ORIGINAL RESEARCH

Comparative Evaluation of Videos with and without Binaural Beat Audio on Anxiety in Pediatric Patients during Dental Procedures: A Preliminary Study

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Abstract

Background: Various behavioral and emotional reactions to dental care are seen in pediatric patients. As a result, pediatric dentists are deeply concerned with effective behavior coaching. The use of audiovisual stimuli at a certain frequency, which causes the brain impulses to adjust to the new frequency, is one such technique. For relaxation, verbal and working memory, multiple cognitive activities, and pain relief, audio beats have proven to be successful. The goal of this pilot study is to compare the impact of auditory beats on children who are worried during dental operations in terms of anxiety reduction.

Materials and methods: A total of 10 children aged between 6 and 9 years were shown cartoon videos with and without binaural beat audio of α wavelength alternately at two consecutive visits. The patients were preconditioned for 30 minutes before the treatment procedures using noise-cancellation headphones with an iPad as the audiovisual aid. The use of the audiovisual aid was then continued throughout the procedure. The pulse rate (PR) and oxygen saturation (SpO_2) were noted preoperatively and after the procedure was completed.

Results: Using paired and unpaired *t*-tests, the resulting mean values before and after the procedure were compared. Compared to the control group's mean PR reduction of 3.6, the binaural beat audiovisual group saw a substantial PR reduction of 8.5 (mean). As for the SpO_2 level, the experimental group's mean value increased significantly (6.8) compared to the control group's value (2.9).

Conclusion: Audiovisual aids with binaural beat audio are a noninvasive therapeutic method that targets the brain centers to influence the psychological and physiological processes of the body. It is an effective anxiolytic modality that should be considered in pediatric dentistry.

Clinical significance: The present article centers on the assessment of anxiety levels among pediatric patients. The study aims to provide insights into the mechanisms of anxiety in this specific population, with the ultimate goal of improving the quality of care and treatment options available.

Keywords: Audiovisual aids, Behavior guidance, Binaural beat audio with video, Brain waves, Dental anxiety.

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Background

Dental anxiety is commonly responsible for the negative perception of treatment in children. Therefore, pediatric dentists and researchers are quite concerned about how a child will act and feel after receiving dental treatment.[1] Patients who receive dental care appear to exhibit anxious, resistant behavior the most commonly, up to 50%.[2] If this uncooperative behavior is not appropriately addressed, a chronic negative reaction pattern develops. This emphasizes the need for efficient methods to lessen anxiety and aid in coping in the dental setting.

It is crucial to create management strategies that are suitable for young patients. Physical restrictions, medication, behavioral modeling, reinforcement/contingency approaches, and distraction techniques are just a few categories that may be used to group together a variety of behavior control strategies documented in the literature. Conversely, clinicians have found that distraction techniques like audiovisual aids employing virtual reality, magic tricks, and white noise are secure, effective, and affordable.[1]

Audiovisual stimuli with a specific frequency can cause the neural waves to adapt and oscillate at the altered frequency. This is known as "brain entrainment." The binaural beat audio may be used to entrain the brain to various frequencies through the auditory system. These are two rhythmic tones with slightly

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different frequencies that are presented separately to each ear (Fig. 1).[3] This alters the neural waves to sync with the different frequencies of the binaural beat, thus changing brain activity and its state.[3–5] The disrupted cortical oscillations produce weaker brain waves, thereby inducing cooperative behavioral responses in anxious patients.

Audiovisual aids are often the distraction methods of choice in pediatric dental practice. Children are engaged and comfortable when exposed to their familiar cartoons, movies, and songs. Hence, it was envisioned to utilize such cartoon videos and incorporate α binaural beats in the audio of these videos. This was planned to gain the dual benefits of brain entrainment and distraction. Thus, the application of audiovisual aids with binaural beats for their anxiolytic effects in pediatric dentistry was proposed. The study aimed to compare the effect of videos with and without α audio beats on anxiety reduction in apprehensive children during dental procedures.

Materials and Methods

Trial Design

This preliminary study was designed as a double-blind randomized controlled (RC) crossover study, and the reporting was done following the Consolidated Standards of Reporting Trials guidelines. This experimental crossover study was conducted with patients reporting to the outpatient department of the institute, in accordance with the guidelines of the Institutional Ethics Committee and the Helsinki Declaration of 1975, as revised in 2000.

Randomization

Sequence Generation

A total of 10 patients with a Frankl's behavior rating scale score of 2 (negative) or 3 (positive) were included in the study.[6]

Implementation

For the patients included in the study, the unedited cartoon videos and the experimental cartoon videos with incorporated α binaural beat audio were played randomly during two consecutive visits.

Blinding

The patients were blinded to the type of video being played. Noise-cancellation headphones connected to an iPad were used for viewing the videos, with preconditioning of the patient for 30 minutes before the procedure and continuing throughout the procedure (Fig. 2).

Participants

Pediatric patients undergoing operative dental procedures, aged between 6 and 9 years, were selected for this RCT.

Interventions

The parameters recorded preoperatively and after the completion of the procedure were pulse rate (PR) (beats/minute) and oxygen saturation (SpO_2%).

Outcome

The pre- and postexposure values were used to calculate the mean and compared using paired and unpaired *t*-tests. The statistical analysis was done using Statistical Package for the Social Sciences version 24.0 software.

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Conflict of interest: None

Results

Evaluation of Pulse Rates

The mean PR before the procedure in the control group was 100.4 ± 4.67 beats/minute, whereas after the procedure, the mean PR was 96.8 ± 3.08 beats/minute. In the experimental group, the mean PR before the intervention was 99.11 ± 5.55 beats/minute, and postintervention with the audiovisual aid of binaural beat audio was 90.44 ± 1.74 beats/minute.

On intragroup analysis, the mean differences in the PR before and after the intervention during the procedure in both the control and experimental groups were calculated and tabulated as shown in Table 1. On intergroup analysis, the calculated mean difference was found to be significantly higher in the experimental group (8.5 ± 4.62) than in the control group (3.6 ± 3.33) (Table 2 and Fig. 3).

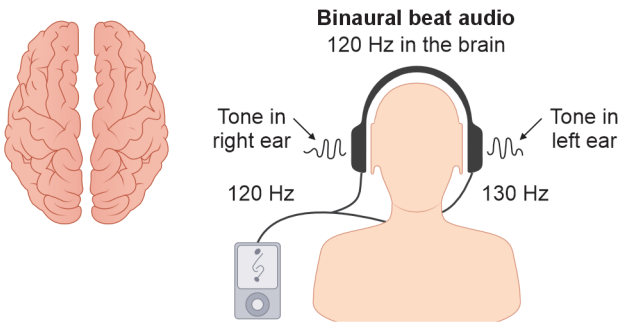

Fig. 1: Binaural beat audio consists of two rhythmic tones with a slightly different frequency which is presented separately to each ear

Fig. 2: Noise-cancellation headphones connected to an iPad were used for viewing the videos for preconditioning the patient for 30 minutes before the procedure and were continued throughout the procedure

Table 1: Comparison between before and after variables of PR and SpO_2 within the group using paired *t*-test

	Parameters	*Mean*	*Standard deviation*	*Standard error mean*	*95% confidence interval of the difference*
Control	PR before and PR after	3.60000	3.33999	1.05620	1.21071
	SpO_2 before and SpO_2 after	–2.90000	1.19722	0.37859	–3.75644
Experiment	PR before and PR after	8.50000	4.62481	1.46249	5.19161
	SPO_2 before and SPO_2 after	–6.80000	1.47573	0.46667	–7.85567

Table 2: Paired samples correlations (Pearson's correlation for paired *t*-test): measure of statistical evidence for a linear relationship between pairs of continuous variables

Parameters		*N*	*Correlation*	*Significance*
Control	PR before and PR after	10	0.700	0.024
	SPO_2 before and SPO_2 after	10	0.872	0.001
Experimental	PR before and PR after	10	0.500	0.141
	SPO_2 before and SPO_2 after	10	0.600	0.067

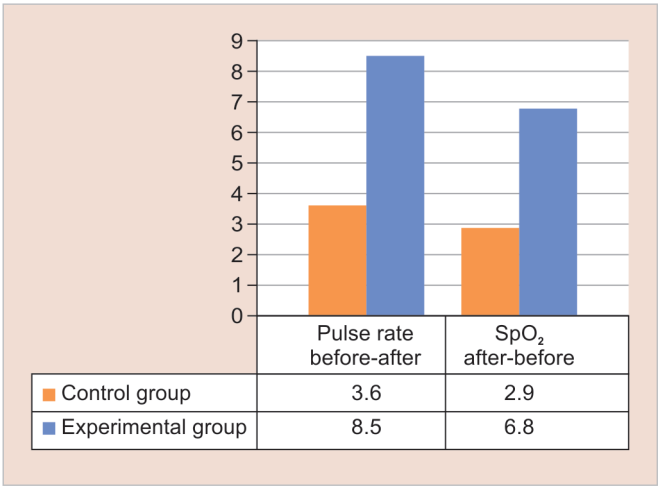

Fig. 3: Comparison between pre- and postvariables of PR and SpO_2 between the groups

Evaluation of Oxygen Saturation

The mean SpO_2 before the procedure in the control group was 93.3 ± 2.21%, whereas after the procedure, the mean SpO_2 was 96.2 ± 2.44%. In the experimental group, the mean SpO_2 before the intervention was 92.44 ± 1.74%, and postintervention with the audiovisual aid with binaural beat audio, the mean SpO_2 was 99.0 ± 0.87%, which was statistically significant.

On intragroup analysis, the mean difference in the SpO_2 before and after the intervention during the procedure in both the control and experimental groups were calculated and tabulated as in Table 1. On intergroup analysis, the calculated mean difference was found to be significantly higher in the experimental group (–6.8 ± 1.47) than in the control group (–2.9 ± 1.19) (Table 2 and Fig. 3).

Discussion

In addition to the degree of disruptive behavior,[7] the level of fear that children experience before or during dental treatment is also linked to an increase in pain perception, which may subsequently lead to worry, anxiety, and sensitization for subsequent appointments.[8] According to McCaul and Mallot's notion, when a patient is diverted from an unpleasant stimulus, their experience of pain is lessened.[9] It makes sense that a patient's attention to an unpleasant stimulus has a direct correlation with their impression of pain. This notion has been supported by several neurophysiological investigations, underscoring the significance of distraction in lowering pain and anxiety levels.[10] Previous studies have shown that dental fear may develop as a result of unpleasant dental experiences in the past,[11,12] while persistent avoidance behavior may make dental anxiety worse. Therefore, fear and anxiety are intimately associated. Therefore, dental fear/phobia is defined as when the disturbed anticipation interferes with normal functioning,[11,13] whereas dental anxiety is described as the upset expectation of a visit to the dentist to the point that a kid would avoid treatment.[14]

Electroencephalogram (EEG) data on cerebral activity are often categorized into one of four groups—the normal waking consciousness's β pattern (frequency: 14 to >100 Hz) is connected to cognition, focus, attentiveness, and arousal. This pattern is linked to anxiety at higher levels. The α EEG pattern (8–13 Hz) is associated with relaxation, the θ pattern (4–8 Hz) with REM sleep, meditation, and creativity, and the delta EEG pattern (0.1–4 Hz) with dreamless sleep.[2] Therefore, it is anticipated that the delta and α rhythms would have calming effects. Numerous studies have been carried out to determine the benefits of binaural beats on relaxation, dual cognitive tasks, working memory, verbal memory, and anxiety and pain reduction.[3] However, the audiovisual behavior coaching approach has not been used to study the anxiolytic effect of binaural beat audio during dental treatment. In the current investigation, movies containing α binaural beat audio were found to be more helpful in reducing anxiety in apprehensive patients compared to the control group.

As a means of detecting anxiety in children, variations in PR, systolic blood pressure, and diastolic blood pressure may be positively connected with a reduction in anxiety, according to research on biofeedback.[15] Further in a study where cataract operations were performed in adults in the year 2016, Wiwatwongwana et al. found that the heart rate in the binaural beat group was significantly lower than the musical interventional ($p = 0.050$) and control groups ($p = 0.004$) while there was no difference in heart rate of patients in the musical interventional group and the control group ($p = 0.303$).[16] Therefore, we suggest that binaural beats may have an additional anxiolytic effect compared to music with mixed wavelengths. In the present study, PR showed a more significant decline on the visit in which videos with binaural beat audio were used.

Binaural beats have a digital acoustic composition of a specific stereo sound. Unlike the cross-feed of speakers evident in stereo sound systems, it works on the effect of the resonance of the resultant tertiary frequency. The primary and secondary frequencies, when presented to the two separate (left and right)

ears, create a tertiary frequency that travels through the neural pathway of the brain. This resonates with the same frequency, which elicits physiological and psychological changes.[17] The neurons of the parietal and temporal lobes are responsive to the binaural audio track.[3]

Audiovisual distraction with cartoon movies and songs is widely used for behavioral guidance. Including binaural audio beats in the cartoon videos may augment the distraction by altering alertness and brain response. In comparison, patients conditioned with binaural beats audiovisual exposure had lower PR and higher SpO_2 postoperatively compared to the control group.[17]

Multicentric research has confirmed that a minimum of 5 minutes of exposure to binaural beats is needed to stimulate resonance in the neurons of the brain. Increasing the duration of exposure to binaural beat stimulation has additive effects on brain entrainment.[3]

It has been noted that the relationship between pain and anxiety is not direct and unidirectional. Lesser intensity of pain is perceived when pain is the only sensation present, compared to when fear or anxiety is added to the associated pain. The story of the cartoon, despite being chosen by the participant, may have also induced physiological responses of anxiety. Videos have been shown to normally arouse autonomic nervous system responses (e.g., muscle tension and heart rate). Participants reported reduced anxiety and an increase in relaxation, as the videos chosen were pleasant and peaceful.[1,18]

It is important that the patient actively participate in this behavior guidance technique for it to be effective. The children must be able to comprehend the nonadaptive quality of their anxiety and choose to control it by concentrating on a stimulus or distraction. Children younger than the subjects we studied may lack the cognitive ability to sustain concentration throughout the appointment. Thus, younger subjects were not included due to the ineffectiveness of the distraction technique.

In other studies, a significant difference was noted in the fear and anxiety measures between those who were treated under sedation using oral medications before carrying out dental care procedures compared to those who did not. This could be because those indicated for treatment under sedation exhibited higher levels of anxiety. Hence, future research is necessary to determine if lower levels of sedation combined with the induction of a multisensory environment using α binaural beat audiovisual aids might be more beneficial.[19]

Conclusion

Binaural audio beats with cartoon videos is a noninvasive therapeutic method targeting the centers of the brain, providing effective anxiolytic effects. The α binaural beat audio was shown to be an effective anxiolytic agent in apprehensive patients and can help the child stay calm and comfortable during dental procedures.

Author Contributions

Nilesh Rathi conceived the idea for the study, supervised the project, and provided critical feedback on the manuscript. Rashi Srivastava contributed to data collection, data analysis, and manuscript preparation. Nilima Thosar contributed to experimental design, conducted experiments, and participated in data interpretation. AK Anjali developed the theoretical framework, contributed to data analysis, and manuscript editing. Francesca Gorassini provided specialized expertise, contributed to data interpretation, and reviewed the manuscript. Vini Mehta assisted in data collection, data preprocessing, and manuscript editing. Luca Fiorillo contributed to the study's conceptualization, provided specialized analytical tools, and contributed to manuscript review and editing. All authors read and approved the final manuscript.

Clinical Significance

The present article centers on the assessment of anxiety levels among pediatric patients. The study aims to provide insights into the mechanisms of anxiety in this specific population, with the ultimate goal of improving the quality of care and treatment options available.

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