DENTAL SERVICES – TO FEAR OR NOT TO FEAR? THE EFFECT OF MUSIC ON PAIN PERCEPTIONS

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Abstract:
In the tertiary sector of economy, consumers have been noticed to pay great attention to dental care services as they make use of such services quite frequently and are emotionally involved in the supply process to a great extent. Among adults, the dentist-patient relationship is often governed by stress, anxiety and fear. In this study, the authors propose exposing the patient to music as a component of ambience for a set amount of time, believing that this external factor may help to alleviate stress and rethink patients' opinions of dentists. To this end, the authors used the EPOCx electroencephalogram (EEG) and conducted the pilot experimental study, where the individuals in the sample were divided into four groups: a control group, on which no intervention was exerted (G1) and three experimental groups. Subjects in G2 were exposed to music without prior notice, study participants in G3 knew the experimental protocol, and those in G4 selected their own music. Using electroencephalogram signals, the authors monitored the reactions of patients

in the experimental groups, which were then compared with the signals obtained for individuals in the G1 group. The results showed significant variations for subjects exposed to music, which were most evident in the right parietal cortex, which is responsible, among other things, for the emergence of positive emotions.

Keywords: EPOCx electroencephalogram (EEG), parietal cortex, ambiance, dental services, music.

1. Introduction

The major concern of health care agencies around the world is quality (Mahrous & Hifnawy, 2012). Dental services have been investigated in different countries to capture the level of patient satisfaction. Dental service providers may experience anxiety and stress, caused by patient dissatisfaction. Patients' complaints and dissatisfaction may lead to a change of dentist, and this will propagate into how friends and family perceive the provider. Patients who are more satisfied with dental services have better compliance, are more determined to keep their appointments, and have low anxiety and pain perception (Mahrous & Hifnawy, 2012).

In order to provide a holistic view on improving understanding of the factors that affect patient satisfaction with health care conditions one has to include patient opinion, since what patients want may differ from what the provider thinks is best for them. Patients' opinion concerns the interaction they have with clinic staff, technical competence, system efficiency, and the setting of the clinic environment (Mahrous & Hifnawy, 2012). Ali (2016) is of the opinion that in the dental field, patient satisfaction helps identify weaknesses and strengths of dental clinics/centres, leading to an increase in the quality of treatment and better future planning. The exploration of customer satisfaction dates back to the 1970s when the consumer movement was directly linked to the quality of service provided. Later, in 1984, consumer satisfaction in health care was measured as a component of quality of life. Thus, unanimity in terms of quality of healthcare services is measured by patient satisfaction (Ali, 2016).

Also, the ambience in dental clinics seems to be of major importance in terms of patient satisfaction with the dentist, being a fairly measured variable (Verma & Jauhari, 2013; Hirani & Masalu, 2013; Dancila & Ionaș, 2016; Bokadia & Varghese, 2020), having an impact on patient well-being and contributing to patient relaxation. Building on the definition postulated by Brawley (1992), Morgan (2013) points out that perception of ambience has a synergistic effect that can influence individual feelings and behaviour including aspects such as mood or atmosphere created by the mix of physical design, lighting, décor, smell and sounds. More and more studies (Pinto & Leonidas, 1995; Ali et al., 2018; Akhtar et al., 2019;) have investigated ambience as a factor that determines patients' satisfaction with healthcare services, with results showing a positive effect on them.

2. Literature Review

From a healthcare marketing perspective, Nitse and Rushing (1997) state that patient satisfaction often begins with the first visit to the doctor's office. Not to be ignored is the fact that consumer loyalty is seen as an attitude towards future experiences that lead to the same type of consumption habits. In this respect, the perception of how the patient views the experience at the doctor's office is paramount to understanding the basis of satisfaction with health care services. In Romania, patient satisfaction follows the same trajectory, with patients having more appreciation for comfortable dental care built on the doctor-patient relationship and less on professional qualifications (David et al., 2017). Thus, what is best for the patient is that he or she should be the focus of the interaction with the specialist.

Some researchers (Reifel et al., 1997) approach patient satisfaction through the lens of its complexity, and it is considered a criterion that affects the measurement of the dentist's performance. Patient satisfaction has an influence on the use of dental services, patient anxiety and on the respect for dental consumer, and is associated with health outcomes.

Satisfaction of patients undergoing dental treatment seems to be an increasingly important component of dental care. As the healthcare industry has become more consumer-driven, patient satisfaction has become the most important measure of the quality of dental care. Determining patient satisfaction with dental services is related to factors such as perceived health, the nature of the provider-patient interaction, and the structure of the dental care delivery system (Sur et al., 2004).

Cărăuș (1999) is of the opinion that patients who choose a dentist have three criteria to refer to: the reputation of the provider, information about the provider and the quality of the services offered by the provider. Not to be overlooked is the fact that patients are determined to evaluate the quality of dental services on the basis of previous experiences. Thus, it is necessary for a dental service provider to continuously improve the quality of its services in the face of competition, providing dental care to the standard desired by the patient and even exceeding these desires. Also, if the level of quality of dental care does not meet the patient's expectations, the patient will abandon the services of that dentist in favour of dental services provided by another health professional. Conversely, if the medical services are above the patient's expected level, the patient will continue to seek the services of the same dentist for dental health problems.

Baldwin and Sohal (2003) identified four factors that refer to separate domains as regards the quality of dental services: responsiveness, empathic assurance, reliability, and tangible services. Responsiveness refers to the relationship between doctor and patient regarding patient accommodation and, statistically, is significantly positively correlated with patients' perceived level of service quality (Baldwin & Sohal, 2003). Empathic assurance is seen as the relationship between treatments that maintain patient comfort and self-esteem, resulting in a low level of patient pain correlating significantly positively with the quality of services provided by the dentist (Baldwin & Sohal, 2003). Reliability refers to the professionalism of the health care provider and has a significant positive effect on patients' perceived level of service quality (Baldwin & Sohal, 2003). The physical characteristics of the dental office are integrated into the factor that refers to tangible materials, which includes décor, layout, ambience, etc. The tangible factor has a significant positive effect on the level of perceived service quality (Baldwin & Sohal, 2003).

Some evidence in the literature (Ghosh & Sahoo, 2016) suggests that patient-centered care services additionally highlight the design of the ambience of a healthcare facility. Ambience cues are tangible elements such as, sight, taste, smell, touch and sound. The physical premises of a healthcare provider are a primary dimension of the overall experience that can encourage or discourage certain patient behaviors and emotions that ramify to the healing process. Healthcare provision is also very different from other services (airline, banking, telecommunications, etc.). It is difficult for patients to measure and evaluate the technical nature of a healthcare service, so tangible elements relating to ambience, layout, facilities, etc., play a determining role in assessing the overall quality of the service.

Suess and Mody (2018) suggest that patients' emotional responses have been shown to correlate between ambience elements and patient relaxation, with extension to high levels of satisfaction with the overall healthcare experience. By contrast, if patients experience stressful aspects, they may not be able to accept or minimise non-ideal atmospheres, thus becoming dissatisfied with the quality of care provided. Hirani and Masalu (2013) state that the physical environment significantly influences patient satisfaction and helps patients to relax, conveying the idea of concern for their well-being. At the same time, the positive external appearance of the clinic will convince the patient that what is inside meets the same standards, and there is a continuity between the atmosphere provided and the place of work.

Thus, ambience, in the context of healthcare, has an influence on patients' cognitive, affective, and conative reactions (Sahoo & Ghosh, 2016), providing researchers with numerous opportunities to explore how these component elements affect patients' perception, attitude, satisfaction, and certain behavioral intentions. Patient satisfaction serves as an indicator of the quality of care provided, and this determines future health-related behavior resulting in serious economic and marketing consequences. Pinto and Leonidas (1995) stress the importance of the quality of health care received from the provider, and those patients who are satisfied and loyal to a provider are most likely to recommend the provider to others. Repeat purchase that turns into loyalty and recommendation to others is very important for healthcare providers, as on this depends the provider's success in the market place.

Furthermore, the patient-dentist relationship is another indicator of patient satisfaction, and this includes, among others, factors related to patient anxiety and the level of stress experienced by the patient (Rouse & Hamilton, 1990; Tan et al., 2019; Yong et al., 2021).

In light of the foregoing, we proposed to use music, which is both a factor of ambience and of the patient-dentist relationship and which could serve, in the future, as an indicator of the satisfaction of patients undergoing dental procedures. Given that some studies (Berger, 1929) suggest that living cells are endowed with the ability to produce bioelectric current, which ensures the normal life cycle of the cell, using an electroencephalogram (EEG) we will investigate to what extent the music selected by the researcher and the music selected by the patients produces variations in bioelectric current in patients undergoing dental treatments and whether this possible effect is maintained after the music is stopped. Berger (1929) states that evidence was provided relatively early on to prove the detectability of bioelectric phenomena in the central nervous system, which constitutes an immense concentration of cells. Also, the idea of detecting through the scalp various psychological acts of perceiving currents occurring in one's own brain, is postulated as early as 1874 by Caton.

The challenges for brain science are not few, one of which being measurements that are contaminated by noise and artefacts (environmental noise, instrumental noise or signal sources in the body that are not useful to the experiment). The presence of artefacts and noise may obscure the targeted signal or overlap with its analysis (de Cheveigné & Nelken, 2019).

3. Research objectives

The authors of this study aim to identify the extent to which music, which is a component of ambience, as well as the patient-dentist relationship, produce changes in EEG signal variations before, during and after listening.

To this end, some specific objectives have been formulated:

1. Identify how the music (Mozart-Piano Sonata No. 16 in C major) selected by the researcher without disclosure of the experimental procedure produces variations of the electrical signal in the brains of patients undergoing dental treatment

2. Identify how the music (Mozart-Piano Sonata No. 16 in C major) selected by the researcher with disclosure of the experimental procedure produces variations of EEG signals on patients undergoing dental treatment.

3. Identify how the music selected by the patients undergoing dental treatment produces variations of the electrical signal in the brain.

3.1 Methodology of research

3.1.1 Participants

The participants in this study were selected from three private dental clinics in Transylvania. They are healthy persons, non-musicians who had received dental treatments. Individuals were not selected according to the method of dental treatment, except that patients who received anaesthesia were not included in the present sample. This was taken into account in order to control, as far as possible, possible confounders that might have interfered with the experimental protocol.

Twenty people were involved in the research, out of which 11 were women and 9 were men, aged between 21 and 63. The 20 subjects were selected based on their willingness to be connected to the non-invasive EPOCx EEG device for 15 minutes.

In order to avoid biasing the results, subjects were informed that no disease or illness was intended to be diagnosed and that there were no risks of any kind, either physical or mental, to which they would be exposed before, during or after the recording of brain activity. They were also made aware that their responses were kept anonymous, participation was voluntary and the reward was altruistic. Subjects also had the right to withdraw from participation at any time, which is the subject of this study.

3.1.2 Assessment tools

The Emotiv EPOC X electroencephalogram with 14 whole brain recording channels, with redesigned galvanized electrodes and electrode rehydration using saline was used to collect the data. The EEG has a rotating band and can be connected wirelessly to a laptop or mobile phone, with 9-axis motion sensors detecting head movements and a battery life of up to 9 hours.

The Emotiv EPOC X is not sold as a medical device and is intended for research applications and personal use. The device can be used in a wide variety of settings, including a brain-computer interface (BCI) and cognitive neuroscience research (Williams et al., 2020). The accuracy of the Emotiv Epoc+ EEG has been demonstrated and validated by experts (Badcock et al., 2013) in comparison to other medical EEG devices. Emotiv EPOC X is the improved version of the Emotiv Epoc+ device, including improved signal quality to reduce noise (Emotiv EPOC®, www.emotiv.com).

Duvinage et al. (2013) take the description of the equipment from the Emotiv website, giving an overview of the EPOC device which is equipped with fourteen brain bioelectric current sensors/channels (AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF4), named after the international 10-20 system, according to their positioning on the scalp. The available channels of the Emotiv EPOC X are illustrated in Figure 1. The device comes with EEG signal monitoring software and emotion prediction software that helps to visualise sensor behaviour and variation of emotional parameters.

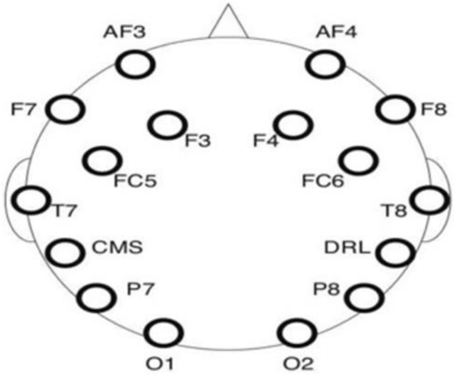

Figure 1. EEG- Emotiv Epoc x. Sensors positioning on the scalp

Source: Duvinage et al. (2013)

3.1.3 Design and model specification

The design is experimental, where subjects were divided into three experimental groups and a control group, and monitored for 15 minutes. The first 5 minutes serve as the baseline interval, the next 5 minutes are allocated to the intervention (music), and the last 5 minutes are to identify a possible maintenance of variations in the signals captured from the right parietal lobe.

The reason why music has not been used as an intervention method from the moment patients occupied the treatment chair is due to the fact that in a study by Messer (1977) it was shown that stress levels are higher at the beginning of each dental visit than at the end of it.

I. Group 1 (G1) is for people who have not undergone any experimental intervention. In other words, it is the control group that was monitored for 15 minutes without listening to music, but underwent dental treatment without anaesthesia.

II. Experimental group 2 (G2) was told that they would be monitored for 15 minutes using EEG, but were not informed that 5 minutes after the start of dental treatment they would be exposed to auditory stimuli (Mozart - Sonata No. 16 in C Major, piano), and that the next 5 minutes continued to record brain activity (5 minutes baseline interval - 5 minutes intervention without disclosure - 5 minutes maintenance). In other words, patients were not disclosed the experimental procedure.

III. Group 3 (G3) was informed that during the 15 minutes of brain activity monitoring they would listen to Mozart - Sonata No. 16 in C Major, piano, with the aim of inducing a state of well-being and whether the possible state of well-being is maintained after the music stops (5 minutes baseline interval - 5 minutes intervention with disclosure - 5 minutes maintenance). In other words, the experimental procedure was revealed.

IV. Group 4 (G4) was allowed to select the music they felt made them feel good, to be played within 5 minutes of the 15 minutes of brain activity monitoring (5 minutes control interval - 5 minutes intervention of their choice - 5 minutes maintenance).

The present research is an exploratory pilot study, which aims to use descriptive investigations to identify variations of electrical currents in the brains of patients undergoing dental treatments.

3.1.4 Research procedure

Data was collected from January to June 2021. Patients who were scheduled for various dental treatments were asked upon entry to the clinic if they were willing to participate in this study which aims to identify ways to improve dental care.

After they signed the agreement to participate in the study, the Emotiv EPOC X electroencephalogram was fitted and they entered the treatment room. In a separate room of the clinic the patients' brain activity was monitored remotely and music was turned on/off according to the established protocol. After completion of the experiment, patients were notified that the experiment was over and the EEG was disconnected and the dental treatment continued.

Initially, 49 subjects took part in the study, but in some individuals the signal was lost and the device automatically disconnected. Although in some cases the signal returned after a few seconds, the recording stopped automatically and a subsequent recording was not made on the same subject to avoid compromising the results of the whole study.

4. Results and discussion

4.1 Data analysis

Matlab software was used to analyze the EEG signal variations before the music played, during listening and after listening to generate the results.

We considered five statistical indices (mean ($\overline{x}$), standard deviation (σ), skewness (τ), kurtosis (κ) and modal value(PPV)) based on which graphs were generated. At the same time, these five statistical indices were observed to have more intense variations in channel 9 (C9) corresponding to the parietal lobe, right side (P8). Therefore, the bioelectric signal generated by the brain was subjected to variation analysis in the channel collecting the bioelectric current of the right parietal lobe.

Thus, four graphs corresponding to the four groups of subjects were generated to summarize the variations of the bioelectric signal in the right parietal lobe.

In the following, we summarize in a table (Table 1) the five features extracted from the right parietal lobe.

Table 1. Statistical indices used to obtain results

Statistical indices	Formula
Mean	$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x\,i$
Standard deviation	$\sigma = \sqrt{\frac{1}{N} + \sum_{n=1}^{N} (xi - \bar{x})^2}$
Skewness	$\tau = \frac{1}{N}\sum_{i=1}^{N} \frac{(xi-\bar{x})^3}{\sigma^3}$
Kurtosis	$\kappa = \frac{1}{N}\sum_{i=1}^{N} \frac{(xi-\bar{x})^4}{\sigma^4}$
Modal value- Peak to Peak	PPV = max. val – min. val

Characteristic values obtained from the right parietal lobe of the control group are as follows: in minutes 1-5 we obtained $\bar{x}$ = .79, σ = .05, τ = -.32, κ = 14.42 and PPV = .48. In the interval 5-10, $\bar{x}$ = .79, σ = .04, τ = -.06, κ = 14.59, and PPV = .48. If we look at minute 10-15, we see that $\bar{x}$ = .91, σ = .02, τ = -1.16, κ = 17.03, and PPV = .18

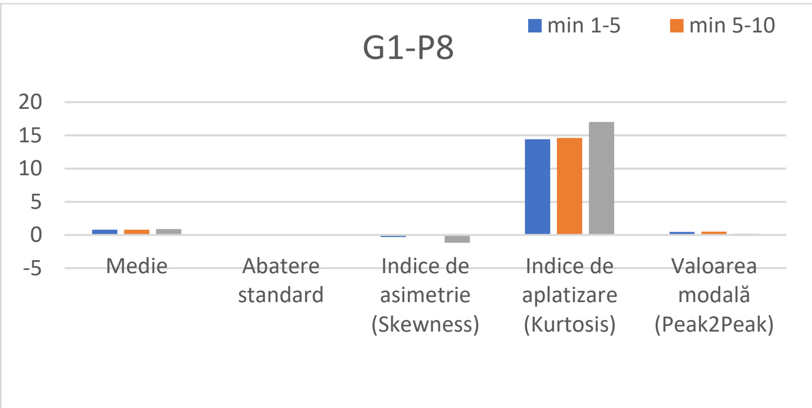

Figure 2. Variations of the electrical signal in the right parietal lobe for subjects in the control group (G1)

Source: authors' research

Based on the values obtained, a graphical representation of the EEG signal variations and of the features extracted from the right parietal lobe for the subjects in the control group was made. After analyzing the data, we can conclude that there were no statistically significant differences between the fifteen minutes of monitoring of brain activity. In other words, it can be seen that in the absence of intervention by the researchers, no changes in EEG signal variations were identified. The values for the features extracted from the right parietal lobe for subjects who were part of the group whose music was selected by the researcher without disclosure of the experimental protocol (G2) are as follows: in minutes 1-5, $\bar{x}$ = .80, σ = .02, τ = .92, κ = 18.71, and PPV = .31 were obtained. In minutes 5-10, $\bar{x}$ = .85, σ = .03, τ = -1.07, κ = 45.35, and PPV = .37. In minutes 10-15, we observe that $\bar{x}$ = .87, σ = .02, τ = .33, κ = 11.99, and PPV = .26.

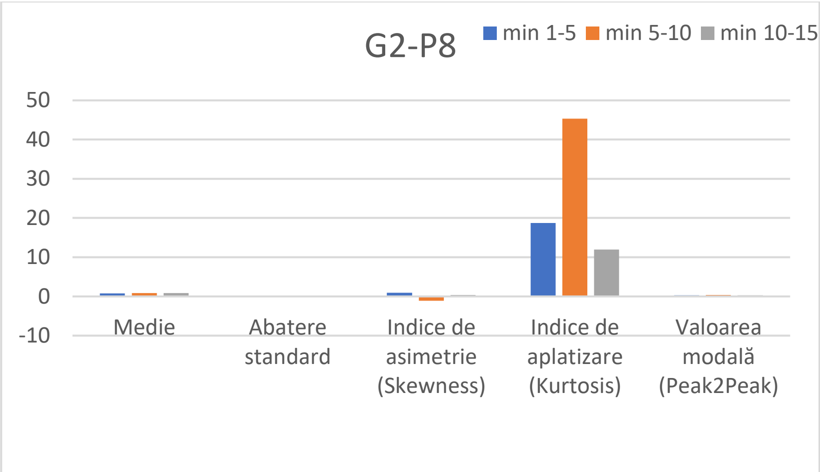

Figure 3. ***Variations of the electrical signal in the right parietal lobe for G2 subjects***

Source: authors' research

We can see from Figure 3, which was generated from the data analysis, that the kurtosis value is statistically significantly different in the fifteen minutes of brain activity monitoring. Thus, the maximum variations of the electrical current captured from the right parietal lobe were evidenced at the time of music listening. In other words, it seems that music had an effect on G2 subjects, but these variations were not maintained after the music stopped.

The values of the extracted right parietal lobe features for subjects who were part of the G3 experimental group are as follows: in minutes 1-5, $\bar{x}$ = .71, σ = .04, τ = .35, κ = 12.94 and PPV = .50 were obtained. In minutes 5-10, $\bar{x}$ = .78, σ = .05, τ = -.23, κ = 17.71, and PPV = .50. In minutes 10-15, we observe that $\bar{x}$ = .75, σ = .03, τ = 1.08, κ = 15.08, and PPV = .40.

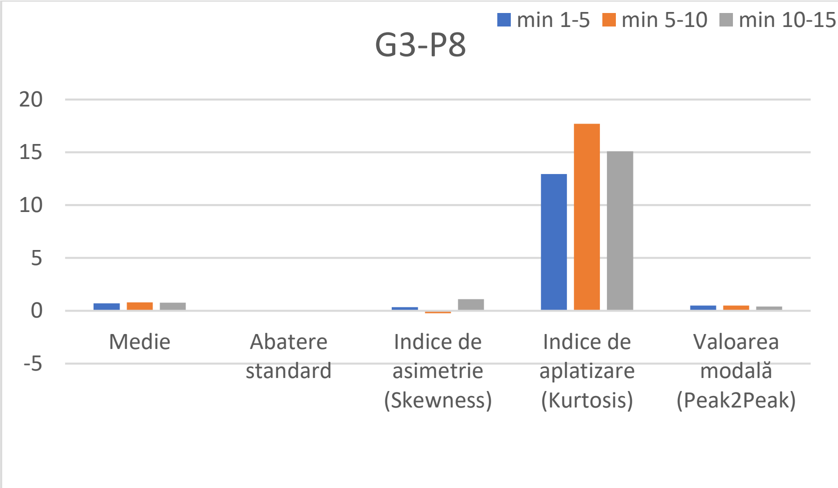

Figure 4. Variations of the electrical signal in the right parietal lobe for G3 subjects

Source: authors' research

Regarding the subjects belonging to the experimental group in which the music selected by the researcher was listened to and they were informed about the experimental procedure, we can deduce from Figure 4 that kurtosis has maximum variations of the EEG signal, which are slightly distinct across the time intervals subjected to analysis according to the experimental protocol, but they are not statistically significantly different. In other words, there is a slight increase in the variations in the intervention interval and some maintenance of the EEG signal variations after the music is stopped.

The values of the features extracted from the right parietal lobe of G4 subjects in the range 1-5 are $\bar{x}$ = .82, σ = .03, τ = -.68, κ = 14.51 and PPV = .39. In range 5-10, $\bar{x}$ = .74, σ = .02, τ = .10, κ = 24.97, and PPV = .48. In minutes 10-15 we observe that $\bar{x}$ = .72, σ = .05, τ = -.55, κ = 13.33, and PPV = .58.

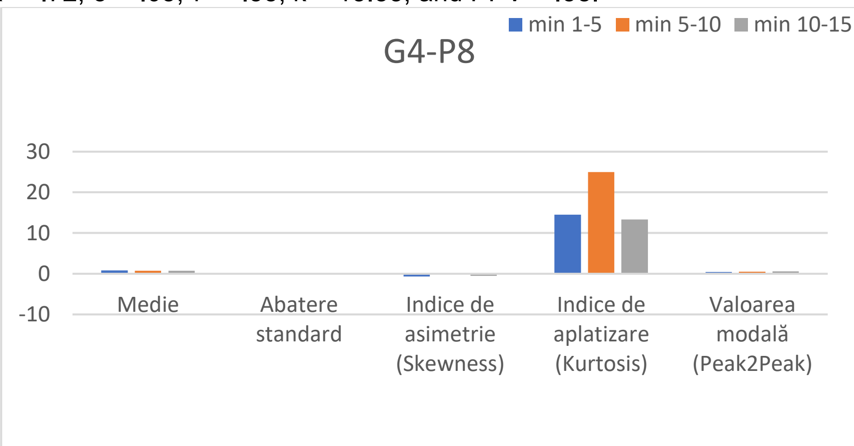

Figure 5. Variations of the electrical signal in the right parietal lobe for G4 subjects

Source: authors' research

The bioelectric signal variations observed in the right parietal lobe of subjects in the G4 group, who self-selected their music, appear to be highlighted in the kurtosis feature, but these differences are relatively small relative to the time interval allocated to brain monitoring, depending on the experimental protocol. In other words, the music that subjects are accustomed to does not produce major changes in EEG signal variations.

5. Conclusions

Some papers in the literature (Levitin, 2006) show that music is distributed throughout the brain, with music composition, performance and listening involving almost every area of the brain and almost every neural subsystem.

The present study revealed that the analysis of EEG signal variations before, during and after music listening were more significant in the right hemisphere of the parietal lobe. The maximum change in variations for the time intervals (1-5, 5-10 and 10-15) was observed in the right parietal lobe (EEG sensor/channel 9) in all experimental conditions, but the effect of music was most evident in the group that did not know they were about to listen to music (G2), in other words, in those individuals who were not disclosed the experimental procedure. According to Horton (1988), the right parietal cortex is involved in the emergence of positive emotions. On the other hand, some studies (Gainotti, 2012) suggest that the right hemisphere of the brain is responsible for the unconscious processing of emotional information. According to Schwartz et al. (1975), the right hemisphere of the brain is indirectly involved in the regulation of affective tone and the identification of a musical instance from an unfamiliar tune. Thus, in addition to the positive effects of music that the literature emphasizes, it is possible that in this case music acted as a distractor from the medical procedure.

This does not mean that the left hemisphere of the brain does not process emotions. According to Gainotti (2005), the left hemisphere of the brain is involved in the control and analysis of conscious emotions and the right hemisphere of the brain is involved in the automatic and unconscious generation of emotions.

Clark et al. (2006) report that listening to music selected by subjects decreases anxiety levels when it comes to treatment-related distress. In this regard, analysis of EEG signal variations of subjects who self-selected their music does not seem to show significant differences between intervals when subjects listened to music (minutes 5-10) and intervals when they did not listen to music (minutes 1-5 and minutes 10-15). Certainly, an argument for this may also be that they were habituated to the stimulus to which they were exposed.

Although most studies support the idea that low-arousal music reduces stress, Chanda and Levitin (2013) say that contextual factors, such as control over music selection (choice of experimenter or choice of subject), need to be taken into account. Which is why the present study wanted to see under what conditions music can have an influence on subjects and two groups whose music was selected by the researchers were introduced. One group (G2) was not shown the experimental protocol and the other group (G3) was shown the experimental protocol and listened to the same music, which was selected by the researcher.

By contrast with experimental studies where the context in which music is listened to is artificial, recent studies suggest that it would be more ecologically valid to study subjects listening to music in their natural environment (North et al., 2004;

Van Goethem and Sloboda, 2011). Based on these considerations, the experiment was conducted under natural conditions.

The most important reason for which music was studied as an auditory stimulus of ambience, which, among other things, can lead to a satisfactory relationship between patient and dentist, is that it represents an economic advantage. In other words, if it turns out that music could have a positive effect on patients undergoing dental treatment, the investment by dental health care providers would be small. Thompson et al. (2001) is of the opinion that the Mozart effect is likely to be associated with a positive rather than a negative mood.

Some studies in the literature (Hodges, 2000) that have looked at the implications of music on the brain highlight that emotional responses to music are the most difficult to study and one of the most important research topics as well. This is not surprising at all as we do not have biological fingerprints of emotions in the brain (Barrett, 2017), and the Positive and Negative Affect Schedule (PANAS) could be used to identify patients' affect.

Music is also believed to produce physical changes, but it also acts as a psychological distractor, being used in surgical procedures to reduce fear, anxiety and pain. At the same time, music produces changes in blood biochemistry leading to affective changes. Ferreri et al. (2019) said that the fascinating part of humans is their ability to experience feelings of pleasure generated by complex patterns of auditory stimuli such as music.

Since the study is exploratory, descriptive rather than inferential statistics were used as each experimental group consists of a small number of subjects.

Almost all statistical methods commonly used in research assume that the data collected are normally distributed (Cain et al., 2017). According to DeCarlo (1997), if skewness is different from 0 the distribution is deviated from symmetry, and if kurtosis is different from 0, then the distribution is deviated from normality in the heaviness of its tail and curvature. In other words, the skewness index conveys information about the direction of skewness relative to a standard bell curve. Similarly, the kurtosis index gives information about the height and sharpness of the peak relative to a standard bell curve. It should be noted that sample skewness and kurtosis are limited to the sample size (Cox, 2010). In other words, it is difficult to draw firm conclusions, but we can refer to the results obtained as a trend followed by the EEG signal variations identified in the right parietal lobe of patients undergoing dental treatment who listened to music, according to the established experimental protocol.

In this case, we were able to capture maximal variations in the right hemisphere parietal lobe in those subjects who were not disclosed the experimental protocol. Although the above-mentioned literature emphasizes the importance of paying attention to how music, selected by the subject or the researcher, has an effect on patients undergoing various medical treatments/interventions, it is not clear which way would be most effective. Thus, we were able to show that although music was selected by the researchers in two of the three experimental groups, only the group that was not disclosed the experimental protocol appeared to have a significant tendency to change variations, in the intervention interval.

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