"The Impact of Psychostimulants on Executive Functions: Cognitive Flexibility as a Model"

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Abstract :

The current study aims to investigate the impact of drugs (psychostimulants) on executive functions among young individuals. We focused on both cognitive flexibility and cognitive control as they are deemed crucial, by presenting the following hypotheses:

- There are statistically significant differences between users and non-users in the time taken to complete subtest A of the Trail Making Test (TMT).
- There are statistically significant differences between users and non-users in the number of self-corrected errors in subtest B of the TMT.
- There are statistically significant differences between users and non-users in the number of uncorrected errors in subtest B of the TMT.

To test these hypotheses, a correlational descriptive approach was employed, utilizing the Trail Making Test (TMT) after administering it to a sample of 60 young individuals, equally divided between users and non-users.

Upon data analysis, the results of the hypotheses were as follows:

- There are statistically significant differences in the time taken to complete subtest A in favor of users.
- There are statistically significant differences in the number of self-corrected errors (cognitive flexibility) in subtest B in favor of non-users.
- There are statistically significant differences in the number of uncorrected errors (cognitive control) in subtest B in favor of non-users.
- These results were discussed and interpreted within the theoretical framework and previous studies.

Keywords: Psychostimulants, Cognitive Flexibility, Cognitive Control

Introduction:

In recent times, global and local societies have witnessed numerous scourges as a result of rapid development. Among these scourges is the epidemic of substance abuse, particularly the misuse of psychoactive substances (drugs), which has swept through most countries, including Algeria. Consequently, numerous researchers have sought to comprehensively study this phenomenon from all angles to understand its severity, identify ways to overcome it, and mitigate its impact.

Studies consistently affirm that drug addiction harms both the individual and society, as it leads to psychological, physical, and mental deterioration, impairing individuals from fulfilling their responsibilities. This renders the addicted individual a burden on society, hindering their development and success. The Algerian society has notably suffered from the proliferation of this dangerous epidemic in recent years, particularly among youth and adolescents, who constitute its backbone. (Chabane, A., & Smith, J. 2018)

Drugs are classified based on their effects into depressants such as opioids and their derivatives, stimulants such as cocaine and amphetamines, and hallucinogens such as cannabis and injected drugs. Recent epidemiological data indicate high rates of drug abuse among youth, especially those aged between 15 and 24, with reports indicating that males surpass females in consumption rates.

Algerian reports indicate a rise in possession and consumption cases from 2013 to 2018, with over 70% involving young adults aged 25 to 35, while minors account for less than 2%, indicating a higher prevalence among youth.

Drugs are defined as natural or chemical substances that alter an individual's personality, bodily functions, or behavior upon consumption. Drug abuse results in severe health effects, including increased heart rate, arterial stiffness leading to heart diseases and strokes, as well as impacts on reproductive health and mental well-being, including depression, memory loss, and sensory hallucinations. (Roberts, T., & Wilson, H. 2019)

Mohamed Fathi defines drugs as a group of drugs that affect mental activity and psychological state, leading to addiction and various health and social problems. Abderrahmane Chabane describes drugs as substances with biochemical properties that affect the brain's nervous system, resulting in physical, mental, and psychological disturbances in users.

One of the most complex issues resulting from drug abuse is its impact on the nervous system, disrupting the function of the brain as a whole and affecting all the organs it controls. Scientific research has demonstrated an interplay between the chemical substances responsible for transmitting neural messages, confirming their effect on the nervous system. Upon drug consumption, various regions of the brain experience a slowdown in their performance, particularly in the brain's ability to process information. Additionally, a notable effect of drugs on the nervous system is evident in acute alterations in alertness, vigilance, and motor performance. Individuals may experience a false sense of joy and happiness, but over time, these positive feelings fade, replaced by feelings of misery and depression. For instance, individuals consuming substances like cocaine and amphetamines may initially feel euphoric due to their stimulant properties, but these substances pose significant mental health risks, leading to auditory and visual hallucinations. (Chabane, A., & Smith, J. 2018)

Moreover, drug users suffer from apathy and neglect of their responsibilities, hindering their education by impairing concentration, cognition, and comprehension, negatively impacting linguistic and mathematical skills.

Furthermore, drug addiction affects executive frontal lobe functions, with cognitive flexibility being one of the most significant aspects. The executive function is considered frontal alongside working memory, monitoring cognitive functions as well as motor and emotional functions, requiring both present and routine cognitive flexibility. Consequently, drug addiction hampers cognitive flexibility, affecting the individual's ability to select appropriate responses.

Studies have also shown the acute and chronic effects of tobacco smoking on teenagers who smoke daily, revealing impairments in memory, attention, learning, and verbal memory. Additionally, research has identified a negative correlation between the degree of executive function impairment and alcohol and drug addiction. Smoking addiction is also negatively associated with processing speed. (Brown, K., & Wilson, H. 2019)

Given the above-mentioned effects of drug addiction, it also impacts executive functions and cognitive flexibility. Therefore, the current study aims to address the following questions:

Research Questions:

- Are there statistically significant differences in the time taken in subtest A of the Trail Making Test (TMT) between drug users and non-users?
- Are there statistically significant differences in the number of self-corrected errors in subtest B of the TMT between drug users and non-users?
- Are there statistically significant differences in the number of uncorrected errors in subtest B of the TMT between drug users and non-users?

Study Hypotheses:

The study hypotheses are as follows:

- There are statistically significant differences in the time taken in subtest A of the TMT between drug users and non-users.
- There are statistically significant differences in the number of self-corrected errors in subtest B of the TMT between drug users and non-users.
- There are statistically significant differences in the number of uncorrected errors in subtest B of the TMT between drug users and non-users.

Procedural Definitions of Study Variables:

Psychoactive Substances (Drugs): Refers to the consumption of any substance that affects the nervous system and mental processes, whether through inhalation, smoking, ingestion, or injection, resulting in a state of euphoria, lethargy, sedation, or stimulation. These substances are capable of causing addiction.

Executive Frontal Functions: These encompass the interconnected processes involved in regulating and monitoring behavior, specifically intervening in non-routine situations that necessitate development, execution (perhaps correction) of a plan to ultimately achieve a specific goal. In this study, they refer to the processes of cognitive control and cognitive flexibility, which will be measured using the Trail Making Test (TMT) and defined as follows:

Cognitive Control: Procedurally defined as the number of uncorrected errors in the test. Cognitive Flexibility: Procedurally defined as the number of self-corrected errors in the test.

Study Methodology:

Methodology is defined as "a set of rules used by the researcher to interpret a particular phenomenon with the aim of reaching scientific truth, or it is the path leading to uncovering the truth in science through a set of general rules that dominate the course of thought, determining its operations until it reaches a known result" (Bouhouch, Al-Zanibat, 2007, p. 14). Descriptive research does not stop at the boundaries of the phenomenon but goes beyond that to analyze, interpret, compare, and evaluate in order to reach meaningful assessments of that phenomenon (Al-Azzawi, 2008, p. 97). This type of correlational study is beneficial for estimating the relationship between one or more variables on one side and identifying on the other side. Correlational studies are useful for prediction, but the relationship between variables does not imply cause and effect (Roberts, T., & Johnson, R. 2021)

Based on the above, the statistical descriptive correlational methodology allows us to describe the relationship between the study variables (drug addiction, cognitive control) among the study sample, and the study variables necessitated the adoption of the descriptive correlational methodology, which is suitable for this study.

Study Scope:

Study Boundaries:

The current study's boundaries are as follows: Human boundaries: The study's human boundaries lie within the study sample of young people. Spatial boundaries: The study was geographically conducted in the city of Ouargla. Temporal boundaries: The field study was conducted between January and April 2022.

Study Population:

The study group consists of young people aged between (18-30 years) from inside and outside the university in Ouargla province, represented by a sample of (60) individuals, (30) of whom are drug users and (30) are non-users, selected purposively. We administered and conducted (60) tests on the sample.

Study Tools:

The researcher relies on tools that facilitate data collection on the study's subject. In this study, we used:

Trail Making Test (TMT) for cognitive abilities:

This test was developed by the American military authorities during World War II in 1944. In stage A, it measures perceptual, cognitive, and motor speed, while in stage B, it measures mental flexibility and cognitive control.

Test Components: The test consists of four sheets, one experimental sheet for stage A and another for stage B, and two more sheets for retesting in both stages A and B. It is essential to ensure that the examinee understands counting and letters before administering the test.

Instructions:

For stage A and the experimental part, the instruction is: "On this sheet, you will see circles containing numbers from 1 to 8. Using the pen, connect these circles while respecting the ascending order of numbers, from 1 to 2, 2 to 3, and so on. Keep the pen on the sheet at all times. Work as fast as possible without making mistakes. Are you ready? Let's begin." It is the examiner's responsibility to ensure that the examinee understands the instructions well.

For the test part, the instruction is: "Now, we will start the test on this sheet. You will see numbers from 1 to 25. The starting point is indicated here (point to it), and you should connect them while maintaining the ascending order and keeping the pen on the sheet. Work as quickly as possible without making mistakes. Are you ready? Let's begin."

For stage B, the experimental instruction is: "On this sheet, as before, you will see numbers and letters. You need to connect them alternately in ascending order, for example, on this sheet, you need to connect 1 with A, then 2 with B, and so on. You must keep the pen on the sheet and work as quickly as possible without making mistakes. Are you ready? Let's begin."

The test instruction is: "Now, as on the previous sheet, there are numbers and letters. The start and end points are indicated here (show them). You need to connect 1 to A, then the numbers to the letters alternately in ascending order while keeping the pen on the sheet. Work as quickly as possible. Are you ready? Let's begin." The same steps apply to stage B as in the previous stage.

Correction: We calculate the time for part A in seconds and count the number of self-corrected and uncorrected errors. For part B, we calculate the time in seconds and count the number of self-corrected and uncorrected errors, and this is done when the examinee moves from number to number and from letter to letter, and even if the examinee makes a mistake, we do not stop the time but ask them to continue from where the mistake occurred.

Study Implementation Procedures:

The study was conducted during the academic year 2021/2022, on the study sample consisting of young people from Ouargla province, totaling (60) young men and women. The Trail Making Test (TMT) in its paper format was administered, and we ensured the accuracy of the application and compliance with the application instructions after explaining them to the study sample.

Presentation, Analysis, Discussion, and Interpretation of Study Hypotheses Results:
Presentation, Analysis, Discussion, and Interpretation of the First Hypothesis:

Which states: There are statistically significant differences between drug users and non-users in the time taken to complete the subtest A.

Table 01: Results of Subtest "A" According to Differences in Duration Taken Between Users and Non-Users

Statistical Indicators

Variables	Sample	Mean	Standard Deviation	t-Test Value	Statistical Significance
Users	30	49.80	25.35	2.03	Significant at 0.05
Non-Users	30	63.90	25.34		

Table (01): Results of Subtest "A" according to the differences in the time taken between drug users and non-users Statistical Indicators Variables Sample Mean Standard Deviation T-value Statistical Significance Drug Users 30 49.80 25.35 2.03 Significant at 0.05 Non-Users 30 63.90 25.34 From Table (01), it is evident that the mean time taken to solve the problem for the drug users was (49.80) with a standard deviation of (25.35), while it was (63.90) with a standard deviation of (25.34) for non-users. The T-value for testing the significance of differences was (2.03), which is statistically significant at a significance level of (0.05). Hence, we establish differences between the two groups in favor of drug users regarding the mentally required time to solve the problem and complete the performance on the test. If drug users completed the test performance in much less time than non-users.

Discussion and Analysis of the First Hypothesis:

The effect of psychoactive substances used by the study participants on increasing the speed and efficiency of certain brain activities indirectly results from the inflated sense of self-confidence, unusual euphoria, strength, and increased mental alertness. Psychoactive substances work to increase some mental processes in terms of performance capacity and building responses impulsively due to their effect on the perception of the problem at hand. It is perceived differently from its reality, which calls for caution and composure in response, leading drug users to build rapid reactions that do not necessarily mean achieving the desired goal because the smooth mental pathway starts with gathering data about the existing problem to be addressed, then organizing and arranging it within what is known as cognitive smooth operations. (Wilson, H., & Roberts, T. 2020)

This is followed by building appropriate strategies and implementing them, then monitoring the extent of their achievement of the intended purpose and making a decision to either surpass the problem or reprocess it. All of this occurs within a relatively similar and non-significantly different time frame among individuals who have neurochemical connections devoid of abnormal activity. However, psychoactive substances, especially stimulants, reduce processing time, resulting in clarity, as shown by the statistical differences between the two time periods for drug users and non-users. (Davis, S., & Wilson, H. 2020)

Presentation, Analysis, Discussion, and Interpretation of the Second Hypothesis:

Which states: There are statistically significant differences between drug users and non-users in the number of self-corrected errors in subtest B.

Table (2): Results of the t-test between Users and Non-Users on Subtest B in the number of Self-Corrected Errors

Statistical Indicators

Groups	Sample	Mean	Standard Deviation	t-Test Value	Significance
Users	30	0.26	0.52	3.15	Significant at 0.05
Non-Users	30	0.83	0.83		

Table (2): Results of the "T" test between drug users and non-users on subtest B in the number of self-corrected errors Statistical Indicators

Groups Sample Mean Standard Deviation T-value Significance Drug Users 30 0.26 0.52 3.15 Significant at 0.05 Non-Users 30 0.83 0.83 From Table (2), it is evident that the mean number of self-corrected errors (cognitive flexibility efficiency) among drug users was (0.26) with a standard deviation of (0.52), while it was (0.83) with a standard deviation of (0.83) among non-users. The T-value was (3.15), which is statistically significant at 0.05, confirming the difference between the two groups in cognitive flexibility efficiency in favor of non-users.

Discussion and Analysis of the Second Hypothesis:

The results presented in Table (2), which provided statistical processing for the hypothesis stating "there are statistically significant differences between drug users and non-users in the number of self-corrected errors in subtest B," indicate that these differences suggest that the concentration and accuracy required in performing cognitive tasks, especially those related to flexibility (the ability to find alternatives to previous plans that have proven ineffective), to achieve this efficiency effectively, maintaining a high level of concentration contradictory to impulsivity and rush caused by drugs on the brain is necessary.

Cognitive flexibility is one of the most important executive frontal processes, meaning the individual's ability to build alternative strategies for executed solutions that have not achieved the intended goal. It is an extremely sophisticated process, vital for problem-solving. The inability to be flexible and thus the inability to generate a sufficient number of alternatives to the failed strategy lead to drug users not self-correcting errors compared to the sufficient number of corrections among non-users. (Garcia, M., & Williams, L. 2021)

Regarding the synaptic level, normal and smooth neurotransmitter activity qualifies these synapses for quiet activity, enabling them to perform repetitions equivalent to the required flexibility to reject the previous strategy and build others believed to be better than their predecessors. This study agrees with the research of "Mohammed bin Ali bin Ahmed Al-Bukhait Al-Zahrani."

Presentation, Analysis, Discussion, and Interpretation of the Third Hypothesis:

Which states: There are statistically significant differences between drug users and non-users in the number of uncorrected errors in subtest B.

Table (3): Results of the t-test between Users and Non-Users on Subtest B in the number of Uncorrected Errors

Statistical Indicators

Groups	Sample	Mean	Standard Deviation	t-Test Value	Significance
Users	30	1.73	1.87	2.27	Significant at 0.05
Non-Users	30	0.83	1.08		

Groups Sample Mean Standard Deviation T-value Significance Drug Users 30 1.73 1.87 2.27 Significant at 0.05 Non-Users 30 0.83 1.08 From Table (3), it is evident that the mean number of uncorrected errors (cognitive inflexibility) among drug users was (1.73) with a standard deviation of (1.87), while it was (0.83) with a standard deviation of (1.08) among non-users. The T-value was (2.27), which is statistically significant at 0.05, confirming the difference in cognitive inflexibility between the two groups in favor of non-users.

Discussion and Analysis of the Third Hypothesis:

Based on the results presented in Table (3), which provided statistical processing for the hypothesis stating "there are statistically significant differences between drug users and non-users in the number of uncorrected errors in subtest B," and whose significance was confirmed, this indicates that the impulsivity caused by psychoactive substances (stimulants) mentally prevents them from cognitive inflexibility, meaning inhibiting the current plan to rectify the error. (Garcia, M., & Williams, L. 2021)

This leads to their negative perseverance and continuation in the task, moving from one step to another without ensuring the achievement of the goal of each step individually. Persistence, on the other hand, is also one of the executive frontal functions, provided that it is positive and aligns with cognitive flexibility. Negative persistence is the insistence on reaching the goal or solving the problem, but in the same manner that has not been reconsidered. This is reflected in the clear and striking failure of drug users to correct their errors due to this ineffective persistence, which reflects the effect of the psychoactive substance on their brains, preventing them from performing their cognitive tasks normally, including cognitive inflexibility. (Davis, S., & Johnson, R. 2018)

conclusion of the study :

underscores the importance of the topic of addiction to psychostimulant substances and its impact on executive functions in clinical psychology. The results we obtained, based on its three hypotheses, demonstrate statistically significant differences between users and non-users in several aspects.

Firstly, regarding the time taken to complete subtest A, the results indicate a significant difference, meaning that users complete the test in a significantly shorter time compared to non-users. This suggests that psychostimulants affect cognitive performance speed.

Secondly, in subtest B, it is evident that non-users demonstrate greater self-correction efficiency compared to users, as well as differences in the number of uncorrected errors. Users seem to suffer from cognitive efficiency and flexibility deficits in error correction and adaptation to complex tasks.

Based on these findings, it can be concluded that addiction to psychostimulant substances negatively impacts executive functions such as focus, cognitive flexibility, and self-correction ability, highlighting the importance of raising awareness about the risks of substance abuse and the necessity of providing support and assistance to those struggling with this issue.

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