Comparison of executive functions in addicted young people who referred to addiction treatment camps with students

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Abstract: Background and aim: Cerebral areas related to executive functions, during adolescence and early youth encounter with structural and functional changes and fluctuations that expose adolescents to many problems including drug abuse. The present study compares the executive functions (Miyake model) between pre-university male students and young addicted people under 21-years old who referred to addiction treatment camps. Method: The study is a causal-comparative research. The sample of study consisted of two groups of 30 male students in pre-university grade and young addicted people who referred to addiction treatment camps (16–21 years old) with coordination of sex, education and public health factors. Data were collected through researcher-made questionnaire and general health questionnaire for primary screening, Wisconsin Card Sorting Test, Stroop Color-Word Test and the Wechsler Digit Span subscale. Data were analyzed by multivariate variance analysis and independent t-test method. Findings of the study: data analysis indicated that there is a significant difference between the executive functions of young addicted people under 21-year old who are in addiction treatment camps and healthy pre-university students. In other words, addicts under 21-year old have weaker executive functions to update working memory, response inhibition and set shifting compared to pre-university students. Conclusion: According to the gathered results, it is likely that in addicts under 21, existence of neuropsychological anomalies such as weakness in executive function of response inhibition, set shifting and updating of working memory, resulting in their weak performance compared to normal peers in the executive functions. It can also be concluded that drug use can weaken the executive

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PUBLIC INTEREST STATEMENT
Drug addiction has been recognized as one of the health, treatment and social problems of the present century. Limited studies on the prevalence of addiction in Iran all indicate a relatively high prevalence of addiction in Iran. This issue is of particular importance for adolescents and students. Therefore, in this study, we have attempted to investigate aspects that may be involved in adolescent addiction or in improving adolescent addiction.
functions of the brain in addicted adolescents and relieve addiction to improve these brain processes due to adolescence. It is the period of growth of brain cells. Although the findings of this study are consistent with the findings of related studies, a definitive opinion in this area needs further research.

Subjects: Addiction - Drugs - Adult; Addiction Disorders - Adult; Addictions and Substance Use; Addiction & Treatment

Keywords: addiction; executive function; response inhibition; set shifting; updating working memory

1. Introduction

You would be surprised if we say that there is a group of mental disorders that annihilates billions of dollars destroying US residents’ lives annually and kills more than 500,000,000 people and causes street and homeless crime and violence. Drug use reaches a climax in people between 19-to 22-year old and then declines in people between 20 and 30 years. Young people in this age before committing themselves to the responsibilities of youth, like to try many more experiences, and among them it is more likely than younger and older people to smoke, consume marijuana and stimulant drugs. Through which they can increase their cognitive and physical performance (Department of Health and Human Services of America, 2005). Alcoholism, experimentation of prescribed drugs (Like OxyContin which is highly addictive painkillers), party drugs (such as LSD, ecstasy) also increase, which sometimes have dire consequences. The most important risks of these drugs are brain injury, durable-impaired mental function and unintentional injury and death.

Drug addiction in humans, especially adolescents, is considered a complex process in the human brain (Goldstein et al., 2007). Hypotheses recently done discuss the role of impairment in the brain's executive functions in addiction. The purpose of this study was to investigate the role of addiction on executive function and vice versa on the role of executive function in adolescent addiction.

Researches have shown that all age groups are not in danger of addiction equally, and their age is important for addiction and putting them at risk. This vulnerability can be seen more especially among teenagers and young people. Adolescence is a period associated with an increase of risk-taking and sensation-seeking and often includes drug abuse (Samerville et al., 2010). Based on a national survey of drug use and health (Organization of Health Survey and Human Services of the United States), young people have shown higher rates of drug abuse compared to older age groups. In other surveys, the history of cannabis use in nearly 45% of high school students (Twelfth grade) was obtained in the United States with a report of continuous use among 5% of them. Evidence shows that a variety of self-regulation in executive functions during adolescence are still in the maturation process.

Executive functions can be defined as the ability of cognitive flexibility and the management of the intervening elements in goal-oriented behaviors and predicting the consequences of a performance. Executive functions are a set of superior organizing and integration capabilities that are linked at different neuro-anatomical levels to different pathways of neural interaction such as the forehead cortex and include goal prediction and creation, planning, self-regulation and goal monitoring, implementation and effective feedback become programs and working memory (Birami et al., 2015).

For this reason, teenagers sometimes unfortunately in some situations, have poor judgment and lack of impulse control, even though they tend to seek to increase the level of freshness and external stimulation (Crews et al., 2007).
One of the factors that may play a role in the high rate of such behavior is the continuation of immaturity in the executive functions (it is a neuropsychological word which refers to a high degree to cognitive control of thinking, action and feeling). Adolescence may indicate a period of special vulnerability and some errors, and the reason is that the executive functions during the period of adolescence grow later than the development of other cognitive skills.

The researchers believe that may be healthy cognitive function and performance is essential and important for self-control behaviors in facing with signs of drug use. Executive function skills start to grow in the early years of the babies’ life and aspects of executive control over the entire life of a person is likely to continue growing. However, big developmental changes in executive control during adolescence are remarkable (According to Blume & Marlatt, 2009), lack of executive cognitive functions linked with drug use among adolescents and young people, and self-regulation problems have been recognized as a risk factor for alcohol polydipsia problems among young people. Recent studies have reported a relationship between executive malfunction and addiction (George & Koob, 2010). They found a relationship between the vulnerability to addiction and defects of self-regulation, lack of attention, decision-making, responsiveness reward, excitement, pain and stress. Garavan and Hester (2007) emphasized the role of attentional control, inhibition control, and revision (set of errors), as factors that predict a person’s addiction.

The results of some studies indicated that, although many studies have shown the relationship between malfunctions of executive functions and curiosity for drugs use, but it is not clear to a large extent, whether malfunctions of executive functions are the results of facing with drugs or it is the result of vulnerability towards addiction.

Considering that, it is not yet entirely clear whether the malfunctions of executive functions in the brain result in addiction to adolescents and young people or these malfunctions are the consequences of drug use. Thus, comparing young people and teenagers who are in addiction treatment camps and do not use drugs can be a good example for comparing them with normal adolescents in their own age group. Teenager’s brain undergoes conditional changes in structural and functional areas, particularly areas of the limbic cortex and the frontal regions, which are known excitement regulators in addition to executive and analytical processes. However, adolescents are in danger of risky behaviors which are the main causes of death and disease in their age group. In the studies of Amini et al., (2012), and Zadeghan et al. (2008), Wisconsin Card Sorting Test (WCST) results indicate that executive functions in addicts were lower than normal group. In other words, addicts showed demolitions in cognitive flexibility and concepts’ changing.

The results of the study by Eshel et al. (2007) revealed that teenagers often use less cognitive executive functions than adults in risky decision-making processes. The researchers believe that the risk assessment capabilities for maturation may be continued until youth.

Yucel and Lubman (2007), in a case-control study, obtained documents indicating that the destruction of the prefrontal functioning (executive functioning), may be created an uncontrolled, obsessive and risky pattern for drug searching which is characterized by dependence on drugs. The results of the study by Li and Sinha revealed that there is a common and important neurobiological substrate in fronto cingulate cortex (prefrontal), which involves in response inhibition control, emotional regulation of stress, and tendency towards drug use. In a study by Tapert et al, it was investigated how much brain responses to a measuring assignment of inhibition in young people (mid-teens) can predict drug use after 16 months. The results showed that disorders in cognitive control are strongly associated with drug use in the future. Word Joe-Garcia et al. (2004) in their study, referred to the distinctive effect of the use of glass in the destruction of working memory and abstract reasoning index, the effect of cocaine in the destruction of inhibition control index and the effect of cannabis in the destruction of cognitive flexibility index. In the review study by Robbins et al. (2008), the evidence suggests that chronic abuse of many drugs could have a direct
effect on memory systems through the dysfunctional effects on nerves and conformity of nerves, which lead to cognitive destructions that are important in memory dysfunction.

Chris and Hag in a review study offered evidence in support of that adolescence is a critical period of cortex growth and vulnerability to addiction. They found that the growth of the frontal cortex is delayed in adolescents. Phil et al, in a review study, discovered that Striatal-frontal circuits are involved in the regulation of inhibition control, and dysfunction of these circuits can be effective in increasing problems related to drug withdrawal.

2. Methodology

2.1. Population and statistical sample of the study
Population of the study included 30 high school male students who were studying during the years 2013–2014 at schools of Babolsar as well as 30 drug addicted boys under 21 years who referred to addiction treatment camps in this city whose age ranges are between 16 and 21. The sample of the study consisted of 30 normal students and 30 addicted young people under 21-year old who referred to addiction treatment camps of Babolsar. Sampling method of the study will be random cluster sampling. After visiting the high schools, 3–10 students from each class were selected for the normal group of students and 30 of students were selected based on the records of the Babolsar Education Department as the addictive group in camps. According to the group of addicts, including young people under 21-years old who referring to addiction treatment camps, and because the number of this age group was not enough, sampling method was used, it should be noted that addicted people stay in the treatment camps for 40 days, and in this study, over a period of 5 months, 30 subjects were selected from the group of addicts and all the following criteria were considered as exclusion criteria for the study groups: having a history of psychiatric disorders, mental health tests, history of head trauma and cerebral injuries, having a physical disability which creates disorder in the performance of the tests, brain tumor, heart disease and drug abuse among students. The control group (normal high school students) was matched based on variables of gender and education; right-handedness was criteria for the entrance of all participants in the study.

After referring to all the pre-university schools of Babolsar, and after initial screening of all students by the criteria set for the withdrawal of the study, General Health Questionnaire (GHQ) was used and from among those who received lower scores than 21 in this test, 30 people were selected through simple random sampling.

Criteria for inclusion in the study: Only male students can participate in this test, and among addicted groups, only those who completed high school were able to participate in this test. In two comparison groups, right handedness, being under 21- and upper 18-years old, having a score below 22 on the GHQ (28 items GHQ), was the criteria for inclusion in this study.

Exclusion criteria from the study: having a history of psychiatric disorders, history of head trauma and cerebral injuries, having a physical disability which creates disorder in the performance of the tests, brain tumor, heart disease, and drug abuse in both groups.

2.2. Measuring tools

2.2.1. Demographic characteristic questionnaires
This questionnaire was prepared by researchers to determine the demographic characteristics of subjects including age, sex, marital status and education level and also to check the exclusion criteria and control variables such as handedness, history of head trauma, mental and physical diseases, brain tumors, heart disease and meningitis.
General Health Questionnaire (28 items GHQ): This questionnaire will be used as a screening tool and to assess the general health of the subjects in this study. General validity coefficient of this test by Taghavi was earned 72.0.

2.2.2. Wisconsin Card Sorting Test (WCST)
It tests the ability of abstract and change of cognitive strategies in response to changing environmental feedback and it requires planning, organized research and ability to use environmental feedback to change cognitive set shifting (Calaver et al., 2003, quoted by Qadiri et al., 2006). For the first time, this test was prepared by Grant and Berger. But Milner was the first one who introduced it as a test which tests the functions of frontal lobe. Miyak et al. (2000) concluded that the ability to change set shifting has an important part in this test. So in this study, the test was used to assess factors of set shifting. The reliability of the test to assess cognitive deficits after brain injuries is higher than 0.68 (quoted by Lezak, 2004). The validity of the tests based on agreement coefficient of assessors in Spearman’s and Strauss’ study (1998, quoted by Qadiri et al., 2006) is reported 0.83. Also, Naderi in Iran estimated reliability of the test in Iranian population by the use of retested method and it was estimated 0.85. A set of 64 cards was given to participants of the test, and on the card, there is one to four symbols (Figure) of triangles, stars, crosses and circles in red, green, yellow and blue, and no two cards are the same. Task of the participants is, based on the presumption of other parties' pattern, replace the card. For example, if the principle being color, red card will be placed under red triangle regardless of the shape or number of symbols. Alternatively, the tester will answer. Tested participant only does the placement of cards, and mutually tester tells him whether replacements are correct or not. Tested participants of this test can be scored in several ways. The highest scores were used for the gathered categories and errors of preservation.

2.2.3. Stroop Color Word Test
This test is one of the most widely used tests of selective attention, focused attention and response inhibition, and for the first time was reported in Jay R. Stroop's doctoral thesis. The version which is used in this study consists of three trials. In each trial, after presenting the agenda for the participants to being familiar with how to run the test, first two, then five workouts are given to participants to do them. In this study, the number of correct answers minus incorrect answers in the third trial (which is considered as interference task) was calculated. The reliability of the Stroop test, based on the researches of Othello and Graf (1995, quoted by Delazar, 2007) for all three trials and by the use of retest method were calculated, respectively, 1.0, 0.83, and 0.90. Test–retest reliability of this test for every three trials was reported, respectively, 0.6, 0.83 and 0.97.

Digit Span subscale of the Wechsler for Adult: this sub-scale is a short-term memory and attention test, and Wolf considers it as measures of working memory, particularly the part of reverse numbers. In a national study in Psychological Association of America (1979), Standardization of the Wechsler memory test was conducted on a sample of 1250 people in 13 age groups, mean of Cronbach's alpha for this subscale in all age groups was 0.82, and test–retest reliability was 0.74, respectively. In a study which was done in Iran by Saed, the reliability of this subscale was 0.74 by the use of Cronbach's alpha method, and by split-half method, it was 0.75.

2.3. The research process
After obtaining permission from the Department of Education in Babolsar city, at first, the demographic questionnaire was presented to all students, after initial screening, the GHQ was presented to students as a secondary screening questionnaire. After screening who were qualified for the study and according to their scores on the GHQ, students were placed in groups of 30 people by the use of clustered random sampling. The order of test performance was the same in all tested participants. At first, the Stroop Test, then Digit Span subscale Test, and finally the WCST were conducted. At the end of each test, the tested participants were given 3 min to rest.
With the permission of the Department of Social Welfare in Babolsar city, we referred to addiction treatment camps. Our only available samples in camps were addicted to young people under 21-years old. Therefore, after screening by demographic characteristics questionnaire test and GHQ, from among the young people under 21-years old, a group of 30 people was selected as a control group. All entry and exit criteria of research were observed like the other two groups and were matched with the other two groups on the basis of gender, education and public health.

3. Results

3.1. Demographic

In this study, out of 60, 50% were 16–21 years in high school, 50% of those who had been referred to addiction camp.

To examine the differences between two groups in all three factors of executive function, multivariate variance analysis test was used, F test results and Eta share coefficient were, respectively, 19.50 and 0.51, which was gained statistically at the significant level of 0.01.

| Variable          | Kolmogorov–Smirnov test |
|-------------------|-------------------------|
|                   | N  | M   | SD  | Z   | Significant level p>0.05 |
| Set shifting      | 60 | 34.81 | 16.71 | 0.68 | 0.73 |
| Working memory    | 60 | 16.08 | 3.48  | 0.93 | 0.34 |
| Inhibition        | 60 | 63.43 | 14.40 | 1.03 | 0.23 |

Levine test to check the homogeneity of variances

| Variable          | Levine test to check the homogeneity of variances |
|-------------------|-----------------------------------------------|
|                   | F    | DF1 | DF2 | Significant level p>0.05 |
| Set shifting      | 6.27 | 1   | 58  | 0.15 |
| Working memory    | 6.37 | 1   | 58  | 0.14 |
| Inhibition        | 0.002| 1   | 58  | 0.96 |

respectively, 19.50 and 0.51, which was gained statistically at the significant level of 0.01.

For the examination of set shifting in two groups, WCST was used. This test gives two indices, the first index refers to the number of categories and the second index refers to perseveration errors.

| Variable          | Eta share coefficient | F    | significant |
|-------------------|-----------------------|------|-------------|
| Level             |                       |      |             |
| Set shifting      | 0.51                  | 19.50| 0.01        |
| Working memory    |                       |      |             |
| Inhibition        |                       |      |             |

In order to compare two groups regarding the number of categories and perseveration errors, t-test was used, which was statistically significant at the level of p <0.05.

According to independent t-test results for the two groups, the value of calculated t for two variables of number of categories and preservation error, in degrees of freedom (58), was obtained, respectively, −5.24 and 9.26, which was statistically significant at the level of P < 0.05. This result is
consistent and aligns with the results of studies by Amini et al. (2012), Zadeghan et al. (2008), Tappert et al. (2012), Visik et al. (2011), Garcia (2005). In the study of Amini et al. (2012), which was done by the use of comparison method between the two groups of 38 addicted people, performance results of tested participants in the WCST showed that addicts had weaker executive functions compared to normal group. In other words, addicts had destructions in cognitive flexibility and change of concepts. This result is also inconsistent with the results of the study by Thoma et al. (2007). In all these studies except the study of Thoma et al. (2007), a significant difference was obtained between executive functions of set shifting addicts with control group. So that addicts showed weaker executive functions, cognitive flexibility and set shifting than control group. On the other hand, the role of executive function of set shifting in tendency to drug abuse can be explained as follows: adolescents and young people when faced with the situation of drug use, who have lower ability to cognitive flexibility, they cannot choose other purposes or other problem-solving strategies except drug use in rewarding situations.

To examine the differences of inhibition factor between the two groups, Stroop test was used. The manual version of the test was used to show the number of correct trials in the third stage and they were calculated as the factor of inhibition.

Calculated $t$ (84.3), at degrees of freedom (58) at the level of $P < 0.05$, is statistically significant.

| Wisconsin test | Addicts | Students | Independent t-test | Significant level P < 0.05 |
|----------------|---------|----------|--------------------|--------------------------|
| Number of categories | 43/3 Mean | 33/5 Mean | -5.24 | 0.001 |
| | 67/1 Standard deviation | 06/1 Standard deviation | | |

| Wisconsin test | Addicts | Students | Independent t-test | Significant level P < 0.05 |
|----------------|---------|----------|--------------------|--------------------------|
| Preservation error | 86/43 Mean | 93/18 Mean | 26/9 | 0.001 |
| | 66/13 Standard deviation | 53/5 Standard deviation | | |

This result is consistent with the results of studies by Mullan et al. (2011), Verdejo-Garcia et al. (2004), Tappert et al. (2012), Yucel and Lubman (2007). In all these investigations, apparent differences were achieved in executive function of response inhibition in addicts compared to the control group, so that addicts showed weaker performance in executive function of response inhibition compared to control group. Among these studies, longitudinal study of Tappert et al. (2012) was a good study to check, if inhibition of a weak response is a strong predictor for drug abuse in the future among teenagers between 16 and 19 years old.
To compare the working memory factor in both groups, Wechsler Digit Span Reverse scales were used.

According to independent t-test results for reverse memory in two independent groups, t was calculated (~6.79) in degrees of freedom (58), which was statistically significant at P < 0.05 level. This result is consistent with the results of the studies by Kane et al. (2001), Noel et al. (2011), Verdejo-Garcia et al. (2004), Robins et al. (2008), Lee wires Yakimoff (2004), and Yucel and Lubman (2007). In all these studies, addicted group had weaker performance on the working memory compared to normal group. According to the results of these studies, it can be said, weakness in working memory cause to teenagers and young people when faced with drugs, could not use their information and previous experiences regarding the negative consequences of drug use at the moment and to consider problem-solving strategies that lead to positive consequences in the future.

4. Conclusion

As shown in the findings section, there are differences between the components of executive functions in normal adolescents and adolescents with drug use disorders, which are in line with the findings of Madani and Alizadeh (2018), Goldstein et al. (2007). Of course, this research is limited in scope because we are limited to comparative studies and have not used causality testing.

As was shown in Chris and Hodge’s review study (2006), adolescence and early youth is a critical stage of growth in prefrontal cortex of the brain, and at this stage of growth due to structural and functional changes in prefrontal cortex, executive functions in some teenagers associated with weaknesses in functions that make them more vulnerable to environmental risks. As mentioned earlier, executive functions are responsible for regulating and controlling of behavior, emotions and our thoughts when dealing with the environment.

Considering that adolescence is a critical period of growth for executive functions, the tendency of adolescents towards drug abuse is caused by the weakness of executive functions in their brain. As mentioned in the results of the study, addicted young people under 21-year old showed weaker performance in executive function (response inhibition, update of working memory and set shifting) compared to pre-university students, while the addict young people under 21-year old, after detoxification, were attempting for drug withdrawal inside the camp and they were controlled there. The results of the study show the comparison of drug addicts in normal mode and away from drugs with students, and the difference in executive functions of addicts can be a sign of weakness in their executive functions. According to the significant difference in executive functions of both groups, we can conclude that in adolescence and early youth, those young people who, due to structural and functional changes in prefrontal cortex and prefrontal areas, experiencing developmental delay or fluctuations in the growth of executive function (working memory,
response inhibition and set shifting), when faced with risky situations, are more likely to show uncontrolled and risky behaviors, including drug abuse and weaker performance on executive functions. In other words, the group of addicts under 21 years showed more weaknesses in the executive functions of response inhibition, updating of working memory and set shifting than the normal group.

The findings also suggest that drug use, especially methamphetamine, can impair executive function and cognitive flexibility in consumers by impairing frontal lobe function. Evaluating solutions that are high levels of cognition makes consumers in control of craving and adopting appropriate solutions to control them inefficient (Birami et al., 2015).

One of the limitations of this study is the inability to investigate the causal (experimental) cause in this study and the other limitation is the small sample size of the study. Therefore, it is suggested that a large volume of research samples with male and female gender be used in the future research. Also, consider the use of brain imaging technology for a fuller review.

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