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REVIEW

Digital drugs (binaural beats): how can it affect the brain/their impact on the brain

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ABSTRACT

To understand the principal functioning of binaural beats signals and the way it can affect the brain, eight drugs were used. This study was carried out on three groups: the first one contains four binaural beats signals, each one refers to a specific tone: alpha, beta, theta, and delta waves. The second group holds three records, representing three separate meditation binaural beats; however, the third one contains only one record that stands for the Marijuana e-drugs. Two types of analyses were performed on these groups, the temporal and the frequency analyses. In the first one, Hilbert transform was used to detect the envelope of the signal; we then determined the cross correlation function to understand the relationship between the two signals of the left and the right ears. However, in the frequency analysis, Fast Fourier Transform (FFT) was applied to extract binaural and carrier frequencies. The obtained results are very satisfactory and show that there is a delay between the two signals of the left and the right ears. Nevertheless, the frequency analysis shows that in the second group, Solfeggio frequencies lambda, theta and delta waves are used to obtain the meditation state, were gamma, lambda, alpha, and delta waves are applied to get the Marijuana effect in the third group.

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1. Introduction

Coming straight from the United States, digital drugs (e-drug or binaural beats) are a natural process that uses specific sound frequencies to synchronise the right and left hemispheres of the brain. The process steps are as follow: being blindfold, wearing a headset lecturing an mp3 file: a "simple" mix of sound frequencies that serve as a dose. The peculiarity of this drug is that he's 100% legal since it doesn't need to be smoked or injected into the blood.

Discovered in Germany in 1839: that hearing two sounds of slightly different frequency in each ear effect the brain waves and thus trigger some kind of sound; which's equal to difference between the two frequencies (Figure 1). This new frequency can change the brainwaves rhythm.

It can find his place in the medical field as legal drug; to reduce anxiety, increases creativity and boosts intellectual performance using Solfeggio frequencies and Leonard Horowitz, limits the doses of anaesthesia and immerses the subject between a waking state and a dream state. Nevertheless, it may be dangerous for users too, it causes the hallucinogenic sensations, bad perception of dreams, may be the cause of psychosis, heart problems (tachycardia or serious heart attack when the subject already has antecedents), vagal discomfort due to hyperventilation, and adverse effects on the brain in the medium and long term.

On the websites, we have found a wide selection of "e-dose" with different effects that vary with frequency, amplitude and duration.

Many studies tried to analyse and determine the effect of binaural beats on the brain, such as Nantawachara et al. [1]. They investigated the effect of a 3 Hz binaural beat on sleep stages, which's considered a behavioural state. They allocated two groups: experimental and control groups. The experimental period was three consecutive nights consisting of an adaptation night, a baseline night, and an experimental night. The results showed that the N3 duration of the experimental group was longer than the control group, and the N2 duration of the experimental group was shorter than the control group. Moreover, the N3 latency of the experimental group was shorter.

Jakub et al. [2] explored the effect of binaural beats on working memory capacity (WMC). In this study, they divided the participants into two groups. One

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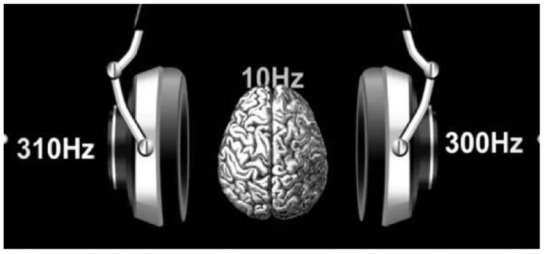

Figure 1. Principle of operation of binaural beats.

group underwent a binaural beat stimulation while listening to the sound of the sea; the other one was listening solely to the sound of the sea without binaural beat stimulation. After measuring the baseline and post-stimulation working memory capacity using the OSPAN method, they noticed that only participants from the binaural beat group showed an improvement in WMC.

The study of Singh et al. [3], was based on the physiological markers of psychological stress assessed by the galvanic skin response (GSR), heart rate (HR), and electroencephalography (EEG). They conclude that the EEG signal correlates of mental stress are unique superimposed pattern of various cognitive domains. With sustained and continuing stress resulting from computer game attention, alertness and performance starts declining.

Christine et al. [4], determined the effects of different acoustic stimulation conditions on participant response accuracy and cortical network topology, as measured by EEG recordings, during a visuospatial working memory task. Three acoustic stimulation control conditions and three binaural beat stimulation conditions were used: None, Pure Tone, Classical Music, 5 Hz binaural beats, 10 Hz binaural beats, and 15 Hz binaural beats. They found that listening to 15 Hz binaural beats during a visuospatial working memory task not only increased the response accuracy, but also modified the strengths of the cortical networks during the task. The three auditory control conditions and the 5 and 10 Hz binaural beats all decreased accuracy. Based on graphical network analyses, the cortical activity during 15 Hz binaural beats produced networks characteristic of high information transfer with consistent connection strengths throughout the visuospatial working memory task.

Kennerly et al. [5] utilised Beta frequency binaural-beat audio signals to investigate facilitation of human performance on two memory tasks and two memory related tasks. The results indicate that beta frequency binaural-beat audio signals are an effective method for facilitating simple free recall memory, ability to attend, and the ability to persevere at routine motor tasks.

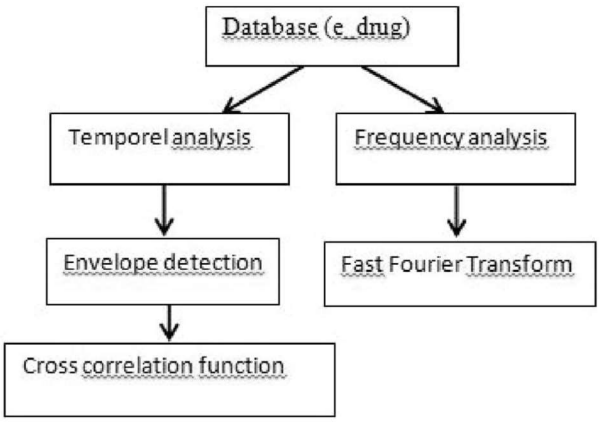

Figure 2. Block diagram of the proposed method.

In this paper, we analysed the binaural beats signals that represent the alpha, beta, theta delta waves, meditation binaural beats and the Marijuana e-drugs to determine if only the binaural frequency affect the brain or other parameters as well. For this aim, we applied two algorithms: the first one used Hilbert transform to detect the envelope of the signal and to determine the cross correlation function; for the second one Fast Fourier Transform (FFT) was applied to extract frequencies that can affect the brain.

2. Method

The block diagram below (Figure 2) illustrate the proposed approach, which includes five steps:

- Database
- Temporal analysis:
  1. Envelope detection
  2. cross correlation function
- Frequency analysis: Fourier Transform (FFT)

2.1. Database

In this work, we obtained our binaural beat signals from the site www.soundcloud.com [6]. The used signals are available for free download.

We listed three groups: the first one contains four signals. One frequency for each: Alpha, Beta, Theta, or Delta wave. The alpha waves signal 10 Hz, beta waves "Calming music for studying" 14 Hz, theta waves "Shamanic healing 5.5 Hz theta waves", and delta waves "Binaural beats 2 Hz delta waves".

The second one is used as a biomedical application, holds the meditation binaural beat representing signals. We utilised three signals: "meditation beat",

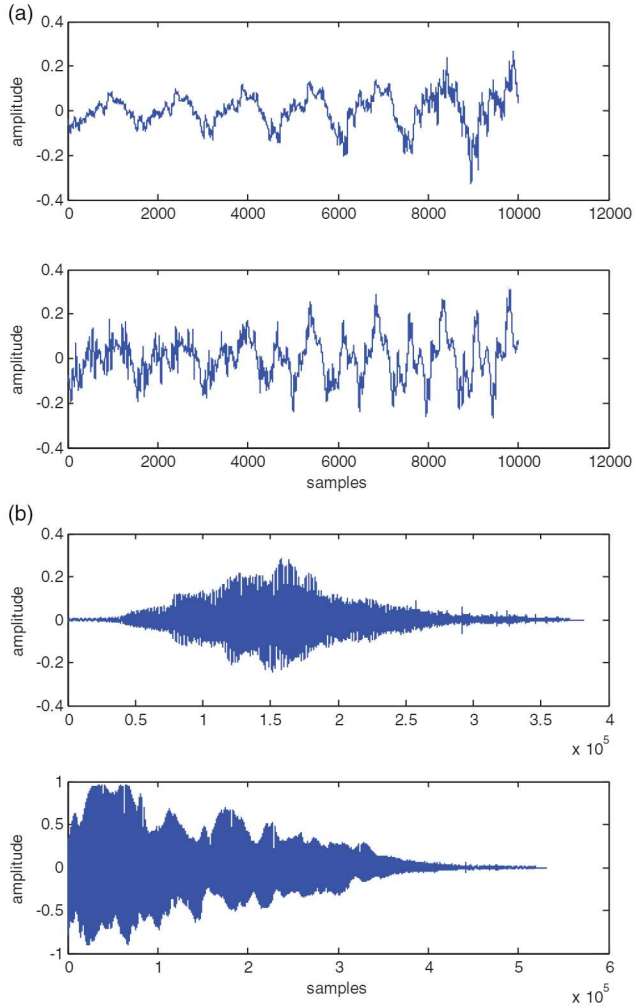

Figure 3. A part of signal of right and the left ear, a) part of signal from the second phase, b) part of signal from the last phase of the record "marijuana/Mubz Beats/Free Beat".

"binaural beats for meditation theta and delta wave", and "chakra meditation wave". For the third group, we used a harmful application, where we employed only one signal, which represents the Marijuana drug beats. The name is "marijuana/Mubz Beats/Free Beat". It is available for free download from the same site. Each signal has its own sampling frequency.

2.2. Parameters extraction

The study of sound has given birth to three different models of representations: temporal representation, frequency representation, and spectrogram representation, each of particular interest. In this work, we used the temporal and the frequency analyses to study and extract the parameters that affect the brain.

In fact, the temporal analysis shows the sound signal intensity evolution over time (Figure 3), however the frequency analysis gives us information about the frequency content.

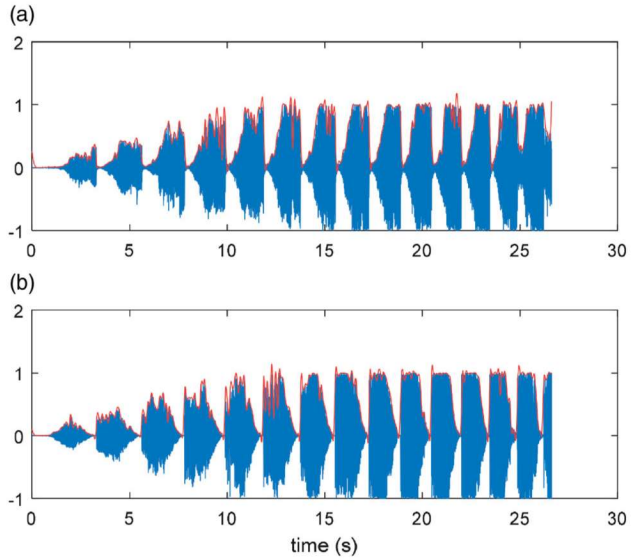

Figure 4. (a): signal of right ear, (b): signal of the left ear, blue line: intensity of the signal, red line: the envelope of the signal "marijuana/Mubz Beats/Free Beat".

2.3. Temporal analysis

We first detected the envelope of the signal, because of her important role in the perception of speech, then we determined the cross correlation in order to assess the relationship between the two signals.

2.3.1. Envelope detection

We used the analytic signal magnitude given by the Hilbert Transform to extract the signal envelope (Figures 4–6).

The analytic signal can capture the slowly varying features of the signal (envelope of the signal), while the phase contains the high-frequency information (carrier frequency) [7].

The analytic signal $x_a(t)$ of signal $x(t)$ is given by Equation (1).

$$x_a = F^{-1}(F(x)2U) = x + iy \tag{1}$$

Where: F: The Fourier transform; U: The unit step function; Y: The Hilbert transform of x [7].

To generate peak envelopes we used spline interpolationover local maxima of the analytic signal separated by an adjustable number of samples, and to smooth's the envelope, we spreaded out the samples. For more details, see [8]. In Figure 4, the blue line shows the evolution of the intensity of a speech sound over time (carrier signal); meanwhile; the red line shows the envelope.

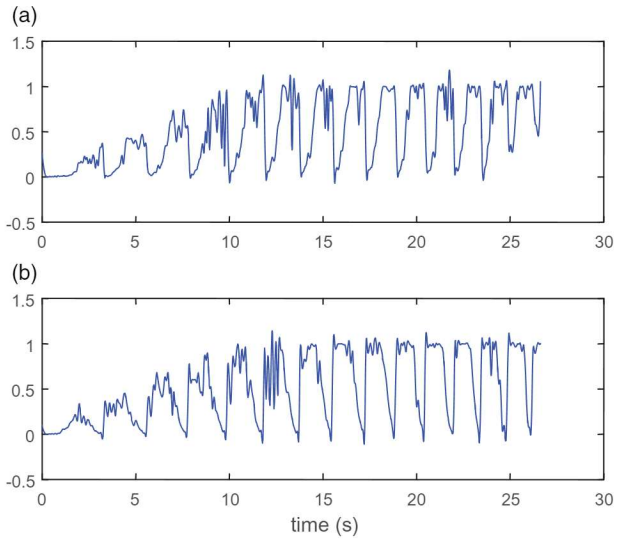

Figure 5. Envelope detection using Hilbert Transform of the record "marijuana/Mubz Beats/Free Beat".

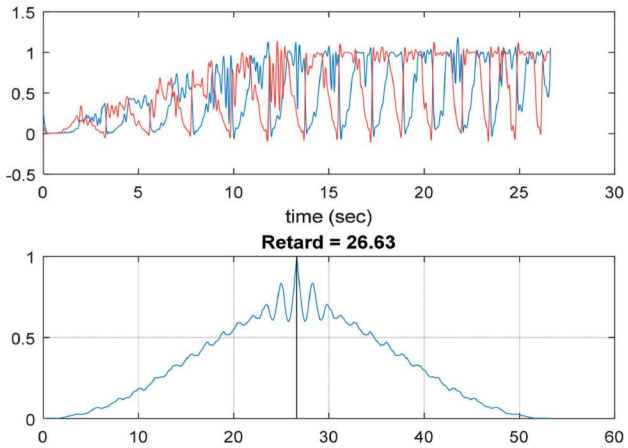

Figure 6. Cross correlation between the envelope signals of the right and the left ears.

2.3.2. Cross correlation function

In order to evaluate the relationship between the signals of the right and the left ear, we determine the crosscorrelation function. Given by the equation (2).

$$C_{xy}(\tau) = \frac{1}{N-\tau}\sum_{i=1}^{N-\tau}\left(\frac{x_i-\bar{x}}{\sigma_x}\right)\left(\frac{y_{i+\tau}-\bar{y}}{\sigma_y}\right) \quad (2)$$

where $\bar{x}$ and σ_x represent the average and the variance of the signal x, and τ is the delay between the two signals x and y. The cross correlation function take its values between zero (x and y are independent) and one (x and y are completely dependent).

2.4. Frequency (or spectral) analysis

This representation makes it possible to visualise the frequency composition of a sound and the intensity of each frequency. In this paper, we used the Fast Fourier Transform (FFT).

The FFT of the signal x(t) is given by the Equation (3).

$$X(f) = \int_{-\infty}^{+\infty} x(t)e^{-j2\pi ft}dt \quad (3)$$

In the group A, the FFT is applied only on a part of each series; because it contains only one tone, and the signal doesn't change over time. However in group B and C, the series are segmented in different phases; because the frequency do change over time to facilitate the transition from phase to another, until we reach the desired phase.

The Figure 3 shows the second and the last phase of the record "Marijuana/Mubz Beats/Free Beat".

3. Result and discussion

We implemented and applied the proposed algorithm on the three groups. The obtained results are discussed in the following sections.

3.1. Temporal analysis

The cross correlation function (Figure 6) shows in all the records, that there is a delay between the both sounds i.e. when the amplitude of the signal of the right ear is maximum; the amplitude of the signal of the left ear is zero.

This delay leads the brain to focus on the firstsignal (right ear), when its magnitude is maximum; so the person can focus using only one hemisphere. Then it focus on the second signal (left ear), when the magnitude of the first signal is zero and the amplitude of the second is maximum; so the person can focus using the second hemisphere.

We might suggest that this delay is very important in the first phase of each signal to delete all the natural brainwaves, and to give it new frequencies, which correspond to binaural beats. i.e. when the brain lose control and can't generate waves, it will take binaural beats waves.

3.2. Frequency analysis

We estimated the spectrum on different frequency bands. Lambda waves are relative to all the $\geq$100 Hz frequencies; the Lambda state appears to be kind of a secretive state, shrouded in a bit of mystery; which make sense as it's incidentally tied to the Tibetan meditation tradition. Lambda is often associated with

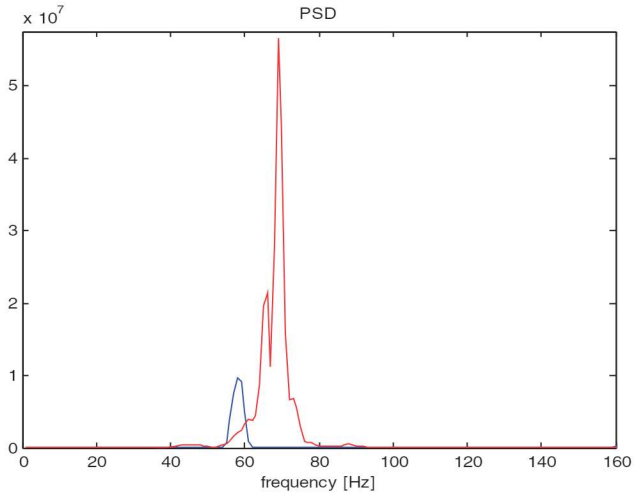

Figure 7. Power spectral density of record "Alpha wave signal 10 Hz".

a moment of discovery. The Gamma waves vary in a $[40-100]$ Hz frequency band and results from the hyperactivity of the brain; beta waves correspond to the frequencies [13–40]Hz; results from the state of an attentive subject, with open eyes; the alpha waves frequencies turn around [8–13]Hz and results from a state of relaxed awakening. The theta waves fluctuate between [4–8]Hz, which results from a light sleep state. While, the delta wave correspond to [0–4]Hz, results from a state of deep sleep, and the epsilon waves change between [0.1–0.5] Hz and results from an extraordinary state of consciousness, one of a much higher awareness.

In the other hand, we notice that there is a slightly difference in frequencies between the signal of the right and left ear, as it is illustrated in Figure 7. This difference is named "binaural beats frequencies".

The obtained results of all the used records are shown in Table 1.

Most of the explanation given in this work, was based and taken from the website "https://free-binaural-beats.com/frequency-list/" [9], and refers to the bibliography "http://www.lunarsight.com/biblio.htm" [10].

3.2.1. Group A

The obtained results shows only one carrier frequency 68 Hz and a binaural beat 10 Hz in "Alpha wave signal 10 Hz"; which represents the frequency of a healthy human body [x]. However, the binaural beat gives a sense of well being, since it enhances and release the serotonin that has a similar role to that of hormones, it decrease pain and elevate the mood. It acts on the nervous system and various actions, especially in the regulation of certain behaviours such as mood or emotion. "She lived in suffering and therefore in depression". As well on sleep, sexual and eating disorders, the reason why it is commonly called the "happiness hormone". This is the safest frequency and it is considered as an analgesic and anti-convusant.

In the record "calming music for studying 14 Hz", the carrier frequency is 145 Hz which supports strength of will and focussed energy, however the binaural beat is 14 Hz which makes brain in a waking state and enhances the concentration on tasks.

In "Shamanic healing 5.5 Hz" record, the based frequency is 160 Hz. Used to relieve headaches; however, binaural frequency is 5.5 Hz (theta wave); it induces relaxation, meditation and produces Enkephalins which inhibits the messages of pain to the brain.

In the record "Binaural beats 2 Hz", the carrier frequency is 111 Hz, releases Beta Endorphines which have an analgesic role and provide a feeling of well-being.

The binaural beat is 2 Hz (delta wave); it gives a sense of relaxation, pain relief, and produces the endogenous opiates. It can be used for sedative effect as well.

3.2.2. Group B

In the three records they used Solfeggio frequencies set as a carrier frequencies (852, 417 and 432 Hz) respectively. In the first record the frequency 852 allows us to let go the fear, overthinking and worries, the second one cleans the negative energy, however, the third one gives us a deepest healing.

We found three binaural beats in the first record a 0.5, 1.5 and 4 Hz. The 0.5 Hz is used for relaxing, and to produce the endogenous opiates, 1.5 Hz is a universal healing rate, while, 4 Hz is used to produce Enkephalin.

3.2.3. Group C

The first 5 min (phase 1) begins with different carrier frequencies and different binaural beats that shifts each 2 s. This phase is very important to unbalance the brain, which leads to an inability of focussing.

The phase 2 lasts 10 min, the carrier frequency is 360 Hz paired with a binaural frequency of 9 Hz. The 360 Hz is used to stimulate sensitivity, creativity, and femininity, while, 9 Hz is associated with sacral Chakra, it affect relationships, and loss the equilibrium of the brain. In the third phase, the base frequency shifts to 41 M Hz and is paired with 2.5 and 9 Hz. 41 MHz corresponds to diseases such cancer, as it is determined by Robert O, and BekerBroché in him book "the body electric". 2.5 Hz is used to stimulate the relationship energy.

Table 1. Carrier frequencies and binaural beats of each signal.

Group	Record	Carrier frequency (Hz)	Binaural tone (Hz)
Group A	Alpha wave signal 10Hz	68	10
	Beta wave "calming music for studying" 14 Hz	145	14
	Theta wave "Shamanic healing 5.5 Hz"	160	5.5
	Delta wave "Binaural beats 2 Hz"	111	2
Group B	Meditation beat	852	0.5–1.5–4
	Binaural beats for meditation theta and delta wave	417	0.5–2–5
	Chakra meditation wave	432	0.5–1.5–4.5
Group C	Marijuana /Mubz Beats/Free Beats	58–43–360–41.106	2.5 – 9

4. Conclusion

Binaural beats is a phenomenon that affect the brain when we introduce two different frequencies to each ear. It is a two-edged sword. It let us feel better just by stimulating the happiness hormones, such as serotonin, using alpha waves; and δ waves to relax more deeply and quickly; accelerates our personal development, increases our capacity attention and concentration using β waves. Yet, it also effects the rhythm of the brain waves, causing a state of trance or euphoria, and stimulate some hormones, which leads to different sensations such as the frequency 9 Hz. In this study, we demonstrated how works the binaurals beats and how these frequencies and the carrier frequency can affect the brain function.

In the light of the analysis of some signals and the observations made on the waves binaural, we could consider several perspectives of application to this theory as: to evaluate in the management of anxiety disorders, depressive disorders, trauma, certain personality disorders, and to overcome addiction.

"**Compliance with Ethical Standards**"

- No, I have nothing to report
- This study was not funded by any party: it is an academic PhD study
- No conflict of interest
- No animal or other used in this study

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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