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Research Paper

The Effectiveness of Neurofeedback on the Behavioral Performance of Children With Social Anxiety Disorder: A Time-series Study

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ABSTRACT

Objective: Social anxiety is one of the most prevalent issues leading to significant functional and behavioral disorders in children. This study aims to investigate the effectiveness of neurofeedback intervention on the behavioral performance of children with social anxiety disorder (SAD).

Methods: A quasi-experimental study was conducted with a time series design and control group. The statistical population included all 6-8-year old children with SAD (according to the clinical interview and the cut-off score in Leibovitz's social anxiety questionnaire) referring to the Ziai Counseling Clinic in Meybod City, Iran. A total of 10 children were selected by convenient sampling method and were randomly assigned to experimental and control groups. The experimental group received 16 sessions of neurofeedback intervention, while the control group received no special intervention. Goodman's abilities and problems questionnaire was used to measure children's behavioral performance in five phases, pre-test, fourth, eighth, and twelfth sessions of the intervention phase, and post-test. The data were analyzed using analysis of variance (ANOVA) with repeated measurements.

Results: The results showed a significant difference between the mean scores of the experimental group and the control group in behavioral performance; additionally, in the experimental group, a significant difference was observed between the scores of behavioral performances in different phases of measurement, but this difference did not exist in the control group.

Conclusion: The neurofeedback intervention is effective in improving the behavioral performance of children with SAD and can be used as a complementary treatment alongside other psychological and drug treatments for these children.

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Highlights

- For the treatment of social anxiety disorder (SAD), various pharmacological and psychological treatments are commonly used, while little attention has been paid to neuro-physiological interventions comparatively.

- The neurofeedback intervention is effective on the behavioral performance of children with SAD.

- The neurofeedback intervention can be considered a complementary therapeutic approach to improve behavioral performance in children with SAD.

Plain Language Summary

Social anxiety disorder (SAD) is characterized by significant fear about social situations and exposure to others. Children with SAD, often exhibit avoidant behaviors during social interactions, evaluative situations, or when experiencing negative thoughts and emotions. Therefore, early intervention is crucial to prevent long-term adverse consequences of this disorder. Identifying effective psychological interventions that improve behavioral performance in these children can provide a promising outlook for parents and enhance the quality of life of the children. While various pharmacological and psychological treatments are commonly used for SAD neuro-physiological interventions, they have received comparatively little attention. Our results showed the neurofeedback intervention is effective on the behavioral performance of children with social anxiety disorder and can be considered as a complementary therapeutic approach for the treatment of SAD.

Introduction

One of the most common disorders in childhood and adolescence is anxiety disorder (Stein, 2008) and one of the most crucial types of these disorders is social anxiety disorder (SAD). SAD is defined as a specific and chronic fear of one or more social situations where the individual feels exposed to the scrutiny and judgment of others. This fear includes concern about potentially doing something that may cause embarrassment or humiliation (Polanczyk et al., 2015). Formerly known as social phobia, social anxiety involves a significant fear or anxiety about social situations in which the person feels observed by unfamiliar people (American Psychiatric Association, 2013). As a result, SAD is characterized by a specific fear or anxiety about social situations and when the individual is exposed to others. It is a chronic disease with a gradual and early onset in childhood that leads to great suffering and disability in behavioral and social functions. As a very debilitating disorder, SAD can disrupt people's social connections, academic progress, and well-being (Haller et al., 2015). According to this issue, the term' social anxiety' can be described as a state of fear or embarrassment in social interactions (Harbort et al., 2013); which is considered as one of the most common emotional disorders, with a reported prevalence of 12% over a lifetime (Alden & Taylor, 2011). Individuals with SAD demonstrate abnormal social development and significant behavior and functional impairment (Dryman et al., 2016). The negative behavioral aspect of SAD becomes apparent during childhood and becomes more prominent in early or mid-adolescence (Donovan et al., 2015). Therefore, children affected by SAD, exhibit avoidant behaviors during social interactions, evaluative situations, or when experiencing negative thoughts and emotions (Piccirillo et al., 2016). They fear receiving feedback from others and thus avoid these situations (Howarth & Forbes, 2015), often relying on maladaptive emotion regulation strategies (O'Day et al., 2019). Hence, their thoughts are shaped by a framework of negative evaluation from others and their behavior manifests as acting impulsively, belittlement, rejection, or provoking others. Therefore, social anxiety in children manifests as noticeable or intense stress or anxiety-related behavior in social interactions with peers, not just in dealing with adults; children face stressful situations due to the fear and anxiety stemming from the anticipation of negative evaluation, and exhibit behaviors, such as restlessness, crying, shouting, withdrawing, freezing, retiring, and so on (Halldorsson & Creswell, 2017). In other words, these children often avoid being in such social situations due to the fear of social circumstances. This avoidance can manifest as reluctance to attend parties or refusal to go to school. Moreover, these children may reluctantly endure social and interactive situations with intense anxiety and fear and counting down the moment to go home if they

are forced to be present at school (Heeren & McNally, 2018). Therefore, children with social anxiety interpret their psychological arousal in interactive situations as a sign of danger and this interpretation leads to the manifestation of physical symptoms and anxious behaviors, such as palpitation, restlessness, and so on, as a result, it can lead to deficient in adaptive coping, behavioral and social inhibition, and even the emergence of avoidant personality in adulthood (Muris et al., 2016). Additionally, the behavioral aspects of children with SAD sometimes manifest as refusal to attend school and opposition towards parents and teachers, and during adolescence, it may manifest as a tendency towards risky behaviors, such as substance and avoidant behaviors, such as social withdrawal and depression (Beesdo-Baum et al., 2012). Therefore, SAD shares high comorbidity with other disruptive behavioral disorders, such as avoidant personality disorder (Frandsen et al., 2020), obsessive-compulsive disorder (Carpita et al., 2020), attention-deficit hyperactivity disorder (Koyuncu et al., 2018), and major depressive disorder (Reilly et al., 2020); studies have shown that 81% of children with SAD also have other coexisting disorders (Hudson et al., 2015). Therefore, early intervention to prevent long-term adverse consequences of this disorder is crucial, and identifying effective psychological interventions that help improve behavioral performance in these children can not only provide a promising outlook for treating this disorder in front of their parents but also enhance the quality of life of the children (Spence et al., 2017). One of the neurotherapeutic approaches that can improve the behavioral performance of children with SAD is neurofeedback. Neurofeedback is a specialized form of biofeedback based on electrical brain wave signals, utilizing brain wave patterns as feedback and it is based on the perspective of the mind-body relationship and emphasizes the mind's ability for flexibility, change, and improvement. The goal of neurofeedback is to reduce symptomatic expressions of the disorder by targeting and modifying abnormal patterns of brain neural activity (Sitaram et al., 2017). In other words, the logic of neurofeedback is based on neurophysiological evidence which believes a connection between electroencephalography and underlying subcortical thalamocortical mechanisms that are responsible for the rhythms and frequencies of electroencephalography (Yousefi Afrashte, 2021). In this therapeutic approach, sensors called electrodes are placed on the person's scalp to provide the individual with their brain's electrical activities in the form of brain wave patterns through computer games or video films, and guiding the game or video through brain wave patterns and receiving rewards enable the individuals to acquire self-regulation and self-control skills (Arns et al., 2017). Regarding, neurofeedback as a tool modifies brain wave patterns and improves individual performance and it is used to suppress excessive frequency brain waves and strengthen waves that are lower than the range, hence individuals can become aware of their cortical brain activities (Ring et al., 2015). Neurofeedback is a comprehensive training approach that promotes growth and change at the cellular level of the brain and refers to a form of learning (operant conditioning) related to brain electrical activity, in which the brain is rewarded for desired activity and discouraged from undesirable brain activity (Demos, 2019). The fundamental idea and theoretical basis of neurofeedback are grounded in the belief that an individual can exert control over their brain activities through conditioning and guide atypical patterns of neural brain activity, and these atypical patterns of brain waves occur in individuals through neurofeedback intervention by decreasing slow waves (θ) and increasing fast waves (β) (Thibault, 2017). Therefore, neurofeedback as a safe and non-invasive method, induces changes and growth in brain cells and it is used to treat various types of mental disorders, such as major depression (Trambaiolli, 2021), hyperactivity/attention deficit (Arnold et al., 2021), learning disorders (Martínez-Briones et al., 2021), and anxiety disorders (Tolin, 2020), especially social anxiety disorder (Kimmig et al., 2019; Lisk et al., 2020; Saul et al., 2022; Zhang, 2017).

Given the lasting effects of social anxiety on children's behavioral performance until adulthood, the importance of solving this problem in children and the sensitivity of the childhood period, especially for those affected by SAD, as well as the research gap in simultaneously examining the impact of neurofeedback in children with social anxiety disorder, the present study aimed to investigate the effect of neurofeedback on the behavioral performance of children with social anxiety disorder.

Materials and Methods

A quasi-experimental study with a time series design, accompanied by a control group was conducted. The research population included all children aged 6-8 years with SAD referring to Ziai Counseling Service in Meybod City, and diagnosed using clinical interviews by the psychologist. Nevertheless, to determine the definitive diagnosis of this disorder, the researcher utilized the parental form of Leibovitz's social anxiety questionnaire (1987), in which if children obtained a score higher than the cut-off score of 65, they received a definitive diagnosis. A total of 10 children from the target population were selected by convenient sampling method and were

randomly assigned into experimental (5 participants) and control (5 participants) groups. It's necessary to mention that the sample size was kept low due to the difficulty in accessing children with high scores on the SAD questionnaire, and practically, a larger accessible was not available for sampling. However, to resolve this probable defect and enhance the credibility of the current experimental study, a time series design was utilized, and the dependent variables were assessed multiple times during the experiment. The inclusion criteria included obtaining a definitive diagnosis of SAD based on the cutoff score of the questionnaire, the age range of 6 to 8 years old, and parental satisfaction. Also, the exclusion criteria included non-cooperation and incomplete delivery of the questionnaires, non-attendance for more than one session in the interventional sessions, receiving other psychological interventions simultaneously, and not having other psychological disorders.

Tools

Neurofeedback device: The device used in this study was a thought technology type and double-channel.

Social anxiety scale (SAS): The social anxiety scale is designed to assess social anxiety in children from a parent's perspective (Liebowitz, 1987), consisting of 48 items and 2 subscales (anxiety-avoidance) and is scored based on a four-point Likert scale (1=none, 2=low, 3=moderate, 4=severe). The cutoff score of this scale is 65. Masia-Warner et al. (2003) evaluated the psychometric properties of the SAS and considered it as one of the most accurate scales available to measure social anxiety disorder in children. The construct validity and discriminant validity of the Persian version of the SAS were confirmed, and the test-retest reliability and Cronbach's α coefficient of this scale were 0.87 and 0.93, respectively (Moghaddam Poor, 2018).

Strengths and difficulties questionnaire (SDQ): The strengths and difficulties questionnaire is a short screening tool that is increasingly used to identify behavioral and emotional problems in children and adolescents (Goodman, 1997). The SDQ consists of 25 items and is considered as an acceptable tool to assess behavioral and emotional problems in children from the perspective of parents. The scoring of this questionnaire is based on a 3-point Likert scale (0=correct, 1=partially correct, 2=completely correct) and scores ranged from 0 to 50. The SDQ assesses five subscales of psychiatric symptoms including conduct problems, hyperactivity problems, emotional problems, communication problems with peers, and desirable social behaviors, and the total score is obtained by summing these subscale scores. Cronbach's α and the test-retest reliability of the SDQ were 0.73 and 0.62, respectively (Goodman, 2001). The validity of the Persian version of the SDQ is confirmed (Tehranidoust, 2007).

Interventional sessions

The experimental group participants (neurofeedback) underwent 16 neurofeedback treatment sessions, three times a week and each session lasted 45 minutes. The content of interventional sessions was designed based on the literature and adapted to the baseline brain wave patterns of the participants. This protocol focused on suppressing high β in the range of 21.5 Hz and above, suppressing α in the range of 8.5 to 11.5 Hz, and enhancing β in the range of 15 to 17 in the left frontal region (point F3). In neurofeedback treatment, one session was dedicated to gathering baseline brain wave data for each participant and identifying any abnormal brain waves. During this session, the participant first sat in front of a computer screen. Using a meter, specific points on the participant's scalp were identified and marked according to the international 10-20 system for mapping brain activity. Then, the neurofeedback device was connected to the electrodes and the computer, and the "biograph software" window was placed in front of the participant. Three active (blue), reference (yellow), and ground (black) electrodes were attached to specific points through a special glue to measure brain waves and earlobes. The reference electrode was connected to the earlobe on the side of the brain where the active electrode was attached. Then, the participant was asked to position their body in the most comfortable state and remain still for two minutes. After the participant was ready, the recording of changes in brain waves began using the device. After two minutes, the electrode was connected to the next desired point, and the recording process was repeated as described above. During certain stages and throughout the process of recording brain waves, the participants were required to either keep their eyes closed, read a text, or listen to an audio. The desired points that are usually examined in baseline brain wave information to identify asymmetrical or abnormal brain waves are Cz, F3, F4, Pz, and Fz. For this purpose, recordings other than brain waves, such as muscle tension and city electrical activity were eliminated and then the results of brain wave recordings, categorized by wave type, were obtained from the biograph software. In the present study, according to the research findings, it was expected that F3 and F4 would exhibit hemispherical asymmetry and have abnormal brain waves. Abnormalities were observed in all participants, and F4 showing higher activ-

ity compared to F3 in α and high β waves. This finding was consistent with the research result. For this reason, the neurofeedback protocol was designed to suppress α and promote β waves while enhancing β waves at the F3 point. In subsequent sessions, at the beginning and end of each session, a baseline recording from the central point of the brain Cz was taken to review the changes resulting from neurofeedback training. The sessions were done three times a week, at a specific time, and during each session, according to the protocol, the participant sat in front of the computer screen for about 40 minutes and watched various animations in the "biograph software". The participant was asked to try to move the animations. Whenever the brain waves changed towards the desired pattern according to the protocol, the animation started to move, and the participant would receive a score after maintaining the ideal brain wave state for 15 s. In this way, the brain unconsciously learns through the conditioning process what the desired brain waves are and under what conditions it can receive a score, and the desire of the brain to produce those waves increases. As the sessions continued, the participant's scoring rate increased and their brain waves changed, which indicated the learning and conditioning process of the brain. Additionally, the child's mother was asked to observe situations during the week in which the child experienced anxiety, see any changes in the child's behavior compared to before the treatment, and also keep an eye on the child's behavioral performance.

Procedures and participants

After approval of the research plan by the university's research committee and obtaining the necessary permits to conduct the study, an ethical code was obtained, and simultaneously, by visiting the Ziai Counseling Center in Meybod City, collaboration with the center's responsible personnel was established, and the therapeutic case presentation was approved. In addition, using a written informed consent form, the consent of the parents of the participating children in the current study was obtained. Participants were selected from the individuals who sought services at the center based on the research's inclusion and exclusion criteria and divided into two experimental and control groups. The parents of both groups completed the goodman's strengths and difficulties questionnaire, in addition to the pre-test (first session) and post-test (last session), during the fourth, eighth, and twelfth sessions. First, baseline recording was taken. In the fifth and tenth treatment of neurofeedback intervention (to examine changes in anxiety and behavioral performance during a quarter of the initial, middle, and final stages of the intervention), one of the parents completed the SDQ again, and after the last session, one of the parents responded to all the questionnaires. The experimental group took part in a 16-session, 45-minute neurofeedback intervention, while the control group did not receive any intervention. It's essential to note that the method and execution process were explained to the parents after the final group selection for the study, and their consent was obtained, and adhere to ethical principles, the researcher assured the parents that all session-related information and results would remain confidential and a consent form for participation in the study was completed by the parents. Also, after the study, neurofeedback sessions were conducted for participants in the control group. Finally, after collecting the date, the data were analyzed using the repeated measure analysis of variance (ANOVA) method via SPSS software, version 16.

Results

The descriptive analysis indicated that 3 girls and 2 boys were in each group with a mean age of 7.01±1.08 in the experimental group and 6.60±0.83 in the control group. In the experimental group, the educational level of mothers was as follows: 3 with a high school diploma, 1 with a bachelor's degree and 1 with a master's degree, and in the control group, 2 mothers with a bachelor's degree and 2 with a master's degree existed. Table 1 presents the Mean±SD of children's behavioral performance, categorized by the stage of the experiment.

According to Table 1, in the experimental group across the five assessment stages, the mean scores of behavioral performances have decreased but in the control group, the scores of this component have increased (higher scores in the behavioral performance questionnaire indicate inappropriate behavioral performance). Next, to investigate the research hypothesis, repeated measures ANOVA was utilized; initially, its assumptions, including the normality of score distributions, homogeneity of variances in scores between the two groups, and homogeneity of regression slopes were examined and confirmed. As shown in Table 2, the Shapiro-Wilk test statistic was not significant at the level of $P<0.05$; therefore, the most crucial assumption (the use of parametric tests) was met and this analysis can be used ($P<0.05$). Also, the one-way ANOVA indicated that in the pre-test, no significant difference was observed in the mean behavioral performance between the experimental and control groups, confirming the homogeneity of the means assumption ($P<0.05$). The Levene's test values for the behavioral performance variable were also non-significant, confirming the assumption of equal variances between

Table 1. Mean±SD of behavioral performance in the experimental and control groups in the assessment stages

Group	Mean±SD				
	1st Stage (Pre-test)	2nd Stage	3rd Stage	4th Stage	5th Stage (Post-test)
Experiment	28.80±2.31	25.80±2.60	22.20±2.94	18.60±1.67	17.20±1.80
Control	31.40±2.88	31.60±3.57	32.00±3.39	32.80±2.77	33.60±3.13

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Table 2. The result of the normality test for score distribution, homogeneity of variances between the two groups, Mauchly's sphericity

The Variable of Behavioral Performance										
Shapiro-Wilk		One-tailed Variance		Levene		Mauchly's Sphericity			Epsilon	
Z	P	F	P	Z	P	W	X^2	P	Greenhouse-Geisser	Huynh-Feldt
0.894	0.375**	1.171	0.343**	0.200	0.821**	0.034	35.130	0.001*	0.373	0.484

*P<0.01,**P>0.05

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Table 3. The results of repeated measures analysis of variance for Neurofeedback intervention in children's behavioral performance

Variable	Sources of Changes	Sum of Squares	df	Mean Squares	F Ratio	Sig.	Effect Size
Behavioral performance	Intervention stage	559.388	4	129.84	95.02	0.001*	0.89
	StageGroup	517.573	8	64.69	43.96	0.001*	0.88
	Error	70.64	48	1.47			

*P<0.01.

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the two groups. Furthermore, the significant result of Mauchly's sphericity test indicated that the assumption of the consistency of the error covariance matrix related to the dependent variables was not confirmed (P<0.01); considering that the epsilon value for the Greenhouse-Geisser index is 0.37 and for the Huynh-Feldt index, it is .48, both of which are less than 0.75, the Greenhouse-Geisser correction for degrees of freedom has been utilized.

The results of the repeated measures ANOVA in Table 3 show that the F value is 43.96, which is significant, and it can be concluded that the changes in scores at least in one of the test stages in the experimental group, compared to the control group, were significant. Also, the eta coefficient value (partial η^2=0.88) indicates that in the experimental group, 88% of the score changes in the five stages of the analysis can be attributed to the neurofeedback intervention program.

Table 4. The result of the Benferroni post hoc test for comparing the effectiveness of neurofeedback on behavioral performance at different stages

Group	Stage 1 and 2		Stage 1 and 3		Stage 1 and 4		Stage 1 and 5	
	Mean Difference	Sig.	Mean Difference	Sig.	Mean Difference	Sig.	Mean Difference	Sig.
Neurofeedback	1.400	0.046**	2.600	0.004*	3.800	0.005*	5.200	0.004*
Control	-0.200	1.000**	-0.600	1.000**	-1.400	1.000**	-2.200	0.514**

*P<0.01, **P>0.05.

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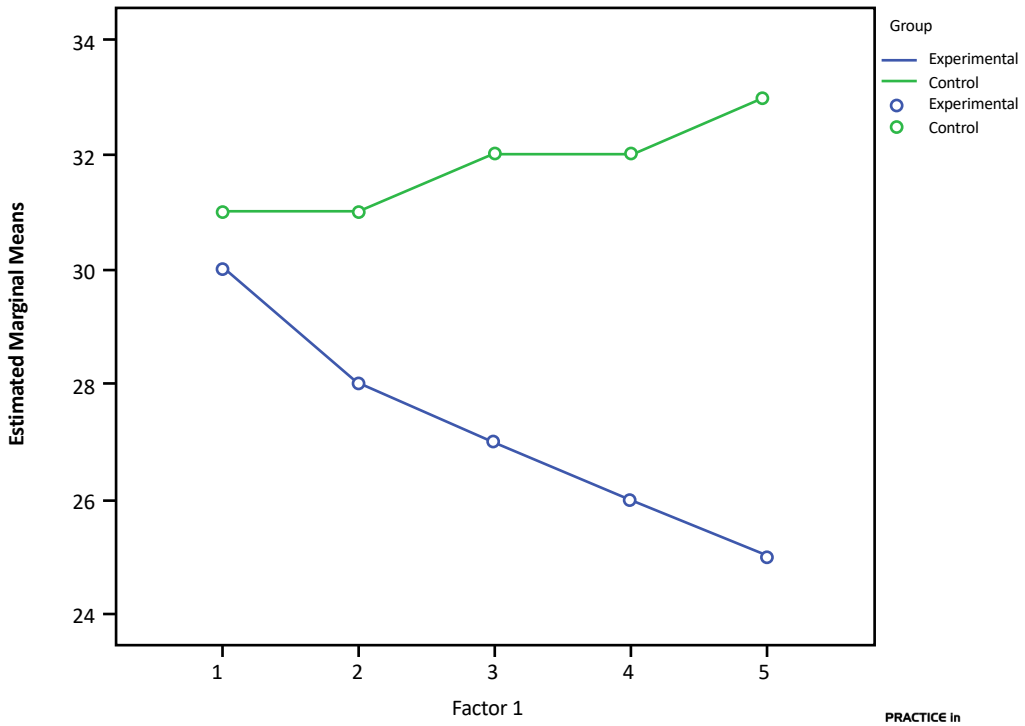

Figure 1. The status of behavioral performance scores in the experimental and control groups

To investigate the specific differences between the stages of the test in the experimental and control groups, Bonferroni correction was used, and the results are shown in Table 4.

As observed in Table 4, the differences between stages 1 and 2, 1 and 3, 1 and 4, as well as in 1 and 5, were statistically significant at a level $P<0.05$ and $P<0.01$, indicating that neurofeedback intervention had a significant impact on the behavioral performance of children across different stages. Also, in the control group, no significant difference was observed between the mean behavioral performances of children across different stages of the test. As depicted in Figure 1, undesirable behavioral performance decreased in the experimental group, whereas it increased in the control group.

Discussion

This study was conducted to determine the effectiveness of neurofeedback on the behavioral performance of children with social anxiety disorder. Based on the results, it was evident that neurofeedback treatment has an impact on the behavioral performance of children with social anxiety; it was consistent with previous studies (Beigi Harchegani, 2023; Ghayour Kazemi, 2018; Kimmig et al., 2019; Lisk et al., 2020; Saul et al., 2022; Shariati, 2017; Zhang, 2017). In explaining these results, it can be said that physiological responses in individuals with social anxiety affect the brain and disrupt brain functioning. Neurofeedback stimulates the brain through a process of self-regulation, assisting individuals to control their psychological responses through conditioning and acquire new skills on the verge of managing their anxiety. In other words, during neurofeedback treatment sessions, the newly acquired skills, both consciously and unconsciously, become internalized and automatically transfer to an individual's daily activities, such as behavioral performance. Therefore, neurofeedback helps the brain regulate itself and address functional deficiencies, and improves an individual's behavioral performance, such as contributing to the formation of emotional relationships, social interactions, and appropriate behavior between the individual and society (Saul et al., 2022). In other words, the purpose of neurofeedback is to gain awareness and self-regulation of brain cortical activity, which is assumed to be related to behavioral signs and symptoms because the foundation of this intervention is based on the mind-body relationship, it enhances the mind's ability to naturally reconstruct and heal itself, and by teaching the principles of operant conditioning, it assists the brain in reducing abnormal waves and increasing desirable ones, ultimately modifying behavioral performance patterns (Teimory, 2021). Therefore, in neurofeedback intervention, the activity of brain waves (including α, β, θ, and δ), which are unconscious and beyond the individual's control, become perceptible to the person, and the person can perceive waves that are outside the normal pattern in terms of higher or lower

frequencies, or greater or lesser intensity than usual, by receiving visual or auditory stimuli; during the sessions, they can regulate and normalize these waves. Therefore, this treatment enables the individual to reduce slow-wave activity and increase fast-wave activity, and by providing appropriate and timely stimulation to the electrical activity of the brain, it enhances the synthesis, secretion, and activity of neutrophins, which itself leads to greater synaptic connectivity and connection, and preventing brain and synapse degeneration, even fostering the formation of new synapses, contributing to the improvement of a social anxiety disorder (Zhang, 2017). Considering that children are unable to significantly influence their brain wave activity, and because they are not aware of it, neurofeedback treatment helps them to not only have representations of their brain wave activity displayed on a computer screen several thousandths of a second after the event, but also they can modify their brain wave patterns through operant conditioning. Therefore, considering the various research on abnormal brain wave patterns, neurotransmitters, synapses, and the action potential in children with social anxiety disorder, reported to differ from typically developing individuals, these differences contribute to behaviors, such as withdrawal, depression, social problems, etc., and neurofeedback treatment, as a neurological treatment, can help modify abnormal brain waves in these children, leading to changes their mood, behavior, and thoughts, and by reducing the physical, cognitive and behavioral symptoms of social anxiety, it can improve and enhance their behavioral performance (Lisk et al., 2020). As a result, the application of neurofeedback treatment for children with social anxiety disorder leads to continuous feedback for producing and regulating brain waves, increasing β wave and their activity in the frontal lobe, reducing the activity of slow waves, such as θ lead to a reduction in social avoidance symptoms and problematic behaviors like behavioral and social problems and with the reduction of these symptoms, children with social anxiety disorder will experience less difficulties at home, school and in society, they will receive less negative feedback from family and others, their social relationships with parents and others will improve and this can help break the cycle of receiving negative feedback about their behavioral performance from others to some extent.

Conclusion

According to the research result, it can be concluded that neurofeedback treatment can be considered a complementary therapeutic approach to improve behavioral performance in children with social anxiety disorder, garnering attention from psychologists and child and adolescent psychiatrists. However, this research had limitations.

One of the limitations of the research was the small sample size due to the challenging access to the target population and also the execution of neurofeedback treatment, which limitation can reduce the generalizability of the results; however, the researcher attempted to enhance the study's validity by utilizing a time-series approach. Also, since this research was only conducted on the age group of 6 to 8 years old, generalizing the findings to other age and educational groups remains constrained. However, according to the research results indicating the effectiveness of neurofeedback treatment, it is recommended to utilize this therapeutic approach in the clinical treatment and rehabilitation centers for children in the field of psychotherapy. Furthermore, for future studies, it is recommended to investigate the impact of neurofeedback treatment on improving various physical, social and psychological functions in children with common disorders, while removing the current limitations.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Yazd University, Yazd, Iran. (Code: IR.YAZD.REC.1399.017).

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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References

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders: DSM-5™, 5th ed. Washington, DC: American Psychiatric Press. [Link]

Stein, M. B., & Stein, D. J. (2008). Social anxiety disorder. *Lancet (London, England), 371*(9618), 1115–1125. [DOI:10.1016/S0140-6736(08)60488-2] [PMID]

PPolanczyk, G. V., Salum, G. A., Sugaya, L. S., Caye, A., & Rohde, L. A. (2015). Annual research review: A meta-analysis of the worldwide prevalence of mental disorders in children and adolescents. *Journal of Child Psychology and Psychiatry, and Allied Disciplines, 56*(3), 345–365. [DOI:10.1111/jcpp.12381] [PMID]

Haller, S. P., Cohen Kadosh, K., Scerif, G., & Lau, J. Y. (2015). Social anxiety disorder in adolescence: How developmental cognitive neuroscience findings may shape understanding and interventions for psychopathology. *Developmental Cognitive Neuroscience, 13,* 11–20. [DOI:10.1016/j.dcn.2015.02.002] [PMID]

Harbort, J., Witthöft, M., Spiegel, J., Nick, K., & Hecht, H. (2013). The widening of the gaze cone in patients with social anxiety disorder and its normalization after CBT. *Behaviour Research and Therapy, 51*(7), 359–367. [DOI:10.1016/j.brat.2013.03.009] [PMID]

Alden, L. E., & Taylor, C. T. (2011). Relational treatment strategies increase social approach behaviors in patients with Generalized Social Anxiety Disorder. *Journal of Anxiety Disorders, 25*(3), 309–318. [DOI:10.1016/j.janxdis.2010.10.003] [PMID]

Dryman, M. T., Gardner, S., Weeks, J. W., & Heimberg, R. G. (2016). Social anxiety disorder and quality of life: How fears of negative and positive evaluation relate to specific domains of life satisfaction. *Journal of Anxiety Disorders, 38,* 1–8. [DOI:10.1016/j.janxdis.2015.12.003] [PMID]

Donovan, C. L., Cobham, V., Waters, A. M., & Occhipinti, S. (2015). Intensive group-based CBT for child social phobia: A pilot study. *Behavior Therapy, 46*(3), 350–364. [DOI:10.1016/j.beth.2014.12.005] [PMID]

Piccirillo, M. L., Taylor Dryman, M., & Heimberg, R. G. (2016). Safety behaviors in adults with social anxiety: Review and future directions. *Behavior Therapy, 47*(5), 675–687. [DOI:10.1016/j.beth.2015.11.005] [PMID]

Howarth, M. P., & Forbes, M. (2015). Examining self-verification processes in social anxiety. *The Cognitive Behaviour Therapist, 8,* e21. [Link]

O'Day, E. B., Morrison, A. S., Goldin, P. R., Gross, J. J., & Heimberg, R. G. (2019). Social anxiety, loneliness, and the moderating role of emotion regulation. *Journal of Social and Clinical Psychology, 38*(9), 751-773. [DOI:10.1521/jscp.2019.38.9.751]

Halldorsson, B., & Creswell, C. (2017). Social anxiety in preadolescent children: What do we know about maintenance?. *Behaviour Research and Therapy, 99,* 19–36. [DOI:10.1016/j.brat.2017.08.013] [PMID]

Heeren, A., & McNally, R. J. (2018). Social anxiety disorder as a densely interconnected network of fear and avoidance for social situations. *Cognitive Therapy and Research, 42*(1), 103-113. [Link]

Muris, P., Hendriks, E., & Bot, S. (2016). Children of few words: Relations among selective mutism, behavioral inhibition, and (social) anxiety symptoms in 3- to 6-year-olds. *Child Psychiatry and Human Development, 47*(1), 94–101. [DOI:10.1007/s10578-015-0547-x] [PMID]

Beesdo-Baum, K., Knappe, S., Fehm, L., Höfler, M., Lieb, R., & Hofmann, S. G., et al. (2012). The natural course of social anxiety disorder among adolescents and young adults. *Acta Psychiatrica Scandinavica, 126*(6), 411–425. [DOI:10.1111/j.1600-0447.2012.01886.x] [PMID]

Frandsen, F. W., Simonsen, S., Poulsen, S., Sørensen, P., & Lau, M. E. (2020). Social anxiety disorder and avoidant personality disorder from an interpersonal perspective. *Psychology and Psychotherapy, 93*(1), 88–104. [DOI:10.1111/papt.12214] [PMID]

Carpita, B., Muti, D., Petrucci, A., Romeo, F., Gesi, C., & Marazziti, D., et al. (2020). Overlapping features between social anxiety and obsessive-compulsive spectrum in a clinical sample and in healthy controls: Toward an integrative model. *CNS Spectrums, 25*(4), 527–534. [DOI:10.1017/S109285291900138X] [PMID]

Koyuncu, A., Alkın, T., & Tükel, R. (2018). Development of social anxiety disorder secondary to attention deficit/hyperactivity disorder (the developmental hypothesis). *Early Intervention in Psychiatry, 12*(2), 269–272. [DOI:10.1111/eip.12372] [PMID]

RReilly, E. E., Whitton, A. E., Pizzagalli, D. A., Rutherford, A. V., Stein, M. B., & Paulus, M. P., et al. (2020). Diagnostic and dimensional evaluation of implicit reward learning in social anxiety disorder and major depression. *Depression and Anxiety, 37*(12), 1221–1230. [DOI:10.1002/da.23081] [PMID]

Hudson, J. L., Rapee, R. M., Lyneham, H. J., McLellan, L. F., Wuthrich, V. M., & Schniering, C. A. (2015). Comparing outcomes for children with different anxiety disorders following cognitive behavioural therapy. *Behaviour Research and Therapy, 72,* 30–37. [DOI:10.1016/j.brat.2015.06.007] [PMID]

Masia-Warner, C., Storch, E. A., Pincus, D. B., Klein, R. G., Heimberg, R. G., & Liebowitz, M. R. (2003). The Liebowitz social anxiety scale for children and adolescents: an initial psychometric investigation. *Journal of the American Academy of Child & Adolescent Psychiatry, 42(9),* 1076-1084. [DOI:10.1097/01.CHI.0000070249.24125.89]

Spence, S. H., Donovan, C. L., March, S., Kenardy, J. A., & Hearn, C. S. (2017). Generic versus disorder specific cognitive behavior therapy for social anxiety disorder in youth: A randomized controlled trial using internet delivery. *Behaviour Research and Therapy, 90,* 41–57. [DOI:10.1016/j.brat.2016.12.003] [PMID]

Sitaram, R., Ros, T., Stoeckel, L., Haller, S., Scharnowski, F., & Lewis-Peacock, J., et al. (2017). Closed-loop brain training: The science of neurofeedback. Nature reviews. *Neuroscience, 18*(2), 86–100. [DOI:10.1038/nrn.2016.164] [PMID]

Yousefi Afrashte, M., Khanahmady, F., & Masoumi, S. (2021). [The effectiveness of neurofeedback in reducing attention deficit and aggression in children aged 7-9 years (Persian)]. *Shenakht Journal of Psychology and Psychiatry, 8*(3), 52-62. [Link]

AArns, M., Batail, J. M., Bioulac, S., Congedo, M., Daudet, C., & Drapier, D., et al. (2017). Neurofeedback: One of today's techniques in psychiatry?. *L'Encephale, 43*(2), 135–145. [DOI:10.1016/j.encep.2016.11.003] [PMID]

Ring, C., Cooke, A., Kavussanu, M., McIntyre, D., & Masters, R. (2015). Investigating the efficacy of neurofeedback training for expediting expertise and excellence in sport. *Psychology of Sport and Exercise, 16*(1), 118-127. [DOI:10.1016/j.psychsport.2014.08.005]

Demos, J. N. (2019). Getting started with EEG neurofeedback. New York: W.W. Norton. [Link]

Thibault, R. T., Lifshitz, M., & Raz, A. (2017). Neurofeedback or neuroplacebo?. *Brain : A Journal of Neurology, 140*(4), 862–864. [DOI:10.1093/brain/awx033] [PMID]

Trambaiolli, L. R., Kohl, S. H., Linden, D. E. J., & Mehler, D. M. A. (2021). Neurofeedback training in major depressive disorder: A systematic review of clinical efficacy, study quality and reporting practices. *Neuroscience and Biobehavioral Reviews, 125,* 33–56. [DOI:10.1016/j.neubiorev.2021.02.015] [PMID]

Neurofeedback Collaborative Group (2021). Double-blind placebo-controlled randomized clinical trial of neurofeedback for attention-deficit/hyperactivity disorder with 13-month follow-up. *Journal of the American Academy of Child and Adolescent Psychiatry, 60*(7), 841–855. [DOI:10.1016/j.jaac.2020.07.906] [PMID]

Martínez-Briones, B. J., Bosch-Bayard, J., Biscay-Lirio, R. J., Silva-Pereyra, J., Albarrán-Cárdenas, L., & Fernández, T. (2021). Effects of neurofeedback on the working memory of children with learning disorders-An EEG power-spectrum analysis. *Brain Sciences, 11*(7), 957. [DOI:10.3390/brainsci11070957] [PMID]

Tolin, D. F., Davies, C. D., Moskow, D. M., & Hofmann, S. G. (2020). Biofeedback and neurofeedback for anxiety disorders: A quantitative and qualitative systematic review. *Advances in Experimental Medicine and Biology, 1191,* 265–289. [DOI:10.1007/978-981-32-9705-0_16] [PMID]

Kimmig, A. S., Dresler, T., Hudak, J., Haeussinger, F. B., Wildgruber, D., & Fallgatter, A. J., et al. (2019). Feasibility of NIRS-based neurofeedback training in social anxiety disorder: behavioral and neural correlates. *Journal of Neural Transmission (Vienna, Austria : 1996), 126*(9), 1175–1185. [DOI:10.1007/s00702-018-1954-5] [PMID]

Lisk, S., Kadosh, K. C., Zich, C., Haller, S. P., & Lau, J. Y. (2020). Training negative connectivity patterns between the dorsolateral prefrontal cortex and amygdala through fMRI-based neurofeedback to target adolescent socially-avoidant behaviour. *Behaviour Research and Therapy, 135,* 10376. [DOI:10.1016/j.brat.2020.103760] [PMID]

Saul, M. A., He, X., Black, S., & Charles, F. (2022).A two-person neuroscience approach for social anxiety: A paradigm with interbrain synchrony and neurofeedback. *Frontiers in Psychology, 12,* 568921. [DOI:10.3389/fpsyg.2021.568921] [PMID]

Zhang P, & Cheng, L. (2017). A randomized controlled trial of a neurofeedback-based training for improvement in social phobia disorder. *NeuroQuantology, 15*(4), 133-138. [Link]

Liebowitz M. R. (1987). Social phobia. *Modern Problems of Pharmacopsychiatry, 22,* 141-73. [DOI:10.1159/000414022] [PMID]

Moghaddam Poor, N., & Sepahvand, T. (2018). [The explanation of social anxiety in primary school children based on difficulties in emotional regulation and cognitive flexibility of mothers (Persian)]. *Quarterly Journal of Child Mental Health, 5*(2), 14-24. [Link]

Goodman R. (1997). The strengths and difficulties questionnaire: A research note. *Journal of Child Psychology and Psychiatry, and Allied Disciplines, 38*(5), 581–586. [DOI:10.1111/j.1469-7610.1997.tb01545.x] [PMID]

Goodman, R. (2001). Psychometric properties of the strengths and difficulties questionnaire. *Journal of the American Academy of Child and Adolescent Psychiatry, 40*(11), 1337–1345. [DOI:10.1097/00004583-200111000-00015] [PMID]

Tehranidoust, M., Shahrivar, Z., Pakbaz, B., Rezaei, A., & Ahmadi, F.(2007). [Validity of Farsi Version of Strengths and Difficulties Questionnaire (SDQ) (Persian)]. *Advances in Cognitive Science, 8*(4), 33-39. [Link]

Beigi, H. N., Sharifi, T., Nikkhah, M., & Ahmadi, R. (2023). [The effectiveness of neurofeedback therapy on social anxiety and rumination in people with social anxiety (Persian)]. *Razi Journal of Medical Sciences, 30*(1), 138-150. [Link]

Ghayour Kazemi, F., Sepehri Shamloo, Z., Mashhadi, A., Ghanaei Chamanabad, A., & Pasalar, F. (2018). [A comparative study effectiveness of metacognitive therapy with neurofeedback training on anxiety symptoms, emotion regulation and brain wave activity in female students with social anxiety disorder (single subject study) (Persian)]. *Neuropsychology, 4*(12), 77-100. [Link]

Shariati, K., Yosfi, F., & Hemmati Sabet, A. (2017). A comparative study of neurofeedback and mindfulness-based stress reduction on social anxiety. *Shenakht Journal of Psychology and Psychiatry, 4(1)*, 51-65. [Link]

Teimory, S., Soltanifar, A., Torkamani, M., Yazdanpanah, F., & Askari Noghani Moghadam, H. (2021). [The effectiveness of neurofeedback therapy on reducing attraction problems and exogenous behavioral problems in children with ADHD (Persian)]. *Journal of Analytical - Cognitive Psychology, 12*(44), 83-95. [Link]