UDC 159.95 doi: 10.21702/rpj.2019.2.1.3

Comparative analysis of dysfunctions in the III block of the brain in men with various types of drug addiction

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Abstract

Introduction. Drug addiction is a worldwide problem in contemporary society. The lack of neuropsychological information on the characteristic features of higher mental functions in men with various types of drug addiction, as well as the social significance of the problem represent unmet needs necessitating a comprehensive solution. The article provides findings of a comparative study of the functional state of the third block of the brain in healthy drug-dependent men.

Methods. The study used methods of neuropsychological diagnostic assessment of A. R. Luria (modified by T. V. Akhutina), and of statistical analysis (descriptive statistics, one-way analysis of variance SPSS for Windows).

Results. The programming and control functions, the function of the serial organization of movements and speech were studied, statistically significant differences between healthy and sick men were determined. No significant differences were found between groups of drug users depending on the specific drug.

Discussion. The findings of the study demonstrate the impairing effects of opioids and cannabinoids on the functions of the third block. The changes were mostly related to the ability to master a program and to automate motor skills, to act complying with voice instructions and to switch over according to their modifications. No significant differences in revealed disorders were observed between subjects with different types of drug addiction. However, an analysis of the individual characteristics of the task performance showed that opioid addicts, as well as addicts with the combined use of different drugs, more often made mistakes when performing experimental tasks compared to cannabinoid-addicted patients. Moreover, mistakes made by the subjects of the former groups were rougher and more repetitive. There is evidence in the available literature consistent with our findings and contradicting them. Further research is needed to clarify these issues.

Keywords
neuropsychological analysis, mental functions, brain block, drug addiction, opioids, cannabinoids, addiction

Highlights

► drugs (opioids and cannabinoids) clearly impair functions of the third block of the brain;

► abilities to master a program and to automate motor skills are most impaired;

► the destructive effect of drugs affects the ability to act according to voice instructions, switch over according to their modifications.

For citation
Perfilova, E. V. (2019). Comparative analysis of dysfunctions in the III block of the brain in men with various types of drug addiction. *Russian Psychological Journal*, *16*(2/1), 33–44. doi: 10.21702/rpj.2019.2.1.3

The manuscript was received in 25 August 2019

Introduction

It is well known that drugs impact various systems and structures of the brain, resulting directly in a pathological addiction (Anokhina, Klimenko, Gabril'yants, & L'vova, 2018; Ivanets, Pylaeva, & Shatenshtein, 2011; Agibalova & Poplevchenkov, 2012; Antsyborov & Morykhin, 2017; Ilyuk et al., 2017; Klimenko, Kozlova, Istomina & Bespalova, 2013; Litvintsev, 2015; Poplevchenkov & Agibalova, 2017; Skryl', 2013; Chernobrovkina, 2015; Chizhova, Mishkina, Pilyavskaya et al., 2013; Chukhrova, 2013; Aguado et al., 2007; Kalwa & Habrat, 2015; Castaneto et al., 2014; Murray, Farrington & Sekol, 2012). The toxic admixtures in drugs increase the destructive effect of the main substance on the central nervous system.

In the available literature, there are studies on the neuropsychological characteristic features of drug addicts. Among the well-described disorders of mental functions in drug addicts syndromes related to the damage anterior parts of the brain (III block) are of special interest. It is assumed that a decrease or an impairment of regulatory functions is an imminent characteristic of any addiction (Shuvalova, & Tsvetkov, 2016).

The consumption of cannabis leads to impairment of the ability to combine and compare information, lack of desire to interpret opinions and motives of others, emotional emptiness (Lundqvist, 2005). The "inner activity plans" are blown, social motives decreased, interest on the long-term planning, programming behavior disappears. Self-criticism and activity control reduce.

Heroin addiction is associated with disorders of the functions of mediobasal sections of the frontal region as well as of diencephalic limbic structures and the dysfunction of convexital areas of the frontal cortex (Baulina, 2002). Persistent impairment of neuropsychological factors settled in the convexital prefrontal cortex does not depend on the stage of the withdrawal syndrome or on the effects of treatment medicaments (Kovshova & Prosvetova, 2015).

Simultaneous or successive use of different psychoactive substances increases the risk of negative effects on the body (Yaltonskii, Sirota, & Yaltonskaya, 2017). Patients with a combined addiction to heroin and alcohol are characterized with more pronounced impairment of visual memory and learning ability, lower reactions switching and cognitive flexibility levels, less problem-solving efficiency compared to patients with isolate heroin addiction (Bushara et al., 2009). A mild, but long-term decrease in executive characteristics of intelligence and memory is characteristic for individuals who use "ecstasy" to cope with cannabis withdrawal symptoms (Klugman & Gruzelier, 2003).

Available neuropsychological findings are of interest to be investigated further.

It is known that the III functional block of the brain ensures the organization of the dynamic, conscious, purposeful activity and is associated with the management of functions of serial movements or speech (A. R. Luria).

Our pilot study enrolled 108 men (4 groups) of middle age (age categories by D. Bromley) registered in the drug abuse clinic. The first group included opioid-addictes patients (according to ICD-10, code F11.2), the second group included patients addicted to cannabinoids (F12.2), the third group comprised patients combining opioids with cannabinoids (F19.2).

The fourth group comprised men without drug addiction disorders. Patients with epilepsy, schizophrenia, severe neurological symptoms, severe somatic pathology, and history of craniocerebral trauma were excluded from the study.

Methods

To characterize the functioning of the third block of the brain in men with various types of drug addiction, neuropsychological diagnostic methods developed by A. R. Luria and modified by T. V. Akhutina were used. To study characteristic features of programming and control functions, we used tests for the choice behavior, rhythmic drawing according to instructions, retelling a text and performing oddball tasks. To study the functions of serial organization of movements and speech, we used tests for dynamic praxis, reciprocal and graphomotor coordination, retelling a text (grammatical arrangement criterion). Data were statistically processed with descriptive statistics methods and one-way analysis of variance (based on the SPSS for Windows software package).

Results

The study of the programming and control functions revealed significant differences between healthy and sick men (see Table 1). The results of the oddball test showed significantly higher maturity levels for verbal-logical operations of classification and generalization in healthy subjects compared to the drug-addicted men ($p < 0.000$). Among the drug-addicted, no significant differences between groups were identified. However, it was noted that patients addicted to cannabinoid coped with tasks more successfully compared to the subjects from groups 1, 3. Data of the test for the choice behavior suggest that healthy men ($p < 0.000$) have a better ability to act according to voice instructions, to regulate their actions suppressing immediate reactions contradicting instructions.

Table 1

Programming and control function differences (scores)

Parameters of the function	ANOVA		1*	2	3	4
	F	p	Mean	Mean	Mean	Mean
Accuracy in an outside term elimination	6.32	0.001	2.9	3.1	2.9	3.9
Accuracy in an outside term explanation	10.6	0.000	2.5	2.8	2.2	3.8
Productivity in the choice behavior test	10.4	0.000	2.69	2.39	2.5	3.82
Assimilation when performing the choice behavior test	5.05	0.001	0.5	0.5	0.6	0.12
Text retelling (logical adequacy)	15.8	0.000	1.4	1.7	1.1	2.6
Text retelling (composition ability)	17.4	0.000	1.29	1.5	1.2	2.48

Notes: 1 –opioid-addicted group, 2 –cannabinoid-addicted group, 3 – combined opioid and cannabinoid using group; 4 – healthy controls*

The study of the ability to the serial organization of movements and speech in healthy men and men with various types of addiction has shown that the use of psychoactive substances noticeably impairs it.

Table 2

Differences in the function of the serial organization of movement and speech (scores)

Parameters of the serial organization	ANOVA		1	2	3	4
	F	p	Mean	Mean	Mean	Mean
Dynamic praxis (mastering skills)	3.7	0.13	2.81	2.86	2.47	3.38
Dynamic praxis (automating skills)	31.5	0.000	1.78	1.79	1.47	3.65
Dynamic praxis (serial organization)	12	0.000	2.1	2.2	1.93	3.47
Dynamic praxis (clumsiness)	19.1	0.000	0.19	0.14	0.27	0.00
Reciprocal organization (productivity)	21.2	0.000	2.59	2.25	1.33	3.85

Table 2

Differences in the function of the serial organization of movement and speech (scores)

Parameters of the serial organization	ANOVA F	ANOVA p	1 Mean	2 Mean	3 Mean	4 Mean
Reciprocal organization (interhemispheric interplay)	2.13	0.000	0.66	0.68	0.93	0.06
Graphomotor coordination (serial expression)	8.32	0.000	2.44	2.5	2.13	3.85
Text retelling (grammatical arrangement)	18.62	0.000	1.75	1.92	2.06	2.78

Healthy individuals master a movement series with the leading hand when performing the dynamic praxis test more successfully (see Table 2) ($p < 0.000$). The average rates of the ability to automate motor skills are significantly higher in healthy men compared to addicted ($p < 0.000$). The addicted patients performed series of movements with the leading hand significantly worse ($p < 0.000$) and more often demonstrated clumsiness when performing the test ($p < 0.000$).

A qualitative measurement of test performance showed the characteristic fluency of healthy control subjects when performing the motor program (see Fig. 1) (70%). Whereas drug addicts more often performed the test for dynamic praxis “in bursts”. It should be noted that cannabinoid-addicted subjects (32%) were more able to switch from delayed or “in bursts” performance to correct fluent movements compared to the opioid-addicted (18%) or to the combined opioid-cannabinoid-addicted (14%). Opioid-addicted subjects (15%) more often than other addicted (7% in the group 2, 2% in the group 3) in this sample made bad mistakes (failures when increasing the pace or element-by-element performance).

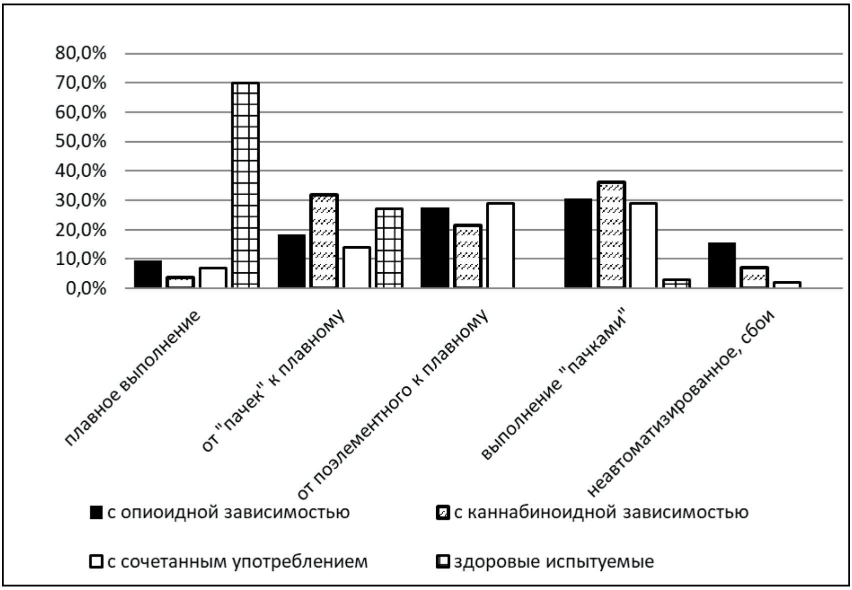

Figure 1. Distribution of subjects depending on the successfulness of the dynamic praxis performance

Noteworthy, differences in the reciprocal coordination scores between the groups were significant ($p < 0.000$). The productivity of the task performance was higher in healthy subjects compared to addicted patients (see Table 2). This indicates not only the difficulties in the serial organization of movements in the drug-addicts but also a decrease in the possibility of the interhemispheric interaction.

Significant differences in parameters of the graphomotor coordination the performance between healthy and drug-addicted individuals suggest that there is a significant decrease in the serial organization function in subjects with opioid ($p < 0.001$), cannabinoid ($p < 0.008$) or combined ($p < 0.002$) addictions (see Table 2). Healthy people had a higher rate of performance accuracy (26%) and made fewer mistakes (see Fig. 2). Opioid-addicted individuals often made mistakes of the "site" type (49%) along with mistaken assimilation of elements and replacing vertical lines with gently sloping ones (30%). Cannabinoids consumers most often stopped in the course of the test (23%). Individuals with combined drug addiction made the worst mistakes in their drawings: mistakes with the program expansion (20%).

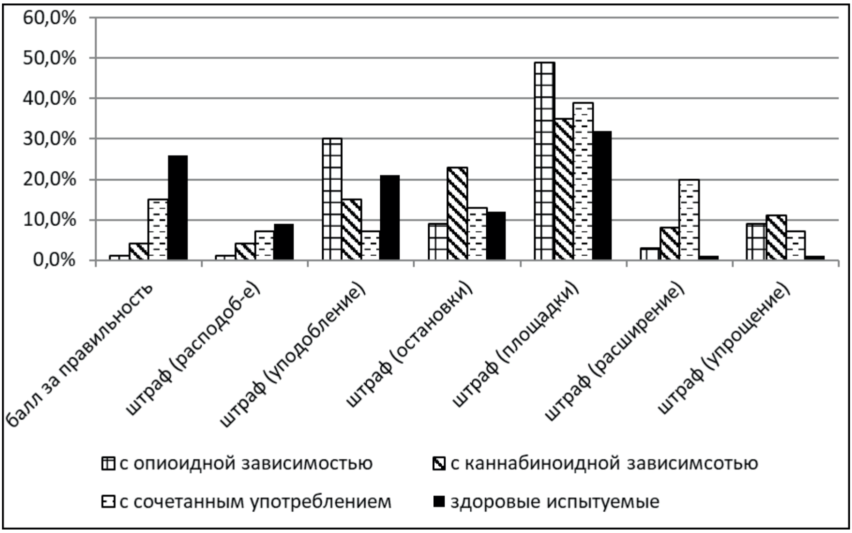

Figure 2. Characteristics of the serial organization in the graphomotor coordination test

Healthy subjects (see Table 2) had higher rates for the grammatical arrangement of the text ($p < 0.001$), using easily more complex and diverse grammatical constructions and detailed retelling.

Discussion

The functions of the III block of the brain suffer changes when they are influenced by opioids or cannabinoids. The serial organization of movements and speech clearly deteriorates, most of all the ability to master the program and automate motor skills. In addition, the destructive effects of drugs manifest themself in the ability to act complying with speech instructions, switching according to its modifications. These findings are consistent with the results of studies of other authors investigating the neuropsychological aspects of drug addiction (Shuvalova & Tsvetkov, 2016; Kovshova & Prosvetova, 2015; Baulina, 2002; Klugman & Gruzelier, 2003; etc.). In the literature, there are also other opinions. Thus, Van Holst & Schilt (2011) argue that a persistent deficit in executive regulatory functions is associated with the use of all narcotic substances but cannabis. It is important to note that the authors in their review focused on studies with small samples, were control groups included former marijuana users within the two-week abstinence period. An opinion exists that the chronic effects of the isolated use of cannabis on brain activity may be unstable, so more sensitive methods are needed to evaluate them. Klugman & Gruzelier (2003) noted a pronounced attention-deficit under the influence of cannabis, discovered in electrophysiological studies. Thus, the use of different-type methods to identify impairments, small sizes of samples as well as methodological inaccuracies may be responsible for the inconsistency of reported empirical data (Perfilova, 2019; Fotekova & Kicheeva, 2012).

In our study, no significant differences were found between different groups of drug users. However, an analysis of individual performance characteristics (see Fig. 1, 2) showed that opioid-addicted individuals, as well as combined drug addicts, more often made mistakes when performing experimental tasks compared to cannabinoid-addicted patients, and moreover, they made rougher and more repetitive mistakes. This echoes the opinion of Yaltonskii et al. (2017). Researchers note that the combined use of different drugs and other psychoactive substances is associated with higher neurotoxicity and leads to neurodegenerative changes and neurocognitive deficiency.

Further researches are needed to clarify these issues.

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