Short Term Exposure to Binaural Beats Adversely Affects Learning and Memory in Rats

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ABSTRACT

Background: Binaural beats (binaural tones) are sound waves created by specific physical stimuli which are believed to induce relaxation, meditation, creativity and other forms of desirable mental states. To experience the binaural beats perception, a sound file should be listened using headphones. The difference in frequencies of each tone (e.g. f1 Hz in right ear and f2 Hz in left ear would make the binaural beats at a frequency of |f1-f2| Hz). Interestingly, binaural beats have been compared with illegal narcotics, and there are warnings that interest in binaural beats can lead to drug use. Current data on the ability of binaural beats to alter consciousness are still controversial.

Objective: This study was aimed at investigating the effect of binaural beats on the memory.

Material and Methods: In this study, 36 Sprague Dawley rats were divided into 4 groups of nine animals each. A shuttle box apparatus was used for the passive avoidance learning and memory study. Twenty-four hr after training, the memory retention test was performed and animals were placed in the light compartment, then the door was opened and the step-through latency (STL) to enter to the dark compartment was measured. Animals in the exposure group were firstly exposed to binaural beats for 10 min (Exp1), 35 min (Exp2) and 75 min (15+25+35 min) (Exp3) before memory test.

Results: Findings of this study showed that both STL time and the number of crossings were significantly affected by binaural beats. The STL time in Cont, Exp1, Exp2 and Exp3 groups were 132.22 ±126.14, 47.88±102.73, 27±20.45, 53.00±69.81 sec, respectively (P=0.017). The number of crossing in Cont, Exp1, Exp2 and Exp3 groups were 1.33±1.32, 5.25±3.77, 4.38±2.67, 5.78±3.93 times, respectively (P=0.02).

Conclusion: It can be concluded that short term exposure to binaural beats adversely affects learning and memory in rat.

Keywords

Binaural Beats, Binaural Tones, Sound, Learning, Memory

Introduction

Binaural beats are auditory waves occurring when using stereo head phones, right and left ears are separately exposed to two tones with slightly different frequencies. In this situation, the

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brain integrates the two signals and produces a sensation of a third sound called binaural beat [1]. The frequency of binaural beats is usually in the range of 30 Hz -1kHz [2]. It has been reported that binaural beats are capable of altering physiological and cognitive processes through synchronization of the brain hemispheres [3]. However, the mechanism of the action of binaural beats is not clearly understood yet [1]. Furthermore, until recently, it was not fully known which brain sites are affected by the stimulation of binaural beats [4]. Binaural beats are reported to be perceived by the superior olivary nucleus of each hemisphere of the brain [2]. The studies conducted so far show significant individual variability and different responses in people exposed to binaural beats [5]. In different countries, binaural beat products are sold as tools for personal development and health improvement. Producers usually claim that these products when listened regularly, cause reduced stress and anxiety and lead to beneficial effects such as increased focus, concentration, motivation, confidence and depth in meditation [6]. Interestingly, binaural beats have been compared with illegal narcotics and there are warnings that interest in binaural beats can lead to drug use. Current data on the ability of binaural beats to alter consciousness are still controversial. Over the past several years, our laboratories have expanded their focus on studying the health effects of exposure to some common and/or occupational sources of electromagnetic fields (EMFs) such as cellular phones [7-16], mobile base stations [17], mobile phone jammers [18], laptop computers [19], radars [8], dentistry cavitrons [20] and MRI [21, 22]. This study was aimed at investigating the effect of binaural beats on the memory.

Material and Methods

In this study 36 Sprague Dawley rats were divided into 4 groups of nine animals each. The rats were kept under standard conditions (12/12 dark-light period in 21 ± 1°C temperature) and had free access to water and food. A shuttle box apparatus was used for the passive avoidance learning study, the apparatus consisted of light and dark chambers. A guillotine door separated two chambers. In the adaptation trial, each rat was placed in the light chamber. Then, the door between two chambers was opened, and the animal was allowed to enter into the dark chamber. In the learning trial, the animal received an electrical shock (0.5 mA, 50 Hz, 2 s once) upon entrance to dark chamber via the floor grid. The retention trial was performed 24 hours after the learning trial, in which the animal was allowed to enter into the dark chamber while the entrance time to the dark chamber was recorded as the step-through latency (STL); however, no foot shock was delivered upon entrance into the dark chamber. The maximum cutoff time for the step-through latency was 300s.

Animals in the exposure group were firstly exposed to binaural beats for 10 min (Exp1), 35 min (Exp2) and 75 min (15+25+35 min) (Exp3) before memory test. The exposure protocol used in this study is shown in Figure 1.

Results

The frequency spectrum and the mean frequency of the sound waves used for exposing the right and left ears of the animals are shown in Figures 2 and 3, respectively. As shown in the figure, the mean frequency for the right and left ears were 349 Hz and 264 Hz, respectively. Findings of this study showed that both STL times and the number of crossings were significantly affected by binaural beats. The STL time in Cont, Exp1, Exp2 and Exp3 groups were 132.22 ±126.14, 47.88±102.73, 27±20.45, 53.00±69.81 sec, respectively (P=0.017). The number of crossings in Cont, Exp1, Exp2 and Exp3 groups were 1.33±1.32, 5.25±3.77, 4.38±2.67, 5.78±3.93 times, respectively (P=0.02). The STL times and the number of crossings in different groups are presented in Table 1. Moreover, Tables 2 and 3 summarize the pairwise comparison of STL

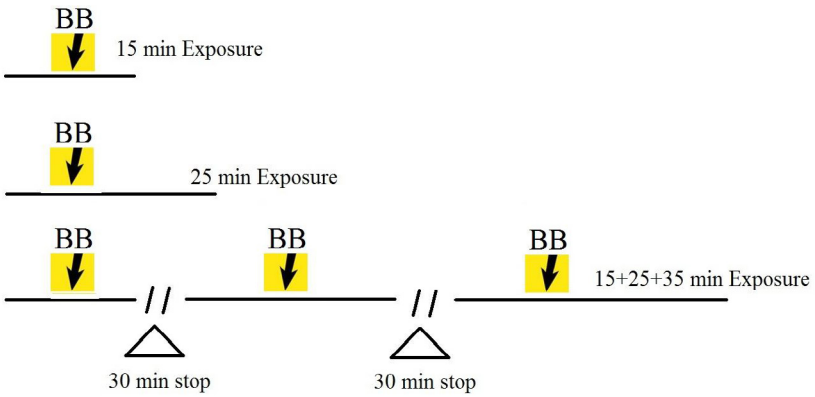

Figure 1: The exposure protocol used in this study

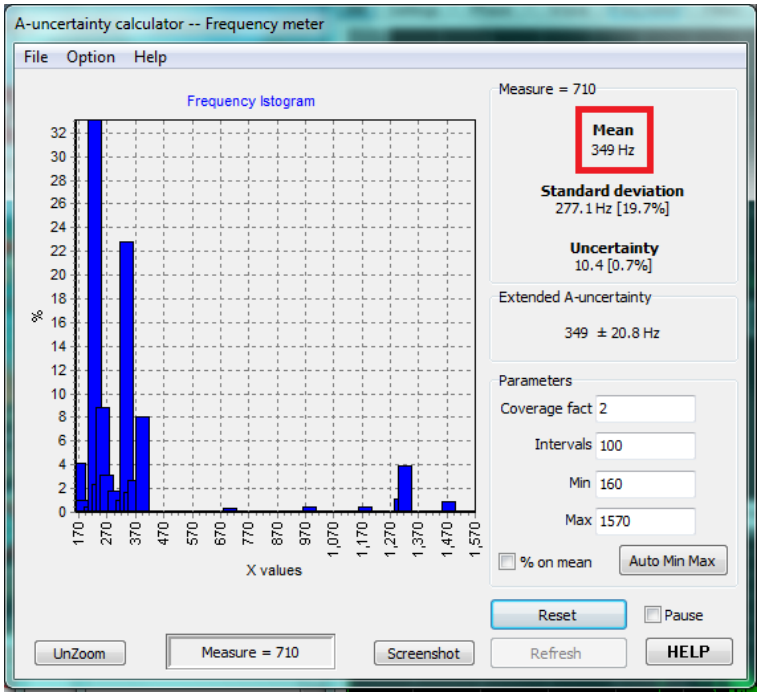

Figure 2: The frequency spectrum and the mean frequency of the sound waves that use for exposing the right ears of the animals.

times (the time length before crossing of the animals to the dark compartment of the shuttle box) and the number of crossings in different groups, respectively.

Discussion

Findings of this study showed that exposure of right and left ears of Sprague Dawley rats to two tones with slightly different frequencies which induces the sensation of a beating sound, significantly altered both the STL times and the number of crossings. It has been reported that binaural beats could alter functional brain connectivity [23]. Also, it has been shown that beat stimulation provides a non-invasive method for the modulation of intracranial EEG characteristics [24]. These findings are generally in line with the reports indicating adverse health effects in exposed humans. Our findings are especially in line

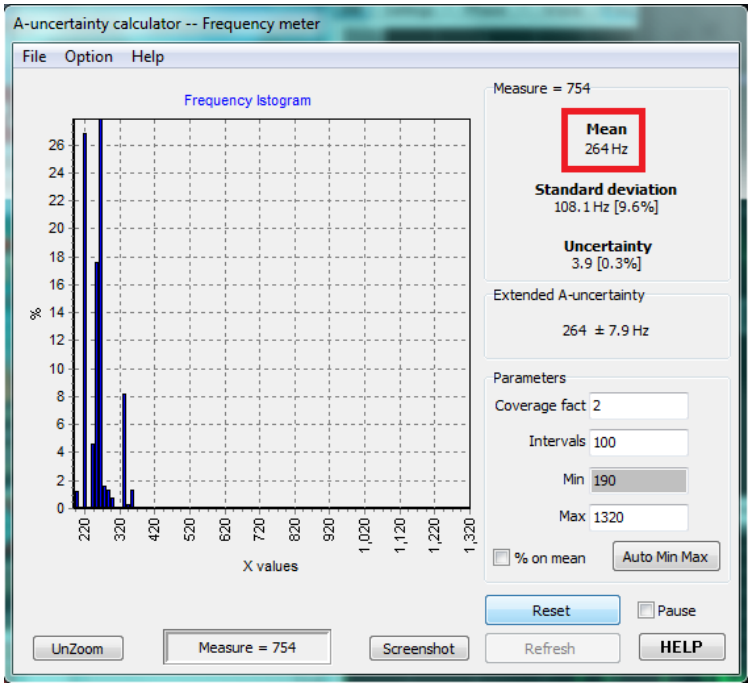

Figure 3: The frequency spectrum and the mean frequency of the sound waves that use for exposing the left ears of the animals.

Table 1: STL times and the number of crossings were significantly affected by binaural beats.

	No. of samples	STL time (sec)	No. of crossings
Control	9	132.22 ±126.14	1.33 ± 1.32
10 min	8	47.88n± 102.73	5.25± 3.77
35 min	8	27 ± 20.45	4.38 ± 2.67
15,25,35 min	9	53.00 ± 69.81	5.78 ± 3.93
Sig. (p-value)		0.001	0.003

Table 2: Pairwise comparison of the STL times (the time length before crossing of the animals to the dark compartment of the shuttle box) in different groups.

	Control	10 min	35 min	15,25,35 min
Control	--------	0.003	0.018	0.058
10 min	0.003	----------	.53	.245
35 min	0.018	0.53	--------	0.606
15,25,35 min	0.058	0.245	0.606	--------

Table 3: Pairwise comparison of the number of crossings in different groups.

	Control	10 min	35 min	15,25,35 min
Control	--------			0.014
10 min	0.014	---------	0.789	0.781
35 min	0.029	0.789	--------	0.581
15,25,35 min	0.005	0.781	0.581	--------

with those of a study that showed that high-frequency binaural beats (gamma-frequency binaural beats with the frequency of 40 Hz) bias the attentional processing style and cause a decreased spotlight of attention [25].

In contrast with our findings, there are reports indicating positive bioeffects of binaural beats. A recent study showed that exposure to binaural beats for eight weeks was associated with improved perceived sleep quality and the post-sleep state in athletes [26]. In another study, auditory stimulation with binaural beats for 8 weeks improved perceived sleep quality and the post-sleep state of athletes [26]. It is worth noting that there were basic differences between our study and the above-mentioned studies (animal study vs. human study, frequency of binaural beats and other exposure parameters). Experiments on human also showed that although older adults had similar Frequency following responses, proportionally fewer older individuals revealed binaural beat responses [27].

Conclusion

The findings of this study revealed that the presentation of two different sinusoidal tones (f1 and f2 Hz), one to each ear, with a slight frequency difference causing an auditory illusion of a beating frequency equal to the frequency difference between the two tones (|f1-f2| Hz), might affect learning and memory. To the best of our knowledge, this is the first animal study which aimed at investigating the cognitive effects of exposure to binaural beats. Altogether, it can be concluded that short term exposure to binaural beats adversely affects learning and memory in rats.

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Conflict of Interest

None Declared.

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