Theses of Doctoral (PhD) Dissertation

THE EFFECTS OF EXPECTATION AND SOUND STIMULI IN THE PHENOMENOLOGICAL EFFECTS OF BINAURAL BEATS

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Introduction

Binaural beats are related to perceptional illusion which occurs during hearing. If we hear two sounds - at the same time - that share slight difference in terms of frequency, we may experience an auditory illusion due to this difference: as if hearing a third sound, which rhythmically gets louder and fades.

Since the 90s, binaural beats have been used in self-help programs and in the 2010s they had received prominent attention in both consumer and media markets. Around 2010, a company selling binaural beats (I-Doser) directly stated that the sounds they distribute provide intense experiences, which could be compared to the effects of certain psychoactive drugs e.g. heroin, cocaine etc. Although the attributed mode of action is not supported by any scientific research evidence, a segment of users noted the beneficial effects of the sounds in their report.

However, in the case of binaural beats, the modes of actions (Wahbeh et al., 2007; Stevens et al., 2003), psychological effects (Lane, 1998; Wahbeh et al., 2007) and clinical applications (Padnmanabhan et al., 2005; Le Scouarnec et al., 2001; Wahbeh et al., 2007) were already investigated; there is no accepted scientific point of view on neither on the result. The reasons for this are as follows: the studies were published in journals that are not peer-reviewed; they employed different scientific methods and the published results were contradictory.

The assumed model for the mode of action blends the results of different scientific fields. A) Binaural beats are special sound stimuli that arise in the brainstem during the interference of sounds with slightly different frequency (Oster, 1973) B) Correspondingly to visual stimuli, it is possible to evoke cortical response congruent to the frequency of external audio stimulus (Batra et al., 1986) C) Different states of mind could be characterised by specific cortical/EEG patterns. (Vaitl et al., 2005) According to the developers and distributors of binaural sounds, the effects these sounds evoke change the brain's frequency following response that has an impact on the activity of the cerebral cortex. As a result, the desired change in the state of mind is reached. For instance, if theta waves appear in the EEG during a creative process or a fantasy activity (i.e. Egner & Gruzelier, 2003), then, as an effect of alike binaural frequency stimulation (4-7 Hz) (thalamical and) cortical changes occur, hence the listener's creativity and fantasy increases (Atwater, 1997). According to the scientific results, it is ambiguous what type of cognitive and emotional changes are evoked by monotonous sensory stimuli. However, based on clinical researches it seems they are capable

of easing psychological symptoms (Huang & Charyton, 2008). It is also equivocal as to what types of advantages binaural sounds have - regarding their usage - contrary to the simple acoustic or visual stimuli (Pratt el al., 2010; Huang & Charyton, 2008); whether binaural sounds are even capable of synchronizing EEG waves to outer audio stimuli; furthermore: which cortical areas are involved and for how long the synchronization could be maintained (Stevens et al. 2003).

Hypotheses

Usually, theoretical sources and psychological literature provide us with observations regarding the neurobiological changes and the easement of clinical symptoms. This means they do not analyse the binaural situation's effects on subjective experiences. Hence, the dissertation observes these effects. We were eager to know whether binaural sounds were able to evoke sharp permutations regarding subjective experiences. Besides the former, we also involved the following in our research: the roles of precursory instructions and the roles of acoustical properties regarding sound stimuli. Based on these, we planned two experiments with the following hypotheses:

Hypotheses of the 1st experiment

1. Due to the effects of binaural sounds the experiences change compared to the normal, awake state.
2. The experiences gained are influenced by instructions.

Hypotheses of the 2nd experiment

1. The groups, provided with sounds that have different acoustical properties, will not have significant differences regarding their experiences.
2. The gained experiences are affected by absorption.

Methods

To measure subjective experiences we have used questionnaires and content analysis.

- *Phenomenology of Consciousness Inventory (PCI, Pekala & Levine, 1982)*

PCI is an internationally widespread, trustable method to measure subjective experiences gained in altered states of consciousness. The test consists of 53 opposite sentence pairs;

these pairs need to be evaluated on a 7-grade Likert-type scale. The test was translated to Hungarian by Csaba Szabó (Szabó, 1989, 1993). PCI originally measures the features of subjective experiences on 12 main and 14 subscales. In this thesis we employed a 5 factored resuming model with the factors below: dissociative control (DC), attention to internal process (AIP), visual imagery (VI), positive affect (PA), negative affect (NA). According to data, the 5 factored model grounds most of the variance and based on the analyses, its validity is certifiable on a Hungarian sample (Pekala, 1991; Varga, 2004). The dissociated control factor observes body image, sense of time, perception, visual imagery, memory, rationality, voluntary control and internal dialogue. This factor measures the presence of trance-like states, hence it is the most significant index of altered states of consciousness.

- *Content analysis*

In the content analysis we employed the Regressive Imagery Dictionary (RID, Martindale, 1990): based on the psychoanalytic framework it measures primary and secondary processes and emotions. The benefit of this content analytic dictionary is that it was already employed in measuring altered states of consciousness; furthermore, besides cognitive processes it is capable of measuring positive and negative emotions as well. So far, this dictionary was available in seven languages, in the dissertation we published a Hungarian adaptation and validation. The dictionary originally contained 3200 English words divided into 43 subcategories. We prepared the words' Hungarian adaptation; its validity was tested on a literary piece in English and Hungarian in a way that during the content analysis we measured hit rate on both texts; these rates were later compared. According to the results, the hit rates of the Hungarian dictionary significantly correlate to the measurements of the English dictionary ($r=0.957$, $p<0.001$). Upon the whole, it can be stated that the adaptation of RID to Hungarian language was successful, the dictionary could also be used to analyse Hungarian corpuses. Hence in the experiments of the dissertation we also employed this method.

Participants

109 (n=109) university students participated in the experiment, their age norm was 21 (SD±4).

Methods

The trial is a randomized, blind, self-controlled study. In the experiment we measured the experience changes – caused by the experimental binaural sounds – to a baseline, therefore we were able to examine variables within people. In the baseline setting, we asked the participants to sit with their eyes closed for five minutes. Based on instructions, the participants were divided into small groups; as such we were able compare individuals. Every single person participated in the experiment alone and heard two different sounds in two different sessions; hence together with the baseline experiments we took four different measurements.

The two different sounds were selected from the webpage of an online distributor (I-Doser) according to their claim, which suggests that their sounds are able to evoke contrasting states in the listeners. During the listening of sound one (further on: negative sound), according to the producer, the listeners can experience fear, fury and anger. In its characteristics, it is corresponsive to the range of delta EEG, this sound contained the binaural beats (0.5-4Hz) on the carrier frequency of 100-400 Hz. The other sound (further on: positive sound), according to the producer, is capable of evoking positive experiences and happiness in the listener. The sound contained binaural beats in the range of theta and alpha EEG (4.5-10 Hz), on the carrier frequency of 300 Hz. Both binaural stimuli lasted for 30 minutes.

The participants were divided into 3 groups. Group A got the test sounds with the original instructions, which showed resemblance to the descriptions on the internet. For Group B we reversed the instructions given for the sounds. Group C only got general instructions regarding the fact that they are going to hear binaural sounds; also that they should pay attention to the experiences that happen meanwhile.

The experiment in practice happened in the following way. After general orientation we asked the participant to close their eyes, to turn their attention inward and sit in this position for 5 minutes. Following this, the participant filled the PCI, in which they noted the experiences of these 5 minutes. This was the baseline setting. Then, we told them they are going to hear binaural sounds that may cause experience alterations. Following this, the participants in different groups were given the instructions (original or reversed), then we asked them to turn their attention inward and observe the alterations. After this, they listened to binaural beats for 30 minutes, and then came the semi-structured interview about their

experiences, and then we took the PCI again. The experiment was repeated after a week, and the participant listened to the other sound.

Results

First, independently of the experimental settings, we compared the baseline to the experimental conditions; consequently, the first and second occasions and the different sounds and circumstances were totalled. According to the results of the students' t-tests, compared to the baseline in the experimental situation, 4 factors in PCI increased significantly: dissociative control ($p<0.001$), attention to internal processes ($p<0.0001$), the positive ($p<0.0001$) and negative affect ($p<0.001$). The difference between the experimental setting and baseline suggests that due to binaural sounds the listeners did experience considerable alterations in their thoughts and affects, regardless of the instructions they were provided with.

To analyse the effect of instruction, we applied Multi-factor Analysis of Variance (MANOVA) on the PCI questionnaire, and according to this data we identified the main effect of instruction ($p=0.011$). The effect of instruction was significant in the positive ($p=0.004$) and negative emotion ($p=0.004$) summing factors. Neither different sounds, nor the interactions of the sounds and instructions were significant.

To analyse the data of the content analysis we adapted Wilcoxon and Mann-Whitney tests. According to the results, the expectations significantly influenced the frequency of the appearance of linguistic contents regarding positive affect ($p=0.001$) and anxiety ($p=0.038$). The experiences were not influenced by the sound stimuli the participants had to listen to.

From the data of the questionnaire and content analysis it is observable that participants reported emotions corresponding to the instructions, and the effect of the different sound stimuli did not differ.

Experiment No. 2: The effects of binaural beats compared to other acoustical sound stimuli

Participants

Altogether 157 ($n=157$) people participated in the experiment; the age norm was 21 years ($SD\pm 2$).

Methods

The experiment was a randomized, blind, between subject study design, in a group setting. Every participant was assigned into the different sound groups randomly. The first group (A) got binaural, the second (B) got monaural, the third (C) group got isochronic beat sounds to listen. Every participant listened to 1 experimental stimulus.

Monaural beats are produced from binaural beats, in which the interference arising from the frequency difference is meaned up in the computer; as opposed to the stereo characteristics of binaural sounds, these are mono sound stimuli. Isochronic beats are simple, pure notes and they mean the interchanges in silence. Furthermore, beats do not have dynamics (just like the sound of the drum). Hence, the given sound immediately reaches its maximal amplitude, then suddenly ends. Every sound stimuli contained 220 Hz base frequency, monotonous (constantly changeless) notes, through 20 minutes. We employed 1.5 Hz binaural and monaural beats that correspond to delta EEG frequency range. Isochronic beats were heard in a 90 beat per minute level (1.5 Hz = 90 BPM).

The experiment took place in groups of 3-6. At the end of the experiment the participants reported their experiences on computers with the help of open ended questions, after this the PCI and the absorption measuring questionnaires were filled.

Results

The results of the PCI questionnaire were analysed by Multivariate Analysis of Covariance (MANCOVA). According to the results, the experiences were unaffected by the sound stimuli provided to the listeners (r=0.845). The absorption significantly influenced the experience differences (r=0.00); people who generally get more involved in their experiences had bigger changes in their experiences in the experimental situation. From the data of the content analysis, among the categories of the Regressive Imagery Dictionary primary and secondary processes, as well as the emotional categories, 12 subcategories were analysed by the Kruskal-Wallis test. No difference was explored between different groups provided with different sounds.

Summary and conclusions

During our experiment we wanted to provide answers to 3 specific questions.

(1) Do binaural sounds have the ability to evoke considerable experience changes in the listener?
(2) How much influence do previously given instructions or expectations have regarding the subjective experiences of binaural beat listening?
(3) Do special acoustic characteristics of sounds matter regarding the subjective experiences, and do sounds of different frequencies trigger different effects?

The results of the first experiment suggested that binaural sounds are able to cause significant changes in subjective experiences. Due to the binaural sounds, most participants reported considerable changes regarding their experiences, which affected both their cognitive and emotional processes. The result shows correspondence to previous experiments (Szabo, 2006), which notes that monotonous sound stimuli can be used in therapy, due to their cognitive and emotional effects.

Based on the results of the first analysis, instructions affected the subjective experiences. If participants were given instructions that they shall have positive experiences, in correspondence to this, they would rather report positive experiences.

According to the results of both the first and second analysis neither binaural beats' frequency range, nor its special acoustical characteristics influence significantly the newly gained experiences. It can be surmised – based on the results of the analysis – that binaural beats have a functional model, whose efficient element is not tied to the evoking of neurobiological actions, but to drive attention to a monotonous sensory stimulus. Besides this, if the attention paying process goes together with strong expectations, it is more probable that there shall be notable subjective experience changes.

Bibliography

Atwater, F. (1988). The Monroe Institute's Hemi-Sync Process, A Theoretical Perspective. *The Monroe Institute of Applied Sciences*, 4.

Batra, R., Kuwada, S., & Maher, V. L. (1986). The frequency-following response to continuous tones in humans. *Hearing Research, 21*(2), 167-177.

Egner, T., & Gruzelier, J. H. (2003). Ecological validity of neurofeedback: modulation of slow wave EEG enhances musical performance. *Neuroreport, 14*(9), 1221-1224.

Huang, T. L., & Charyton, C. (2008). A comprehensive review of the psychological effects of brainwave entrainment. *Alternative Therapies in Health and Medicine, 14*(5), 38-50.

Le Scouarnec, R.-P., Poirier, R., Owens, J., Gauthier, J., Taylor, A., & Foresman, P. (2001). Use of binaural beat tapes for treatment of anxiety: a pilot study of tape preference and outcomes. *Alternative therapies in health and medicine, 7*(1), 58-63.

Martindale, C. (1990). *The clockwork muse: The predictability of artistic change*: Basic Books, New York.

Oster, G. (1973). Auditory beats in the brain. *Scientific American, 229*(4), 94-102.

Owens, J. D., Kasian Justine, E., & Marsh, G. R. (1998). Binaural auditory beats affect vigilance performance and mood. *Physiology & Behavior, 63*(2), 249-252.

Padmanabhan, R., Hildreth, A., & Laws, D. (2005). A prospective, randomised, controlled study examining binaural beat audio and pre-operative anxiety in patients undergoing general anaesthesia for day case surgery*. *Anaesthesia, 60*(9), 874-877.

Pekala, R. J. (1991). *Quantifying consciousness: An empirical approach*: Plenum Press, New York.

Pekala, R. J., & Levine, R. L. (1982). Quantifying states of consciousness via an empirical-phenomenological approach. *Imagination, Cognition and Personality, 2*(1), 51-71.

Pratt, H., Starr, A., Michalewski, H. J., Dimitrijevic, A., Bleich, N., & Mittelman, N. (2010). A comparison of auditory evoked potentials to acoustic beats and to binaural beats. *Hearing Research, 262*(1), 34-44.

Stevens, L., Haga, Z., Queen, B., Brady, B., Adams, D., Gilbert, J., . . . McManus, P. (2003). Binaural beat induced theta EEG activity and hypnotic susceptibility: contradictory results and technical considerations. *American Journal of Clinical Hypnosis, 45*(4), 295-309.

Szabó, Cs. (1989). *Szubjektív élmények különböző indukciós technikákkal létrehozott hipnózisokban.* PhD thesis, KLTE, Debrecen.

Szabó, Cs. (1993). The phenomenology of the experiences and the depth of hypnosis: Comparison of direct and indirect induction techniques. *International Journal of Clinical and Experimental Hypnosis, 41*(3), 225-233.

Szabó, Cs. (2006). The effect of monotonous drumming on subjective experiences. In D. Aldridge & J. Fachner (Eds.), *Music and Altered States. Consciousness, Transcendence, Therapy and Addictions.* (pp. 51-59.). Jessica Kingsley Publishers, London.

Szabó, G., Drótos, G., & Szabó, Cs. (2013). A Regresszív Képzeleti Szótár (RID) magyar adaptációja. *Pszichoterapia, 22*(3), 176-185.

Szabó, G., Drótos, G., & Szabó, Cs. (2014). A binaurális ütemek szubjektív élményekre gyakorolt hatásainak összehasonlítása más akusztikai tulajdonságú hangokkal. In Á. Münnich (Ed.), *Pszichológiai kutatások* (195-203.). Debreceni Egyetemi Kiadó, Debrecen.

Szabó, G., & Szabó, C. (2014). Az audiovizuális stimuláció gyakorlati felhasználási területei. In Á. Münnich (Ed.), *Pszichológiai kutatások* (pp. 179-193.). Debreceni Egyetemi Kiadó, Debrecen.

Vaitl, D., Birbaumer, N., Gruzelier, J., Jamieson, G. A., Kotchoubey, B., Kübler, A., . . . Pütz, P. (2005). Psychobiology of altered states of consciousness. *Psychological Bulletin, 131*(1), 98.

Varga, K. (2004). A hipnotikus kapcsolat élményvilágának interakciós szemléletű elemzése. *Habilitation thesis, ELTE, Budapest.*

Varga, K., Józsa, E., Bányai, É. I., Gősi-Greguss, A. C., Kumar, V. K. (2001) Phenomenological experiences associated with hypnotic suggestibility. *International Journal of Clinical and Experimental Hypnosis, 49(1),* 19-29.

Wahbeh, H., Calabrese, C., & Zwickey, H. (2007). Binaural beat technology in humans: a pilot study to assess psychologic and physiologic effects. *The Journal of Alternative and Complementary Medicine, 13*(1), 25-32.

Wahbeh, H., Calabrese, C., Zwickey, H., & Zajdel, D. (2007). Binaural beat technology in humans: a pilot study to assess neuropsychologic, physiologic, and electroencephalographic effects. *The Journal of Alternative and Complementary Medicine, 13*(2), 199-206.

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List of publications related to the dissertation

Hungarian book chapter(s) (3)

1. **Szabó G.**, Szabó C.: Az audiovizuális stimuláció gyakorlati felhasználási területei. In: Pszichológiai kutatások: Debreceni Egyetem Pszichológiai Doktori Program. Szerk.: Münnich Ákos, Debreceni Egyetemi Kiadó, Debrecen, 179-193, 2014.

2. **Szabó G.**, Drótos G., Szabó C.: A binaurális ütemek szubjektív élményekre gyakorolt hatásainak összehasonlítása más akusztikai tulajdonságú hangokkal. In: Pszichológiai kutatások: Debreceni Egyetem Pszichológiai Doktori Program. Szerk.: Münnich Ákos, Debreceni Egyetemi Kiadó, Debrecen, 195-203, 2014. ISBN: 9789633184158

3. Pék G., Kőszeghy A., Almássy Z., **Szabó G.**, Máth J.: Magyarország legnagyobb vegyi katasztrófájának reprezentációi: Az emlékezethely kialakulásának dinamikája. In: Nemzeti emlékezethelyek. Szerk.: Kovács Judit, Münnich Ákos, Debreceni Egyetemi Kiadó, Debrecen, 145-164, 2012. ISBN: 9789633182628

Hungarian scientific article(s) in Hungarian journal(s) (2)

4. Kondé Z., Szabó C., **Szabó G.**: Hipnotikus fogékonyság és exekutív hatékonyság. *Pszichológia. 33* (4), 271-291, 2013. ISSN: 0230-0508. DOI: http://dx.doi.org/10.1556/Pszicho.33.2013.4.2

5. **Szabó G.**, Szabó C.: A Regresszív Képzeleti Szótár magyar adaptációja (RID). *Pszichoterápia. 22* (3), 176-185, 2013. ISSN: 1216-6170.

List of other publications

Hungarian book chapter(s) (1)

6. Kondé Z., **Szabó G.**, Lejkó R.: Az implicit nemzeti elfogultság vizsgálata felvidéki magyarok körében.
In: Nemzeti emlékezethelyek - attitűdök, reprezentációk, élmények, funkciók, struktúrák. Szerk.: Kovács Judit, Münnich Ákos, Debreceni Egyetemi Kiadó, Debrecen, 91-106, 2012. ISBN: 9789633182628

Foreign language scientific article(s) in Hungarian journal(s) (1)

7. Kondé, Z., **Szabó, G.**, Dósa, Z.: Investigating implicit attitudes toward historical memories. *Appl. psychol. Hung. 2011* (1), 22-40, 2012. ISSN: 1586-7382.

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