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Research Article

The Effectiveness of Neurofeedback on the Mental Health of Deaf Students

Marziyeh Sarvi[1], Ali Ghanaee Chaman Abad[2], Mohammad Javad Asghari ebrahim abad[3], Sahar Khosravan[4]

1.PhD in Psychology, Faculty of Education and Psychology, Ferdowsi University of Mashhad, Mashhad, Iran.

2.Associate Professor of the Department of Psychology, Faculty of Educational Sciences and Psychology, Member of the Research Core of Cognitive Sciences, Ferdowsi University of Mashhad, Mashhad, Iran

3.Associate Professor, Department of Psychology, Faculty of Educational Sciences and Psychology, Ferdowsi

4.MS in Clinical Psychology, Mashhad, Iran.

Correspondence:

Ali Ghanaee Chaman Abad

Email:

ghanaee@um.ac.ir

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Abstract

Objective: This study aimed to examine the effectiveness of neurofeedback in reducing symptoms of depression, anxiety, and stress in high school deaf girls. **Method:** A total of 24 deaf female students were randomly assigned to experimental (n=12) and control (n=12) groups. The experimental group received 15 neurofeedback training sessions targeting the F3 and F4 regions. Both groups completed the DASS-21 questionnaire before and after the intervention.. **Results:** Multivariate analysis of covariance indicated significant reductions in depression ($F = 15.680$, $p<.05$), anxiety ($F = 5.991$, $p<.05$), and stress ($F = 6.100$, $p<.05$) scores in the experimental group compared to the control group. **Conclusion:** Neurofeedback appears to be an effective intervention for improving mental health among deaf adolescents.

Keywords: Neurofeedback, Mental health, Depression, Anxiety, Deaf students.

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Extended Abstract

Background and Objectives

Hearing loss is a prevalent sensory disability affecting numerous individuals worldwide, impacting their socio-economic status, mental and physical health, academic progress, and employment opportunities. Deaf individuals often face behavioral and social challenges, reporting lower life satisfaction, reduced engagement in physical activities, and increased risk of isolation and depression. These factors contribute to cognitive problems, feelings of isolation and rejection, and increased anxiety and stress in communication situations. Given the elevated rates of mental health issues in deaf populations, particularly depression, anxiety and stress, it is crucial to explore effective interventions tailored to their specific needs. Neurofeedback emerges as a promising therapeutic approach that warrants investigation in this context.

This study aimed to investigate the effectiveness of neurofeedback in reducing symptoms of depression, anxiety, and stress in high school deaf girls, addressing the gap in mental health interventions tailored for this vulnerable population.

Materials and Methods

A quasi-experimental pretest-posttest design with a control group was employed. Twenty-four deaf female students were randomly assigned to either an experimental group (n=12) or a control group (n=12). The experimental group received 15 neurofeedback training sessions, each lasting 45 minutes and conducted three times per week. neurofeedback protocol targeted the F3 and F4 regions of the brain, areas associated with emotional regulation and cognitive function., using beta/theta treatment for F3 and alpha/beta protocol for F4. The goal was to increase beta activity in the F3 area and alpha activity in the F4 area. The Baseline recordings were taken from each area (F3 and F4) for two minutes and 10 seconds before and after each session. During each session, participants received real-time feedback based on their brainwave activity, encouraging them to modulate their neural activity toward healthier patterns. The control group did not receive neurofeedback training during the study period. Inclusion criteria included being congenitally deaf adolescents in the first and second years of high school, with moderate to profound deafness, aged between 13 and 20 years, and not using antidepressants or anxiety medications. Exclusion criteria included taking drugs prescribed by a psychiatrist, unwillingness of parents or students to continue participation, and being absent for more than 3 consecutive sessions or more than 6 sessions during the treatment period.

Both the experimental and control groups completed the Depression, Anxiety, and Stress Scale (DASS-21) questionnaire before the intervention (pre-test) and after the completion of the 15 neurofeedback sessions (post-test). The DASS-21 is a widely used and validated self-report instrument that measures the severity of depression, anxiety, and stress symptoms.

Results

Multivariate analysis of covariance (MANCOVA) was used to analyze the data. Levene's test indicated that the data were normally distributed with equal variances. The MANCOVA results showed significant reductions in depression ($F = 15.680$, $p<.05$), anxiety ($F = 5.991$, $p<.05$), and stress ($F = 6.100$, $p<.05$) scores in the experimental group compared to the control group after the neurofeedback intervention. These findings suggest that neurofeedback training had a positive impact on the mental health of the deaf female students.

Discussion and Conclusion

The results of this study indicate a significant reduction in depression, anxiety, and stress levels among deaf female high school students who underwent neurofeedback training, compared to a control group. These findings suggest that neurofeedback is a promising intervention for improving the mental health of deaf adolescents, a population often facing unique challenges related to communication barriers and social isolation.

The observed improvements may be linked to neuroplasticity, the brain's ability to reorganize itself by forming new neural connections. The neurofeedback protocol, which targeted the F3 and F4 regions of the brain, is believed to have facilitated improved emotional regulation and cognitive function in the participants. By providing real-time feedback on their brainwave activity, the neurofeedback training likely enabled the students to learn self-regulation strategies, helping them to modulate their neural activity towards healthier patterns associated with decreased depression, anxiety, and stress. These effects align with previous research showing that neurofeedback lateral dominance training increases the right frontal alpha power and deeply impacts emotion and cognition, further highlighting the potential of neurofeedback for emotional regulation.

The findings are particularly relevant given the documented higher rates of mental health issues, including depression and anxiety, among deaf individuals compared to their hearing peers. Factors such as communication difficulties, social isolation, and potential language deprivation can contribute to these disparities. Neurofeedback offers a non-pharmacological and non-invasive approach to address these issues by directly targeting brain activity patterns associated with emotional regulation. It has been suggested that with the increase in visual perception that deaf people have, that neurofeedback is the best treatment.

This study provides evidence supporting the effectiveness of neurofeedback as an intervention to improve mental health outcomes in deaf adolescents. Specifically, neurofeedback training resulted in a statistically significant reduction in symptoms of depression, anxiety, and stress in the experimental group. This suggests that neurofeedback may be a valuable tool for addressing the mental health needs of deaf adolescents. The study underscores the potential of neurofeedback as a non-pharmacological approach to managing mental health in this population with unique communication and social challenges.

Further research is recommended to explore the long-term effects of neurofeedback interventions in deaf individuals and to identify optimal neurofeedback protocols for this population. Future studies with larger and more diverse samples of deaf individuals are needed to enhance the generalizability of the findings. Also, further studies should be conducted that target an experimental group that contains both deaf and hearing participants. These studies could give a clearer picture of the correlation of neurofeedback and mental health. The present findings contribute to the growing body of evidence supporting the use of neurofeedback in mental health care and highlight its potential to improve the well-being of deaf adolescents.

Introduction

Hearing loss is the most common sensory disability worldwide that affects many people (Wilson et al., 2017; Deal et al., 2018). Hearing impairment can affect many aspects of a person's life, including socio-economic status, mental and physical health, academic progress, and obtaining employment opportunities (World Health Organization, 2017), as hearing is one of the most essential sensory abilities. It is effective in people's communication. Hearing loss affects all age groups, from infancy to old age, and at any level, it can affect a person's social communication, education, performance, and security (Adigun, 2017).

Hearing plays a significant role in developing speech skills as the most effective way of communication between humans, and people with hearing loss face more behavioral and social problems (Rutherford et al., 2017). Most of them report a lower level of satisfaction with life, show less interest in movement and recreational activities, and are more at risk of isolation and depression than hearing people (Ramage-Morin, 2016; Golub et al., 2018). Also, deaf people have lower self-esteem (Adigun, 2017), which increases their anxiety and stress in communication situations with others (Brown & Cornes, 2015). People with hearing problems have more cognitive problems than their healthy peers and suffer from feelings of isolation and rejection (Barker et al., 2017; Ray et al., 2018).

Generally, hearing parents with impaired children feel shame socially due to owning a deaf child who is unable to communicate correctly, and this may lead to rejection of the deaf child or adolescent, obviously, which causes motor maladaptation and social retreat in deaf or hard-of-hearing people (Valizadeh, Ghobadzadeh, & Parsa, 2016).

Deaf children seem to have trouble getting help from others because the way to communicate to get help is to use their sense of hearing; deaf people usually cannot tell their problems to others, and others cannot help them if necessary, which leads to more anxiety in deaf people. According to the conducted research and the significantly higher level of depression in deaf children compared to their hearing peers, it seems that some behaviors of deaf children are considered as a direct sign of guilt and shame on their part. Conflict, moodiness and anger, fatigue and avoidance, and a tendency to social distance are among the features of the unequal world in deaf children, and this inequality is especially evident in deaf girls (Bouldin et al., 2021; Opoku et al., 2022). Hearing loss (HI) lowers the quality of life and has many adverse physical, psychological, and social effects. Hearing loss can be associated with dementia and decreased cognitive function in people. Similarly, deaf children have more school and psychological problems, severe depression, and poor social interaction. Also, hearing loss is significantly associated with anxiety (Sayed et al., 2018).

Hearing-impaired children and teenagers' interpretation of social events is less than average due to language deprivation, so their language disorder damages their self-esteem, verbal skills, and relationships with the external environment, and makes them less satisfied with their relationship status. These people feel isolated and lonely and experience more anxiety (Long, 2021; Duncan, Colyvas, & Punch, 2021).

Mental health is a condition that affects the general health of individuals and reflects the satisfaction of the individual or society. In other words, it determines how a person reacts to interpersonal, intrapersonal, and social relationships at the norm. Thus, when a person's mental health status becomes a concern, especially in adolescence and adulthood, it is a threat to all members of society and can even be catastrophic (Sommers, 2014). According to Summers (2014), the issue of mental health in deaf people with poor communication skills is very worrying. The inability to respond to auditory-verbal stimuli performed by hearing peers significantly affects the psychosocial development of deaf people. Congenital deafness causes problems in understanding others and thus has a direct impact on the development of language skills that are essential for communication in both emotional and social dimensions, family bonding, social competence, and quality of life.

Research results indicate that deaf people have a significant increase in depression and anxiety compared to the hearing group (Golub et al., 2018). Therefore, at every stage of the development process, deaf people are faced with problems such as a sense of isolation and separation from others, isolation, and the presence of hostile attitudes towards their hearing peers, which often lead to social isolation, poor self-concept, low self-esteem, and ultimately depression. It hurts the cognitive and social-emotional development of deaf children (Adigun, 2017). The existence of low self-esteem causes these people to feel inferior and more isolated in front of their hearing peers and causes their communication and emotional problems to increase (Clarke et al., 2019).

Deaf people face more social and behavioral problems than their hearing peers. These people often experience low life satisfaction, low interest in physical and recreational activities, isolation, and consequently more psychosocial problems. In addition, due to communication problems, random learning is lower in these people. They may also have problems with abstract thinking, problem-solving, peer relationships, and low self-esteem. Therefore, deaf people are more exposed to health and environmental risks and are more prone to social maladaptation, depression, and poor sleep quality compared to their hearing peers (Adigun, 2017).

Depression is one of the most common mental disorders that can prevent people from progressing and improving in performing their duties by reducing their abilities. The correction of depression refers to a set of behaviors whose characteristic element is slowness in movement and speech. Crying, sadness, lack of active responses, lack of interest, low self-worth, insomnia, and lack of appetite are also among its symptoms (Mirzaei, 2022). Rostami, Bahmani, Bakhtyari, and Movallali (2014) found that crying, loss of interest, isolation, weight loss, and slower responses are signs of depression. However, the only factor that can differentiate between deaf-depressed and hearing-depressed people is the existence of communication barriers that significantly affect the development of depression in deaf people (Friedman, 2008).

It has been found that visual stimulation centers located in the right hemisphere of the brain are more active in deaf people. The right hemisphere is responsible for the recognition of differences between shapes, recognizing and expressing emotions, understanding geometric shapes, processing visual and spatial relationships, and processing non-verbal information; on the other hand, the left hemisphere is responsible for language skills, mathematical calculations, skillful movements, and time sequence pattern (Özyel, 2016). The right frontal systems are related to negative emotional states, such as sadness, anger, and fear, and the left frontal systems are associated with positive emotional states, such as happiness. Therefore, people who have a more active right hemisphere experience more negative emotional states, such as depression, and in contrast, people with a strong left hemisphere have positive emotional states related to mania (Gökçay, 2010). As it was said, deaf people have a strong visual perception compared to their hearing peers, and it may be used as a compensation mechanism for deafness; the best treatment for the deaf in this regard is neurofeedback.

Brain activity is based on the electronic firing of neurons. Therefore, it is possible to adjust, facilitate, or disrupt this electrical activity, which can help to create temporary or, to some extent, permanent changes. One of these methods is neurofeedback, which uses EEG amplifiers to measure the electrical activity of the cerebral cortex and is used as a therapeutic approach to improve anxiety, brain damage, depression, increase focused attention, and sleep disorders (La Marca, 2014; Micoulaud-Franchi, 2021; Choi et al., 2011). The main brain waves—Alpha, Beta, Gamma, Theta, and Delta — are measured by neurofeedback. In general, neurofeedback is a non-pharmacological and non-invasive treatment that increases brain efficiency by reducing adverse neural processes (Bennett, 2023).

The effect of neurofeedback on anxiety and attention, changes in gamma power and reduction of reaction time, differences in hemispheric function in the left temporal region, changes in increasing attention and response time, and improvement in the field of stable control over symptoms of hyperactivity and emotional instability are shown. It has been given and made a useful method in improving symptoms of attention deficit and impulsivity in hyperactive children and adolescents (Enriquez-Geppert et al., 2019; Schneider, H., Riederle, J., & Seuss, 2021). It has also been found that neurofeedback lateral dominance training increases the right frontal alpha power and deeply impacts emotion and cognition. Neurofeedback lateral dominance training is vital to control and regulate emotion and facilitates the function of the left frontal lobe (Choi et al., 2011).

Neurofeedback is a treatment for depression and anxiety (Lofthouse, Arnold, & Hurt, 2012; Hammond, 2005). This treatment helps people regulate cortical electroencephalography activity when receiving feedback, and this change reduces the symptoms of depression and anxiety in individuals (Peeters, Oehlen, Ronner, et al., 2014).

Neurofeedback was invented to correct and treat brain wave abnormalities. Neurofeedback training is a state-of-the-art technique based on functional conditioning of brain activities, which normalizes abnormal brain activities by changing the frequency range or the coherence of brain waves, leading to the improvement of behavioral and cognitive functions in people (Shereena et al., 2019).

This study aimed to investigate the effect of neurofeedback on anxiety, depression, and stress in high school deaf girls. The present study seeks to ask whether neurofeedback with a treatment protocol in F3 and F4 areas will reduce depression, stress, and anxiety in deaf girls or not.

Method

Participants

This quasi-experimental study is a pretest-posttest design with a control group. In the present research, since there was no possibility of random selection of subjects and only random assignment was done, the quasi-experimental method was used. The statistical population of this study is all deaf female students in Mashhad. After introducing deaf people through exceptional education, these people were randomly invited to participate in the treatment process. After meeting the entry criteria, the participants were informed about the purpose of the research, and verbal and written consent was obtained from them. The samples were selected as available sampling and were randomly divided into experimental and control groups. From these people, 24 deaf students were selected and divided into control and experimental groups with 12 members. Inclusion criteria were congenitally deaf adolescents who were in the first and second courses of high school and did not use antidepressants or anxiety drugs.

Yalom (2005) suggests that the appropriate size for a therapy group is 7 or 8 members. According to him, the range between 5 and 10 people is also accepted. Due to the nature of the research, which is part of the quasi-experimental designs, and considering the drop in subjects, 12 people were selected for each group.

Inclusion criteria

1. Participating students should be between 13 and 20 years old.
2. Deafness in these people should not be influenced by factors such as developmental disabilities of intelligence, visual impairment, mobility disability, etc.
3. Participants should not use any medication (prescribed by a psychiatrist) during the research.
4. Participants should not have undergone cochlear implant therapy.
5. People’s deafness should be moderate to deep.

Exclusion criteria

1. Taking drugs prescribed by a psychiatrist.
2. Parents or students are unwilling to continue cooperation and participation in research.
3. Being absent for more than 3 sessions in a row and more than 6 sessions during the treatment period.

Ethical Statements

This research has been approved by the Bioethics Committee of Ferdowsi University of Mashhad with the ethics ID IR.UM.REC.1398.062, and the organizers of the project have taken into account factors such as maintaining the confidentiality of personal information, preventing any harm to the participants, and the optionality of the initiation and continuation of the study process were observed in this research

Neurofeedback therapy

In the present study, neurofeedback therapy was performed in 15 sessions (three sessions per week) for 45 minutes in each session for the experimental group at F3 and F4 points. In the pre-test and post-test, the control and experimental groups completed the DASS stress, anxiety, and depression questionnaire.

According to the International System of 10-20, electrodes were installed in the F3 area for beta/theta treatment and the F4 area for alpha/beta protocol in two 20-minute steps. The goal is to increase the beta in the F3 area and the alpha in the F4 area. At the beginning of each session, before and after the treatment, a baseline recording was taken from each area for two minutes and 10 seconds. The data were analyzed through the statistical method of multivariate covariance.

Our brain waves have different frequencies: delta waves have a frequency of 0.5 to 4 Hz (e.g. during sleep), theta waves have a frequency of 4 to 8 Hz (memory consolidation, learning, encoding, and retrieval), alpha waves have a frequency of 8 to 12 Hz (long-term semantic memory and helps overall mental coordination, relaxation, alertness, mind-body integration, and learning), beta waves have a frequency higher than 13 Hz (concentration and cognitive processing). Beta brain waves are divided into 3 bands. Lo-Beta or Beta 1 (12 to 15 Hz) can be thought of as the fast idler or thinker. Beta, or Beta 2 (15-22 Hz), is highly involved and involves new experiences, high anxiety, or excitement. High-beta, or beta 3 (22 to 38 Hz), involves highly complex thoughts, integration of new experiences, high anxiety, or excitement (Hammond, 2011). Sensory-motor rhythm is part of beta waves with a frequency of 12 to 15 Hz, which is characterized by an active mind and a calm body with high concentration and attention, and storing and retrieving information (Grin-Yatsenko & Kropotov, 2020).

Depression Anxiety Stress Scales-21 (DASS-21). The DASS-21 is a self-report questionnaire including 21 items, 7 items consistent with subscales: depression, anxiety, and stress. Individuals are asked to rate every object on a scale of zero (did not apply to me at all) to three (very applicable to me). Total ratings are calculated by adding the ratings according to the things per (sub)scale and multiplying them using detail 2. An element's overall ratings in the DASS scale vary between 0 and 120, and therefore, the ratings for each of the subscales can also vary between 0 and 42. Cut-off ratings of 60 and 21 are used for the depression subscale and the DASS score, respectively. These cut-off ratings are derived from a hard and fast severity rating. Scores ≥ 60 (for total DASS) and ≥21 (for the depression) are labeled as high or severe. The reliability of the DASS-21 on this observed population becomes $\alpha dass\_T1 = 0.95$ and $\alpha dass\_T2 = 0.92$.

Results

After collecting the data, the data were analyzed through SPSS16 software. First, Levene's test was used to check the normality of the data, and the results of these tests were not significant for each variable in the pre-test and post-test, indicating that the data were assumed to be normal and the variances were equal. So, multivariate analysis of covariance may be used to analyze the data (Table 1).

Table 1: Test of Homogeneity of Variances

Related Variables	Levene Statistic	df1	Df2	Significance Level
Anxiety	.063	1	22	.804
Depression	2.168	1	22	.155
Stress	3.408	1	22	.078

According to the findings of Table 2, the mean and standard deviation of anxiety, depression, and stress in the neurofeedback group in the post-test had a significant decrease compared to the control group.

Table 2. Mean and standard deviation of anxiety, depression, and stress in the experimental and control groups in pre-test and post-test

Variable	Group	Mean		*SD*	
		Pre-test	Post-test	Pre-test	Post-test
Anxiety	Experimental	6.00	3.83	4.78	2.48
	Control	4.50	4.75	3.03	2.86
Depression	Experimental	6.08	3.25	3.08	1.81
	Control	6.50	5.75	1.31	1.28
Stress	Experimental	6.16	4.33	3.35	2.38
	Control	6.25	6.75	1.35	1.81

Table 3 shows the differences between the experimental and control groups in depression, anxiety, and stress in the post-test. As can be seen, there is a significant difference between the two groups in the anxiety scores ($F = 4.326$, $p = .05$), depression ($F = 15.254$, $p<.05$), and stress ($F = 7.434$, $p<.05$). In other words, the level of anxiety, depression, and stress in the post-test and after the intervention showed a significant decrease compared to the control group. Based on the ETA coefficient, 17% of anxiety, 42% of depression, and 26% of stress scores differences between the experimental and control groups were related to the effect of neurofeedback. So, our hypotheses were confirmed.

Table 3. Results of multivariate analysis of covariance on the effectiveness of neurofeedback on anxiety, depression, and stress

Related Variables		Total Sum of Squares	Degree of Freedom	Mean Square	*F*	Significance Level
Post-test	Anxiety	18.854	1	18.854	5.991	0.02
	Depression	36.556	1	36.556	15.680	0.001
	Stress	27.703	1	27.703	6.100	0.02

Discussion and Conclusion

This study aimed to examine the effectiveness of neurofeedback on anxiety, depression, and stress in deaf girl students in Mashhad. The results showed that neurofeedback significantly reduced depression, anxiety, and stress in deaf students. These findings are consistent with the results of previous research, including Cheon, Koo, and Choi (2016); Dias and van Deusen (2011); Hammond (2005); Harris et al. (2019); Hashemian and Sajjadi (2015); Moradi et al. (2011); Peeters et al. (2014); Simkin et al. (2014); Samadi and Shakerinia (2022); Jalali and Pourahmadi (2023); and Abdian et al. (2021).

Regarding the effectiveness of neurofeedback on depression and anxiety, it can be said that three networks in the brain are responsible for emotion regulation processes: the central executive network, the default mode network, and the salient network (Menon, 2011). These three networks play an essential coordinating role in cognitive functions and regulate brain functions for optimal work (Critchley, 2005). The activity of the default mode network increases the individual's ability to self-regulate neural functions (Caria et al., 2007). The central executive network plays an important role in the storage and proper use of memory information in cognitive functions. The activity of this network is impaired in people with anxiety and depression (Menon, 2011). The function of the salient network is to integrate emotional, physical, visual, and automatic information, which includes the insula, anterior cingulate cortex, and subcortical regions (Barreiros, Almeida, Baía, & Castelo-Branco, 2019). The function of these areas is disturbed in depression, impulse control, and anxiety (Menon, 2011). Neurofeedback by affecting brain waves (alpha-theta) with low frequency improves the functioning of these networks and inhibits the activity of specific and decisive areas in inducing excessive arousal (Caria et al., 2007).

Davison et al. (2004) showed in their research that low beta and high alpha in the right frontal cortex and high beta and low alpha in the left frontal cortex with positive emotion and low alpha and high beta in the right frontal cortex and high alpha and low beta In the left frontal cortex, they are related to negative emotions (quoted by Jalali and Pourmand, 2022). Based on this, it seems logical to design a protocol for activating the left frontal or reducing the activity of the right frontal to lessen the intensity of anxiety and depression in this research.

Decreasing the activity of the right prefrontal cortex improves mood symptoms (Hölzel et al., 2013). Neurofeedback improves emotional symptoms by increasing right frontal alpha and decreasing left frontal alpha (Cha et al., 2014). An increase in alpha wave also improves cognitive performance (Paret et al., 2014). Yang et al. (2014 & 2018) found that the anterior insular cortex, which is a region for regulating emotions, neurofeedback causes the activity of this region to decrease and improve emotional symptoms.

Davidson (1998), in his research, showed that depression is associated with activation of the left and right cortex. Numerous studies have shown that the right hemisphere is involved in negative emotions and withdrawal, and the left hemisphere is involved in positive emotions and motivation in behavior. When alpha activity increases in the left hemisphere, it becomes less active. As a result, people experience less positive emotions and withdrawal (Hammond, 2005). Studies have shown that beta rhythms increase with attention, arousal, and cortical stimulation (Cheon et al. 2016). Walker and Lawson (2013) showed that beta training in FPO2 reduces depression. They also showed that activating the left hemisphere is very important in happiness. Therefore, training to increase beta in the left hemisphere is a more direct way to treat depression. In our study, we used the protocol of increasing beta and decreasing alpha in the left hemisphere for depressed patients.

Studies have shown that a significant increase or decrease in alpha leads to anxiety and sleep disorders, and the use of alpha increase and decrease protocols depends on the alpha range in the occipital and parietal lobes. If the alpha range is low, alpha amplification occurs, and if it is high, the decrease in alpha leads to a reduction in anxiety symptoms (Moradi et al., 2011). According to the mentioned research, it seems logical to design a protocol for activating the left frontal or reducing the activity of the right frontal to decrease the intensity of anxiety and depression in this research.

In general, neurofeedback, by conditioning brain waves, helps people to acquire better and more adapted mood control skills to reduce disturbances such as anxiety and depression. The neurofeedback process is based on the principle of operant conditioning, which is based on the two concepts of reinforcement and reinforcer. In this process, operant conditioning occurs when a person is rewarded for finding the appropriate mental state. Thus, when a certain rhythm of a person's brain signal reaches the threshold, he receives audio or visual feedback; consequently, the person tries to adjust his mental state to receive more rewards, which increases the individual's behavior and desired mental state. A person can enhance their relaxation and reduce their depression and anxiety by practicing repeating and focusing more (Barreiros et al., 2019).

Limitations

One limitation of this study is the relatively small sample size, which may affect the generalizability of the findings. Additionally, the participants were all female high school students from one city, which might limit the application of the results to broader populations.

Future Research

Further studies are recommended to replicate these findings in larger, more diverse populations, including male participants and students from different age groups or regions. It would also be beneficial to compare the effects of different neurofeedback protocols to determine the most effective approach for improving mental health outcomes in deaf students.

Conflict of Interest

The authors declare that there are no conflicts of interest.

Reference

Abdian, H., Rezaei, M., Eskandari, Z., Ramezani, S., Pirzeh, R., & Dadashi, M. (2021). The Effect of Quantitative Electroencephalography-Based Neurofeedback Therapy on Anxiety, Depression, and Emotion Regulation in People with Generalized Anxiety Disorder. *Basic and clinical neuroscience, 12*(2), 281–290. https://doi.org/10.32598/bcn.12.2.2378.1.

Adigun, O. (2017). Depression and individuals with hearing loss: A systematic review. *Journal of Psychology & Psychotherapy*,*7*(5), 32. https://doi.org/10.4172/2161-0487.1000323

Barker AB, Leighton P, Ferguson MA. (2017). Coping together with hearing loss: a qualitative metasynthesis of the psychosocial experiences of people with hearing loss and their communication partners. *Int J Audiol, 56*(5), 297–305. https://doi.org/110.1080/14992027.2017.1286695

Barreiros A. R., Almeida I., Baía B. C., Castelo-Branco M. (2019). Amygdala modulation during emotion regulation training with fMRI-based neurofeedback. *Frontiers in Human Neuroscience, 13*, 89. https://doi.org/10.3389/fnhum.2019.00089.

Benatti, B., Girone, N., Conti, D., Celebre, L., Macellaro, M., Molteni, L, et al. (2023). Intensive Neurofeedback Protocol: An Alpha Training To Improve Sleep Quality and Stress Modulation In Health Care Professionals During The COVID-19 Pandemic. A Pilot Study. Clinical Neuropsychiatry, 20(1), 61. https://doi.org/10,36131./cnfioritieditore20230108

Bouldin, E., Patel, S. R., Tey, C. S., White, M., Alfonso, K. P., & Govil, N. (2021). Bullying and children who are deaf or hard-of-hearing: A scoping review. *The Laryngoscope, 131*(8), 1884-1892. https://doi.org/10.1002/lary.29388

Brown P, Cornes, A. (2015). Mental health of deaf and hard-of-hearing adolescents: What the yt students say? *Deaf Stud Deaf Educ, 20*, 75-81. https://doi.org/10.1093/deafed/enu031

Caria A., Veit R., Sitaram R., Lotze M., Weiskopf N., Grodd W., et al. (2007). Regulation of anterior insular cortex activity using real-time fMRI. *Neuroimage, 35*(3),1238-4 https://doi.org/10.1016/j.neuroimage.2007.01.018

Cha J., Greenberg T., Carlson J. M., DeDora D. J., Hajcak G., Mujica-Parodi L. R. (2014). Circuit-wide structural and functional measures predict ventromedial prefrontal cortex fear generalization: implications for generalized anxiety disorder. *Journal of Neuroscience, 34*(11), 4043–53. https://doi.org/10.1523/JNEUROSCI.3372-13.2014.

Cheon, E.-J., Koo, B.-H., & Choi, J.-H. (2016). The efficacy of neurofeedback in patients with major depressive disorder: An open-label labeled prospective study. *Applied Psychophysiology and Biofeedback*, *41*(1)*,*103-110. https://doi.org/103-110. 10.1007/s10484-015-9315-8

Choi SW, Chi SE, Chung SY, Kim JW, Ahn CY, Kim HT. (2011). Is alpha wave neurofeedback effective with randomized clinical trials in depression? A pilot study. *Neuropsychobiology, 63*(1), 43-51. https://doi.org/10.1159/000322290.

Clarke NA, Hoare DJ, Killan EC. (2019). Evidence for an Association Between Hearing Impairment and Disrupted Sleep: Scoping Review. *Am J Audiol, 28*(4):1015-1024. https://doi.org/10.1044/2019_AJA-19-0026

Critchley H. D. (2005). Neural mechanisms of autonomic, affective, and cognitive integration. *Journal of Comparative Neurology, 493*(1), 154–66. https://doi.org/10.1002/cne.20749.

Deal JA, Reed NS, Kravetz AD, et al. (2018). Incident hearing loss and comorbidity: a longitudinal administrative claims study. *JAMA Otolaryngol Head Neck Surg, 145*(1):36–43. https://doi.org/10.1001/jamaoto.2018.2876

Dias, Á. M., & van Deusen, A. (2011). A new neurofeedback protocol for depression. *Spanish Journal of Psychology*, *14*(1), 374-384. https://doi.org/10.5209/rev_SJOP.2011.v14.n1.34

Duncan, J., Colyvas, K., & Punch, R. (2021). Social capital, loneliness, and peer relationships of adolescents who are deaf or hard of hearing. *The Journal of Deaf Studies and Deaf Education, 26*(2), 223-229. https://doi.org/10,1093/deafed/enaa037.

Enriquez-Geppert, S., Smit, D., Pimenta, M. G., & Arns, M. (2019). Neurofeedback as a treatment intervention in ADHD: current evidence and practice. *Current psychiatry reports, 21*, 1-7. https://doi.org/10.1007/s11920-019-1021-4

Friedman, J. (2008*). Predictors of depressive symptoms in persons with deafness and hearing loss* (Doctoral dissertation). Drexel University, Philadelphia.

Golub JS, Brewster KK, Brickman AM, et al. (2018). Association of audiometric age-related hearing loss with depressive symptoms among Hispanic individuals. *JAMA Otolaryngol Head Neck Surg, 145*(2):132–129. https://doi.org/10.1001/jamaoto.2018.3270

Gökçay D. (2010). Affective Computing and Interaction: Psychological, Cognitive and Neuroscientific Perspectives:

Psychological, Cognitive and Neuroscientific Perspectives: IGI Global. https://doi.org/10.4018/978-1-61692-892-6

Grin-Yatsenko, V. A., & Kropotov, J. (2020). Effect of Infra-Low Frequency (ILF) Neurofeedback on the Functional State of the Brain in Healthy and Depressed Individuals. In Restoring the Brain (pp. 244-255). Routledge. ISBN: 9780429275760

Hammond, D. C. (2005). Neurofeedback treatment of depression and anxiety. *Journal of Adult Development*, *12*, 131–138. http://dx.doi.org/10.1007/s10804-005-7029-5

Hammond D. (2011). What is Neurofeedback: an update. *Journal of Neurotherapy, 15*(7), 305-336. http://dx.doi.org/10.1080/10874208.2011.623090.

Harris, S., Hundley, G., & Lambie, G. (2019). The effects of neurofeedback on depression, anxiety, and academic self-efficacy. *Journal of College Student Psychotherapy*,*35*, 15-29. https://doi.org/10.1080/87568225.2019.1606689

Hashemian, P., &Sadjadi, S. A. (2015). Evaluation of neurofeedback therapy in adolescents with major depressive disorder who take fluoxetine. *Journal of Psychiatry*, *18*(1),14-37. https://doi.org/10.4172/Psychiatry.1000180

Hölzel B. K., Hoge E. A., Greve D. N., Gard T., Creswell J. D., Brown K. W., et al. (2013). Neural mechanisms of symptom improvements in generalized anxiety disorder following mindfulness training. *NeuroImage: Clinical, 2*, 448–58 https://doi.org/10.1016/j.nicl.2013.03.011.

Jalali, M., & Pourahmadi, E. (2023). The Effectiveness of Neurofeedback on Pregnancy Anxiety and Prenatal Depression in Pregnant Women during the COVID-19: A Single-Case Research with Multiple Baseline Design. *Health Psychology*, *12*(47), 1-18. https://doi.org/10.30473/hpj.2024.64013.5544

La Marca, JP. (2014). Neurofeedback as an intervention to improve reading achievement in students with attention deficit hyperactivity disorder, inattentive subtype. UC Riverside.

Lofthouse, N., Arnold, L. E., &Hurt, E. (2012). Current status of neurofeedback for attention-deficit/hyperactivity disorder. *Current Psychiatry Reports*,*14*, 536–542. https://doi.org/10.1007/s11920-012-0301-z

Long J. (2021). Factors Associated With Anxiety Symptoms in Australian Deaf or Hard of Hearing Children, *The Journal of Deaf Studies and Deaf Education, 26*(1): 13–20. https://doi.org/10.1093/deafed/enaa035

Menon V. (2011). Large-scale brain networks and psychopathology: A unifying triple network model. *Trends in Cognitive Sciences, 15*(10), 483–506. https://doi.org/10.1016/j.tics.2011.08.003.

Micoulaud-Franchi, J. A., Jeunet, C., Pelissolo, A., & Ros, T. (2021). EEG neurofeedback for anxiety disorders and post-traumatic stress disorders: A blueprint for a promising brain-based therapy. *Current psychiatry reports, 23*, 1-14. https://doi.org/ 10.1007/s11920-021-01299-9

Mirzaei, P. (2022). Effectiveness of Positive Thinking Training on Self-Efficacy and Reduction of Depression and Anxiety of Recovered Students with Coronavirus. *Iranian Journal of Health Psychology, 5*(4), 81-95. https://doi.org/10.30473/IJOHP.2024.68244.1316

Moradi, A., Pouladi, F., Pishva, N., Rezaei, B., Torshabi, M., &Mehrjerdi, Z. A. (2011). Treatment of anxiety disorder with neurofeedback: case study. *Procedia-Social and Behavioral Sciences*, *30*, 103-107. https://doi.org/10.1016/j.sbspro.2011.10.021

Opoku, M. P., Nketsia, W., Benefo, E. B., & Mprah, W. K. (2022). Understanding the parental experiences of raising deaf children in Ghana. *Journal of Family Studies, 28*(4), 1235-1254. https://doi.org/10.1080/13229400.2020.1815557

Özyel M. (2016). The Correlation between Brain Dominance and Language Learning Strategy Use of English Preparatory School Students. Eastern Mediterranean University (EMU)-DoğuAkdenizÜniversitesi (DAÜ).

Paret C., Kluetsch R., Ruf M., Demirakca T., Hoesterey S., Ende G., et al. (2014). Down-regulation of amygdala activation with real-time fMRI neurofeedback in a healthy female sample. *Frontiers in Behavioral Neuroscience, 8*, 299. https://doi.org/10.3389/fnbeh.2014.00299.

Peeters, F., Oehlen, M., Ronner, J., van Os, J., &Lousberg, R. (2014). Neurofeedback as a treatment for major depressive disorder: A pilot study. *PLOSONE*, *9*(3),e91837. https://doi.org/10.1371/journal.pone.0091837

Ramage-Morin PL. (2016). Hearing Difficulties and Feelings of Social Isolation among Canadians Aged 45 or Older. Ottawa, Canada: Statistics Canada. *Health Rep 16*;27(11):3-12. PMID: 27849313.

Rostami, M., Bahmani, B., Bakhtyari, V., &Movallali G. (2014). Depression and deaf adolescents: A review. *Iranian Rehabilitation Journal*, *12*, 43-53. http://irj.uswr.ac.ir/article-1-359-en.html

Rutherford BR, Brewster K, Golub JS, Kim AH, Roose SP. (2017). Sensation and psychiatry: linking agerelated hearing loss to late-life depression and cognitive decline. *Am J Psychiatry, 175*(3), 215–224. https://doi.org/10.1176/appi.ajp.2017.17040423

Samadi Taherghorabi M,., , Shakerinia I. (2022). The Effectiveness of Neurofeedback on Working Memory and Cognitive Flexibility in Patients With Mild Depression. *Journal of Guilan University of Medical Sciences*, 30(4):4-4. https://doi.org/10.32598/jgums.30.4.1835.1.

Sayed, S. Z., Mounir, S. M., Mohamed, A. A.-H., Nabil, A. M., & Hassan, M. H. (2018). Assessment of psychological disorders in Egyptian children with hearing impairment. *Sudanese Journal of Paediatrics*, *18*(2),25-32. https://doi.org/10.24911/SJP.106-1531768895

Schneider, H., Riederle, J., & Seuss, S. (2021). Therapeutic effect of infra-low-frequency neurofeedback training on children and adolescents with ADHD. Brain-Computer Interface. https://doi.org/10.5772/intechopen.97938

Shereena EA, Gupta RK, Bennett CN, Sagar KJV, Rajeswaran J. (2019). EEG neurofeedback training in children with attention deficit/hyperactivity disorder: a cognitive and behavioral outcome study. *Clinical EEG and neuroscience, 50*(4): 242-255. https://doi.org/10.1177/1550059418813034

Simkin, D. R., Thatcher, R. W., &Lubar, J. (2014). Quantitative EEG and neurofeedback in children and adolescents: Anxiety disorders, depressive disorders, comorbid addiction and attention-deficit/hyperactivity disorder, and brain injury. *Child and Adolescent Psychiatric Clinics*, *23*(3), 427-464. https://doi.org/ 10.1016/j.chc.2014.03.001

Sommers, J. (2014). *The mental health status of deaf and hard of hearing children in the mainstream education system*(Undergraduate Honors Theses). King's University College, Western.

Valizadeh, H., Ghobadzadeh, S., & Parsa, B. (2016). The predict of social-emotional adjustment based on variables their perception and emotional control in deaf students. *International Journal of Humanities and Cultural Studies, 2016*, 740-745.

Wilson BS, Tucci DL, Merson MH, O'Donoghue GM .(2017). Global hearing health care: New findings and perspectives. *Lancet, 390*: 2503–2515. https://doi.org/10.1016/S0140-6736(17)31073-5

Walker, J. E., & Lawson, R. (2013). FP02 beta training for drugresistant depression: A new protocol that usually reduces depression and keeps it reduced. *Journal of Neurotherapy*, *17*, 198–200. https://doi.org/10.1080/10874208.2013.785784

WHO.(2017). Global Costs of Unaddressed Hearing Loss and Cost-Effectiveness of Intervention. Geneva: World Health Organization. ISBN: 9789241512046

Yalom, I. & Leszcz, M. (2005). The theory and practice of group psychotherapy. New York: Basic Books.

Young K. D., Zotev V., Phillips R., Misaki M., Drevets W. C., Bodurka J. (2018). Amygdala real-time functional magnetic resonance imaging neurofeedback for major depressive disorder: A review. *Psychiatry and Clinical*

Neurosciences, 72(7), 466–81. https://doi.org/10.1111/pcn.12665.

Young K. D., Zotev V., Phillips R., Misaki M., Yuan H., Drevets W. C., et al. (2014). Real-time FMRI neurofeedback training of amygdala activity in patients with major depressive disorder. *PloS One, 9*(2), e88785. https://doi.org/10.1371/journal.pone.0088785.