Effects of Binaural Auditory Beats on Attention

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Abstract

Binaural auditory beats have been a topic of research considering areas such as cognition, attention and memory for some time. It has been discussed that different frequencies leads to various results in the brain wave activities and balance, for example, high frequency binaural beats are said to increase attention, while low frequency beats are theorized to be associated with relaxation. Presenting two slightly different frequencies, separately, to each ear at the same time, leads to an illusion called "subjective auditory sensation", which results in the listener hearing only the difference between the frequencies. Our research was set to use this illusion as a way to test its effect on sustained and selective attention. The results showed a significant difference between the mean total attention scores of the experimental, who listened to a nature soundtrack with binaural beat and control groups who only listened to the nature soundtrack.

Keywords: attention, auditory binaural beats, cognitive processes

Introduction

The human brain has a complicated and complex structure, which inspires many research (Kraus & Porubanova, 2015; Colzato et. al., 2017) about how it works and whether manipulation of its capabilities is possible. As technology advanced, more and more methods of measuring and observing brain activity came to existence. EEG, being one of the most familiar one, has been used to observe many different mechanisms in the brain and it paved the way for future studies. Because of this, one of the measurable things about our brain is brain waves.

Brain waves and their effects can be measured by the number of waves, and with the use of Hertz (Hz), as in measuring the electrical frequencies which can occur in any given time. This brain wave measuring technologies and the use of Alfa, Beta, Theta and Delta waves, being the four types of brain waves, have caused different arguments on the effects of the sound waves on said brain waves. (Puzi, Jailani, Norhazman, Zaini, 2013)

The alpha brain wave leads to relax and calm conditions, Beta wave leads to activity in the brain and thinking, Delta wave is associated with deep sleep and Theta Wave is linked with meditation or deep relaxation. These different outcomes of different balances between the brain waves has given way to the idea of whether their levels can be manipulated, the state which they cause can also be achieved. Binaural auditory beats can cause an illusion, forcing the brain frequency to be tuned in a manner to achieve one of the desired outcomes, either being relax, deep sleep, or focusing and alertness. (Puzi, et al., 2013)

The binaural beats can cause the brain to synchronize its own rhythm and wave of the binaural beat audio presented. This can lead to altered states, due to the effect of the brain waves being more active. Researches have looked into these changes through EEG readings and many other testing, and found significant results proving that binaural auditory beats are affecting brain performance. (Puzi, et al., 2013)

A research done on the effect of binaural beats on working memory showed that there was a visible improvement in the working memory of participants from the binaural beat group (Kraus & Porubanova, 2015) Another research was done on the effect of alpha and gamma beats on reaction time and short-term memory revealed that there was a significant decrease in reaction time. Although there was also an increase in memory scores, this was not statistically significant. (Shekar, Suryavanshi, Nayak, 2018)

Attention, in the broad sense, is “the ability to concentrate on specific stimuli”. (Park, Kwon, Kang, Lee, 2018) This ability, helps a person to achieve and work on complicated cognitive tasks, such as learning. Attention is another subject which has been a topic of curiosity in research, as it can lead to success or failure in a person’s life depending on the task one tries to manage. Since the functionality in the world lays so heavily on how a person can focus, and therefore is able to finish complicated cognitive tasks, research also worked on various factors which could influence one's attention level or ability. (Kraus & Porubanova, 2015)

For all the importance given to attention, there have been many research on how to elevate or alter its level. Auditory stimulation and manipulation, is one of the ways looked into by researchers. (Colzato et. al., 2017) Effects of white noise, binaural beats, or pink noise have

been looked into, and there have been findings that support the idea of appropriate voices and sounds being helpful for balancing creativity, concentration, or relaxation. In our research, we will look into the effects of binaural auditory beats on selective attention abilities.

Binaural beats is a version of auditory stimuli as mentioned, and it occurs when two slightly different frequencies are given to each ear. For example, while one ear receives a tone of 410 Hz, the other is receiving 400 Hz, and the brain nucleus therefore resonates with the beat which is an auditory illusion, causing the person to hear only the difference, which is 10 Hz. (Kraus & Porubanova, 2015) This rhythmic frequency is said to cause the brain waves to be affected, and depending on the frequency, the brain waves change accordingly. (Park, Kwon, Kang, Lee, 2018)

Our aim is therefore testing whether we can get a significant result on the effects of binaural beats on attention. There are different frequencies of binaural beats, each causing a different reaction in the brain activity, and since low frequencies can cause relaxation and higher frequencies cause alertness and focus, we will use higher frequencies in our research. (Colzato et. al., 2017)

Hypothesis: Listening to binaural beats increases performance on selective and sustained attention test.

Methods

Sample: Our target population for the experiment is university students aged between 19 to 26. Our sample includes an equal number of female and male students studying at İstanbul

Bilgi University. We used the convenience sampling technique to reach 20 accessible individuals randomly across campus, which included our friends, mutual friends, and any others available within our criteria and were willing to participate. The participants were assigned randomly to one of the conditions of our independent variable, either the control or experimental group. In total there is 10 participants in each group. All our participants indicated that the don't have any hearing or attention problems.

Measure: For measuring selective and sustained attention we've chosen to use the D2 test of Attention which measures shift and maintain attention (sustained attention) and the focus on target stimuli (selective attention) (Bates & Lemay, 2004) D2 test of attention, which is conceptualized by Brickenkamp, is a visual cancellation test in order to measure the attention and concentration and it's proposed as particularly useful. D2 test involves 14 rows (items) with 47 letters in each row. What is expected from the participant is to cross out the letter "d with two dashes" (the position of the dashes may vary) ignoring the other distractors on the same row, like letters p and d with different number of dashes. Dashes range from zero to four. For each line the participant is given 20 seconds to identify and cross out the target and when time ends, they move immediately to the next line without resting, which means 14 successive timed trials in total. At the end we get 6 scores, TN is total number of figures, E2 is wrong figures, CP is total of correct figures, TN-E the test performance and E% which is the ratio of the wrong answers. The researches (Bates & Lemay, 2004; Yaycı, 2013) suggest that the D2 Test is an internally consistent and valid measure of selective and sustained attention in adult samples and has high construct validity.

Design: A true experiment with in-between subject design was held. With post-test only and a

control group design. There was one independent variable with two conditions. Listening to binaural beats is the independent variable of the experiment, which was manipulated. Both the experimental and control groups listened to the same soundtracks while doing the test. Along with the music, the experimental group also listened to binaural beats embedded in the same track. While the control group did not. Participants were expected to answer the D2 Attention Test while they're listening. Our dependent variable is selective and sustained attention, which was operationalized as the D2 Attention Test scores of the participants. Other confounding variables that were held constant among groups include, the volume of the music, the sound frequency of the binaural beats (+24hz), the time given to finish the test, the setting in which the test is taken, the instructions or prompts, and the headphones. The conditions were standardized among all the participants. The experiment took place in an arranged room, with no other environmental stimulants such as excessive noise, bright lighting or moving objects for minimizing distractions and optimizing conditions.

Procedure: All participants were randomly assigned to experimental and control groups using random assignment generator. There was one researcher with each individual participant administering the experiment and giving the same instructions to the participants. First, participants were asked to sign the informed consent ensuring them that their personal information will be kept confidential and that no harm will be involved. The aim of the research was not fully revealed, participants only knew that the aim is to test the effect of sounds on attention. Later participants were asked to fill in a questionnaire for demographic information. The experiment was held in the same environment for all participants with the same conditions maintaining reliability. Both groups listened to nature soundtrack. The experiment group also listened to binaural beats along with the sounds. They listened to it for

3 minutes before the test and continued listening to it after starting answering the D2 attention test, till the end. Every 20 seconds the experimenter had to tap on the paper to notify the participant that they should get to the following item on the test. The D2 test takes approximately 4.40 minutes to finish since it has 14 items. Upon completion of the test, participants were debriefed about the real aim of the experiment for ethical reasons and were given the right to withdraw or re-claim their data if they wish so.

Results

We were interested in understanding whether there is an effect between listening to binaural beats and its effect on sustained and selective attention. Our hypothesis was that the group who listened to binaural beats will have higher scores than the control group.

The D2 Attention test, gives us different scores like, the TN, which is the score that reveals the test takers speed to finish each item. The E1 score, which shows the omission of the items, like missing one of the correct answers. The E2 score, which shows the commission of the items, like choosing a wrong answer as correct. The TN-E, which is the total test performance score after comparing the TN scores, E1 errors, and E2 errors. The formula in the manual was used to calculate this score, and our inferential and descriptive statistical analysis was based on this TN-E score.

The results showed that there is a visible difference in mean between the test scores (TN-E) of the control and experimental group. The experimental group showed a mean of 91.63 and standard deviation of 11.63, while the control group revealed a mean of 77.93 with standard deviation of 23.01. Diagram 1 shows the difference.

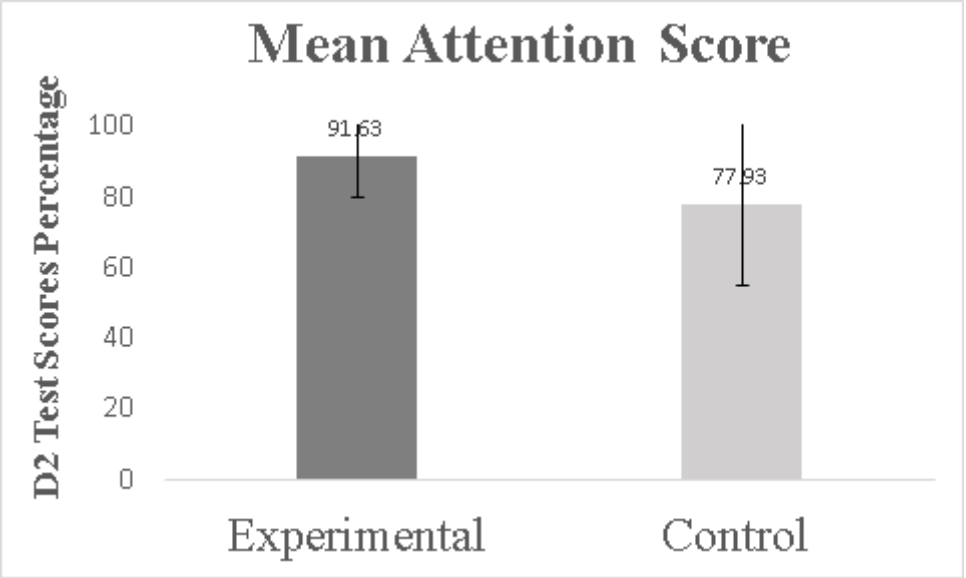

Diagram 1. This diagram shows mean differences in attention scores between experimental and control groups.

Since we were only testing one dependent variable, which is the attention operationalized as D2 test scores, and one independent variable with two conditions, listening with binaural beats and without, the appropriate inferential statistics test to analyze the data was independent sample t-test. The independent sample t-test showed that the experimental group (M=91.63, SD = 11.63) had higher total attention scores (dependent variable) than the control group (M=77.93, SD = 23.01). With the t-test results of $t(19) = -1.680$, $p < 0.5$, $d=-0.751$.

Which suggests that Levene's test is significant ($p < .05$) suggesting a violation of the equal variance assumption. Cohen's d of -0.751 suggests that the there is a high negative effect size between the control and the experimental groups, which supports our research, since it shows that not only is there a difference between the groups but that it is also a considerable

difference.

There was no any missing data since the experimenter giving the instruction made sure that the participants answered all the items on the D2 test as well as all the questions on the research questionnaire. There were also no outliers data encountered, which we examined by looking at plus and minus 3 standard deviations from the mean score of each group. The descriptive statistics for the experimental score showed that the range was 34.40, with the minimum being 65.5 and maximum of 99.90. While for the control group, the range was 57.10, with minimum of 42.10 and maximum of 99.20.

The results of the questionnaire revealed that none of our participants have hearing or attention problems. Also, it showed that 9 of the participants listen to music while studying, 6 of them sometimes, and 5 of them never listen to music while studying. We asked this question to eliminate any effect of preference on the performance of the participants, the analysis of the data showed that some of the people who said yes, still got bad scores, while some who said "no" got high ones, so this analysis eliminated any confounds related to listening to music while studying/working.

Discussion

Our research was focused on the effects of the binaural auditory beats, specifically beta frequency binaural beats, on the levels of sustained and selective attention. We used D2 attention test in order to measure this effect, and we have found more or less significant results. Our research showed that people who listened to binaural beats, scored higher in the

D2 attention test than those who did not.

However, there were limitations to our research. The results seems to suggest that there is a significant relation between selective attention and listening to binaural auditory beats, which leads us to accepting our original hypothesis that listening to binaural beats increases sustained and selective attention.

With our findings, we have seen that binaural beats indeed affected the participants attention levels. The experimental group who received beta frequency binaural beats generally scored higher in the D2 attention test. This result leads us to think that the auditory stimulation, has an effect on focus. We couldn't measure how the brain activity changes through EEG or any other measurement technology for the lack of accessibility. However the D2 attention test yielded differences, and that is enough for us to believe that if this research was conducted in a longer time period with a wider age range, more participants, and facilities, it can show higher significance in results.

Some of the limitation of our study include, a sample bias, since we conducted the experiment in Istanbul Bilgi University, among students, aged from 18 to 26. This can be considered as a limitation since it is a limited demographic scale and might not be representative of the whole population of wider age range, education levels, socio-economic status and so on. Even though we tried to control the confounds as best as we could, it was still a research conducted in a limited location, with a limited age range.

Another limitation on our research was the lack of pretest application. Out of concern for the learning effect, we couldn't conduct a pretest, and that limited our research since we had no

way of knowing the individual levels of attentions of our participants. The pre-test could have eliminated any individual differences among the participants especially that we used a between subject design. However, we tried to eliminate this limitation in our questionnaire, by asking whether any participants were diagnosed with attention problems such as ADHD or hearing problems, in order to control really high deviations, but no participant reported any such history.

The last limitation we can mention that although we planned on standardizing the procedure, only the time of the day was not identical for every participant, given that we had only a limited time to conduct our research. We used the same classroom and same environment, however in order to use the same headphones and create the same qualities, we couldn't conduct the experiment at the same time for all participants, being that we were only four people and we had to personally control each line in the test separately. Since we were making the participants listen to an audio track, we had to physically signal them to change the line when their 20 seconds was up, and that made it impossible for us to conduct the research at the same time with all participant.

Conclusion

Our lives are determined largely by how well we perform in complex cognitive tasks, and for that reason, attention, has been and will continue to be a topic of research in science. For this reason, there have been many suggested tools for elevating performances. In this research, we attempted to measure the effects of binaural beats, which was one of those tools suggested within the literature, on the selective attention and focus of the participants. Despite the limitations aforementioned, our research showed that there was indeed some effect of beta

binaural auditory beats on attention. We believe this can help with the curiosity of how our attention levels can be manipulated, and show a different direction for future research.

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Appendix

Appendix A - Informed Consent

İstanbul Bilgi Üniversitesi

PSY 322 Araştırması

BİLGİLENDİRİLMİŞ GÖNÜLLÜ ONAM FORMU

Sizi Sesil Tok, Dicle Temiz, Selva Daşdemir ve Sara Eissa tarafından yürütülen "Effects of Sounds on Attention" başlıklı araştırmaya davet ediyoruz. Bu araştırmanın amacı, arka plan sesleriyle dikkatinizin etkilenip etkilenmediğini ölçmektir. Araştırmaya, sizden tahminen 15 dakika ayırmanız istenmektedir. Araştırmaya sizin dışınızda tahminen 19 kişi katılacaktır.

Demografik bilgilerinizin alınmasının ardından, arka plandan gelen sesler size 3 dakika boyunca dinletilecektir. Daha sonra size D2 Dikkat Testi verilecek ve oradaki yönergelere göre testi çözmeniz istenecektir. Test 1 sayfadır. Bu çalışmaya katılmak tamamen **gönüllülük** sonucunda olmalıdır. Çalışmanın amacına ulaşması için sizden beklenen, bütün soruları eksiksiz bir şekilde, kimsenin baskısı veya telkini altına girmeden, olabildiği kadar dikkatinizi vererek ve başka bir şeyle ilgilenmeden cevaplamanızdır. Bu formu onaylamanız ve imzalamanız, araştırmaya katılmayı kabul ettiğiniz anlamına gelmektedir. Ancak, çalışmaya katılmama veya katıldıktan sonra, çalışmanın herhangi bir anında çalışmayı bırakma hakkınız her zaman bulunmaktadır. Bu çalışmadan elde edilecek olan bilgiler, tamamen araştırma amacı ile kullanılacaktır ve kişisel bilgileriniz kesinlikle **gizli tutulacaktır**, sadece verileriniz, araştırmanın basılması durumunda yayın amacı ile kullanılabilir. Araştırmanın amacı ile hakkında verilen bu bilgiler dışında, şimdi veya sonra daha fazla bilgiye ihtiyaç duyarsanız, uygulayan araştırmacıya şimdi sorabilir veya dicle.temiz@gmail.com mail adresine e-posta adresinden ulaşabilirsiniz. Araştırma tamamlandığında genel veya size özel sonuçların sizinle paylaşılmasını istiyorsanız lütfen araştırmacıya test numaranızla birlikte dileğinizi iletmeyi unutmayınız.

Yukarıda yer alan ve araştırmadan önce bana verilmesi gereken bilgilerin tamamını okudum ve katılmam istenen çalışmanın içeriğini ve amacını, gönüllü olarak üzerime düşen sorumlulukları anladım. Çalışma hakkında yazılı ve sözlü açıklama aşağıda adı belirtilen araştırmacı/araştırmacılar tarafından yapıldı. Bana, çalışmanın muhtemel riskleri ve faydaları sözlü olarak da anlatıldı. Kişisel bilgilerimin özenle korunacağı konusunda yeterli güven verildi.

Bu koşullarda söz konusu araştırmaya kendi isteğimle, hiçbir baskı ve telkin olmaksızın katılmayı kabul ediyorum.

Katılımcının

Adı Soyadı:

İmzası:

İletişim bilgilerimin diğer araştırmacıların benimle iletişime geçebilmesi için "ortak araştırma havuzuna" aktarılmasını;

Kabul ediyorum [ ]

Kabul etmiyorum [ ]

(lütfen uygun seçeneği işaretleyiniz)

Araştırmacının

Adı-Soyadı:
İmzası:

Appendix B

Random Assignment Screenshot

Assign subjects to groups

Subject #	Group Assigned
1	B
2	A
3	A
4	B
5	A
6	A
7	B
8	A
9	A
10	A
11	A
12	B
13	A
14	B
15	B
16	B
17	B
18	B
19	A
20	B

We used an online random assignment website to generate a list to assign participants to either B (Control group) and A (Experimental group). For example, our first participant was assigned to the control group while the second and third to the experimental etc. The procedure was equal to all of our 20 participants, and the program ensured that there is an equal number for participant in each group.

Appendix C

Research Questionnaire for demographic information

1. Test üzerindeki numaranız nedir? [ ]

2. Yaşınız? [ ]

3. Cinsiyetiniz?

Kadın [ ]

Erkek [ ]

Diğer [ ]

Belirtmek istemiyorum [ ]

4. Çalışırken müzik dinler misiniz?

Evet [ ]

Hayır [ ]

Bazen [ ]

5. Herhangi bir işitme probleminiz var mı? Varsa belirtiniz.

Hayır [ ]

Evet [ ] (…….)

6. Daha önce dikkat bozukluğuyla ilgili herhangi bir teşhis var mı? Varsa belirtiniz.

Hayır [ ]

Evet [ ] (…….)

Survey link: https://www.surveymonkey.com/r/RTHQ3ZZ

D2 Attention Test Instructions:

Şimdi size önünüzde bulunan kulaklıklarla müzik dinleteceğim. 3 dakikalık bir dinlemenin ardından omzunuza yavaşça dokunacağım ve önünüzdeki testi çözmeye başlayacaksınız (D2 Attention Test). Test sırasında herhangi bir iletişimimiz olmaması gerekiyor.

Bu test 14 sıra ve her sırada 47 adet figurden oluşmaktadır ve testte yalnızca ‘d’ ve ‘p’ harfleri kullanılmaktadır.

(Figürleri göstererek) Bazı harflerin altında veya üstünde bir, iki, üç ya da dört nokta bulunmaktadır. Testte temel hedef ‘d’ harfinin üzerinde iki çizgi, altında iki çizgi ve bir üstünde bir de altında çizgi bulunan d harflerini bulmaktır.

Testte belirtilen her bir görev için 20 saniye süre verilmektedir. Her 20 saniyede bir, kalemle testin ucuna dokunacağım. Kâğıdınıza dokunduğumda, yaptığınız satırın ortasında bile olsanız diğer satıra geçmeniz gerekmektedir.

Testin uygulanma süresi ise yaklaşık 8 dakikadır.
(Teste başlamadan önce süreyi tutun)

Şimdi deneme için ilk sayfadaki örnek satırı yapabilirsiniz. Süreniz 20 saniyedir. Daha sonra kulaklığı taktığınızda süreyi başlatacağım.

(Deneme yapmadan önce süreyi tutun)

Test bitiminde demografik bilgilerinizin olduğu küçük bir anket çözmenizi isteyeceğim.

D2 Attention Test

Sample Test

Adı Soyadı :

Sınıf : **Meslek :** Öğrenci **Tarih : 20… / /**

Cinsiyet : Erkek ☐ Kız ☐ **Doğum Tarihi: / /**

Kullandığı el: Sağ el ☒ Sol el ☐ **Yaş:** :

Uygulayan :

Örnek: d″ d„ d′

Uygulama:

d″	p„	d′	d′	d″	d„	p„	d″	d„	p′	d′	d″	d„	d″	p″	p„	d„	d″	d″	p„	d′	d′
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**

	Ham Puan	**Yüzdelik**	**Yorum**
TN (Toplam Puan)			
E1 (Omissions)			
E2 (Commissions)			
E (Errors)			
TN-E (total errors)			
CP (concentration)			
FR (fluctuation)			

TN															
E1															
E2															
CP