








Effects of a 14-day bioacoustic correction program on neuropsychological parameters in sports science students: A randomized controlled clinical trial

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Abstract

Study aim: This study aimed to determine the influence of a 14-day bioacoustic correction (BAC) program, which in the future may become a solution for individuals experiencing increased psycho-emotional stress, on the properties of attention and concentration of sports science students. BAC translates EEG activity into auditory feedback, facilitating cognitive self-regulation.

Material and Methods: The study involved 20 volunteers among sports science students, 10 males, and 10 females, who were randomly allocated to experimental and control groups.

Results: A significant group \times time interaction was revealed for the variables attention stability ($F = 7.36$, $\eta_p^2 = 0.29$, $p = 0.01$) and mistakes ($F = 15.49$, $\eta_p^2 = 0.46$, $p = 0.001$) in the Bourdon test, and for concentration ($F = 36.99$, $\eta_p^2 = 0.67$, $p = 0.001$), switch ability ($F = 17.86$, $\eta_p^2 = 0.49$, $p = 0.010$), and mistakes ($F = 29.43$, $\eta_p^2 = 0.62$, $p = 0.001$) in the Landolt test, in favor of the experimental group. There was no statistically significant group \times time interaction in the Toulouse-Pieron or Schulte table tests. Additionally, following the 14-day BAC program, the experimental group demonstrated improvement in almost all parameters of the tests used.

Conclusion: This study provides novel evidence regarding the efficiency of the BAC program in increasing the concentration and attention parameters of students of sports science and physical education. The improvements observed were statistically significant, supporting the potential recommendation of BAC for wider use.

Keywords: Attention – Brain – Concentration – Music – Stress – University students – Exercise – Physical activity

Introduction

The education process in a higher educational institution is accompanied by numerous external factors that negatively affect the psycho-emotional state of individuals, which is reflected in the disruption of the normal functioning of the nervous system (Joëls et al., 2006). The permanently increased level of stress is one of the major problems not only among students but also for professors in higher education. An elevated level of stress

develops due to the consistent pressure induced by exams and the processing of a large amount of information in a short time. Consequently, scientific evidence suggests that the mentioned phenomenon negatively affects academic performance (Joëls et al., 2006) and provokes mental health disorders (Grant et al., 2001; Hammar & Årdal, 2009; Komarova & Frolova, 2016; Panchenko et al., 2013; Yakovlev et al., 2013). Moreover, existing research indicates that prolonged stress is associated with reduced concentration, increased cognitive distractions, and impaired memory functions (Li et al., 2008; Mrazek et al.,

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2012). One of the conditions for the successful implementation of bioacoustic correction (BAC) is that individuals must pay attention to the music and focus on its sound. Thus, we engage in the process of self-regulation and self-learning of the brain. Several investigations have found that this intervention effectively reduced stress and distraction (Bennike et al., 2017; Morrison et al., 2014). In light of these considerations, the present investigation focuses on the processes of voluntary self-regulation, neuroplasticity, and self-learning, which elicit considerable effects relating to the neuropsychological processes (Brefczynski-Lewis et al., 2007; Brewer et al., 2011; Jha et al., 2015; Mrazek et al., 2013).

Given the growing evidence of the efficacy of brain stimulation techniques in enhancing cognitive functions and academic skills, there has been significant interest among young people in accessible methods of brain stimulation that promise rapid improvements. Techniques such as binaural beats or music interventions have become popular among students due to their simplicity and perceived immediate benefits, although scientific support for their efficacy remains variable and context-dependent (Axelsen et al., 2022; Enriquez-Geppert et al., 2017). It is crucial to differentiate between rigorously tested scientific approaches and home-grown, popularized forms of brain stimulation, as unvalidated methods may lead to misconceptions or even negative outcomes, as shown by research indicating potential reverse or counterproductive effects (e.g., the reverse effect of home-use binaural beats brain stimulation, and cumulative effects of theta binaural beats on brain power and functional connectivity) (Klichowski et al., 2023).

Based on the principles of neuroplasticity, it is possible, by influencing the sensory systems of the body, to improve the psycho-physiological state of individuals and correct cognitive skills. According to the basic principles of neurogenesis, stress is a negative factor for nerve cells and slows down the formation of new neural connections (Arvidsson et al., 2002). However, creating a comfortable learning environment contributes to training lost skills and the growth of new nerve cells (Dubrovin et al., 2015). Brain nerve impulses are weak electrical impulses passing through the nerve cells of the central nervous system, producing a certain pattern of bioelectrical activity. Due to the simultaneous operation of electrical impulses in many neurons, certain rhythms are created, which can be defined as "brain waves." Each of these waves has a specific frequency that can be recorded on the electroencephalogram (EEG). The intensity of each wave is comparable to certain mental states: anxiety, concentration, and superficial or deep sleep (Dubrovin et al., 2015).

The main focus of this paper is self-regulation of the functional state of the central nervous system by applying the BAC method. It is based on the principle of computer conversion of the subject's EEG wave activity into sound signals that represent a melody, which allows the person

to imagine and hear the "musical melody of his brain" (Konstantinov, (2007)). Music is a complex process for the brain's work and has a significant impact on changing cognitive and psycho-emotional parameters (Peretz & Zatorre, 2005). Brain images show that music has an impact not only on the auditory cortex but also extends to all parts of the brain, which is most reflected in memory changes (Brown et al., 2004; Dehghani et al., 2023; Esteves et al., 2021; Koelsch et al., 2006; Menon & Levitin, 2005; Thompson et al., 2005). Despite promising findings in clinical settings, evidence on using the BAC method among healthy individuals, particularly within educational contexts, remains limited. Thus, this research aims to investigate the efficacy of a 14-day BAC intervention in enhancing attention and concentration among sports science students, hypothesizing significant improvements compared to a control group. By grounding our research in existing empirical evidence and delineating the scientific basis of the intervention, this study aims to provide rigorous, evidence-based insights into BAC's potential academic and cognitive benefits, thereby contributing responsibly to the growing interest among young adults in effective and scientifically validated brain stimulation techniques.

Material and methods

Participants

A total of 20 respondents, 10 males and 10 females, were randomly assigned to the experimental (age 19.90 ± 1.85 years; height 174.50 ± 6.72 cm; weight 65.40 ± 8.34 kg) and control group (age 19.10 ± 0.57 years; height 172.60 ± 9.70 cm; weight 68.30 ± 10.84 kg). Randomization was conducted using numbered containers and was carried out by experienced researchers. The study started on November 20 and ended on December 5, 2022. Clinical registration was carried out after the beginning of the study (ISRCTN15263884). To be included in the present investigation, the participants needed to be sports science students without hearing impairments. The data were collected at the Combat Sport Lab, Faculty of Sport and Physical Education, University of Novi Sad, Novi Sad, Serbia. The participants were also informed about the need to attend a 14-day BAC program aimed at reducing stress levels and enhancing attention and concentration. The classes involved attending sessions for 20 minutes 6 days a week, without additional treatments outside of the laboratory. Before and after the experiment, a set of neuropsychological tests was selected and implemented to determine previously mentioned parameters. Before the beginning of the experiment, all participants from both groups filled out a questionnaire with personal data and signed an agreement on the use of the data for scientific research. The investigation was conducted in line with the principles of the Declaration of Helsinki, and ethical approval was obtained from the ethics committee of the

University of Novi Sad, Serbia (Ref. No. 48-10-2022-1). Informed consent was obtained in written form from all subjects and or legal guardians

Treatment protocol

The respondents of the experimental group were subjected to a program of work on a computer complex of BAC (the method of EEG-dependent biofeedback), while the control group did not receive any intervention. During the lesson, the subjects had to listen to a music session while simultaneously registering EEG potentials in 4 leads (2 frontal and 2 occipital). EEG recording was performed using four channels at points Fp1, Fp2, O1, and O2 as unipolar recordings relative to combined ear electrodes. Furthermore, the participants were asked to follow and concentrate on the flow of the musical pattern. An important factor was the volume level, which needed to be loud enough but not annoying.

Measurements

To test the concentration and attention of participants, a set of neuropsychological tests that are most commonly used in international practice were applied.

Bourdon test

The proofreading test was used to examine the concentration and stability of attention. The subjects were offered a form with letters, in which it was necessary to consistently cross out a certain letter (in our case, "I"). There were 60 lines in the test, with 34 characters in each line, making a total of 2040 characters. The duration of the entire test was 5 minutes. After the command "start," the respondents began searching and crossing out the appropriate characters. Every minute, the experimenter said the word "line," upon which the participants marked the current place with a vertical line and continued searching for letters. This was necessary to calculate the results for a certain time and draw up a schedule for changing the pace and quality of work. After testing, the total number of marked or missed characters and the incorrect marks by the subject were calculated. The levels of concentration and attention stability were computed using the formulas available below (Kuruc et al., 1992).

1. Stability of attention:

$$Ku = C \times \frac{C}{(P + O) + (1)},$$

where Ku – stability of attention; C – total number of rows viewed; P – missing characters; O – wrongly selected characters. If there were no errors or omissions, it is necessary to add one to the divisor.

2. Concentration:

$$K = (M - O) \times \frac{100}{n},$$

where K – concentration; M – total number of crossed-out characters; O – wrongly selected characters; n – total number of characters that had to be crossed out.

Landolt test

As in the proofreading test, the subjects were offered a form on which rings with a gap in different directions were drawn. At the command of the experimenter, the respondents began to cross out all the rings with a gap of "12 hours". There were 60 lines in the test, with 34 characters in each, making a total of 2040 characters. The whole test lasted 5 minutes. Every minute, the experimenter said the word "line." The respondents then marked the mentioned sign and continued with the test. After 5 minutes, the test ended, and the total number of processed characters, the number of correctly crossed out signs, and the number of errors were counted. Based on the results, concentration, switch ability, and tempo, were calculated using the following formulas:

1. Concentration (the percentage of correctly selected characters from the total number that needed to be allocated):

$$K = \frac{S^2}{n},$$

where K – concentration; S^2 – line; n – total number of characters that had to be crossed out.

2. Switch ability:

$$C = \frac{S^*}{S} \times 100,$$

where C – switch ability; S^* – total number of rows with errors; S – total number of rows.

3. Tempo (productivity of attention):

$$A = \frac{N}{t},$$

where A – tempo; N – number of total characters viewed; t – time spent on work.

Toulouse-Pieron test

In this test, the participant is given a form containing figures arranged in a random order, inside which the subject must put a certain sign (plus, minus, dash, or dot). The form contained 104 figures, and the time to complete the test was 60 seconds. At the command "start," the subject began to place signs in the figures. At the command "stop," the subject stopped the task. After testing, the correctly placed signs were counted, and for each error, the result was reduced by one point. After summing up the results, the overall test performance was evaluated. The test also evaluated the amount of time a person spent arranging all the signs inside the figures. This allowed speed and efficiency to be calculated, as well as accuracy (Espírito-Santo et al., 2015; Rey, 1959).

Schulte table test

Schulte tables are designed to diagnose visual search skills and peripheral vision, to help assess attention and the rate of information perception, as well as to evaluate concentration. Five 5x5 square tables were provided to the participants, in each of which the numbers from 1 to 25 were randomly arranged. The respondents were supposed to concentrate with their eyes on the central cell and find all the numbers. After finding them, the participants moved to the next table. The experimenter recorded the time required to complete each table, the presence of errors while taking the test, and periods of "getting stuck" or skipping a number. After the experiment, the results were analyzed to obtain data regarding the attention and concentration of participants. As part of this test, the time spent on each table and the average time spent on solving all 5 tasks were estimated (Cattell, 1966).

Statistical analysis and sample size

A priori sample size calculation was carried out using G*Power (version 3.1.9.4) (effect size = 0.4, 1 - β = 0.80, α = 0.05). It was determined that a minimum of 16 respondents was necessary to detect differences between groups. Data processing was carried out with SPSS version 20.0 (IBM Corp., Armonk, NY, USA). The normality of distribution and homogeneity of variances were checked using Shapiro-Wilk and Leven's tests, respectively. An independent-sample t-test was used to compare baseline values between the experimental and control groups. A general linear model with repeated measures and Bonferroni adjustment was conducted to determine the potential group and time interactions (group × time) for all neuropsychological variables. Partial eta squared (η_p^2) was computed as a measure of effect size and interpreted as small (0.01), moderate (0.06), or large (0.14) (Cohen, 2013). Within groups, a comparison was performed

with a paired-sample t-test. Mean and standard deviation are presented from descriptive statistics. Differences were deemed statistically significant if the p-value was < 0.05.

Results

A total of 20 respondents completed the initial and final testing. The baseline characteristics of the examined population are available in Table 1. There were no statistically significant differences between groups in age, anthropometrics, or neuropsychological variables.

Table 1. Baseline characteristics

Variable	Experimental group (n = 10)	Control group (n = 10)
Age (years)	19.90 ± 1.85	19.10 ± 0.57
Height (cm)	174.50 ± 6.72	172.60 ± 9.70
Weight (kg)	65.40 ± 8.34	68.30 ± 10.84
BMI (kg/m ²)	21.41 ± 1.79	22.79 ± 1.55

Note: BMI – body mass index.

Bourdon test

A statistically significant group × time interaction was found for the variables attention stability ($F = 7.36, \eta_p^2 = 0.29, p = 0.01$) and mistakes ($F = 15.49, \eta_p^2 = 0.46, p = 0.00$). The experimental group demonstrated significantly greater improvement in attention stability and reduction of mistakes relative to the control group (Table 2). The paired-sample t-test results revealed significant enhancement of concentration ($p < 0.01$), signs ($p < 0.05$), and decrease in mistakes ($p < 0.01$) in the experimental group at the final testing compared to baseline values. An increase in mistakes was observed in the control group ($p < 0.05$).

Table 2. Effects of bioacoustic correction program on parameters of Bourdon test

Variable	Experimental group (n = 10)		Control group (n = 10)		Group × time interaction		
	Baseline	Final	Baseline	Final	F	η_p^2	p
Attention stability	290.75 ± 335.27	536.68 ± 353.89	372.82 ± 316.72	160.44 ± 98.55	7.36	0.29	0.01
Concentration	49.56 ± 10.05	59.35 ± 13.36**	50.25 ± 14.77	56.04 ± 19.96	0.66	0.04	0.43
Mistakes	6.90 ± 4.28	2.70 ± 1.49**	4.10 ± 3.14	8.70 ± 4.95*	15.49	0.46	< 0.001
Signs	1210.80 ± 217.13	1320.00 ± 248.01*	1184.20 ± 237.37	1314.60 ± 351.10	0.09	0.01	0.76

Note: statistically significant values are bolded (general linear model with repeated measures); * – significant changes at $p < 0.05$ (paired-samples t-test); ** – significant changes at $p < 0.01$ (paired-samples t-test); F – statistic; η_p^2 – partial eta squared; p – probability.

Landolt test

A significant group \times time interaction was revealed for concentration ($F = 36.99$, $\eta_p^2 = 0.67$, $p < 0.00$), switch ability ($F = 17.86$, $\eta_p^2 = 0.49$, $p < 0.00$), and mistakes ($F = 29.43$, $\eta_p^2 = 0.62$, $p < 0.00$) in favor of the experimental group (Table 3). Compared to baseline values, the experimental group demonstrated

significant improvements in all parameters of the Landolt test, including concentration ($p < 0.001$), switch ability ($p < 0.01$), tempo ($p < 0.01$), mistakes ($p < 0.01$), and signs ($p < 0.001$) at the final testing. A decrease in concentration ($p < 0.05$), and increases in mistakes ($p < 0.01$) and signs ($p < 0.05$) were noted in the control group.

Table 3. Effects of bioacoustic correction program on parameters of Landolt test

Variable	Experimental group ($n = 10$)		Control group ($n = 10$)		Group \times time interaction		
	Baseline	Final	Baseline	Final	F	η^2	p
Concentration	10.22 \pm 8.68	30.56 \pm 13.76***	11.12 \pm 6.72	6.94 \pm 3.68*	36.99	0.67	< 0.001
Switch ability	23.81 \pm 13.53	7.58 \pm 13.17**	20.76 \pm 13.06	25.62 \pm 9.05	17.86	0.49	< 0.001
Tempo	0.09 \pm 0.02	0.12 \pm 0.02**	0.10 \pm 0.02	0.12 \pm 0.35	2.76	0.13	0.11
Mistakes	9.70 \pm 7.15	2.90 \pm 1.66**	7.80 \pm 4.89	13.10 \pm 6.62**	29.43	0.62	< 0.001
Signs	903.00 \pm 147.40	1095.80 \pm 207.24***	967.90 \pm 207.36	1111.10 \pm 299.79*	0.63	0.34	0.44

Note: statistically significant values are bolded (general linear model with repeated measures); * – significant changes at $p < 0.05$ (paired-samples t-test); ** – significant changes at $p < 0.01$ (paired-samples t-test); *** – significant changes at $p < 0.001$ (paired-samples t-test); F – statistic; η_p^2 – partial eta squared; p – probability.

Toulouse-Pieron and Schulte table tests

There was no statistically significant group \times time interaction, either in the Toulouse-Pieron or the Schulte table test (Table 4). However, following the 14 days of

the BAC program, the experimental group showed significantly enhanced values obtained in the Toulouse-Pieron test ($p < 0.05$) relative to the initial testing. No improvements were observed in the control group for both tests.

Table 4. Effects of bioacoustic correction program on Toulouse-Pieron and Schulte table tests

Variable	Experimental group ($n = 10$)		Control group ($n = 10$)		Group \times time interaction		
	Baseline	Final	Baseline	Final	F	η_p^2	p
Toulouse-Pieron test	76.70 \pm 20.42	88.50 \pm 14.18*	71.80 \pm 12.19	74.90 \pm 15.43	3.08	0.15	0.09
Schulte-table test	28.30 \pm 5.87	25.28 \pm 5.36	29.40 \pm 5.10	28.66 \pm 4.77	0.84	0.05	0.37

Note: * – significant changes at $p < 0.05$ (paired-samples t-test); F – statistic; η_p^2 – partial eta squared; p – probability.

Figures 1–4 illustrate significant changes in α -wave activities of two participants. Moreover, α -wave activities increased following BAC.

Discussion

The goal of this investigation was to examine the impact of the BAC program on neuropsychological parameters using the Bourdon, Landolt, Toulouse-Pieron, and Schulte table tests among students of the Faculty of Sport and Physical Education, University of Novi Sad. The main finding was that implementation of BAC intervention for 14 days, 6 times per week, for 20 minutes per session,

induced improvements in most of the neuropsychological variables. More specifically, at the final measurement, the experimental group demonstrated greater enhancement in attention stability in the Bourdon test, concentration, and switch ability in the Landolt test relative to the control group. Additionally, a potential difference, although not statistically significant, was suggested by the Toulouse-Pieron test ($p = 0.09$). Finally, the paired-sample t-test revealed the positive effects of BAC intervention in the experimental group in nearly all parameters of the applied tests, while values in the control group were mostly unaltered.

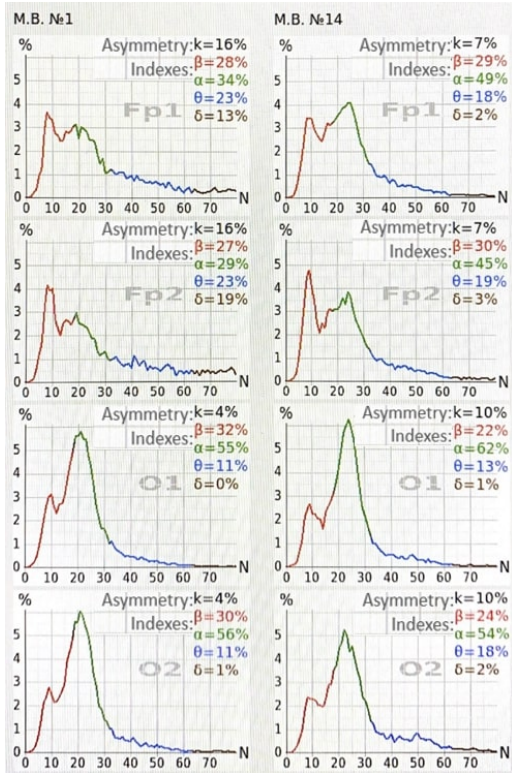


Figure 1. Indexometric reflection of wave activity in the occipital lobe (O1 and O2) and in frontal leads (FP1 and FP2)

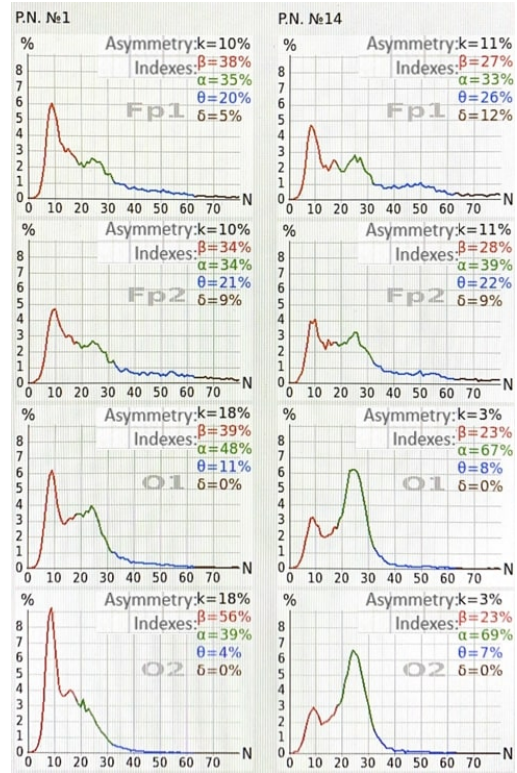


Figure 3. Indexometric reflection of wave activity in the occipital lobe (O1 and O2) and in frontal leads (FP1 and FP2)

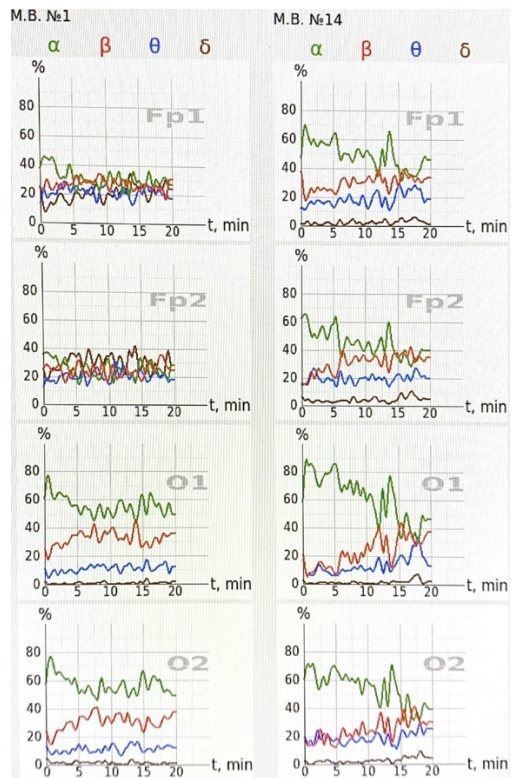


Figure 2. Graphical representation of the change in wave activity in the occipital lobe (O1 and O2) and in frontal leads (FP1 and FP2). The ordering of waves by amplitude is characteristic of the state of involuntary attention

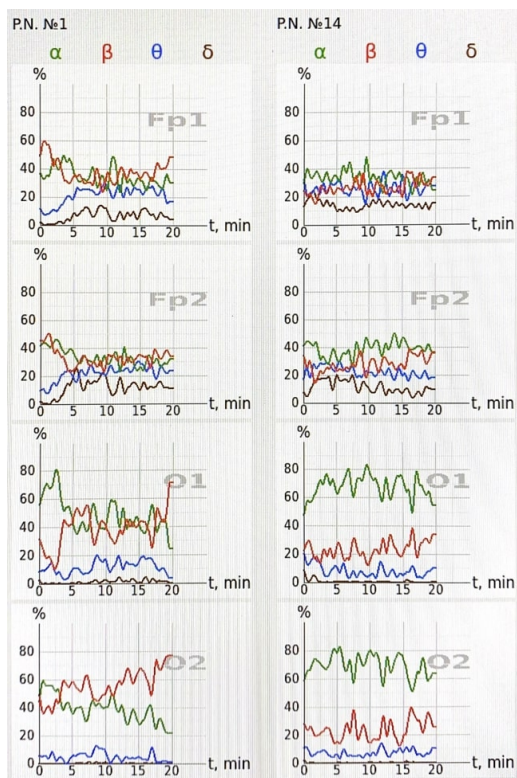


Figure 4. Graphical representation of the change in wave activity in the occipital lobe (O1 and O2) and in frontal leads (FP1 and FP2). The ordering of waves by amplitude is characteristic of the state of involuntary attention

To better understand the significance of these results, effect sizes (η_p^2) were interpreted based on Cohen's guidelines (Cohen, 2013). The results demonstrated that the effects of BAC intervention on attention and concentration were large ($\eta_p^2 = 0.29 - 0.67$), indicating a significant impact on cognitive functions among participants. These findings align with previous research highlighting the role of conscious self-regulation as a critical factor in academic performance and psychological well-being (Morosanova, Fomina, & Bondarenko, 2023). Since BAC facilitates cognitive self-regulation through auditory neurofeedback, it is plausible that its effects extend beyond attention and concentration, potentially contributing to broader academic and emotional benefits.

Although significant improvements were observed in the Bourdon and Landolt tests, no statistically significant effect of BAC intervention was recorded in the Toulouse-Pieron and Schulte table tests. Possible reasons for this outcome include the specific cognitive demands of these tests, which rely on rapid visual processing and motor responses, potentially requiring a longer adaptation period or additional cognitive training strategies. Furthermore, the duration of the intervention (14 days) may have been insufficient to induce measurable changes in these tasks. The neurophysiological mechanisms underlying BAC primarily affect attention and cognitive flexibility, whereas tests emphasizing complex visuomotor processing might require alternative approaches. Additionally, individual variability among participants and the relatively small sample size may have influenced the results, highlighting the need for future studies with extended intervention durations and larger sample populations.

To date, the majority of the available scientific literature has addressed the impact of BAC programs on neuropsychological variables in clinical populations (Enriquez-Geppert et al., 2017; Komarova & Frolova, 2016; Konstantinov et al., 2000; Yakovlev et al., 2013; Zhukova et al., 2020). For instance, Yakovlev et al. (2013) explored the effects of the BAC method in 15-17-year-old adolescents with the onset of schizophrenia. Following the experimental procedure, levels of depression and anxiety were substantially decreased. Analogously, Konstantinov et al. (2000) evaluated the efficiency of BAC in improving various psychological aspects, such as anxiety and mood state, in individuals with functional disturbances (asthenic-neurotic, neurotic, and depressive states). The results obtained unequivocally suggested that applied intervention reduced anxiety and improved the mood state. Furthermore, Komarova and Frolova (2016) carried out a study on patients with cerebrovascular disturbances. They found that the BAC method successfully reduced the state and trait anxiety of participants. In addition, an improvement in the cognitive skills of patients was observed. Finally, Zhukova et al. (2020) reported that music therapy intervention positively affected social-emotional reciprocity in children with autism. Overall, as well as in the present

research, studies performed in a clinical population also recorded the enhancement of various neuropsychological parameters following the BAC program.

To the best of the authors' knowledge, only one study has investigated the influence of music therapy on neuropsychological parameters in apparently healthy participants. More precisely, Axelsen et al. (2022) estimated the influence of 10 min of music daily for 30 days in a sample of 152 volunteers aged 38.5 years. The researchers documented a reduction in self-perceived stress of 38% following the applied treatment. Additionally, it was demonstrated that conducting a mindfulness intervention with the same duration as music therapy substantially improved sustained attention, working memory capacity, and perceived stress (Axelsen et al., 2022). As previously emphasized, 14 days of the BAC program improved attention stability and concentration assessed with the Bourdon and Landolt tests, respectively. Of note, changes in wave activities could potentially explain increased values in neuropsychological variables after the implemented treatment. Also, the mechanisms responsible for the positive neuropsychological responses in a healthy population, such as students of sports sciences, should be additionally clarified in the subsequent examinations. Considering that the BAC program elicited positive effects regarding attention stability and concentration, in future research, it would also be useful to explore how it reflects on the exam performances of university students. The improvements in cognitive functions observed in this study may be partly attributed to the enhancement of self-regulation abilities, as BAC facilitates cognitive control through neurofeedback mechanisms. Self-regulation has been identified as a key factor in mitigating behavioral and cognitive issues, particularly in educational settings (Fasihi & Rostami, 2023). Future studies should explore whether these improvements translate to broader academic and psychological benefits.

Regarding the choice of participants, sports science students were specifically selected due to their regular exposure to demanding cognitive and physical activities requiring high levels of concentration and attention. Given that cognitive performance directly influences their academic and physical performance, assessing BAC's effectiveness within this specific group can provide valuable insights. Although potential differences could arise with participants from other disciplines (e.g., medicine or music students), investigating such discipline-specific variations represents a meaningful direction for future research.

There are certain strengths of the investigation that must be emphasized. Firstly, this was a pilot study that used the aforementioned tests to evaluate neuropsychological aspects among sports science students. Therefore, the present research is the basis for the evaluation of attention stability and concentration in healthy populations in the future. Secondly, the randomization of respondents and the presence of both genders have also been recorded. Thirdly, each participant attended all sessions; thus, there was high adherence to the BAC intervention. On the other hand,

there were also several limitations. In terms of the intervention employed, the duration was 14 days. This shortcoming can be considered one of the reasons why statistically significant differences between groups in the Toulouse-Pieron and Schulte table tests were not obtained. In addition, psychological questionnaires that assess the anxiety, mood state, or depression of respondents were not implemented, and they should be used in future investigations. Lastly, although this study had sufficient statistical power to reveal differences between experimental and control groups, in the future, to verify these findings, it is recommended to conduct randomized controlled trials with a slightly larger number of recruited participants, as well as to carry out these protocols for longer periods of time.

Conclusions

This study provides preliminary evidence on the use of the BAC method to improve certain neuropsychological indicators among sports science students. Specifically, applying BAC for just two weeks suggested a potential improvement in attention stability, concentration, and cognitive switch ability, as measured by the Bourdon and Landolt tests. However, given the limited sample size and intervention duration, further studies are needed to confirm these findings. Considering that the BAC method is non-invasive and does not require specialized equipment, it could be a promising strategy for enhancing neuropsychological parameters and mental health in various applied settings, such as education, sports training, and clinical populations.

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Conflict of interest: Author state no conflict of interest

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