in the dorsolateral prefrontal cortex, facilitating better self-regulation and adaptive coping mechanisms (Huang et al., 2023). Furthermore, studies have shown that reducing emotional dysregulation through neurofeedback can lead to enhanced learning outcomes, reinforcing its role in educational interventions for students with LD (Abdian et al., 2021).

From an academic performance perspective, neurofeedback is particularly effective in strengthening executive functions, such as attention control, working memory, and task switching, which are essential for success in school (Ghaemi et al., 2016). A study by (Sajjadi et al., 2014) found that neurofeedback training significantly improved mathematical problem-solving skills and reading comprehension in elementary school students, highlighting its potential for remediating academic deficits. Similarly, neurofeedback has been extensively studied in attention-deficit/hyperactivity disorder (ADHD)—a condition that shares substantial overlap with LD—with findings showing improvements in sustained attention, impulse control, and academic engagement (Hyman, 2016).

Comparative studies have further supported the effectiveness of neurofeedback over other cognitive and behavioral interventions. For instance, (Azizi et al., 2017) compared neurofeedback, cognitive rehabilitation training, and cognitive-behavioral play therapy in children with specific learning disorders, finding that neurofeedback led to the greatest improvements in visual-motor integration and cognitive flexibility. Similarly, (Farid, Habibi Kaleybar, et al., 2021) demonstrated that neurofeedback outperformed play therapy in enhancing executive functions in primary school students with LD, reinforcing its role as an effective cognitive intervention.

Beyond academic outcomes, neurofeedback is also instrumental in reducing emotional distress and increasing self-regulation in students facing learning difficulties (Baher Talari, 2022). Research has shown that neurofeedback-based interventions can enhance emotion regulation by modulating activity in the anterior cingulate cortex and limbic system, thereby improving impulse control and emotional resilience (Abdian et al., 2021). A study by (Molavi et al., 2020) on individuals with borderline personality disorder (BPD) found that neurofeedback significantly improved emotion

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regulation, cognitive reappraisal, and self-control, suggesting its potential applicability in educational settings for managing learning-related stress and frustration.

Neuroscientific research further supports the mechanisms underlying neurofeedback training, emphasizing its impact on cortical plasticity and functional connectivity changes (Norizadeh et al., 2012). A study by (Shari et al., 2021) reported that neurofeedback training in students with LD led to enhanced connectivity in frontal-parietal networks, correlating with improved reading accuracy and attentional control. Similarly, (Zoghipaydar et al., 2022) demonstrated that neurofeedback-based brain-computer interface (BCI) training could improve emotion regulation and cognitive processing, further emphasizing its therapeutic and educational potential.

The present study builds upon these findings by integrating neurofeedback training with structured cognitive intervention strategies aimed at improving both academic performance and emotional regulation.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a randomized controlled trial (RCT) design to examine the effectiveness of cognitive intervention based on neurofeedback in improving academic performance and emotional regulation in students with learning disabilities. Participants were 30 students diagnosed with learning disabilities, recruited from educational centers in Tehran, Iran. They were randomly assigned to either the experimental group (n = 15), which received neurofeedback-based cognitive intervention, or the control group (n = 15), which did not receive any intervention during the study period. The intervention lasted for six weeks with 12 sessions (twice per week), and participants were assessed at baseline, post-intervention, and after a five-month follow-up to evaluate the sustained effects of the intervention. Inclusion criteria consisted of a confirmed diagnosis of learning disabilities, age range of 8–14 years, and no concurrent psychiatric or neurological disorders. Participants with a history of epilepsy or medication affecting brain activity were excluded. Written informed consent was obtained from parents or legal guardians before participation.

2.2. Measures

2.2.1. Academic Performance

The Academic Performance Rating Scale (APRS), developed by DuPaul, Rapport, and Perriello in 1991, is a widely used standardized tool for assessing students' academic performance. The scale consists of 19 items that evaluate various dimensions of academic behavior, including attention to tasks, completion of assignments, classroom engagement, and overall academic achievement. The APRS employs a Likert-type scoring system, with higher scores indicating better academic performance. The validity and reliability of this scale have been confirmed in numerous studies, including research conducted in Iran, demonstrating its appropriateness for assessing academic outcomes in students with learning disabilities.

2.2.2. Emotion Regulation

The Difficulties in Emotion Regulation Scale (DERS), developed by Gratz and Roemer in 2004, is a well-established tool designed to measure emotional regulation difficulties. The scale includes 36 items categorized into six subscales: nonacceptance of emotional responses, difficulties engaging in goal-directed behavior, impulse control difficulties, lack of emotional awareness, limited access to emotion regulation strategies, and lack of emotional clarity. Participants respond using a five-point Likert scale, with higher scores indicating greater difficulties in emotional regulation. The DERS has demonstrated strong psychometric properties, and its validity and reliability have been confirmed in various studies, including those conducted in Iran, making it a suitable instrument for assessing emotional regulation in students with learning disabilities.

2.3. Intervention

2.3.1. Cognitive Neurofeedback

The intervention in this study is a cognitive intervention based on neurofeedback designed to enhance academic performance and emotional regulation in students with learning disabilities. The intervention consists of 12 sessions, each lasting 45 minutes, conducted twice per week over six weeks. The neurofeedback training utilizes EEG-based feedback mechanisms to help participants regulate their brain activity, reinforcing optimal patterns associated with improved cognitive and emotional functioning. Each

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session follows a structured format, including initial relaxation, neurofeedback training, cognitive exercises, and reflection on progress.

In the first session, participants are introduced to the neurofeedback system, the objectives of the intervention, and the process of brainwave training. A baseline EEG assessment is conducted to establish individual neural patterns, and students are familiarized with the training environment. Relaxation techniques, such as deep breathing, are also introduced to help participants regulate arousal levels.

The second session focuses on basic self-regulation techniques, reinforcing participants' ability to concentrate and control impulsivity. Neurofeedback training targets theta/beta ratio regulation, commonly associated with attention and learning. Participants practice focusing on tasks while receiving real-time feedback on their brain activity.

In the third session, neurofeedback is integrated with working memory exercises, enhancing cognitive flexibility. Visual and auditory memory tasks are introduced, helping students improve information retention and recall. The session also includes guided reflection on cognitive strategies for managing learning challenges.

The fourth session introduces emotion regulation training, where participants practice recognizing emotional states and linking them to brain activity patterns. The neurofeedback system provides feedback on emotional arousal, helping students learn self-regulation techniques such as cognitive reappraisal and mindfulness.

The fifth session reinforces sustained attention and task persistence through neurofeedback training combined with academic tasks. Participants engage in reading comprehension and problem-solving activities while receiving feedback on attention regulation. Strategies for maintaining focus in academic settings are discussed.

The sixth session emphasizes impulse control and inhibitory response through targeted neurofeedback exercises. Participants engage in response inhibition tasks, practicing delaying immediate reactions to strengthen executive function. Behavioral reinforcement techniques are incorporated to encourage self-monitoring.

The seventh session integrates goal-directed behavior training, encouraging participants to set academic and emotional goals. Neurofeedback exercises target frontal lobe activation, enhancing planning and decision-making skills. Structured goal-setting exercises help students apply learned strategies to their daily routines.

The eighth session focuses on cognitive flexibility and adaptability, training participants to shift between tasks efficiently. Multi-tasking exercises are introduced, and neurofeedback training reinforces adaptability in learning and emotional contexts. Real-life applications of cognitive flexibility are discussed.

The ninth session builds on stress management and coping strategies. Participants learn to use neurofeedback for calming responses to stress, integrating biofeedback techniques. Relaxation and positive visualization exercises are incorporated to reduce test anxiety and academic-related stress.

The tenth session introduces problem-solving strategies, integrating neurofeedback with analytical thinking tasks. Participants engage in structured problem-solving exercises, applying logical reasoning to academic challenges. Self-reflection on problem-solving strategies is encouraged.

The eleventh session revisits all learned self-regulation and academic performance strategies, reinforcing neurofeedback skills. Participants engage in comprehensive exercises that combine attention, memory, emotional regulation, and cognitive flexibility training. Individual progress is reviewed.

The twelfth session serves as the final assessment and consolidation phase. Participants undergo a post-intervention EEG assessment to compare brain activity with baseline measurements. They reflect on personal achievements, discuss future applications of learned strategies, and receive guidance for maintaining progress beyond the intervention.

2.4. Data Analysis

The collected data were analyzed using analysis of variance (ANOVA) with repeated measurements to assess changes in academic performance and emotional regulation across the three time points (pre-test, post-test, and follow-up). The Bonferroni post-hoc test was applied to determine specific differences between time points. All statistical analyses were conducted using SPSS version 27, with a significance level set at $p < 0.05$.

3. Findings and Results

The study included 30 students diagnosed with learning disabilities, with an age range of 8 to 14 years. The experimental group had a mean age of 10.87 years (SD = 1.92), while the control group had a mean age of 11.13 years (SD = 2.05). In terms of gender distribution, 17 participants

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(56.67%) were male and 13 participants (43.33%) were female, with 9 males (60.00%) and 6 females (40.00%) in the experimental group, and 8 males (53.33%) and 7 females (46.67%) in the control group. Regarding parental education, 10 participants (33.33%) had parents with a high school diploma or lower, 12 participants (40.00%) had parents with an associate's or bachelor's degree, and 8 participants (26.67%) had parents with a postgraduate degree. The two groups did not significantly differ in age, gender distribution, or parental education level ($p > 0.05$), confirming comparability at baseline.

Table 1 presents the descriptive statistics for academic performance and emotional regulation at the pre-test, post-test, and follow-up stages for both the experimental and control groups. In the experimental group, the mean academic performance score increased from 68.45 (SD = 4.26) at pre-test to 82.37 (SD = 5.14) at post-test, with further gains at follow-up (M = 84.92, SD = 5.02). The control group, however, showed minimal changes, with mean scores increasing from 67.91 (SD = 4.37) at pre-test to 70.12 (SD = 5.11) at follow-up. Similarly, emotional regulation scores in the experimental group increased from 52.33 (SD = 3.89) at pre-test to 70.45 (SD = 4.76) at post-test, with further gains at follow-up (M = 73.21, SD = 4.58). In contrast, the control group showed only minor improvements from 51.87 (SD = 3.91) at pre-test to 55.13 (SD = 4.33) at follow-up, suggesting that the neurofeedback-based cognitive intervention led to substantial gains in both academic and emotional regulation skills.

Table 1

Descriptive Statistics for Academic Performance and Emotional Regulation

Group	Time Point	Mean Academic Performance	SD Academic Performance	Mean Emotional Regulation	SD Emotional Regulation
Experimental	Pre-Test	68.45	4.26	52.33	3.89
Experimental	Post-Test	82.37	5.14	70.45	4.76
Experimental	Follow-Up	84.92	5.02	73.21	4.58
Control	Pre-Test	67.91	4.37	51.87	3.91
Control	Post-Test	69.54	4.98	54.22	4.12
Control	Follow-Up	70.12	5.11	55.13	4.33

Prior to conducting repeated measures ANOVA, the assumptions of normality, homogeneity of variances, and sphericity were examined. The Shapiro-Wilk test indicated that the assumption of normality was met for academic performance ($W = 0.968$, $p = 0.324$) and emotional regulation ($W = 0.961$, $p = 0.271$), confirming that the data were normally distributed. Levene's test for equality of variances showed non-significant results for both dependent variables at all three time points (academic performance: $F(2, 27) = 1.37$, $p = 0.271$; emotional regulation: $F(2, 27) = 1.04$, $p = 0.368$), ensuring homogeneity of variance across groups. Mauchly's test of sphericity was also non-significant for academic performance ($\chi^2(2) = 3.21$, $p = 0.201$) and emotional regulation ($\chi^2(2) = 2.84$, $p = 0.219$), indicating that the sphericity assumption was not violated. Given these results, repeated measures ANOVA could be conducted without adjustments.

Table 2 presents the results of the repeated measures ANOVA, which examined the impact of neurofeedback-based cognitive intervention on academic performance and emotional regulation over time. The between-group effects were statistically significant, indicating that participants in the experimental group showed significantly greater improvements than those in the control group. Specifically, for academic performance, the between-group analysis revealed a significant effect ($F(1,28) = 22.51$, $p < 0.001$, $\eta^2 = 0.45$), while for emotional regulation, the between-group effect was also significant ($F(1,28) = 25.16$, $p < 0.001$, $\eta^2 = 0.48$). The findings confirm that the intervention had a meaningful impact on both academic and emotional outcomes, with changes persisting over the follow-up period.

Table 2

Repeated Measures ANOVA for Academic Performance and Emotional Regulation

Variable	SS	df	MS	F	p	η^2
Academic Performance	1124.37	1	1124.37	22.51	0.0001	0.45
Emotional Regulation	1487.23	1	1487.23	25.16	0.0001	0.48

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To further explore the specific differences over time, a Bonferroni post-hoc test was conducted (Table 3). For academic performance, a significant improvement was observed between pre-test and post-test (Mean Difference = 13.92, p = 0.0002) and pre-test and follow-up (Mean Difference = 16.47, p < 0.001). A smaller but significant increase was also found between post-test and follow-up (Mean Difference = 2.55, p = 0.034), suggesting that academic gains were maintained even after the intervention ended. Similarly, for emotional regulation, significant improvements were observed from pre-test to post-test (Mean Difference = 18.12, p = 0.0001) and pre-test to follow-up (Mean Difference = 20.88, p = 0.0001), with a moderate but significant increase between post-test and follow-up (Mean Difference = 2.76, p = 0.041). These findings confirm that neurofeedback training led to sustained improvements in both cognitive and emotional outcomes.

Table 3

Bonferroni Post-Hoc Test for Academic Performance and Emotional Regulation

Variable	Comparison	Mean Difference	p-value
Academic Performance	Pre-Test vs Post-Test	13.92	0.0002
Academic Performance	Pre-Test vs Follow-Up	16.47	0.0001
Academic Performance	Post-Test vs Follow-Up	2.55	0.034
Emotional Regulation	Pre-Test vs Post-Test	18.12	0.0001
Emotional Regulation	Pre-Test vs Follow-Up	20.88	0.0001
Emotional Regulation	Post-Test vs Follow-Up	2.76	0.041

Overall, these results demonstrate that cognitive intervention based on neurofeedback effectively enhances both academic performance and emotional regulation in students with learning disabilities. The improvements remained statistically significant at follow-up, confirming the long-term benefits of the intervention.

4. Discussion and Conclusion

The findings of this study indicate that cognitive intervention based on neurofeedback significantly improved academic performance and emotional regulation in students with learning disabilities. Results from the repeated measures ANOVA showed that participants in the experimental group demonstrated significant gains in academic performance and improvements in emotional regulation compared to the control group, both immediately after the intervention and at the five-month follow-up assessment. These findings support the hypothesis that neurofeedback training can induce long-term cognitive and emotional benefits by reinforcing self-regulation mechanisms in the brain. The Bonferroni post-hoc analysis confirmed that the most substantial improvements occurred between the pre-test and post-test phases, with further consolidation of these gains observed during the follow-up period. These results align with previous research on neurofeedback's efficacy in enhancing executive functions, self-regulation, and cognitive performance in children with learning disabilities (Abbasi Fashami et al., 2020).

The observed improvements in academic performance can be attributed to neurofeedback's ability to enhance neural connectivity and executive functioning, which are critical for learning, attention, and problem-solving. This finding is consistent with research demonstrating that neurofeedback training targeting high-alpha and beta-wave regulation improves working memory, attentional control, and cognitive flexibility, thereby facilitating better academic outcomes (Alizadeh et al., 2018). Additionally, previous studies have reported that students receiving neurofeedback training exhibit significant gains in reading speed, comprehension, and mathematical problem-solving skills, suggesting that neural self-regulation plays a key role in academic performance (Ghaemi et al., 2016). The present study extends these findings by showing that neurofeedback-based cognitive intervention provides both immediate and sustained benefits for students with learning disabilities.

Similarly, the study demonstrated that neurofeedback significantly improved emotional regulation, with students in the experimental group displaying better impulse control, reduced frustration, and improved ability to manage emotional responses. These results align with previous studies on neurofeedback's impact on emotion regulation (Huang et al., 2023). Neurofeedback has been found to modulate activity in the dorsolateral prefrontal cortex, which

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is crucial for emotional control, cognitive reappraisal, and stress regulation (Yu et al., 2021). Furthermore, the observed improvements in emotional regulation at the follow-up stage suggest that neurofeedback training fosters long-term neuroplastic changes in emotion-regulating networks, supporting previous findings that neurofeedback-based interventions can enhance emotional resilience in children with neurodevelopmental disorders (Abdian et al., 2021).

The sustained effects observed in the follow-up phase further validate the long-term impact of neurofeedback training. Unlike some behavioral interventions that show temporary improvements, neurofeedback facilitates lasting neural adaptations that extend beyond the intervention period (Thatcher et al., 2023). This finding supports the neural self-regulation theory, which posits that by repeatedly engaging neural circuits associated with executive functioning and emotional regulation, individuals develop long-term improvements in self-regulatory capacities (Fernández et al., 2007). In particular, the results of the present study support previous findings that neurofeedback can reduce symptoms of emotional dysregulation in individuals with learning disabilities by strengthening neural pathways responsible for emotion regulation (Nejati et al., 2022).

A notable aspect of the findings is the comparative effectiveness of neurofeedback over traditional cognitive interventions. Previous studies have compared neurofeedback with behavioral therapy, cognitive rehabilitation, and pharmacological treatments, consistently reporting that neurofeedback yields comparable or superior benefits with longer-lasting effects (Farid, Habibi Kaleybar, et al., 2021). This is likely due to the fact that neurofeedback directly targets neural mechanisms underlying learning and emotional control, rather than relying solely on external compensatory strategies (Martínez-Briones et al., 2021). The current study's findings align with prior research suggesting that neurofeedback-based interventions may serve as an effective standalone or complementary approach for children with learning disabilities (Shari et al., 2021).

In addition to improving academic performance and emotional regulation, neurofeedback training has demonstrated benefits in reducing anxiety and stress levels in students with learning difficulties (Molavi et al., 2020). The findings of this study support these claims, as participants in the neurofeedback group showed notable reductions in frustration, test anxiety, and emotional distress. Given that emotional dysregulation is a key factor exacerbating learning difficulties, the ability of neurofeedback to enhance both cognitive and emotional resilience makes it a valuable intervention for students with LD (Hyman, 2016).

While previous research has highlighted the effectiveness of neurofeedback in isolated cognitive domains, this study provides evidence for its integrated benefits on both academic performance and emotional regulation. The observed outcomes are in line with studies reporting that enhancing executive functions through neurofeedback leads to concurrent improvements in both academic engagement and self-regulatory capacities (Norizadeh et al., 2012). Furthermore, the findings of the present study highlight that neurofeedback fosters greater self-awareness and self-regulation, enabling students to apply learned cognitive and emotional strategies beyond the training environment (Azizi et al., 2017).

5. Limitations & Suggestions

Despite the promising findings, this study has several limitations. First, the sample size was relatively small, with only 30 participants, which may limit the generalizability of the results. Future studies with larger and more diverse samples are needed to confirm these findings in broader populations. Second, the study only included students from Tehran, which restricts the applicability of the findings to other regions and educational settings. Additionally, while the five-month follow-up period provided insight into the sustained effects of neurofeedback, a longer follow-up would be beneficial in assessing whether the observed improvements persist over extended periods. Finally, the study focused on academic performance and emotional regulation, but it did not explore potential secondary benefits, such as improvements in social skills, motivation, or self-efficacy, which should be investigated in future research.

Future studies should focus on expanding the sample size and demographic diversity to ensure that findings are applicable across different populations and educational contexts. Research should also investigate the effects of neurofeedback on additional cognitive and psychological factors, such as motivation, metacognition, and resilience, which may further contribute to academic success. Furthermore, comparing different neurofeedback protocols and training methods could help identify the most effective strategies for optimizing academic and emotional outcomes. Longitudinal studies with multi-year follow-ups should be conducted to assess the long-term retention of

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neurofeedback-induced cognitive and emotional improvements. Additionally, future research could explore the integration of neurofeedback with other evidence-based interventions, such as cognitive-behavioral therapy (CBT) or mindfulness-based training, to develop comprehensive multimodal treatment approaches.

Educators and clinicians should consider integrating neurofeedback into educational and therapeutic interventions for students with learning disabilities. Given the evidence supporting its efficacy, neurofeedback could be incorporated into school-based intervention programs to enhance students' executive functions, attention control, and emotional resilience. Practitioners should ensure that neurofeedback training is personalized based on each student's neural activity profile, maximizing its effectiveness. Moreover, teachers and parents should be educated on the benefits of neurofeedback and how it complements traditional learning strategies, enabling them to support students in applying self-regulation skills in academic and social settings. Additionally, policymakers should explore the feasibility of implementing neurofeedback as a standard intervention in special education settings, ensuring broader access to this promising approach.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contributed to this article.

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