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TREBALL FINAL DE MÀSTER

**How can Binaural Beats be used to improve
Working Memory in the Additional Language
classroom?**

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DECLARACIÓ D'AUTORIA DEL TREBALL FINAL DE MÀSTER

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Abstract

This study investigates the impact of binaural beats on working memory in the context of additional language learning. Binaural beats are auditory illusions created by presenting two slightly different frequencies to each ear. The difference between the two frequencies creates a third tone, which is perceived as a pulsing sound that can affect brain waves. The difference between the two frequencies generates a rhythmic pulsation that can be perceived as a beat. The brain then synchronizes its neural activity with the perceived frequency, leading to changes in cognitive processes. An increasing number of studies have suggested that binaural beats can be used to alter or enhance cognitive processes., learners can increase their attentional resources which can enhance focus and memory. The purpose of this study was to determine whether binaural beats can enhance student's working memory retention in additional language learning. To achieve this goal, two memory tests were given to a group of 120 students at a private school in Cataluña, Spain. Both memory tests were carried out in the same format, however the second test also required students to listen to 40Hz binaural beats through earphones during both the learning and testing phases. The quantitative data analysis showed that binaural beats had a negative impact on the working memory on most students who participated in the study. However, there were some positive findings and many students reported that they would consider using binaural beats as a study tool in the future. This discrepancy between the negative impact on test scores and the willingness to consider using binaural beats in the future is an interesting finding that demands a full evaluation of the procedure used in this study and investigation on how better to use binaural beats in the additional language classroom of the future.

Key Words: Binaural Beats, Working memory, Additional language learning

Abstracto

Este estudio investiga el impacto de los pulsos binaurales en la memoria de trabajo en el contexto del aprendizaje adicional de idiomas. Los pulsos o latidos binaurales son ilusiones auditivas creadas al presentar dos frecuencias ligeramente distintas para cada oído. La diferencia entre las dos frecuencias crea un tercer tono, que se percibe como un sonido pulsante que puede afectar a las ondas cerebrales. La diferencia entre las dos frecuencias genera una pulsación rítmica que puede percibirse como un latido. Entonces, el cerebro sincroniza su actividad neuronal con la frecuencia percibida, dando lugar a cambios en los procesos cognitivos. Múltiples estudios han encontrado que al escuchar pulsos binaurales durante las actividades de aprendizaje de idiomas, los estudiantes pueden aumentar sus recursos de atención, lo que puede mejorar la concentración y la memoria. El propósito de este estudio fue determinar si los pulsos binaurales pueden mejorar la retención de la memoria de trabajo de los estudiantes en el aprendizaje adicional de idiomas. Para lograr este objetivo, se realizaron dos pruebas de memoria a un grupo de 120 alumnos de un colegio privado de Cataluña, España. Ambas pruebas de memoria se llevaron a cabo en el mismo formato, sin embargo, la segunda prueba también requería que los estudiantes escucharan pulsos binaurales de 40 Hz a través de auriculares durante las fases de aprendizaje y prueba. El análisis de datos cuantitativos mostró que los pulsos binaurales tuvieron un impacto negativo en la memoria de trabajo de la mayoría de los estudiantes que participaron en el estudio. Sin embargo, hubo algunos hallazgos positivos y muchos estudiantes informaron de que considerarían usar pulsos binaurales como herramienta de estudio en el futuro. Esta discrepancia entre el impacto negativo en los puntajes de las pruebas y la voluntad de considerar el uso de pulsos binaurales en el futuro es un hallazgo interesante que exige una evaluación completa del procedimiento utilizado en este estudio y una investigación sobre cómo utilizar mejor los pulsos binaurales en el aula de lenguaje adicional del futuro.

Palabras clave: Pulsos Binaurales, memoria de trabajo, lenguaje adicional

Abstracte

Aquest estudi investiga l'impacte dels polsos binaurals en la memòria de treball en el context de l'aprenentatge addicional d'idiomes. Els polsos o batecs binaurals són il·lusions auditives creades presentant dues freqüències lleugerament diferents a cada oïda. La diferència entre les dues freqüències crea un tercer to, que es percep com un so polsant que pot afectar les ones cerebrals. La diferència entre les dues freqüències genera una pulsació rítmica que es pot percebre com un batec. Aleshores, el cervell sincronitza la seva activitat neuronal amb la freqüència percebuda, donant lloc a canvis en els processos cognitius. Múltiples estudis han trobat que escoltant polsos binaurals durant les activitats d'aprenentatge d'idiomes, els estudiants poden augmentar els seus recursos d'atenció, el que pot millorar la concentració i la memòria. L'objectiu d'aquest estudi era determinar si els polsos binaurals poden millorar la retenció de la memòria de treball dels estudiants en l'aprenentatge addicional d'idiomes. Per aconseguir aquest objectiu, es van fer dues proves de memòria a un grup de 120 alumnes d'una escola privada de Catalunya, Espanya. Ambdues proves de memòria es van dur a terme en el mateix format, però la segona prova també va requerir que els estudiants escoltessin polsos binaurals de 40 Hz a través d'auriculars durant les fases d'aprenentatge i de prova. L'anàlisi de dades quantitatives va mostrar que els polsos binaurals tenien un impacte negatiu en la memòria de treball de la majoria dels estudiants que van participar en l'estudi. Tot i això, hi va haver algunes troballes positives i molts estudiants van informar que considerarien l'ús de polsos binaurals com a eina d'estudi en el futur. Aquesta discrepància entre l'impacte negatiu en les puntuacions de les proves i la voluntat de considerar l'ús de polsos binaurals en el futur és una troballa interessant que exigeix una avaluació completa del procediment utilitzat en aquest estudi i una investigació sobre com utilitzar millor els polsos binaurals a l'aula del llenguatge addicional del futur.

Paraules clau: Polsos binaurals, memòria de treball, llenguatge addicional

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1. Introduction

In the fast modern world we live, technologies such as laptops and cell phones have invaded the classroom, raising considerable concerns about their effects on college student's attention in the classroom (Attia et al., 2017). Research in neuroscience has shown that attention is a limited resource (Isbell et al., 2017). This presents a challenge for teachers who strive to capture and maintain their student's attention.

There is a known link between attention and learning. In order to learn, students' needs to pay attention. The same is true for learning within the additional language (ALL) classrooms where teachers make instructional decisions to harness the attention of their students (Hlas et al, 2019).

While a huge amount of language processing is relatively automatic, deficits within the phonological loop, and to a lesser extent, within other aspects of working memory, may seriously impair language processing (Baddeley, 2003). Working memory is the retention of a small amount of information in a readily accessible form. It facilitates planning, comprehension, reasoning, and problem-solving (Cowan, 2014). These are key features required by students in the ALL classroom.

Recent studies have suggested that binaural beats (BB) can be used to enhance cognitive processes such as attention, focusing, and memory, including working memory (Colzato et al., 2017; Wang et al., 2022). Wang et al. (2022) found that 40 Hz binaural beats can improve working memory, induce frequency-following responses which may also account for changes in working memory performance.

Given the link between attention, focus and working memory this study aims to explore whether 40 Hz BB can improve students working memory in the ALL classroom.

2. Objectives and research questions

The objective of this action research study is to investigate the potential effectiveness of improving students working memory by using BB. The study involves two memory tests, a control test and an experimental test using BB.

Specifically, the study aims to:

1. Investigate the impact of binaural beats on the working memory of students in the additional language classroom.
2. Determine whether the use of binaural beats can lead to improved academic performance in the additional language classroom.

2.1 Hypothesis

Based on the research by Colzato et al., 2015 and Wang et al., 2022, the hypothesis for this study is that the use of binaural beats will lead to improved working memory for students which will result in higher academic performance in the experimental memory test.

3. Theoretical Framework

This section outlines how binaural beats work and their prospective utility in the additional language classroom whilst also underscoring their importance and their need for investigation as a possible tool to aid students focus and improve working memory, both of which are key elements to additional language learning.

3.1 Binaural Beats

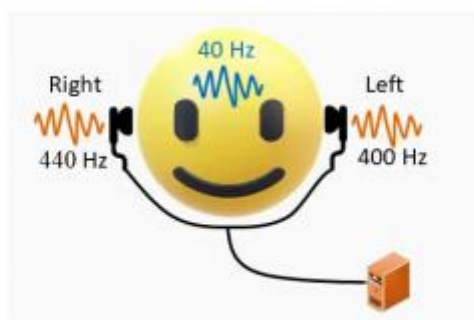


FIGURE 1. 40 Hz binaural beats on a 400 Hz carrier tone generated within the brain.

(Figure 1 - Wang et al. 2022)

As shown in figure 1, when two beats of slightly different frequency (for instance 300 and 340 Hz) are presented separately to the left and right ears, the hearer detects a single beat that differs in amplitude at a frequency equal to the frequency difference between the two beats (40 Hz); a perceptual illusion known as the binaural auditory beat (Colzato et al., 2015).

There have been multiple studies with positive findings investigating the use of binaural beats and how they can potentially aid academic performance.

Colzato et al. (2015) found that high-frequency binaural beats bias attentional processing towards a reduced spotlight of attention. Beats in the gamma range (30-100 Hz) achieve this effect by increasing attentional focusing rather than by suppressing irrelevant tasks and task-related information.

Wang et al. (2022) found that that 40 Hz binaural beats improve working memory. He asserted that binaural beats deal with cognitive aspects, such as attention, focusing and memory. In

particular, binaural beats mobilize more attentional resources and perceptual arousal (i.e., more complex) brain responses, with an increased distribution of cortical activity.

The underlying neural mechanisms are still yet to be unravelled (Chiab et al. 2015). However, neuroscientists hypothesize that binaural beats originate in the inferior colliculus in the central nervous system auditory pathway and that by delivering a continuous external stimulus of relatively constant frequency, it can induce frequency-following response, which can entrain brain rhythms to the frequency of the external stimulation Wang et al. (2022). Put simply, by listening binaural beats, your brain has an additional sound to process and is less distracted when trying to focus on a specific learning tasks.

It should be noted that the use of binaural beats are still a relatively unexplored and scientists have found mixed evidence of their success. Garcia-Argibay (2019) found that the presentation of binaural auditory beats can affect long-term memory both positively and negatively, depending on the frequency used. Additionally, Mahajan (2021), didn't find significant leads to the conclusion that binaural beats have [the] potential to improve executive functioning in individual when exposed to it. This finding was mirrored by Kennel et al (2009) pilot study in the use of binaural beats for reducing symptoms of inattention in children and adolescents with attention-deficit/hyperactivity disorder and found that binaural beats did not significantly reduce the symptom of inattention in the experimental group but suggested that a longer study was required as the modality was easy to use and helpful.

3.2 Memory & Sustained Attention in Additional language learning

Working Memory and sustained attention are vital to the additional language classroom.

Selective attention is the ability to select and preferentially process specific information while simultaneously suppressing the processing of irrelevant, competing distractors. It is a fundamental ability linked to various cognitive skills and academic achievement. (Isbell, et al., 2017).

Working memory is the retention of a small amount of information in a readily accessible form. It facilitates planning, comprehension, reasoning, and problem-solving (Cowan, 2014).

The use of working memory is quite ubiquitous in human thought, but the best way to improve education using what we know about working memory is still controversial. When you are listening to language, you need to retain information about the beginning of the sentence until you can make sense of it. Without sufficient working memory, the information would be lost before you could combine it into a coherent, complete thought. (Cowan, 2014).

Children with various kinds of learning and language disability generally test below grade level on working memory procedures, and children with low working memory and executive function don't do well in school (Cowan, 2014).

Hlas et al., 2019 study of 17 classes included 274 undergraduates found that students report short lapses, 1 minute or less, that occur two to three times throughout most classes and often state being fatigued, thinking about other things, and making connections to other topics as possible reasons for the lapses [of attention].

Gignac et al (2021) study of 1667 students (13–16 years old) from 28 schools in Barcelona describes how poor attention in adolescents can be detrimental to their academic performance and socioemotional development. Additionally, students proposed factors that are not extensively studied, and in some cases, those factors appeared to influence attention.

From a teacher's perspective, Gignac et al. describes how attention is particularly difficult to garner from teenagers as during adolescence the brain continues to refine and undergo important morphological and functional transformations. Among the last areas of the brain to mature are the frontal lobes, which are known to mediate essential cognitive processes including attention.

Attia et al. (2017) found that students self-reported that technology and distractions such as computers and mobile phones can have negative effects on undergraduate student's concentration, highlighting the importance of minimizing such disruptions in the classroom.

While little research exists regarding attention spans in second language classrooms, instructional factors that can be controlled by the teacher include the timing of the task

during the lesson, the task duration, the L2 language demands, the medium of instruction, and the task itself (Hlas et al., 2019).

To improve attentional focus, teachers can implement student-centred pedagogies at different times throughout a lecture, not only to decrease attention lapses but also to increase attention during subsequent lectures (Bunce et al., 2010).

Clearly, working memory is extremely important to additional language learning but in a technology filled world full of distraction it is a finite resource. Binaural beats potentially offer students a tool to improve their focus and working memory and should be investigated further.

4. Method

Based on the theoretical framework the following educational action plan was designed and implemented.

4.1 Contextualisation

The study was conducted during February and March of 2023 at a private school situated in an affluent neighbourhood in Barcelona. The students enrolled in the school predominantly come from a middle-class background. The research involved four classes, comprising of two groups of students: ESO 1 and ESO 2. As per the school's policy of co-teaching, three additional English teachers were present in the classroom to monitor the students and address any issues that arose during the tests. The tests were conducted online, using the students' own tablets and earphones. The classrooms were open-plan layout, accommodating a total of 60 students and four English teachers in the same room. Typically, there were 4 students sitting at a group of desks.

4.2 Participants

The study comprised a sample size of 120 students, with 60 students from ESO 1 and 60 students from ESO 2. The participants were aged between 11 to 12 years old. However, only 96 students completed both memory tests in their entirety and provided sufficient evidence to be fully evaluated. The majority of the student's first language was Catalan/Spanish. Based on the Common European Framework of Reference for Languages (CEFR), the estimated English proficiency level of the students in ESO 1 was A2, while in ESO 2, it was B1.

4.3 Stages of the action plan

There were 3 stages of testing. Stage 1 was used to obtain a control grade for the student. Stage 2 was carried out a week later and included the use of binaural beats (the experimental stage). Stage 3, data gathering after an informational presentation on the potential utility of binaural beats occurred straight after Stage 2.

Stage 1 - Memory Test (Control)

Objective: To establish a control grade for the student's vocabulary memory test scores.

- Students were asked to complete a questionnaire that collected their personal details and self-evaluated their focus, perceived ability to memorize vocabulary, and the perceived importance / relationship to studying English (*Annex 1 – Questionnaire 1*).
- Students were given 5 minutes to learn key vocabulary (*Annex 2*). They were informed that there were 40 questions in total but only 20 of these questions would be included in the memory test game. To ensure standardized testing conditions, an online timer was utilized and projected on the whiteboard so that students could know how long they had to study the vocabulary.
- The students were directed to sign into the Quizziz Memory Test and the online game began. The game tested the student's on 20 of the key words that they had studied (*Annex 3*).
- Following the memory test game, students were asked to complete a questionnaire that self-reported their perceived level of focus during the game and their perception of their performance (*Annex 4 – Questionnaire 2*).
- The teacher collected the data to be analysed.

Stage 2 - Vocabulary test with the use of binaural beats

Objective: To investigate the effect of binaural beats on student's working memory

- Students were asked to complete a questionnaire that collected their personal details and self-evaluated their focus for the day (*Annex 5 – Questionnaire 3*).
- Students were asked to download and begin listening to binaural beats (*Annex 6*) using their own earphones.
- Students were told to listen to “the sound” (binaural beats) at a low comfort level for both the vocabulary learning section and the memory test.
- Students were given 5 minutes to learn a new set of 40 new phrases (*Annex 7*). To ensure standardized testing conditions the same an online timer was utilized in the class.
- The students were directed to sign into the Quizziz Memory Test and the game began. The game tested the student's memory on 20 of the key words from the vocabulary (*Annex 8*).
- Following the memory test game, students were asked to complete a questionnaire that self-reported their level of focus during the game and their perception of their performance (*Annex 9 – Questionnaire 4*).
- The teacher collected the data to be analysed.

Stage 3 - Presentation about Binaural Beats and their Utility

Objective: To gather additional information from the students and determine whether they would consider using binaural beats in the future after being told of their (potential) utility.

- Students were given a brief presentation about the use and purpose of binaural beats which included video and theory (*Annex 10 - Presentation*).
- Students were asked to complete a questionnaire asking whether their opinion on binaural beats had changed (*Annex 11 – Questionnaire 5*).

Instruments & Tools Used

In my educational action research, a mixture of quantitative and qualitative instruments were used.

Google Forms

In this study, five Google Form questionnaires (*Annex 1, 4, 5, 8, 11*) were employed to collect quantitative and qualitative self-reporting data from the students. Google Forms was chosen as the students were very used to using the tool on a daily basis and because both quantitative and qualitative data could be collected from the students confidentially.

The first four questionnaires (*Annex 1, 4, 5, 8*) were designed to collect information for comparison before and after each memory test. This also allowed for investigation on the perceived difficult of the test and the students perceived performance which could be used to add reliability / credibility to the findings of the investigation.

The final Google Form questionnaire (*Annex 11*) was sent to the students after they had been informed about the purpose of binaural beats. The objective of this form was to see if there was a perceived difference in students attitudes towards binaural beats after being told of their (hypothetical) utility and potential to aid students focussing in the classroom and it future studies.

Quizziz

This study employed Quizziz as the platform for the memory test. The platform was chosen as it allowed for the collection of data on the large sample size. The students were also used to similar platforms (such as Kahoot) which meant that no explanation was needed in how to play *the game*.

Multiple choice answers were provided to the students which meant that students of all levels were able to take part in the investigation. Crucially for this investigation, the platform offered a feature to turn off background sounds during the game which meant that students were distracted during stage 2 when listening to the binaural beats.

Binaural Beats

The binaural beats were sourced from a YouTube website and downloaded as an audio file, which was then saved under the name "*Sounds for Test*". This was done to avoid revealing the name "binaural beats" to the students and unintentionally influencing their perception of the technology. This also prevented the students from accessing the comments section on YouTube before the test started. The students were asked to listen to the binaural beats at a low comfortable volume for the entirety of Stage 2 testing.

5. Results

The results are presented in the order of the action plan stages as confirmed below. The only difference between the order of action plan and way the result are presented are that memory test 1 (control) and memory test 2 (experimental - using binaural beats) are presented together in order to provide a side-by-side comparison.

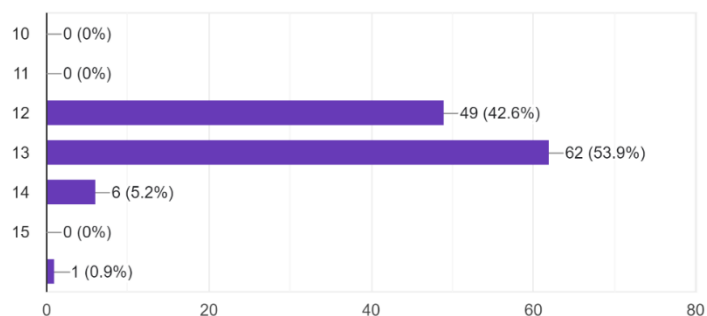
Order of the action plan:

1. Questionnaire 1
2. Memory Test 1 (Control)
3. Questionnaire 2
 - *One week gap*
4. Questionnaire 3
5. Memory Test 2 (Experimental – using Binaural Beats)
6. Questionnaire 4
 - *Presentation on the suggested utility of binaural beats*
7. Questionnaire 5

5.1 Questionnaire 1

Data Point 1 - Confirmation of participants age (across ESO 1 & ESO 2)

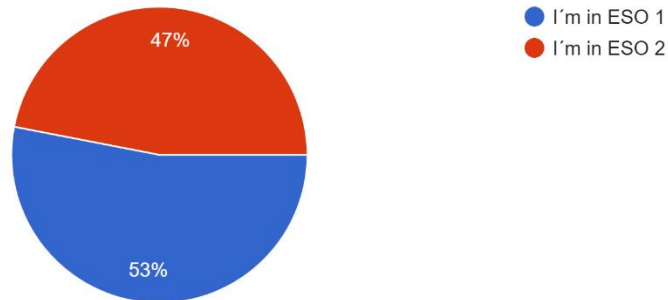
Please tick your age
115 responses



Data Point 2 - Confirmation of division sample size

Please tick which class you're in

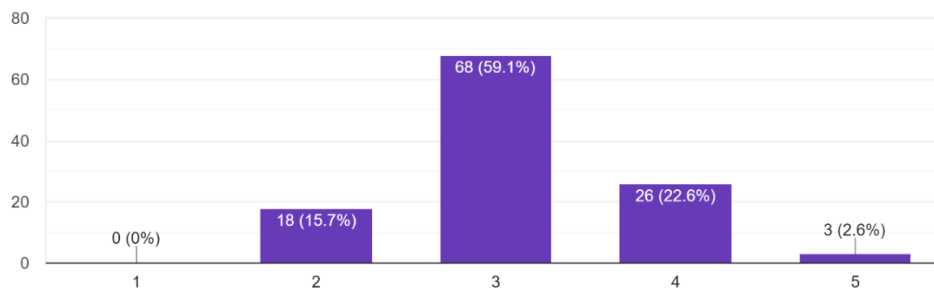
115 responses



Data Point 3 - Students self-reporting their Focus before Memory Test 1 (Control)

How focussed do you feel right now?

115 responses



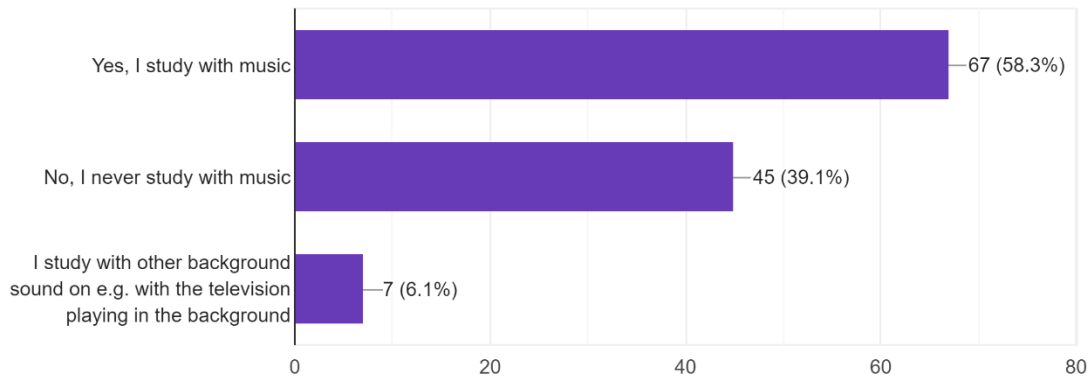
1 – Not Focussed at all (I'm very distracted)

5 - Extremely Focussed

Data Point 4 Students self- reporting on whether they listen to sound (music) when studying at home

If you study at home do you listen to music?

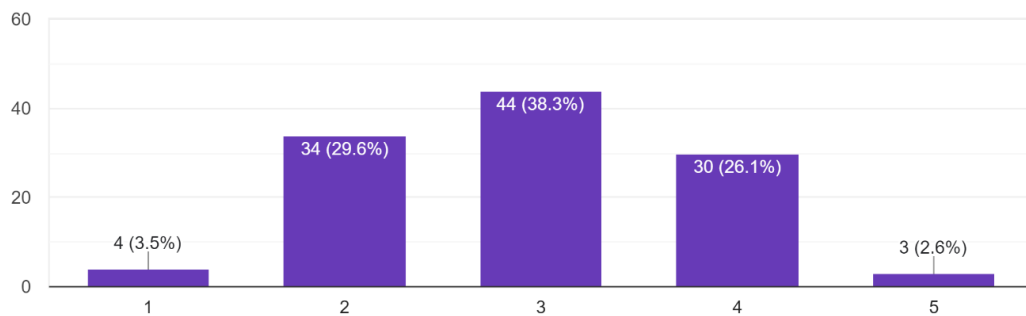
115 responses



Data Point 5 - Students self- reporting on whether they feel they have the capacity to learn new vocabulary in English class

Please rate your memory learning capacity for learning new vocabulary in the English class

115 responses



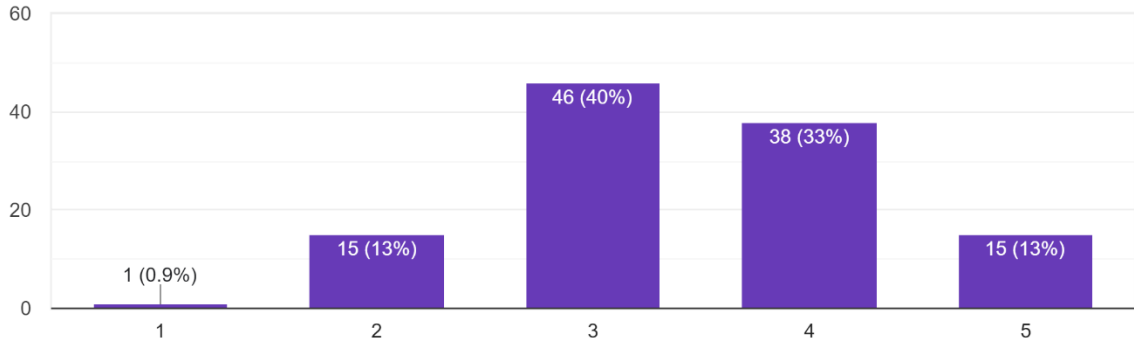
1 - I have a terrible memory for learning new vocabulary

5 - I have an excellent memory for learning vocabulary

Data Point 6 - Students self- reporting on whether they perceive their focus in class varies a lot

On a daily basis, my focus in class varies a lot

115 responses



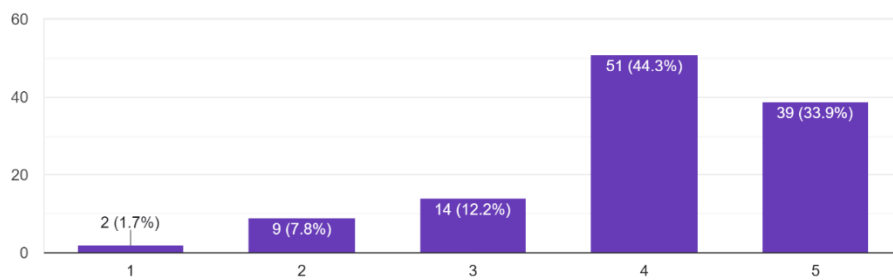
1 - My focus never changes in class

5 - Depending on the day my focus changes a lot

Data Point 7 - Students self- reporting on whether they perceive that memory is important to language learning

I feel memory is important to language learning

115 responses

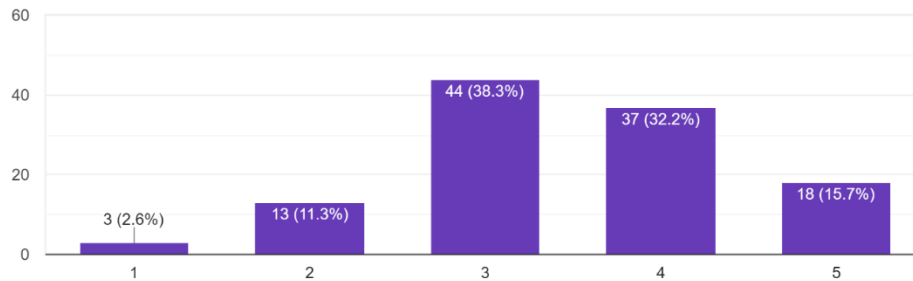


1. Memory isn't important at all to language learning

5. Memory is very important to language learning

Data Point 8 - Students self- reporting on whether they wish they could focus more in class

I wish I could focus more in class
115 responses

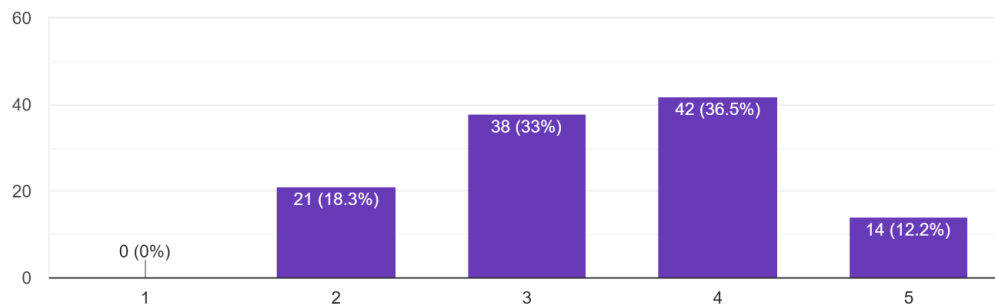


1. I strongly disagree

5. I strongly agree

Data Point 9 - Students self- reporting on whether think they can improve their memory

I think I can improve my memory
115 responses

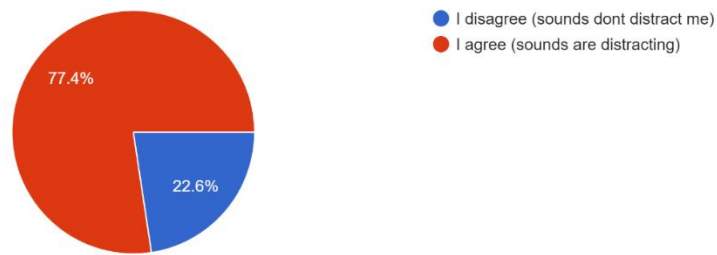


1. I disagree (it's impossible to improve memory)

5. I agree (I think it's easy to improve memory)

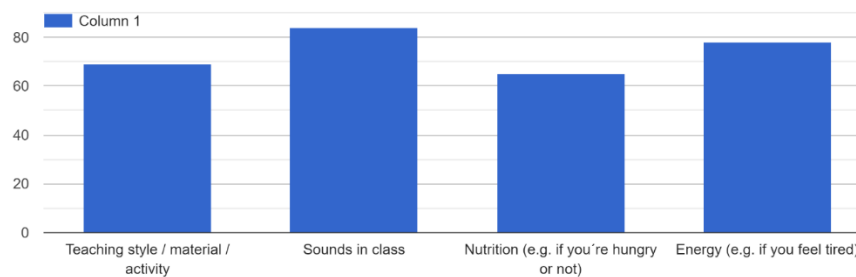
Data Point 10 - Students self- reporting on whether they perceive that different sounds /noises in class distract them

I find different sounds / noises in class distracting
115 responses



Data Point 11 -Students self- reporting on which element most effects their concentration

Please tick the box that you feel most affects your concentration in class (Choose 1 Box)



Data Point 12 – Students providing qualitative data on factors that distract them in class

Optional - Please specify any other factors that affect your attention (not already mentioned in this questionnaire)

22 responses

The teaching style does not distract me, it is an accident

People

My friends

A bad time outside, like it is raining a lot or that I feel bad

My mates, and how i'm feeling (I'm sad, exhausted or happy)

If one person is talking to me or if I'm really tired.

My friends distract because sometimes I talk with them during the class.

I get distracted if I have some materials near to me, because I need to touch it

If it's in the first hour or in the mid day.

A thing that affects to my attention is the wethear.

If I don't like the subject that I'm learning, if I don't feel well...

If there are people around me on general.

Other partners of my class that talk to me during class

Me distraen los profesores

Las personas que estan a tu lado, la matèria que estas dando.

Probably the people that comes to me to distract me

The climate

Persons that speak very loud.

I think that in this questionnaire all the factories of distraction are explained.

The people

When the other people close to you don't work

the temperature

5.2 Memory Test Results

Data Point 13 – ESO 1 Memory Test Results – Taken from Quizziz

The results of the ESO 1 Vocabulary Test are presented below:

- Test 1: Control Test
- Test 2: Test with the use of binaural beats

To facilitate easy interpretation, the results are color-coded.

- Red colour indicates a decline in performance from Test 1 to Test 2
- Yellow indicates that the same grade was achieved in both tests,
- Green denotes an improvement between Test 1 and Test 2.

Test 1

Number	Questions	Correct	Accuracy
Student 1	20	10	50 %
Student 2	20	3	15 %
Student 3	20	7	35 %
Student 4	20	9	45 %
Student 5	20	16	80 %
Student 6	20	11	55 %

Test 2

Number	Questions	Correct	Accuracy
Student 1	20	6	30 %
Student 2	20	9	45 %
Student 3	20	8	40 %
Student 4	20	14	70 %
Student 5	20	14	70 %
Student 6	20	9	45 %

Student 7	20	6	30 %
Student 8	20	6	30 %
Student 9	20	8	40 %
Student 10	20	7	35 %
Student 11	20	4	20 %
Student 12	20	9	45 %
Student 13	20	15	75 %
Student 14	20	5	25 %
Student 15	20	12	60 %
Student 16	20	17	85 %
Student 17	20	12	60 %
Student 18	20	9	45 %
Student 19	20	14	70 %
Student 20	20	12	60 %
Student 21	20	5	25 %

Student 7	20	8	40 %
Student 8	20	6	30 %
Student 9	20	3	15 %
Student 10	20	2	10 %
Student 11	20	7	35 %
Student 12	20	6	30 %
Student 13	20	19	95 %
Student 14	20	6	30 %
Student 15	20	14	70 %
Student 16	20	17	85 %
Student 17	20	8	40 %
Student 18	20	10	50 %
Student 19	20	11	55 %
Student 20	20	10	50 %
Student 21	20	8	40 %

Student 22	20	8	40 %
Student 23	20	13	65 %
Student 24	20	13	65 %
Student 25	20	12	60 %
Student 26	20	6	30 %
Student 27	20	14	70 %
Student 28	20	14	70 %
Student 29	20	5	25 %
Student 30	20	13	65 %
Student 31	20	9	45 %
Student 32	20	10	50 %
Student 33	20	6	30 %
Student 34	20	15	75 %
Student 35	20	17	85 %
Student 36	20	16	80 %

Student 22	20	13	65 %
Student 23	20	15	75%
Student 24	20	16	80 %
Student 25	20	5	25 %
Student 26	20	4	20 %
Student 27	20	10	50 %
Student 28	20	14	70 %
Student 29	20	3	15 %
Student 30	20	16	80 %
Student 31	20	10	50 %
Student 32	20	3	15 %
Student 33	20	7	35 %
Student 34	20	14	70 %
Student 35	20	17	85 %
Student 36	20	12	60 %

Student 37	20	13	65 %
Student 38	20	4	20 %
Student 39	20	11	55 %
Student 40	20	12	60 %
Student 41	20	10	50 %
Student 42	20	7	35 %
Student 43	20	12	60 %
Student 44	20	7	35 %
Student 45	20	8	40 %
Student 46	20	18	90 %
Student 47	20	13	65 %
Student 48	20	11	55 %
Student 49	20	15	75 %
Student 50	20	7	35 %

Student 37	20	10	50 %
Student 38	20	6	30 %
Student 39	20	10	50 %
Student 40	20	14	70 %
Student 41	20	6	30 %
Student 42	20	7	35 %
Student 43	20	7	35 %
Student 44	20	5	25 %
Student 45	20	6	30 %
Student 46	20	15	75 %
Student 47	20	15	75 %
Student 48	20	9	45 %
Student 49	20	14	70 %
Student 50	20	6	30 %

Data Point 14 – Summary of ESO 1 Memory Test 1 & 2

- Test 1: Control Test
- Test 2: Test with the use of binaural beats

Test 1

Mean
10.32
Median
10.5
Mode
12
Range
15
Minimum
3
Maximum
18
Count <i>n</i>
50
Sum
516
Quartiles
Quartiles:
Q ₁ --> 7
Q ₂ --> 10.5
Q ₃ --> 13
Interquartile
Range IQR
6
Outliers
none

Test 2

Mean
9.68
Median
9
Mode
6
Range
17
Minimum
2
Maximum
19
Count <i>n</i>
50
Sum
484
Quartiles
Quartiles:
Q ₁ --> 6
Q ₂ --> 9
Q ₃ --> 14
Interquartile
Range IQR
8
Outliers
none

Data Point 15 – ESO 2 Memory Test Results – Taken from Quizziz

The results of the ESO 2 Vocabulary Test are presented below:

- Test 1: Control Test
- Test 2: Test with the use of binaural beats

To facilitate easy interpretation, the results are color-coded.

- Red colour indicates a decline in performance from Test 1 to Test 2
- Yellow indicates that the same grade was achieved in both tests,
- Green denotes an improvement between Test 1 and Test 2.

TEST 1			
Rank	Attempt	Correct	Accuracy
Student 1	20	14	70 %
Student 2	20	4	20 %
Student 3	20	11	55 %
Student 4	20	16	80 %
Student 5	20	18	90 %
Student 6	20	7	35 %
Student 7	20	15	75 %

TEST 2			
Rank	Attempt	Correct	Accuracy
Student 1	20	17	85 %
Student 2	20	6	30 %
Student 3	20	9	45 %
Student 4	20	9	45 %
Student 5	20	19	95 %
Student 6	20	5	25 %
Student 7	20	13	65 %

Student 8	20	18	90 %
Student 9	20	19	95 %
Student 10	20	10	50 %
Student 11	20	20	100 %
Student 12	20	14	70 %
Student 13	20	20	100 %
Student 14	20	17	85 %
Student 15	20	16	80 %
Student 16	20	15	75 %
Student 17	20	16	80 %
Student 18	20	20	100 %
Student 19	20	18	90 %
Student 20	20	16	80 %
Student 21	20	16	80 %
Student 22	20	18	90 %

Student 8	20	19	95 %
Student 9	20	17	85 %
Student 10	20	8	40 %
Student 11	20	18	90 %
Student 12	20	19	95 %
Student 13	20	16	80 %
Student 14	20	20	100 %
Student 15	20	19	95 %
Student 16	20	11	55 %
Student 17	20	12	60 %
Student 18	20	19	95 %
Student 19	20	18	90 %
Student 20	20	17	85 %
Student 21	20	12	60 %
Student 22	20	15	75 %

Student 23	20	14	70 %
Student 24	20	16	80 %
Student 25	20	12	60 %
Student 26	20	15	75 %
Student 27	20	16	80 %
Student 28	20	16	80 %
Student 29	20	16	80 %
Student 30	20	18	90 %
Student 31	20	11	55 %
Student 32	20	16	80 %
Student 33	20	18	90 %
Student 34	20	15	75 %
Student 35	20	15	75 %
Student 36	20	12	60 %
Student 37	20	18	90 %

Student 23	20	13	65 %
Student 24	20	17	85 %
Student 25	20	6	30 %
Student 26	20	9	45 %
Student 27	20	14	70 %
Student 28	20	12	60 %
Student 29	20	16	84 %
Student 30	20	10	50 %
Student 31	20	8	40 %
Student 32	20	19	95 %
Student 33	20	11	55 %
Student 34	20	19	95 %
Student 35	10	9	45 %
Student 36	20	11	55 %
Student 37	20	19	95 %

Student 38	20	10	50 %
Student 39	20	18	90 %
Student 40	20	16	80 %
Student 41	20	11	55 %
Student 42	20	15	75 %
Student 43	20	17	85 %
Student 44	20	11	55 %
Student 45	20	14	70 %
Student 46	20	16	80 %

Student 38	20	13	65 %
Student 39	20	7	35 %
Student 40	20	18	90 %
Student 41	20	13	65 %
Student 42	20	10	50 %
Student 43	20	17	85 %
Student 44	20	3	15 %
Student 45	20	10	50 %
Student 46	20	11	55 %

Data Point 16 – Summary of ESO 2 Memory Test 1 & 2

Mean
15.0869565
Median
16
Mode
16
Range
16
Minimum
4
Maximum
20
Count <i>n</i>
46
Sum
694
Quartiles
Quartiles:
Q ₁ --> 14
Q ₂ --> 16
Q ₃ --> 18
Interquartile
Range IQR
4
Outliers
4, 7

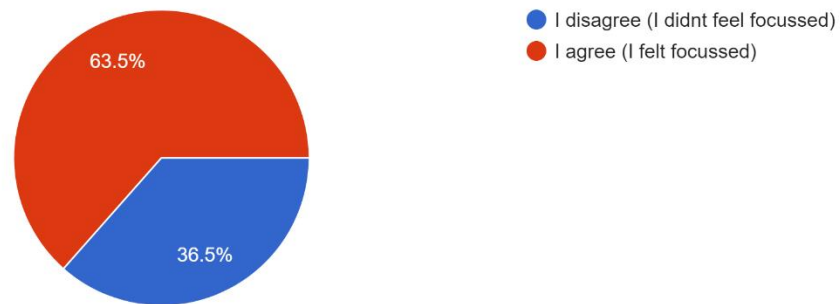
Mean
13.326087
Median
13
Mode
19
Range
17
Minimum
3
Maximum
20
Count <i>n</i>
46
Sum
613
Quartiles
Quartiles:
Q ₁ --> 10
Q ₂ --> 13
Q ₃ --> 18
Interquartile
Range IQR
8
Outliers
none

Questionnaire 2

Data Point 17 - Students self-reporting their focus after the control vocabulary test

During the test I felt very focussed

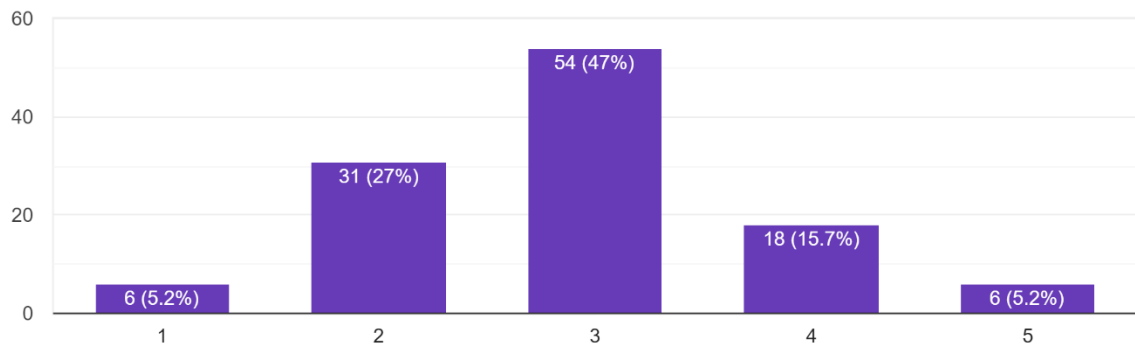
115 responses



Data Point 18 - Students self-reporting the difficult of the control memory test

How difficult was the test?

115 responses

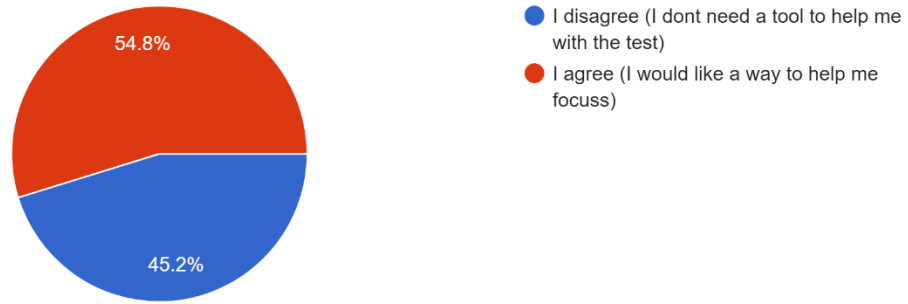


1. The test was easy

5. The test was hard

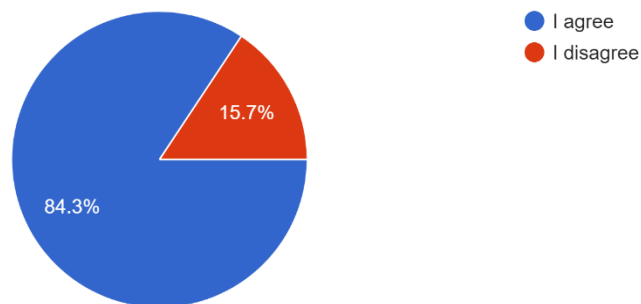
Data Point 19 -Students self-reporting whether they thought a “tool” could help them with the control memory test

I wish I had a tool that could help me focus more on the test
115 responses



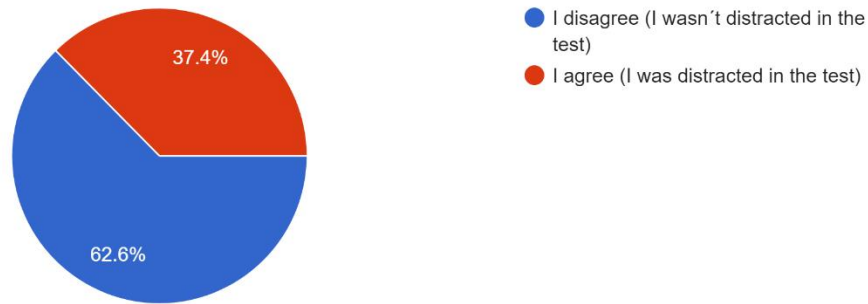
Data Point 20 - Students self-reporting whether they thought the test control memory test is important to language learning

Test like these are important in English language learning
115 responses



Data Point 21 - Students self-reporting whether they were distracted in the control memory test

I was distracted in the test
115 responses



Data Point 22 - Students self-reporting additional information about the level of focus during the test

Optional -

Please add any additional information about your level of focus in the test

11 responses

I was focused when I had to answer, but between question and question I coul talk to my partners and relax.

There was noise but I wasn't distracted.

The adrenaline didn't make a good paper during the test

I was very focused because I wanted to do it well!

I feel tired because it's the first hour, and I am not focused.

It si very difficult to memory all the list of vocabulary in 5 minutes. I think that I have a lot of memory but in 5 minutes I culdn't memory's all that.

I think it was a 9/10 of attention

I was focused but the ranking kinda distracted me between questions.

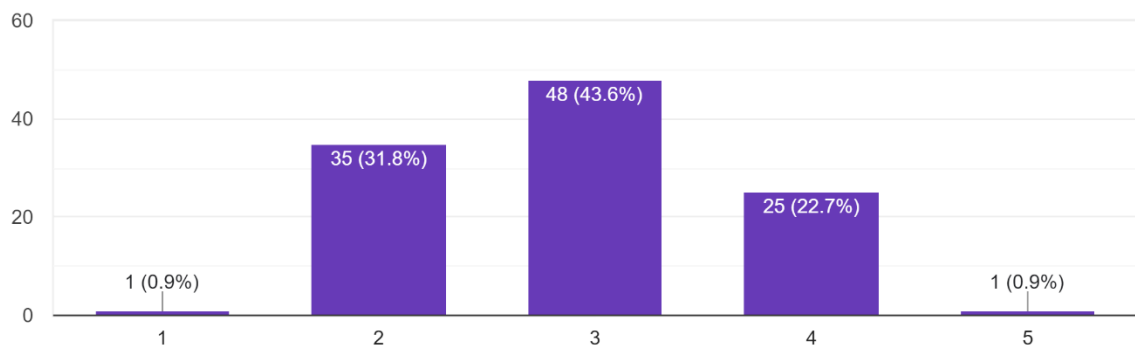
Questionnaire 3

Carried out before the memory test (stage 2) with the use of binaural beats

Data Point 23 - Students self-reporting their focus before memory test 2

How focussed do you feel right now?

110 responses



1. Not Focussed at all (I'm very distracted)

5. Extremely Focussed

Data Point 24 - Students self-reporting their focus before memory test 2

I feel more focussed in class today than I did in last week's memory test

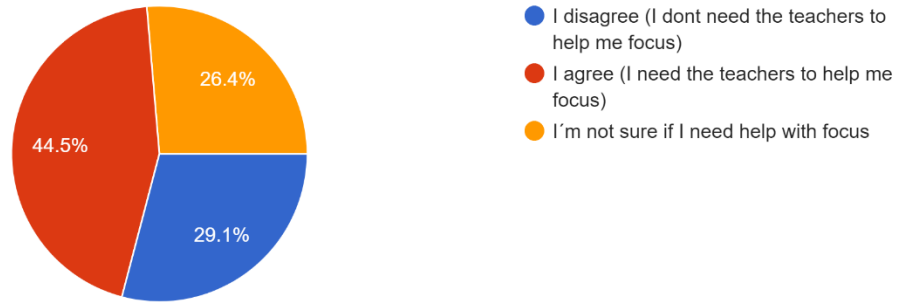
110 responses



Data Point 25 - Students self-reporting whether they would like the teacher to help them with their focuss

I would like the teachers to help me focus in class

110 responses



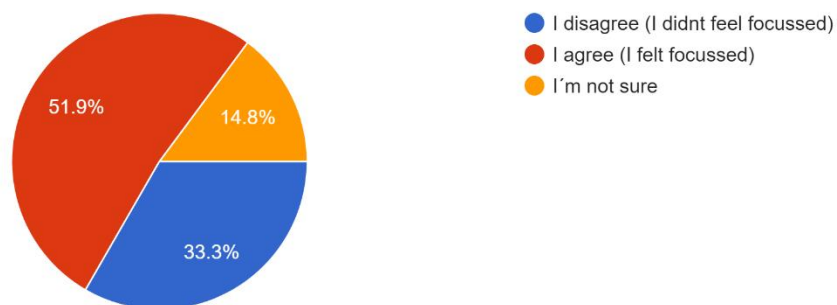
Questionnaire 4

Student responses after memory 2 – having used binaural beats

Data Point 26 – Students self reporting on their focuss during the test

During the test I felt very focussed

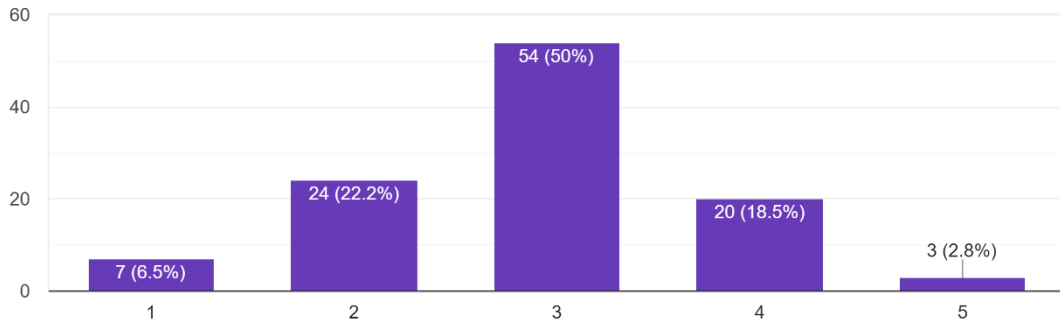
108 responses



Data Point 27 – Students self reporting the difficult of memory test 2

How difficult was the test?

108 responses



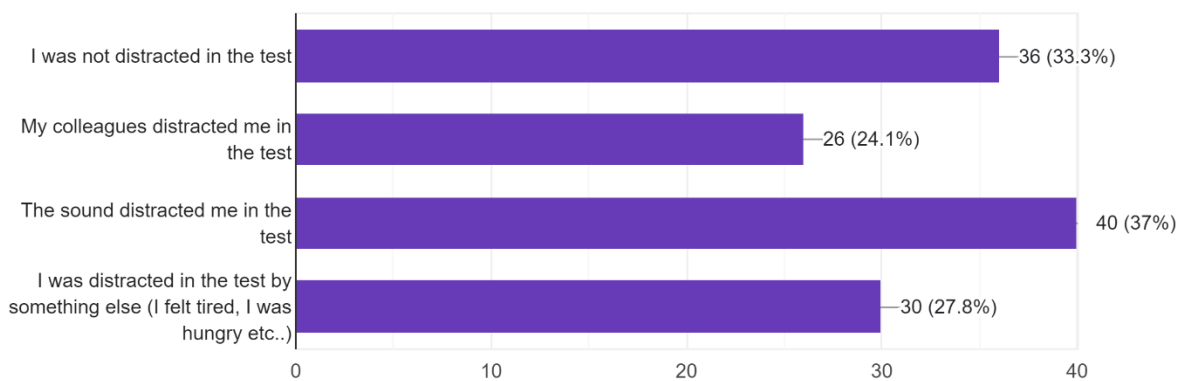
1. The test was easy

5. The test was hard

Data Point 28 – Students self reporting on what distracted them during memory test 2

Please tick the option that you feel best describes your focuss in the test

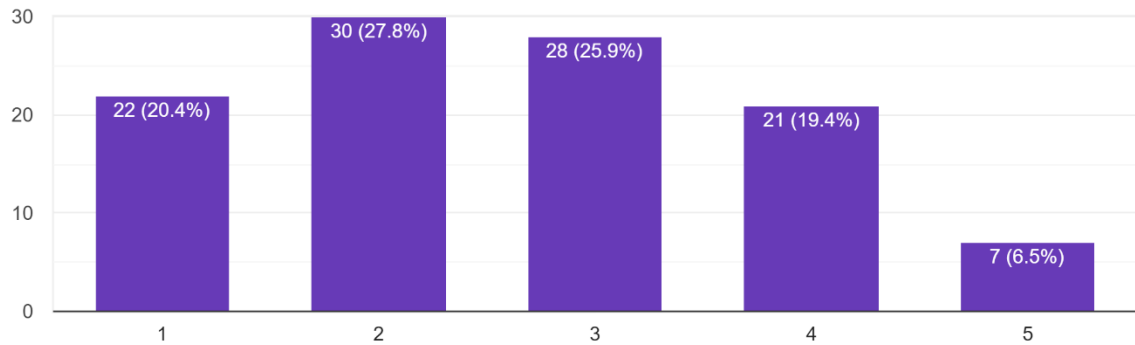
108 responses



Data Point 29 – Students self reporting to what level the sound helped them focus during memory test 2

The sound I heard during the test helped me focus

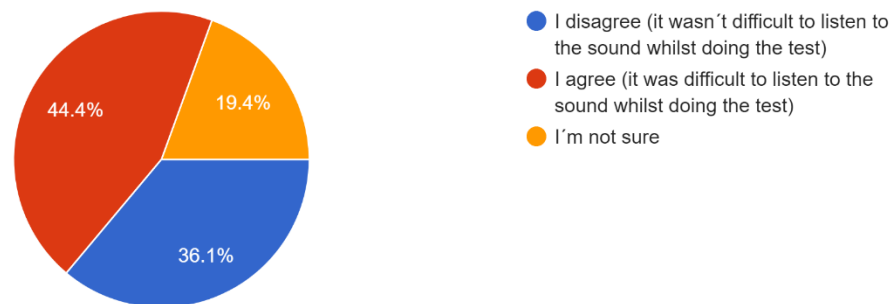
108 responses



Data Point 30 – Students self-reporting to what level the sound helped them focus during memory test 2

It was difficult to do the test whilst listening to the sound

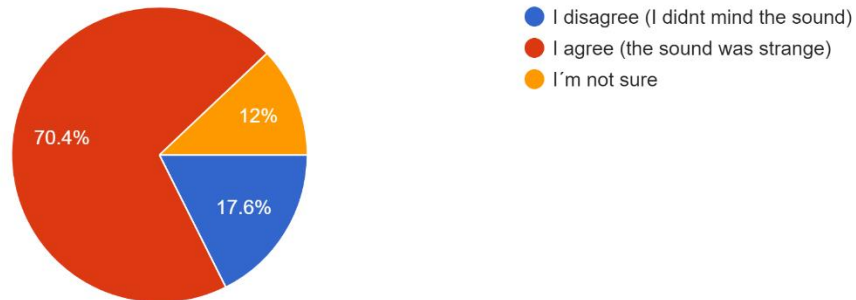
108 responses



Data Point 31 – Students self reporting whether they found the sound strange during memory test 2

The sound was very strange

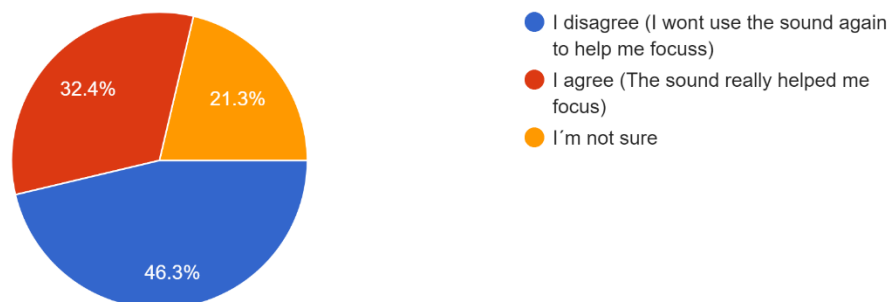
108 responses



Data Point 32 – Students self reporting whether they would listen to the sound again to help them focus during a memory test

I would listen to the sound again to help me focus

108 responses



Data Point 33 – Students self reporting qualitative feedback on their perception of the sound after memory test 2

Optional

Please add any additional information about the sound, whether you liked the sound and whether you think the sound helped you with the memory test 11 responses

The sound helped me a lot

The sound was annoying, and I was more focused to the sound than the test.

The sound was distracting but, I Don't know why I did it Better than the other day because of the sound.

It didn't help me. It was very distracting and it gave me headache.

I think that if you put a sound when you are studying and then, in the test. You remember all more.

To know if this sound helped me during the test I would need to use it again in another questionnaire to compare and see if this really helped me to focus or it's just causality

I think I would listen the sound again to focus, because it helped me in the beginning but it got annoying and irritating

The sound did not distract me, but I'm not sure if it have helped me

I did worst in this test but I felt more focused during the test (Not the memory

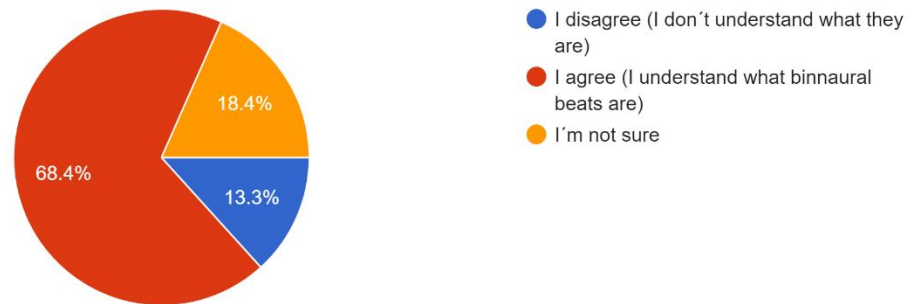
Questionnaire 5

Given after a 5 minute presentation on the purpose and potential use of Binaural Beats

Data Point 34 – Students self reporting on whether or not they understood the utility of binaural beats after the presentation

I understand what Binaural Beats are

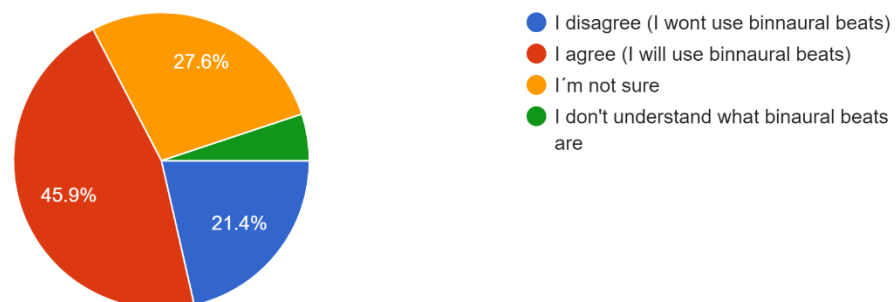
98 responses



Data Point 35 – Students self reporting on whether they would use binaural beats to study in the future

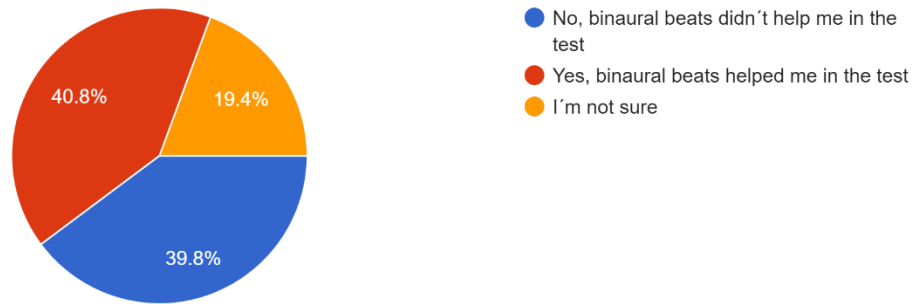
Now that I understand how Binaural Beats work, I will listen to them when studying as it might help me improve my focus and memory

98 responses



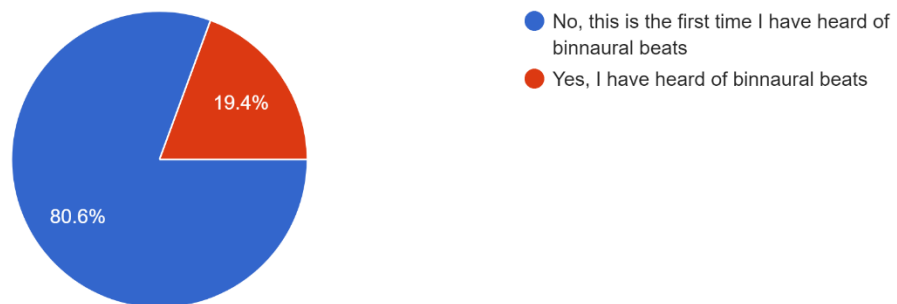
Data Point 36 – Students self reporting on whether they feel binaural beats helped them in memory test 2

Binaural Beats helped me in the memory test
98 responses



Data Point 37 – Students self reporting on whether they had heard of binaural beats before the experiment

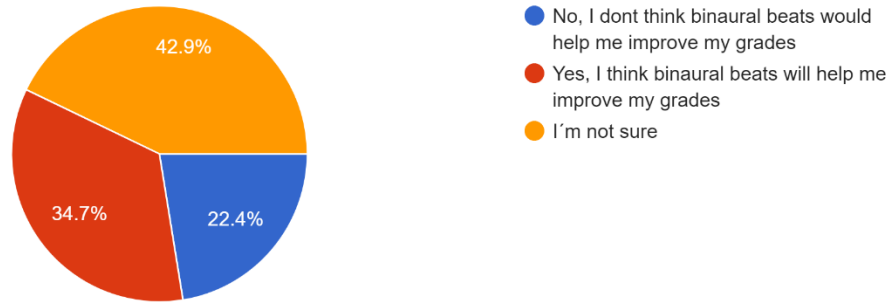
I had heard of binaural beats before the experiment
98 responses



Data Point 38 – Students self reporting on whether they think their grade will improve in the future

I think my grades will improve if I use binaural beats more in class or studying at home

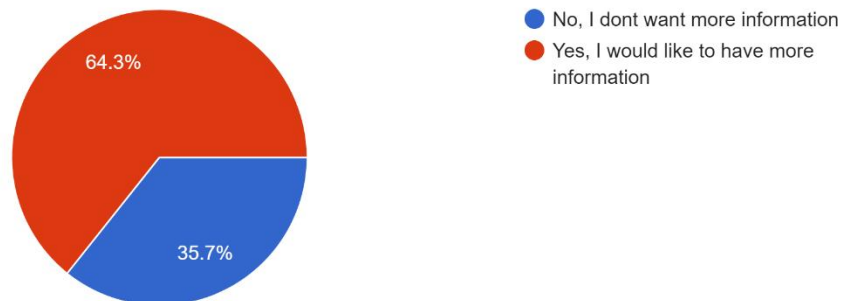
98 responses



Data Point 39 – Students self reporting on whether they would like more information about binaural beats

I would like to have more information about binaural beats

98 responses



Data Point 40 – Students giving qualitative feedback on their opinion on binaural beats

Optional -

What do you think of the concept of binaural beats? Did the sound annoy you? Has your opinion changed about binaural beats now that you understand why they are used? 8 responses

Henry, thank you so much! It is so interesting. My opinion about the binaural beats, has changed after the test.

When I was doing the test, the sound annoyed me, but now that I know that it can help me, maybe I will use it more.

I think it was a little bit disturbing, it gave me a headache

After doing the test I didn't think that the binaural beats help me to concentrate but after the presentation I think that maybe in the future I can try another time the binaural beats, and see if it's real that helps you to concentrate.

I didn't quite understand if the binaural beats have any bad consequences.

The sound annoyed me a lot!

Well at the start it's a torture, but when you get used to it, it's not so bad.

6. Analysis of Results

Key Results relating to the effectiveness of Binaural Beats

- Data point 14 & 16 - The quantitative data shows that overall binaural beats had a negative impact on the working memory on most students who participated in the study.
- In ESO 1 the mean score reduced from 10.32 to 9.68. The Median score reduced from 10.5 to 9 and the mode score declined from 12 to 6.
- In ESO 2 the mean score reduced from 15.08 to 13.32, the median reduced from 16 to 13
- In ESO 2 the mode score increased from 16 to 19.
- ESO 1 & ESO 2 collectively the mean scored declined from 12.6 to 11.4, the median score declined from 13 to 11 and the mode declined from 16 to 6.
- Data point 33 – showed a mixture of qualitative feedback on whether students thought “the sound” helped them during the test. Roughly 50% seemed to indicate the sound “helped me a lot” and “I did worst in the test but I felt more focussed”, other saying “the sound was annoying” or “gave me a headache”.

Changes in Opinion on Binaural Beats after Receiving 5-minute presentation on their (possible) Utility

- Data point 24 - 68.4% of the students understood the meaning of binaural beats after the presentation.
- Data point 35 - 45.9% of students reported that they will listen to binaural beats to help them with their focus and memory in the future.
- Data Point 36 - 40.8% of students said binaural beats didn't help them with the test, 39.8% said yes, the binaural beats helped them with the test and 19.4% said that they were not sure if the binaural beats helped them or not.
- Data Point 39 - 64.3% of students said that they would like more information on binaural beats in the future.

- Data point 40 - showed students had mix feedback about the utility of binaural beats, some students stated *"it's interesting...my opinion of the binaural beats, has changed after the test"* and *"it was a little disturbing, it gave me a headache"*.

Additional Results

Validity of the test

- Data Point 3 & 26- the majority of students self-reported that their focus was very similar before memory test 1 and memory test 2.
- Data Point 18 & 27 - the majority of students self-reported they found memory test 1 and memory test 2 equally difficult.

Sound when studying

- Data Point 4 - showed that the majority of students (58.3%) listen to music whilst studying.
- Data Point 11 - confirmed that out of all of the distractions listed, sound in class was the factor that most distracted students.
- Data Point 21 - 62.6% of students said that they were not distracted in the control test.
- Data Point 30 - 44.4% of students said it was difficult to do the test with "the sound" (Binaural Beats), 36.1% Disagreed and 19.4% were not sure.
- Data Point 31 - 70.4% of students said they found "the sound" (Binaural Beats) "strange"

Memory & Focus when studying

- Data Point 7 - showed that the majority of students feel memory is important to language learning.
- Data Point 12 - students repeatedly indicated distractions are plentiful in the classroom: *"other partners of my class that talk to me in the class"*, *"the temperature"*, *"when other people close to you don't work"*, *"my friends distract me..."*.

- Data Point 19 - showed that 54.8% of students felt that a “tool” could help them improve their focus.

7. Conclusions

Overall, the investigation found that binaural beats didn't improve the working memory of students in the English language classroom. There were, however, some interesting results which warrant future exploration.

The study achieved its aim to examine the use of binaural beats on working memory by creating two comprehensive data sets across 96 students which allowed for comparison between an initial memory test assessment (*test 1 - control*) and an experimental memory test using binaural beats (*test 2 - experimental*).

As both the control and experimental tests were successful in collecting sufficient evidence to gain comprehensive and reliable results it can also be argued that the second aim, to determine whether binaural beats can enhance academic performance in the classroom was also achieved. The quality of the tests is corroborated by data points 3 & 27 and 18 & 27 which confirm that both the control test and experimental test were equally difficult and students focus level before both of the tests were very similar. There was no significance external factor bias between the two tests.

The overall results however, contradicted the hypothesis based on the research by Colzato et al. (2015), and Wang et al. (2022) which suggested that the use of binaural beats would enhance working memory and lead to better academic outcomes. The results clearly showed the opposite. The use of binaural beats had a negative affect on the academic performance of the students.

8. Discussion

The overall results showed a decline in the mean, mode and median score in the ESO 1 class. The mean and median score also declined in the ESO 2 class however the mode score did increase, rising from 16 to 19, an increase of 18.75%. Overall, the results were contrary to those found by Colzato (2015) and Wang (2022).

It is interesting to consider why the results were so significantly different to previous studies and it's worth noting that the Wang (2022) and Colzato (2015) investigations were carried on adult participants. This investigation involved 11 and 12-year-old students and we can speculate that student immaturity might have played a role in the findings. This idea is partly corroborated by the fact that the only positive finding, the mode score increase in the ESO 2 class, was that found in the more mature students. Further evidence that binaural beats might work better in older participants is shown in data point 31 which confirmed that 70.4% reported that the sound was "strange" and additionally, data point 40 showed that some students were "disturbed" by the sound and or the sound gave them a "headache".

I personally, witnessed that that many of the students, particularly in the ESO 1, were distracted by the pure *novelty* of the *sound* and thus the results might not have been handicapped by the ESO 1 students to disrupt the class rather than focus on the task at hand. The fact that the classes were open plan, with 60 students in each class, compounded the novelty factor of study especially in the younger ESO 1 class.

The sound quality and volume were also factors that should be taken into account when reviewing the results of this study. It was extremely difficult to confirm the exact level of sound of the binaural beats that were given to the students. The students listened to a downloaded version of self-reported 40HZ binaural beats but the exact frequency of the beats were impossible to confirm before the investigation. Furthermore, students were asked to bring their own earphones for the test and instructed to play the volume to a low comfortable level. Garcia-Argibay (2019) outlined in his investigation that frequency was pivotal in the utility of binaural beats on long-term memory so we can speculate that it is equally important when

investigating binaural beats on working memory and perhaps this study fell short on providing the exact required frequency of binaural beats to the students.

Much of the additional evidence also supported the theory outlined in this investigation.

Data point 7 showed that students understand memory is important to language learning and data point 12 shows just how many factors students are conscious of as potential distractors in the classroom. These findings perfectly match Gignac's 2021 study of Barcelona students' observations of factors that distract them in class and adds weight to the fact that teachers need to address and help students focus in the additional language class and beyond. This is further proved by data point 19 which shows that 54.8 % of students would like a *tool* to help them focus better in class.

Data point 7 showed the majority of students are aware of the relationship between memory and learning an additional language. We can speculate that Cowan (2014) would be delighted at this finding. Students know that attention, focus and memory are fundamental to additional language learning.

This study has proved that students want to improve their focus, that they recognize that memory is important to language learning and would like a tool to be able to focus more. It is debatable whether that 40HZ binaural beats is the tool that they require, but the improvement to the more mature ESO 2s mode score offers a glimpse that it further investigation into binaural beats is required.

9. Limitations of the Study

As outlined, the investigation tried to exclude any potential bias throughout the testing but there were severe limitation in the study some of which are outlined below.

Testing

The memory tests were carried out on Quizziz, which generally ran smoothly. However, the students were automatically ranked in their class order whilst they took the test. This led to an unexpected competitiveness across both the ESO 1 and ESO 2 classes as the students were distracted by the possibility of moving up the leader board rather than solely focusing on the memory test. This was confirmed in qualitative feedback (data point 22) *“I was focused but the ranking kinda distracted me between questions”*.

Sound Quality and Volume

The quality of the sound was critical for the test, students were asked to bring their own earphones but the investigation could not fully account to the quality of the actual sound that students listened to.

Additionally, students were instructed to listen to the binaural beats at a low/comfortable level, but as the sound was new to them and it was challenging to ensure consistent volume levels and many students self-reported that the sound gave them a “headache” indicating they were probably playing the binaural beats too loudly.

Sound Source

The binaural beats sound was downloaded from a YouTube webpage which claimed to be 40 Hz cognitive beats. While the webpage seemed legitimate and had many users, there was no scientific way to verify that the sound was exactly what was advertised. This is a critical point that I couldn't control in this investigation.

Sample Size

The sample size was large which generally could be considered a positive, however the investigation was carried out in open-plan classrooms with around 60 students in class at

one time. This resulted in a lot of background noise which was made even more challenging, particularly during memory test 2 when the excitement of doing the memory test with a “strange” new sound.

English Level

It was challenging to gauge the memory test level questions to cater to all student abilities in both ESO 1 and ESO 2 classes. The idea was to use language that the students might recognize but not necessarily fully understand. However, as there was a broad range of ability in the class, with some students attending a language school some students might have known some of the key words beforehand potentially making the memory test unfair for them. Additionally, some students found filling out the questionnaires difficult as they did not fully understand the question that was being asked of them.

Future Research Opportunities

The investigation has demonstrated that students are interested and curious when presented with a potential tool to help them focus in class. Future research should develop student curiosity and explore ways to help students focus in class and improve their academic performance.

Future studies could review and improve upon the many limitations of this study. This could be done by simply guaranteeing the 40HZ binaural beats is played at the correct frequency and volume. Working with smaller groups which are easier to manage and carrying out multiple control and experimental tests across a greater number of students would also generate more useful findings. It would also be interesting to properly monitor and gauge the effects of binaural beats on students with language disabilities.

Future investigations might also consider exploring other frequency sounds with the potential to help students focus such as white, pink or brown noise.

The placebo effect in regards to binaural bears should also be explored. It would be interesting to measure the difference between students who are told the potential utility of binaural beats before doing the test and compare them to students who do a blind test.

Offering binaural beats, even if proved to only work as a placebo, might create an interesting space for students to settle, focus and study in an increasingly chaotic world. I believe that there is real value in the potential of using binaural beats in the additional language classroom and providing students with an opportunity to focus and improve their academic performance.

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Annex

Annex 1 – [Questionnaire 1](#)

Focus Questionnaire 1

A quick questionnaire to discover how you focus in class and whether you feel it's important to be focussed in class

southallhm@gmail.com [Switch accounts](#)

* Indicates required question

Email*

Your email address

Please write your full Name & Surname: *

Your answer

Please tick your age*

10

11

12

13

14

15

Other:

Please tick which class you're in*

I'm in ESO 1

I'm in ESO 2

How focussed do you feel right now?*

Not Focussed at all (I'm very distracted)

- 1
- 2
- 3
- 4
- 5

Extremely Focussed

Do other students distract you in class when you're trying to study?*

I am never distracted by other students

- 1
- 2
- 3
- 4
- 5

I find other students extremely distracting

If you study at home do you listen to music? *

Yes, I study with music

No, I never study with music

I study with other background sound on e.g. with the television playing in the background

I have a good memory for learning vocabulary*

I have a terrible memory

I have an excellent memory

Please rate your memory learning capacity for learning new vocabulary in the English class*

I have a terrible memory for learning new vocabulary

- 1
- 2
- 3
- 4
- 5

I have an excellent memory for learning vocabulary

On a daily basis, my focus in class varies a lot *

My focus never changes in class

- 1
- 2
- 3
- 4
- 5

Depending on the day my focus changes a lot

I feel memory is important to language learning *

Memory isn't important at all to language learning

- 1
- 2
- 3
- 4
- 5

Memory is very important to language learning

I wish I could focus more in class*

I strongly disagree

- 1
- 2
- 3
- 4
- 5

I strongly agree

I think I can improve my memory *

I disagree (it's impossible to improve memory)

- 1
- 2

3

4

5

I agree (I think it's easy to improve memory)

There is a strong relationship between memory and focus*

I disagree (there is no relationship between memory and focus)

1

2

3

4

5

I agree (there is a strong relationship between memory and focus)

I find different sounds / noises in class distracting *

I disagree (sounds dont distract me)

I agree (sounds are distracting)

Please tick the box that you feel most affects your concentration in class (Choose 1 Box)

Column 1

Teaching style / material / activity

Sounds in class

Nutrition (e.g. if you're hungry or not)

Energy (e.g. if you feel tired)

Teaching style / material / activity

Sounds in class

Nutrition (e.g. if you're hungry or not)

Energy (e.g. if you feel tired)

Optional -

Please specify any other factors that affect your attention (not already mentioned in this questionnaire)

Your answer

Annex 2 – Memory Game – Vocabulary Questions 1

Vocabulary List 1

adult		I think I became an adult when I left home.
arrangement		Have you made an arrangement for tomorrow morning?
attention		I didn't get as much attention as my brother when we were children.
bedcovers		I hid from my sister under the bedcovers.
boarding school		I was sent away to boarding school when I was eleven.
carbohydrates		Rice is an important source of carbohydrates.
childhood		I had a happy childhood.
close family		Do you think you have a close family?
decline		The results show a decline in traditional family structures.
depressed		After he lost his job he became really depressed.
emotional		She's really emotional and often cries.
extended family		I have a big extended family, including eighteen cousins!
extrovert		My dad is a real extrovert and loves meeting new people.
fight		My brother always wants to fight with me.
fresh		I bought some wonderful fresh fish today.

frozen		Have we got any frozen vegetables?
gang		I'm not comfortable with being one of a gang.
gathering		My parents have arranged a family gathering.
immediate family		How many people are there in your immediate family?
innocent		My sister hit me but my mum thought she was innocent.
intention		His intention is to study hard and go to university.
low-fat		Would you like a low-fat yoghurt?
mood		Don't talk to Barry today because he's in a bad mood.
newborn		That newborn baby is so tiny.
no wonder		My parents were always nicer to me so no wonder my sister hated me.
only child		I don't have any brothers or sisters – I'm an only child.
prediction		His prediction is that people will holiday in space in the near
promise		I made a promise to my father that I would look after my mother when he died.
protein		Meat is a good source of protein.
raw		I hate the taste of raw onions.
relative		I'm my mother's closest relative.
rivalry		There was a lot of rivalry between me and my sister when we were younger.
share		I share a lot of hobbies with my sister.
sick		He's been off sick for two weeks.
spicy		I love spicy Thai curries.

stressed	Richard works too hard and is always stressed.
suffocate	I remember my brother trying to suffocate me under the bedcovers.
tension	There was always a lot of tension in our house – our parents always argued.
value	Now that I am older I really value my parents.

Annex 3 – Quizizz Memory Test 1 (Control Test)

QUIZZ

Memory Test 1
20 Questions

NAME : _____

CLASS : _____

DATE : _____

1. I hid from my sister under the

<input type="checkbox"/> A Plant	<input type="checkbox"/> B Book
<input type="checkbox"/> C Lamp	<input type="checkbox"/> D Bedcovers

2. I was sent away to when I was eleven.

<input type="checkbox"/> A shopping	<input type="checkbox"/> B school
<input type="checkbox"/> C France	<input type="checkbox"/> D boarding school

3. Do you think you have a?

<input type="checkbox"/> A close family	<input type="checkbox"/> B dog
<input type="checkbox"/> C table	<input type="checkbox"/> D sandwich

4. I'm not comfortable with being one of a

<input type="checkbox"/> A team	<input type="checkbox"/> B fruit
<input type="checkbox"/> C football	<input type="checkbox"/> D gang

4. I'm not comfortable with being one of a

- | | | | |
|----------------------------|----------|----------------------------|-------|
| <input type="checkbox"/> A | team | <input type="checkbox"/> B | fruit |
| <input type="checkbox"/> C | football | <input type="checkbox"/> D | gang |

5. I hate the taste of onions.

- | | | | |
|----------------------------|-----------|----------------------------|--------|
| <input type="checkbox"/> A | crude | <input type="checkbox"/> B | cooked |
| <input type="checkbox"/> C | delicious | <input type="checkbox"/> D | raw |

6. I loveThai curries.

- | | | | |
|----------------------------|-------|----------------------------|-----------|
| <input type="checkbox"/> A | spicy | <input type="checkbox"/> B | delicious |
| <input type="checkbox"/> C | weak | <input type="checkbox"/> D | hot |

7. His is that people will holiday in space in the near

- | | | | |
|----------------------------|------------|----------------------------|-----------|
| <input type="checkbox"/> A | prediction | <input type="checkbox"/> B | knowledge |
| <input type="checkbox"/> C | idea | <input type="checkbox"/> D | decision |

8. The results show a in traditional family structures.

- | | | | |
|----------------------------|-------------|----------------------------|-----------|
| <input type="checkbox"/> A | improvement | <input type="checkbox"/> B | decline |
| <input type="checkbox"/> C | boom | <input type="checkbox"/> D | downwards |

9. I bought some wonderful fish today.

- | | | | |
|----------------------------|--------|----------------------------|-------|
| <input type="checkbox"/> A | tasty | <input type="checkbox"/> B | hot |
| <input type="checkbox"/> C | hungry | <input type="checkbox"/> D | fresh |

10. I had a happy

- | | | | |
|----------------------------|-----------|----------------------------|-----------|
| <input type="checkbox"/> A | childhood | <input type="checkbox"/> B | adulthood |
| <input type="checkbox"/> C | fish | <input type="checkbox"/> D | party |

11. Have you made an for tomorrow morning?

- | | | | |
|----------------------------|-----------|----------------------------|-------------|
| <input type="checkbox"/> A | meeting | <input type="checkbox"/> B | activity |
| <input type="checkbox"/> C | appetizer | <input type="checkbox"/> D | arrangement |

12. My parents were always nicer to me so my sister hated me.

- | | | | |
|----------------------------|-----------|----------------------------|-----------|
| <input type="checkbox"/> A | indeed | <input type="checkbox"/> B | therefore |
| <input type="checkbox"/> C | of course | <input type="checkbox"/> D | no wonder |

13. There was a lot of between me and my sister when we were younger.

- | | | | |
|----------------------------|-----------|----------------------------|---------|
| <input type="checkbox"/> A | hatred | <input type="checkbox"/> B | anger |
| <input type="checkbox"/> C | tiredness | <input type="checkbox"/> D | rivalry |

14. His is that people will holiday in space in the near future.

- | | | | |
|----------------------------|------------|----------------------------|-------------|
| <input type="checkbox"/> A | prediction | <input type="checkbox"/> B | imagination |
| <input type="checkbox"/> C | idea | <input type="checkbox"/> D | concept |

15. I'm my mother's closest
- | | | | |
|----------------------------|----------|----------------------------|-----------|
| <input type="checkbox"/> A | relative | <input type="checkbox"/> B | neighbour |
| <input type="checkbox"/> C | nephew | <input type="checkbox"/> D | friend |
16. I remember my brother trying to me under the bedcovers.
- | | | | |
|----------------------------|-----------|----------------------------|-------|
| <input type="checkbox"/> A | silence | <input type="checkbox"/> B | drown |
| <input type="checkbox"/> C | suffocate | <input type="checkbox"/> D | hurt |
17. Now that I am older I really my parents.
- | | | | |
|----------------------------|--------|----------------------------|-------|
| <input type="checkbox"/> A | price | <input type="checkbox"/> B | like |
| <input type="checkbox"/> C | afford | <input type="checkbox"/> D | value |
18. I made a to my father that I would look after my mother when he died.
- | | | | |
|----------------------------|----------|----------------------------|------------|
| <input type="checkbox"/> A | promise | <input type="checkbox"/> B | compromise |
| <input type="checkbox"/> C | argument | <input type="checkbox"/> D | suggestion |
19. I don't have any brothers or sisters - I'm an
- | | | | |
|----------------------------|---------------|----------------------------|------------|
| <input type="checkbox"/> A | adult | <input type="checkbox"/> B | only child |
| <input type="checkbox"/> C | single person | <input type="checkbox"/> D | niece |
20. I think I became an when I left home.
- | | | | |
|----------------------------|-----------|----------------------------|-------------------|
| <input type="checkbox"/> A | exception | <input type="checkbox"/> B | exciting |
| <input type="checkbox"/> C | adult | <input type="checkbox"/> D | extre-terrestrial |

Annex 4 – Questionnaire 2

Focus Questionnaire 2

Focus Questionnaire 2

southallhm@gmail.com [Switch accounts](#)

* Indicates required question

Email*

Your email address

Please write your full Name & Surname*

Your answer

Please tick your age*

10

11

12

13

14

15

Other

Please tick the correct option

I'm in ESO 1

I'm in ESO 2

During the test I felt very focussed *

I disagree (I didnt feel focussed)

I agree (I felt focussed)

How difficult was the test?*

The test was easy

- 1
- 2
- 3
- 4
- 5

The test was hard

I wish I had a tool that could help me focus more on the test*

I disagree (I dont need a tool to help me with the test)

I agree (I would like a way to help me focuss)

My opinion on my memory has changed since doing the test*

My opinion on my memory has changed

My opinion on my memory is the same

Test like these are important in English language learning*

I agree

I disagree

I was distracted in the test*

I disagree (I wasn't distracted in the test)

I agree (I was distracted in the test)

Please tick the option that you feel best describes your focuss in the test*

I was not distracted in the test

My colleagues distracted me in the test

Other sounds distracted me in the test

I was distracted in the test by something else (I felt tired, I was hungry etc..)

Optional -

Please add any additional information about your level of focus in the test

Your answer

Annex 5 – Questionnaire 3

Focus Questionnaire 3

A quick questionnaire to discover how you focus in class and whether you feel it's important to be focussed in class

southallhm@gmail.com [Switch accounts](#)

* Indicates required question

Email*

Your email address

Please write your full Name & Surname:*

Your answer

Please tick your age*

10

11

12

13

14

15

Other:

Please tick which class you're in*

I'm in ESO 1

I'm in ESO 2

How focussed do you feel right now?*

Not Focussed at all (I'm very distracted)

- 1
- 2
- 3
- 4
- 5

Extremely Focussed

On a daily basis, my focus in class varies a lot*

My focuss never changes in class

- 1
- 2
- 3
- 4
- 5

Depending on the day my focus changes a lot

I feel more focussed in class today than I did in last week's memory test*

I disagree (I feel less focussed in class today than last week)

I agree (I feel more focussed today in class than last week)

I feel the same focuss today in class as I did last week

I'm not sure if I am focussed or not

Other:

I would like the teachers to help me focus in class*

I disagree (I dont need the teachers to help me focus)

I agree (I need the teachers to help me focus)

I'm not sure if I need help with focus

I would like to improve my memory*

I disagree (I dont need to improve my memory)

I agree (I need to improve my memory)

I'm not sure if I need to improve my memory)

I think I will get a better test score on my memory test today than I did last week*

I disagree (I don't think I will get a better test score)

I agree (I think I will get a better test score)

I think I will get the same test score

I'm not sure

Optional -

Please specify why you feel you will do better in this week's memory test

Your answer

Annex 6 – Binaural Beats

https://www.youtube.com/watch?v=1_G60OdEzXs&t=754s&ab_channel=BeInspired%7CTUDIO

Annex 7 – Vocabulary List 2

Vocabulary List 2

amazed		I was amazed to hear that Bob is getting married.
boiling		It's boiling at the moment – 34 degrees Celsius!
boutique		She works in a designer clothes boutique.
broke		I was always broke when I was a student.
cheque		I wrote a cheque for £300.
consecutive		She ran three consecutive marathons in 23 hours and 50 minutes.
contract		We signed the contract.
current		I had to paddle against the current.

delicious		The food was delicious.
delighted		My parents are delighted that I'm getting married.
dyslexia		My son can't read very well because he has dyslexia.
enormous		His house is enormous and has six bedrooms.
exhausted		I was exhausted after the race.
exhaustion		I suffered from heat exhaustion.
fantastic		I've had a fantastic time here.
figures		He calculated figures in his head.
filthy		John's kitchen is filthy.
freezing		The sea was freezing so we didn't swim.
furious		Maria is furious that you didn't invite her to your birthday party.
gamble		Starting my own business was a bit of a gamble.
go on sale		When will his new book go on sale?
hilarious		The film was hilarious – we laughed so much.
humidity		The humidity here is 80 per cent in the summer.
infested		The river is infested with crocodiles.
inspire		I've been listening to power ballads to inspire me.
kayak		Why did you agree to kayak down the Amazon?
make money		I want to make money from my paintings.
millionaire		Jeff became a millionaire, but lost most of his money.
paddle		We used a wooden paddle to move the boat.

positive		Did you have a positive experience when you went abroad?
put aside		Every week, I put aside some money for a holiday.
recession		Our business lost a lot of money during the recession.
risky		This is a very risky trip.
sponsor		She asked me to sponsor her for a charity programme.
starving		I was starving when I came home from school.
suffer		I really suffer in hot weather.
target		100 kms per day is my target.
terrified		Are there any animals that you're terrified of?
tiny		My flat is really tiny with only two rooms.

Annex 8 – Memory Game 2

QUIZZZ	NAME : _____
Memory Test 2	CLASS : _____
20 Questions	DATE : _____

1. She works in a designer clothes

<input type="checkbox"/> A place	<input type="checkbox"/> B boutique
<input type="checkbox"/> C current	<input type="checkbox"/> D shop
2. She ran three marathons in 23 hours and 50 minutes.

<input type="checkbox"/> A difficult	<input type="checkbox"/> B long
<input type="checkbox"/> C consecutive	<input type="checkbox"/> D current
3. I was always when I was a student.

<input type="checkbox"/> A rich	<input type="checkbox"/> B broke
<input type="checkbox"/> C tired	<input type="checkbox"/> D happy
4. I wrote a for £300.

<input type="checkbox"/> A payment	<input type="checkbox"/> B note
<input type="checkbox"/> C cheque	<input type="checkbox"/> D money

5. The food was

- | | | | |
|----------------------------|-----------|----------------------------|-----------|
| <input type="checkbox"/> A | tasty | <input type="checkbox"/> B | excellent |
| <input type="checkbox"/> C | delicious | <input type="checkbox"/> D | sweet |

6. His house is and has six bedrooms.

- | | | | |
|----------------------------|----------|----------------------------|-------------|
| <input type="checkbox"/> A | enormous | <input type="checkbox"/> B | expensive |
| <input type="checkbox"/> C | big | <input type="checkbox"/> D | comfortable |

7. I suffered from heat

- | | | | |
|----------------------------|------------|----------------------------|------------|
| <input type="checkbox"/> A | exhaustion | <input type="checkbox"/> B | excitement |
| <input type="checkbox"/> C | stroke | <input type="checkbox"/> D | tiredness |

8. He calculated in his head.

- | | | | |
|----------------------------|-----------------|----------------------------|---------|
| <input type="checkbox"/> A | multiplications | <input type="checkbox"/> B | numbers |
| <input type="checkbox"/> C | answers | <input type="checkbox"/> D | figures |

9. John's kitchen is

- | | | | |
|----------------------------|--------|----------------------------|----------|
| <input type="checkbox"/> A | clean | <input type="checkbox"/> B | enormous |
| <input type="checkbox"/> C | filthy | <input type="checkbox"/> D | dirty |

10. Starting my own business was a bit of a

- | | |
|-------------------------------------|---------------------------------------|
| <input type="checkbox"/> A exciting | <input type="checkbox"/> B gamble |
| <input type="checkbox"/> C risk | <input type="checkbox"/> D experience |

11. When will his new book

- | | |
|---------------------------------------|---|
| <input type="checkbox"/> A go on time | <input type="checkbox"/> B be interesting |
| <input type="checkbox"/> C be good | <input type="checkbox"/> D go on sale |

12. The river is with crocodiles.

- | | |
|-------------------------------------|---------------------------------------|
| <input type="checkbox"/> A full | <input type="checkbox"/> B implicated |
| <input type="checkbox"/> C infested | <input type="checkbox"/> D long |

13. We used a wooden to move the boat.

- | | |
|-----------------------------------|-----------------------------------|
| <input type="checkbox"/> A paddle | <input type="checkbox"/> B object |
| <input type="checkbox"/> C oar | <input type="checkbox"/> D kayak |

14. Our business lost a lot of money during the

- | | |
|--------------------------------------|------------------------------------|
| <input type="checkbox"/> A recession | <input type="checkbox"/> B decline |
| <input type="checkbox"/> C crisis | <input type="checkbox"/> D sale |

15. I was when I came home from school.

- | | |
|-------------------------------------|------------------------------------|
| <input type="checkbox"/> A starving | <input type="checkbox"/> B annoyed |
| <input type="checkbox"/> C tired | <input type="checkbox"/> D hungry |

16. 100 kms per day is my
- | | | | |
|----------------------------|--------|----------------------------|------------|
| <input type="checkbox"/> A | run | <input type="checkbox"/> B | distance |
| <input type="checkbox"/> C | target | <input type="checkbox"/> D | trajectory |
17. My flat is really with only two rooms.
- | | | | |
|----------------------------|---------|----------------------------|------|
| <input type="checkbox"/> A | massive | <input type="checkbox"/> B | big |
| <input type="checkbox"/> C | small | <input type="checkbox"/> D | tiny |
18. We signed the
- | | | | |
|----------------------------|------|----------------------------|----------|
| <input type="checkbox"/> A | book | <input type="checkbox"/> B | company |
| <input type="checkbox"/> C | deal | <input type="checkbox"/> D | contract |
19. I've had a time here.
- | | | | |
|----------------------------|-----------|----------------------------|----------|
| <input type="checkbox"/> A | great | <input type="checkbox"/> B | funny |
| <input type="checkbox"/> C | fantastic | <input type="checkbox"/> D | fabulous |
20. I want to from my paintings.
- | | | | |
|----------------------------|--------------|----------------------------|------------|
| <input type="checkbox"/> A | make friends | <input type="checkbox"/> B | make money |
| <input type="checkbox"/> C | enjoy views | <input type="checkbox"/> D | do art |

Annex 9- Questionnaire 4

Focus Questionnaire 4

Focus Questionnaire 2

southallhm@gmail.com [Switch accounts](#)

* Indicates required question

Email*

Your email address

Please write your full Name & Surname*

Your answer

Please tick your age*

10

11

12

13

14

15

Other

Please tick the correct option*

I'm in ESO 1

I'm in ESO 2

During the test I felt very focussed*

I disagree (I didnt feel focussed)

I agree (I felt focussed)

I'm not sure

How difficult was the test?*

The test was easy

1

2

3

4

5

The test was hard

The sound I was asked to listen to made me more focussed on the memory test*

I disagree (the sound was distracting)

I agree (the sound made me more focussed)

I'm not sure

Other:

My opinion on my memory has changed since doing the test*

My opinion on my memory has changed

My opinion on my memory is the same

My opinion is the same

Please tick the option that you feel best describes your focuss in the test*

I was not distracted in the test

My colleagues distracted me in the test

The sound distracted me in the test

I was distracted in the test by something else (I felt tired, I was hungry etc..)

The sound I heard during the test helped me focus*

The sound didnt help me focuss

1

2

3

4

5

The sound helped me focuss a lot

It was difficult to do the test whilst listening to the sound*

I disagree (it wasn't difficult to listen to the sound whilst doing the test)

I agree (it was difficult to listen to the sound whilst doing the test)

I'm not sure

I would like to listen to the sound again whilst doing the test*

I disagree (I wouldn't listen to the sound again)

I agree (I would like to listen to the sound)

I'm not sure

The sound helped me focus more in the test and for this reason I think I did better in the memory test*

I disagree (I think I did worse in the test because of the sound)

I agree (I think I did better in the test because of the sound)

I'm not sure

I think I did better in the test for a different reason (not the sound)

The sound helped me improve my level of focus*

The sound didnt help me focus

1

2

3

4

5

The sound helped me focus a lot

The sound was very strange*

I disagree (I didnt mind the sound)

I agree (the sound was strange)

I'm not sure

I would listen to the sound again to help me focus*

I disagree (I wont use the sound again to help me focuss)

I agree (The sound really helped me focus)

I'm not sure

Optional -

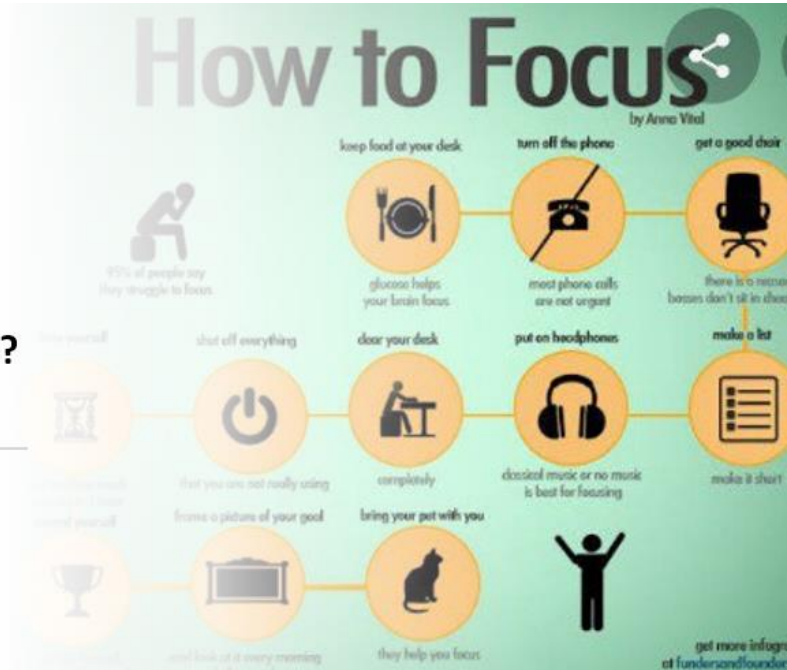
Please add any additional information about the sound, whether you liked the sound and whether you think the sound helped you with the memory test

Your answer

Annex 10 – Presentation on Binaural Beats

How can Binaural Beats be used to Improve Memory in the Additional Language classroom?

Henry Southall
Ramon Lull University



What are Binaural Beats?



- Mins: 0:00 – 1:05
- https://www.youtube.com/watch?v=QQQsoSM1XIg&t=14s&ab_channel=Infinite

- Source:
https://www.youtube.com/watch?v=QQQsoSM1XIg&t=14s&ab_channel=Infinite

What are Binaural Beats?

When two beats of slightly different frequency (for instance 300 and 340 Hz) are presented separately to the left and right ears, the hearer detects a single beat that differs in amplitude at a frequency equal to the frequency difference between the two beats (40 Hz); [this] perceptual illusion [is] known as the binaural auditory beat.

Colzato LS et al (2017)

BINAURAL BEATS EXPLAINED

CASCADE
NEUROSCIENCE CENTER
FOR TRAINING & RESEARCH

WHAT ARE BINAURAL BEATS?



Binaural beats are created by playing one tonal frequency in your left ear and a slightly different frequency in your right ear. The difference in tones creates an auditory illusion of a third tone in our brains – also known as a **binaural beat**.



Based on the difference in frequencies or Hz, we can recreate specific brainwaves to support our goals.



Brainwave entrainment is the theory that our brains naturally sync to the frequency of external stimuli.

Theory

- “An increasing number of studies have suggested that BB [Binaural Beats] can be used to alter or **enhance** cognitive processes.”
- “The reason may lie in the fact that BB deal with cognitive aspects, such as attention, **focusing** and **memory**. In particular, BB mobilize more attentional resources and perceptual arousal (i.e., more complex) brain responses, with an increased distribution of cortical activity.”

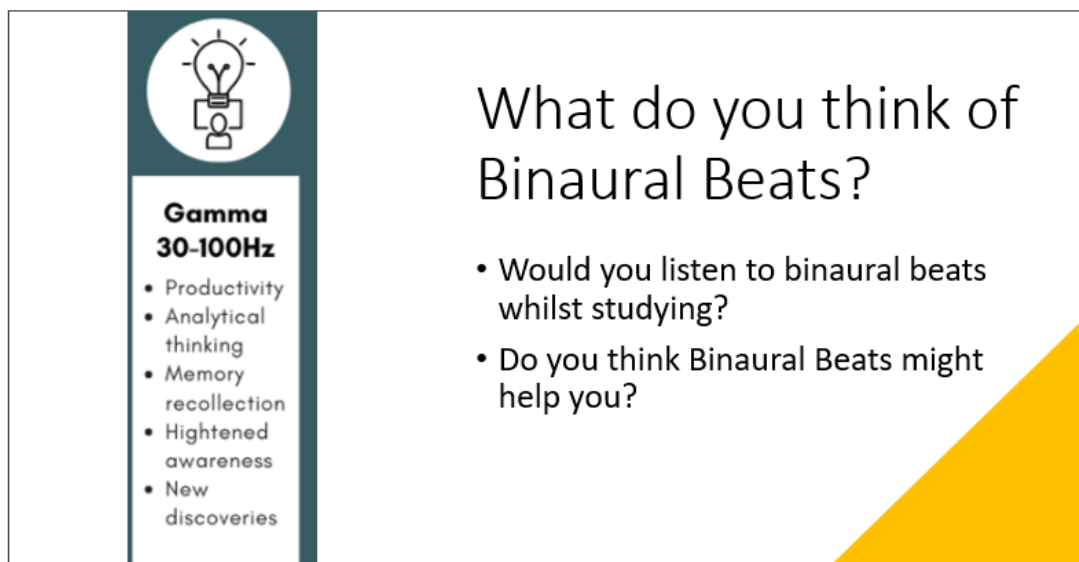
Wang, Lei et al (2022)

WHAT DOES
YOUR BRAND SOUND
LIKE?



Colzato's Investigation

- *The study included* - Thirty-six students (22 female, 14 male; aged 18–28 years old) from Leiden University
- He found high-frequency binaural beats did have a significant impact on the global precedence effect suggesting that **visual attention became more focused** than in the control condition.
- beats in the gamma range achieve this effect by **increasing attentional focusing**....



Gamma 30-100Hz

- Productivity
- Analytical thinking
- Memory recollection
- Heightened awareness
- New discoveries

What do you think of Binaural Beats?

- Would you listen to binaural beats whilst studying?
- Do you think Binaural Beats might help you?

Annex 11 – Questionnaire 5

Focus Questionnaire 5

Focus Questionnaire 2

southallhm@gmail.com [Switch accounts](#)

* Indicates required question

Email*

Your email address

Please write your full Name & Surname*

Your answer

Please tick your age*

10

11

12

13

14

15

Other

Please tick the correct option*

I'm in ESO 1

I'm in ESO 2

I understand what Binaural Beats are*

I disagree (I don't understand what they are)

I agree (I understand what binnaural beats are)

I'm not sure

Now that I understand how Binaural Beats work, I will listen to them when studying as it might help me improve my focus and memory*

I disagree (I wont use binnaural beats)

I agree (I will use binnaural beats)

I'm not sure

I don't understand what binaural beats are

Binaural Beats helped me in the memory test*

No, binaural beats didn't help me in the test

Yes, binaural beats helped me in the test

I'm not sure

I think binaural beats can help me focus and improve my memory whilst studying*

I don't think binaural beats can help me with my memory and focus

1

2

3

4

5

I think binaural beats can help me improve my memory and focus a lot

I had heard of binaural beats before the experiment*

No, this is the first time I have heard of binaural beats

Yes, I have heard of binaural beats

I think my grades will improve if I use binaural beats more in class or studying at home*

No, I don't think binaural beats would help me improve my grades

Yes, I think binaural beats will help me improve my grades

I'm not sure

My opinion has changed about "the sound" (Binaural beats) since the presentation*

No, my opinion hasn't changed

Yes, my opinion has changed

I'm not sure

I would like to use binaural beats in the future*

No, I won't use binaural beats in the future

Yes, I will use binaural beats in the future

I'm not sure

I would have preferred to not listen to binaural beats during the test*

No, I liked listening to binaural beats

Yes, I liked listening to binaural beats

I'm not sure

I think binaural beats has the potential to help me with my future studies

No, I disagree - binaural beats wont help me

Yes, I agree - binaural beats will help me

I'm not sure

I would like to have more information about binaural beats*

No, I dont want more information

Yes, I would like to have more information

Optional -

What do you think of the concept of binnaura beats? Did the sound annoy you? Has your opinion changed about binnaural beats now that you understand why they are used?

Your answer