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Research Article

REWIRING THE FRONTAL LOBE: COULD EDUCATIONAL GAMES BE A SOLUTION FOR DRUG ADDICTION?

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ABSTRACT

Responses, senses, movement, emotions, language, communication, thinking, and memory are the responsibility of that complicated organ of nervous tissue: the brain. The part that is mainly responsible for cognitive function is the frontal lobe, where all our movements, tasks, and skills are related to it. Drug addiction has many effects on the frontal lobe because it affects self-control and behavioral monitoring, emotion regulation, motivation, awareness and self-analysis, attention and flexibility, memory, learning, and decision making. Thus the primary objective of this study is to investigate if we can rewire the frontal lobe by using educational games. Brain waves were measured using an "EmotivEpoc" machine for a group of students (5 students) from Safir High School-aged between 12 and 16 years old. The brain waves measurement was divided into two stages; the first stage: Measuring the brain waves in a relaxed state, the second stage: Measuring brain waves while playing an educational game (3 levels from easy to expert), and an interview with a doctor specialist in addiction treatment was done. The average power band and P-values for Beta H. and Gamma waves from six electrodes on frontal location between the two stages were calculated. The results show significant P-values ($P<0.05$) mainly in AF3, F7, and F8, and noticeable differences in the average power band in Beta H. and Gamma waves between relaxation state and when playing educational games at the six sensor locations (AF3, F7, F3, F4. F8 and AF4).

INTRODUCTION

Responses, senses, movement, emotions, language, communication, thinking, and memory are the responsibility of that complicated organ of nervous tissue: the brain. The brain consists of 3 parts: brain stem, cerebellum, and cerebrum (Maldonado & Alsayouri, 2021). Cerebrum, the largest part of the brain, consists of two cerebral hemispheres: the inner layer (white matter) and the outer layer (gray matter) called cortex (Jawabri& Sharma, 2021). Cerebral cortex is a thin layer that covers the outer portion of the cerebrum (1.5mm to 5mm). It is divided into 4 lobes: occipital lobe, temporal lobe, parietal lobe, and frontal lobe (Bailey & Regina, 2021).

Frontal lobe*:* (Front Section)

Blaise Pascal (1623 – 1662), French philosopher, writer, inventor, physicist, and mathematician, said: "I can well conceive a man without hands, feet, and head. But I cannot conceive man without thought; he would be a stone or a brute". Frontal lobe is the lobe that makes us humans.

Location

Location of Frontal lobe

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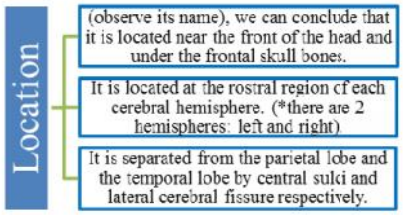
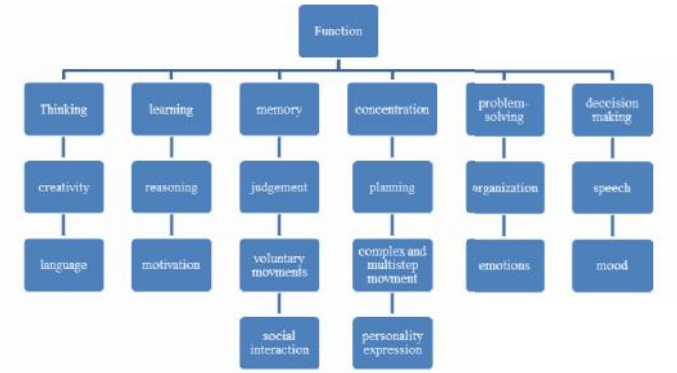


Doc.1 Frontal Lobe Location

Size

It is the largest between the four mentioned lobes. It comprises about one-third of the cerebrum.

Function: (Cognitive Control)



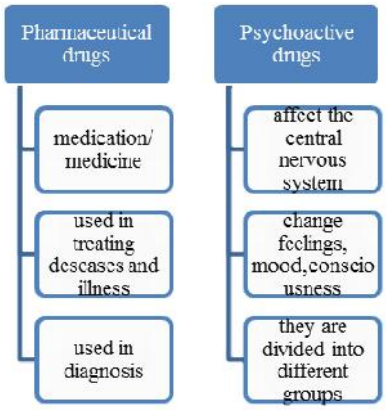
Doc.2 Frontal Lobe Function

Drug Addiction

"Substance dependence" is the term used by The World Health Organization and The American Psychiatric Association instead of "Drug Addiction".

Types: There are two types of drugs: Pharmaceutical drugs and psychoactive drugs.

Action: Nida (2018) argues that when people take drugs, their brain's "reward circuit" is affected. A chemical messenger (neurotransmitter) named "dopamine" is secreted leading to euphoria. The flooding of dopamine in the reward circuit causes a motivation to repeat the action again and again because dopamine leads to reinforcement of pleasurable including bad behaviors like drugs.



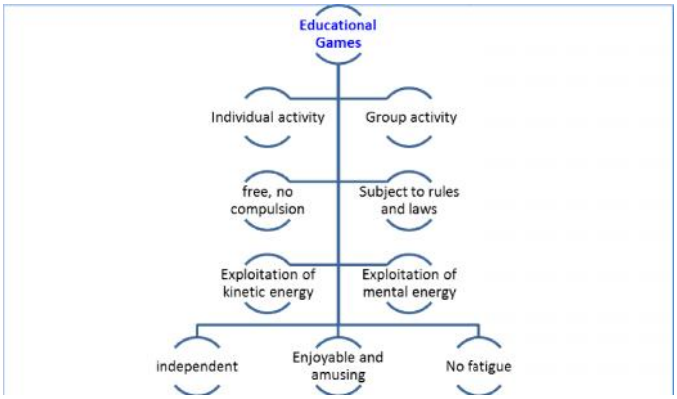
Doc.3 Drugs Type

Effects of drug addiction on Frontal Lobe

Drug addiction has many effects on the frontal lobe because it affects self-control and behavioral monitoring, emotion regulation, motivation, awareness and self-analysis, attention and flexibility, memory, learning, and decision making (Goldstein &Volkow, 2011).

- ***Self-control and behavioral monitoring:*** Drug addiction leads to impulsivity (inappropriate, inordinately behaviors or actions) causing risk behaviors. Add to that, it causes compulsivity (repeating actions that have harmful consequences). Also drug addiction affects the person's ability to monitor or regulate self-emotions, personality and behaviors to be unaware of their effects on situations or environment (Self-monitoring)
- ***Emotion regulation:*** Drug addiction increases the stress level and it puts the person in a state of being unable to suppress emotional intensity.
- ***Motivation:*** The frontal lobe, in a state of drug addiction, motivates the person to take drugs. On the other hand, it reduces other goals' motivation.
- ***Awareness and self-analysis:*** Addicted people deny their illness and refuse the treatment. In addition, drugs reduce satiety.
- ***Attention and flexibility:*** Drug addiction increases the attention towards drugs and its stimuli far away from other fields.
- ***Memory:*** Strong memory created toward drugs, while a weak one formed for other things.
- ***Learning:*** Drugs decrease the ability to reinforce non-drug, and it leads to drug conditioning.
- ***Decision making:*** An addicted person prefers immediate reward on delayed gains. Also, he has no exact predictions or plans.

- **Educational Games**
- **Characteristics:**



Doc.4 Educational Games Characteristics

Examples

Doc.5 Educational Games Examples

METHODOLOGY

- Interview with a Doctor: Specialist in Addiction Treatment

An interview with Dr. Hassan Bourji was done, a specialist in psychiatry and drug addiction treatment and the manager at Shifaa Specialty Hospital – Aaramoun

Interview with a Doctor: Specialist in Addiction Treatment

Interview with Dr. Hassan Bourji, a specialist in psychiatry and drug addiction treatment and the manager at Shifaa Specialty Hospital – Aaramoun, and is this what we get:

1. **What types of drugs cause addiction, and which chemical components cause it?**
   Dr. Hassan Bourji said that there are about 10 types of drugs, each has its own structure and effects, which a person can be addicted to, and he mentioned some: alcohol, cannabis, caffeine, stimulants (type) such as cocaine and amphetamine, hallucinogens ((type) such as PCP "Primary care physician" and phencyclidine and LSD and MDMA "Methylenedioxy methamphetamine", inhalants… The components of these substances that leads to addiction differs, for example we have alcohol: ethanol, hallucinogens: magic mushrooms…
2. **When do we say that this person is an addicted person?**
   Dr. Bourji explained that according to DSM-5 (Diagnostic and Statistical Manual of Mental Disorders) there are specific criteria they refer to such as:
   1. consuming a large amount of drugs
   2. consuming lounger time in obtaining, recovering and using the drugs
   3. using in hazardous situations
   4. drug tolerance (willing to have higher doses of drugs to have the same effect of the first use)
   5. Withdrawal symptoms like: diaphoresis, nausea, vomiting…
   6. has no ability to stop drugs or control taking it
   7. Failing to fulfill his main roles in society, home, work…
   8. changing in behavior

   And he explained that the symptoms differ from one substance to another. For example:
   - alcohol → ataxia
   - sedatives → becomes sedated
   - hallucinogens→ hallucination/ hear sounds…
3. **How does drug addiction affect brain activity?**
   Concentrating on the main point that each substance (drug) has a different structure and effects, Dr. Bourji illustrates the effects of stimulants (type of drugs) in increasing the activity of the brain for short time by the secretion of large amount of hormones. For the long period, there will be no neurons. On the contrary, some types of drugs decrease the activity of the brain, slow the neurotransmission, and decrease the ability to achieve tasks in the day. And as we can see, an addicted person talks slowly, walks slowly, and can't think. Add to that, he showed the bad effects of drugs on cognition (mental actions) where it causes deterioration and deficit. Also, he explained that an addicted person has thought blocking, delayed answers, no focus, no concentration, short memory, and in advanced stages judgment and insight. In general, and if the substances differ, in a way or another they all will cause sedation and malfunction of the brain.
4. **Which brain lobe is mostly affected by drugs?**
   Dr. Bourji justified that the frontal lobe is the most affected lobe; using the functional MRI (Magnetic resonance imaging: measures brain activity by detecting changes associated with blood flow) we can observe how frontal lobe function is affected. Add to that, the emotions, irritability, and the impulsivity resulting from drug addiction show that the frontal lobe is mostly affected lobe in the brain.
5. **How many brain waves are stimulated in the brain? Does drug addiction stimulate a specific type of brain wave?**
   There are 5 brain waves: Alpha, Beta, Gamma, Theta, and Delta, Dr. Bourji said. He explained the significance of each:
   - Alpha: normal state
   - Beta: more work/ busy
   - Gamma: high processing/ concentration
   - Theta: deeply relaxed
   - Delta: sleep state

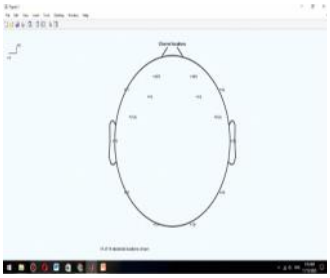
   For drugs, Dr. Bourji explained that for stimulants (type of drugs) Beta and Gamma are observed where we see that the brain is motivated to work and think; but this is for an instant, or short time. And he added that having Gamma and Beta for a long time leads to damage. After

long term drug taking, Theta and Delta are the dominant brain waves.

6. **In your opinion, after or parallel to the biological therapy, what kind of physical and mental therapy should be performed by the addicted people?**
   Dr. Hassan explained the process of the biological treatment, and then he talked about the importance of modifying the pattern of thinking that leads the person to addiction, using psychotherapies. After that he mentioned some activities that stimulate high-performance for the brain such as: watching the news, reading newspapers, enrolling in university, doing sports…
7. **Educational games are one of the most known thinking games that activate higher-order thinking processes; do you think educational games can be a part of drug addiction treatment?**
   Dr. Hassan welcomed the idea and confirmed its importance in the treatment if it was proved. He compared an addicted person to a child because educational games can motivate the brain to reorganize the form of thoughts and the content of these thoughts in order to help the addicted person to think logically and solve problems.

- Measuring Brain Waves

The brain waves were measured using an "EmotivEpoc" machine for a group of students (5 students) from Safir High School aged between 12 and 16 years old. The brain waves measurement was divided into two stages; First stage: Measuring the brain waves in a relax state, Second stage: Measuring brain waves while playing an educational game (3 levels from easy to expert).



Doc.6 Sensors Location

EmotivEpoc machine: It is an EEG (Electroencephalogram) that studies the brain signals via BCI (Brain Computer Interphase). It has 14 electrodes that are distributed on the four main lobes of the brain (frontal, parietal, occipital, temporal). In this research, the frontal lobe sensors were used

The following 6 sensors locations have been detected and analyzed:

	Sensor	Brain Region	Specific area	Function
1.	AF3	Left Frontal lobe		Higher mental thinking
2.	AF4	Right Frontal lobe		Higher mental thinking
3.	F7	L. Frontal lobe	triangular (part of Broca's area on left hemisphere)	Higher mental thinking
4.	F8	R. Frontal lobe	opercular (part of Broca's area on left hemisphere)	Higher mental thinking
5.	F3	L. Frontal lobe	intermediate frontal (includes Frontal eye fields)	Motor function area (eye movement and orientation), and initiation of voluntary muscles.
6.	F4	R. Frontal lobe		Motor function area (eye movement and orientation) and initiation of voluntary muscles.

Doc. 7 Rush Hour Game

Educational game: The game chosen is "Rush Hour". The aim of this game is to get out the "red" car from the traffic jam. It includes the game board, cars, and cards (From easy to expert). We chose 3 cards from 3 different levels. To remark the game suits and benefits all ages.

Results

Table 1 Average power band and P-value of "Beta H. waves" during Playing game and Relax

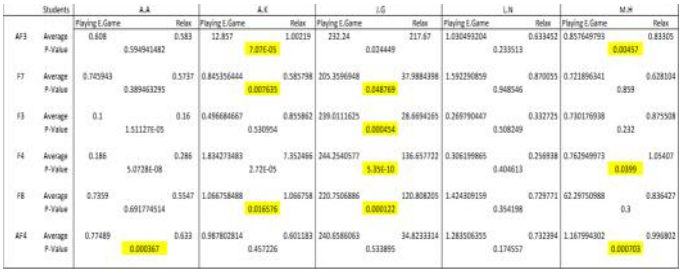
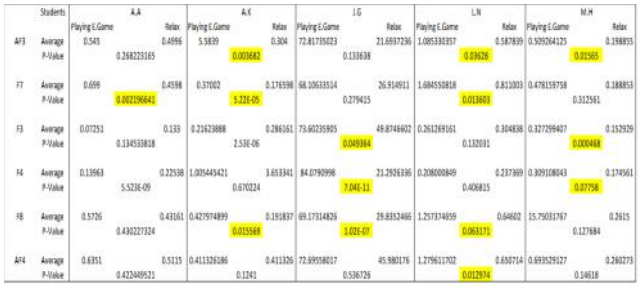


Table 2 Average power band and P-value of "Gamma waves" during Playing game and Relax.



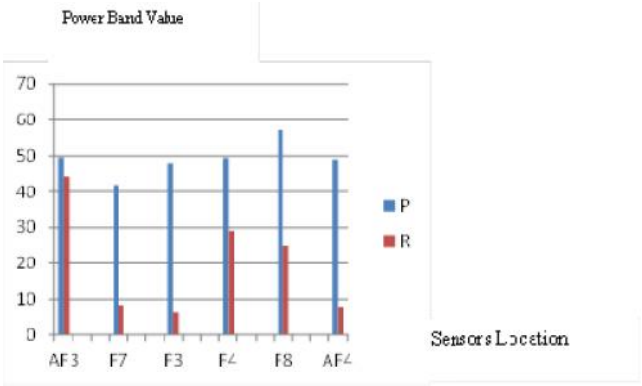
Students		AA		AK		JG		LN		MH	
		Playing E.Game	Relax	Playing E.Game	Relax	Playing E.Game	Relax	Playing E.Game	Relax	Playing E.Game	Relax
AF3	Average	0.545	0.4996	5.5839	0.304	72.81735023	21.6937236	1.085330357	0.587839	0.929264125	0.198935
	P-Value	0.268223165		0.003682		0.133638		0.03628		0.01565	
F7	Average	0.699	0.4598	0.37002	0.176598	68.10633514	26.914911	1.684550818	0.811003	0.478158758	0.188853
	P-Value	0.002196641		5.22E-05		0.279415		0.013603		0.312561	
F3	Average	0.07253	0.133	0.21623888	0.286161	73.60235905	49.8744602	0.261269161	0.304838	0.327299407	0.152929
	P-Value	0.134553818		2.53E-06		0.049364		0.132031		0.000488	
F4	Average	0.13963	0.22538	1.005445421	1.653341	84.0790998	21.2926336	0.208000849	0.237369	0.309108043	0.174561
	P-Value	5.523E-09		0.670224		7.04E-11		0.406815		0.07758	
F8	Average	0.5726	0.43161	0.427974899	0.191837	69.17314826	29.8352466	1.253734659	0.64602	15.75031767	0.2615
	P-Value	0.430227324		0.015569		1.02E-07		0.063171		0.127684	
AF4	Average	0.6351	0.5115	0.411326386	0.411326	72.69558017	45.980176	1.279611702	0.650714	0.693529127	0.260273
	P-Value	0.422449521		0.1241		0.536726		0.012974		0.14618	

Power Band Value

Legend

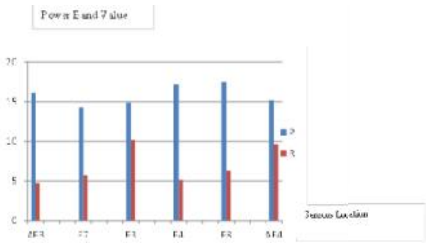
significant P-value < 0.05 with higher power band average for Playing E.Game

Histogram 1: The average power band variation at different sensor locations in "Beta Waves"



Histogram 2: The average power band variation at different

Legends: P: Playing Educational game; R: Relaxed



DISCUSSION AND CONCLUSION

The results show significant P-values (P<0.05) mainly in AF3, F7, and F8, and the histograms show noticeable differences in the average power band in Beta H. and Gamma waves between relaxation state and when playing educational games at the six sensor locations (AF3, F7, F3, F4. F8, and AF4). This means that Educational games can contribute to high Beta H. and Gamma waves in the brain leading to rewiring and activating the frontal lobe. The Gamma waves stimulated by the educational games will lead to enhancing long-term memory according to Friedrich (2015) by enhancing brain plasticity. Moreover according to Herman *et al*. Gamma waves are responsible for cognitive function. Beta waves are involved in conscious thoughts and logical thinking and tend to have stimulating effects, and having the right amount of beta waves allows us to focus. This means that by stimulating Gamma and Beta H. waves, through educational games, higher-order thinking is activated. In conclusion, educational games are significant tools to stimulate the gamma waves in the brain and rewiring again the frontal lobe. Further than that, Educational games could be a significant tool in treating the damaged frontal lobe of an addicted person.

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