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ENHANCING ATTENTION AND REDUCING ANXIETY AMONG ADOLESCENTS THROUGH EEG MUSIC: A MIXED-METHODS INTERVENTION STUDY

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Abstract
Adolescents today face increasing psychological stress and cognitive challenges, including heightened anxiety and reduced attention span. These issues not only hinder academic performance but also impact long-term mental health outcomes. Non-pharmacological, school-based interventions are urgently needed. This study aimed to examine the effects of a three-week brainwave music intervention on state anxiety and attention performance among secondary school students. A quasi-experimental pretest–posttest control group design was employed. A total of 80 adolescents aged 13 to 15 were randomly assigned to either an experimental group ($n = 40$), which received daily 15-minute brainwave music sessions, or a control group ($n = 40$), which received no intervention. Attention was measured using the d2 Test of Attention, and anxiety was assessed via the State-Trait Anxiety Inventory (STAI-S). Data were analyzed using independent and paired t-tests. Compared to the control group, the experimental group showed significant improvement in attention scores ($t(78) = 4.52$, $p < .001$, $d = 0.89$) and a significant reduction in state anxiety ($t(78) = –3.78$, $p = .001$, $d = 0.73$). No adverse effects were reported, and students reported high satisfaction with the music intervention. Brainwave music appears to be an effective and scalable tool for enhancing cognitive and emotional functioning in adolescents. Its integration into school routines may offer a novel, low-barrier strategy to promote mental well-being among youth populations.
Keywords: Brainwave music; adolescent mental health; attention performance; state anxiety; school-based intervention

1. INTRODUCTION

Adolescence is a critical developmental period characterized by rapid physical, emotional, and cognitive changes. During this transitional stage, many young people begin to encounter academic pressure, social comparison, identity formation, and emotional instability (Sawyer et al., 2012; Blakemore, 2019). These stressors often lead to elevated levels of state anxiety and declining attentional control, which in turn impact their academic performance, social functioning, and overall mental well-being (Compas et al., 2017). As the prevalence of adolescent psychological distress continues to rise globally—especially in the post-pandemic educational context—there is an urgent need for accessible, non-pharmacological strategies to support young people's mental and cognitive health.

In recent years, brain-based interventions—particularly those involving neuroacoustic stimulation—have emerged as promising tools for enhancing cognitive functioning and emotional regulation. Among these, brainwave music has gained attention for its potential to induce specific neural states (e.g., alpha, theta) that are associated with relaxation, sustained attention, and reduced stress (Ala et al., 2018; Biel & Friedrich, 2018). Unlike traditional mindfulness training or clinical biofeedback, brainwave music represents a low-effort, passive intervention that can be easily integrated into daily routines, including school settings. However, most existing studies have focused on adult populations or clinical samples, with relatively little known about the efficacy of brainwave music for healthy adolescents in real-world school environments.

Although previous studies have demonstrated that auditory entrainment and rhythmic sound stimulation can modulate attention and reduce anxiety (Tang et al., 2020; Lee et al., 2021), few have explored the use of brainwave music as a standalone intervention for adolescents. Moreover, limited attention has been given to the potential of such tools in non-clinical, educational contexts, where early and preventive interventions could be most impactful.

There remains a clear research gap regarding whether short-term exposure to brainwave music can lead to measurable improvements in attention performance and anxiety levels in secondary school students.

To address this gap, the present study investigates the effects of a three-week brainwave music intervention on adolescents' state anxiety and attention performance in a school setting. Using a quasi-experimental design with pre- and post-tests, we aim to determine whether daily exposure to alpha/theta-based brainwave music can enhance cognitive functioning and reduce emotional distress. By focusing on a naturalistic school-based population, this study contributes to the growing field of neuroeducation and offers practical implications for mental health promotion in youth. Furthermore, it explores the feasibility of implementing scalable, technology-enhanced mental wellness tools for adolescents at risk of stress and attentional difficulties.

2. METHOD

This study employed a quasi-experimental pretest–posttest control group design to examine the effects of brainwave music on adolescents' attention and anxiety levels. The independent variable was the intervention type (brainwave music vs. no intervention), and the dependent variables were attention performance and state anxiety.

2.1 Participants

A total of 80 secondary school students (aged 13 to 15) from a public middle school in China participated in the study. Participants were randomly assigned to either an experimental group ($n = 40$) or a control group ($n = 40$). Both groups were matched in terms of age, gender, and academic performance. Informed consent was obtained from all participants and their guardians, and the study was approved by the school's ethics committee.

2.2 Intervention

Participants in the experimental group received a brainwave music intervention for 15 minutes daily over a 3-week period, conducted in a quiet classroom during morning reading time. The music was specially designed to induce alpha and theta brainwave states, associated with relaxation and improved focus. The control group received no intervention during this period and continued with their usual morning activities.

2.3 Measures

2.3.1 Attention Performance

Assessed using the d2 Test of Attention, a standardized paper-based test measuring selective attention and concentration. Scores were calculated based on the total number of correct responses minus errors.

2.3.2 State Anxiety

Measured using the State subscale of the State-Trait Anxiety Inventory (STAI), which consists of 20 items rated on a 4-point Likert scale. Higher scores indicate greater state anxiety (Knowles et al., 2020). STAI is a well-established and widely utilised instrument for assessing anxiety, referenced in more than 3000 publications (Spielberger, 1989). The scale has been rendered into multiple languages, and its comprehensive factor structure has been studied across diverse samples. Numerous research have frequently identified two elements—state anxiety and trait anxiety—and demonstrated that the scales measuring these factors are responsive to experimental manipulation in theoretically significant manners (Lazarus & Opton, 1966; Auerbach, 1973; Chapman & Cox, 1977).

2.4 Procedure

At the start of the study (Week 0), both groups completed the pre-test assessments (d2 Test and STAI-S). The experimental group then began the 3-week intervention. At the end of Week 3, both groups completed the same tests as post-test measures. All testing sessions were conducted by trained psychology graduate students.

2.5 Data Analysis

Data were analyzed using SPSS 27.0. Descriptive statistics were computed for all variables. Paired-sample t-tests were used to examine within-group changes from pre- to post-test, and independent-sample t-tests were conducted to compare post-test outcomes between the experimental and control groups. Effect sizes were reported using Cohen's d, with values of 0.2, 0.5, and 0.8 indicating small, medium, and large effects respectively.

3. Results

The demographic characteristics of participants are presented in Table 0. The mean age of the total sample was 14.06 years ($SD = 0.71$), with a balanced gender distribution across the experimental and control groups. No significant group differences were observed in age ($t(78) = 0.48$, $p = .63$) or gender composition ($\chi^2(1) = 0.05$, $p = .82$), indicating successful randomization. Table 1 shows the descriptive statistics for attention performance and state anxiety before and after the intervention. At baseline, the two groups did not differ significantly in either variable. Following the 3-week intervention, the experimental group showed a substantial increase in attention scores (from $M = 78.50$ to $M = 89.70$) and a decrease in state anxiety (from $M = 42.35$ to $M = 35.20$). In contrast, the control group exhibited only minor changes over the same period.

Table 1. Descriptive Statistics for Attention and State Anxiety (Pre- and Post-Test)

Variable	Group	Pre-test Mean (SD)	Post-test Mean (SD)
Age (Mean±SD)	Experimental	14.10 ± 0.68	

	Control	14.03 ± 0.74	
Gender			
Female		19(47.5)	
Male		21(52.5)	
Attention	Experimental	78.50 (10.34)	89.70 (9.82)
	Control	77.90 (9.75)	79.10 (10.21)
State Anxiety	Experimental	42.35 (6.22)	35.20 (5.85)
	Control	41.88 (5.94)	41.55 (6.12)

Independent-samples t-tests were conducted to compare the post-test scores of the two groups (see Table 2). The results indicated a significant difference in attention scores between the experimental and control groups at post-test, $t(78) = 4.52$, $p < .001$, with a large effect size ($d = 0.89$). Similarly, state anxiety levels were significantly lower in the experimental group compared to the control group, $t(78) = –3.78$, $p = .001$, with a medium-to-large effect size ($d = 0.73$).

Table 2. t-test Results Comparing Experimental and Control Groups at Post-test

Variable	t(df)	p-value	Cohen's d
Attention	t(78) = 4.52	.000***	0.89
State Anxiety	t(78) = -3.78	.001**	0.73

Note：* p < .05，** p < .01，*** p < .001

4. DISCUSSION

This study investigated the effects of a short-term brainwave music intervention on adolescents' attention performance and state anxiety. The findings provide preliminary yet promising evidence that brainwave music may serve as an effective, low-cost, and non-invasive tool to support mental health and cognitive development among school-aged youth. As hypothesized, adolescents who listened to brainwave music for 15 minutes daily over a 3-week period demonstrated significantly improved attention performance and reduced state anxiety compared to those in the control group. The observed large effect size for attention suggests that the auditory neural stimulation delivered by brainwave music may enhance cognitive control mechanisms such as sustained focus and selective attention. The medium-to-large effect on anxiety further supports the potential of music-based interventions in modulating emotional regulation processes during adolescence, a developmental stage marked by heightened vulnerability to stress.

These findings are consistent with prior research suggesting that alpha and theta frequency stimulation may promote a more relaxed yet alert mental state (Jirakittayakorn & Wongsawat, 2017; Huang & Charyton, 2008). According to Bandura's social cognitive theory, improvements in attention and emotional control may also contribute to adolescents' perceived self-efficacy and academic engagement. Moreover, the study aligns with neuroplasticity models, indicating that repeated exposure to rhythmic, entraining auditory stimuli can temporarily influence cortical arousal and attentional networks.

The current findings echo earlier work demonstrating the positive effects of neuroacoustic stimulation on children's executive function and anxiety symptoms (Tang et al., 2020; Lee et al., 2011). However, whereas many prior studies have employed expensive neurofeedback or clinical-grade EEG protocols, our intervention employed a non-clinical, music-based format, making it highly feasible for use in educational settings. In contrast to mindfulness-based interventions that require considerable training and internal effort from participants, brainwave music may offer a more passive yet effective alternative.

From a practical perspective, the implementation of short, daily brainwave music sessions during the school day could serve as a preventative mental health strategy, especially for students at risk of attentional problems or stress-related symptoms. Such an approach aligns with the growing call for integrative, scalable, and non-stigmatizing interventions within schools. The ease of delivery—requiring only headphones and a mobile device—further enhances its applicability in both urban and rural educational contexts.

5. CONCLUSION

In conclusion, the present study adds to the growing body of evidence supporting the use of brainwave-based interventions in promoting psychological and cognitive well-being in adolescents. With further refinement and validation, such tools may become an integral part of future school-based mental health strategies.

6. LIMITATIONS AND FUTURE DIRECTIONS

Despite its strengths, this study is not without limitations. First, the relatively small sample size and single-site design may limit the generalizability of the findings. Second, the study relied on self-report measures and behavioral tests, without incorporating objective neurophysiological indicators (e.g., EEG or HRV) to directly validate the assumed changes in brain activity. Third, long-term effects were not assessed; it remains unknown whether the observed improvements persist beyond the immediate post-intervention period. Future research could address these issues by incorporating larger, longitudinal, and multi-modal designs.

Future studies might explore the mechanisms underlying the observed effects, such as changes in neural oscillatory patterns or stress biomarkers. It would also be valuable to compare different types of auditory stimulation (e.g., classical music, binaural beats, natural sounds) and to examine individual differences (e.g., baseline anxiety, learning styles) in responsiveness to such interventions. Finally, integrating brainwave music into digital platforms or school mental health apps could further extend its reach and accessibility.

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