

## Executive Functions in People with Different Alcohol Consumption Experiences

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### Abstract

**Introduction.** Executive functions are multidimensional cognitive processes that provide organization and regulation of behavior. Impairments in executive functions are considered to be a risk factor for addiction, including alcohol dependence. However, it is not clear which domains of executive functions are the most vulnerable and how their changes relate to progression to addiction. **Methods.** A total of 244 individuals with different alcohol consumption experiences (78 with safe alcohol consumption and 166 with diagnosed alcohol dependence) participated in this study. All study participants were male and comparable in age and education. Executive functions were investigated with the Go/No-Go task, the Simon Test, the Wisconsin Card Sorting Test, and the Corsi Block-Tapping Test, implemented in a computerized version on the Cognitive Symphony platform (Russia). In participants with alcohol dependence, data on dependence duration, remission duration, and treatment courses were also considered. **Results** of the study showed that participants with alcohol dependence had significantly lower outcomes of executive cognition performance than those who practiced safe alcohol consumption. In particular, alcohol-dependent participants performed worse in cognitive control task ( $p = 0.0001$ ), attention task ( $p = 0.026$ ), and cognitive flexibility task ( $p = 0.006$  and  $p = 0.040$ ). Working memory was also found to be vulnerable, with all alcohol-dependents who performed with lower working memory span compared to participants with safe alcohol consumption ( $p = 0.044$ ). Subsequent regression analysis showed that cognitive control errors and cognitive flexibility errors in individuals with alcohol dependence were associated with years of alcohol abuse ( $p < 0.01$ ). In addition, the higher rate of progression to alcohol dependence, the more vulnerable was working memory ( $p = 0.002559$ ). **Discussion.** The study showed that executive cognition vulnerability in people with alcohol dependence was associated with alcohol abuse duration and dependence progression rate. The study

results may contribute to intervention programs that target executive cognitive functions in alcohol addicts and those at high risk for alcohol dependence.

### **Keywords**

executive functions, cognitive control, cognitive flexibility, attention, working memory, alcohol dependence, vulnerability, Cognitive Symphony, Corsi Block Tapping Test, Wisconsin Card Sorting Test

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## **Introduction**

Cognitive functions, especially executive functions – cognitive control, cognitive flexibility, decision making, and working memory – are mainly affected by alcohol consumption (Bourgault, Rubin-Kahana, Hassan, Sanches & Le Foll, 2022). With chronic alcohol consumption, impairments in executive functions and memory loss are observed even after several weeks of alcohol abstinence (Galkin, Peshkovskaya, & Bokhan, 2021; Lees et al., 2020; Ramey & Regier, 2019). Cognitive recovery usually occurs within six months of abstaining from alcohol. However, impaired cognitive control and decision-making may persist for 1 year after ceasing alcohol consumption (Sømhovd, Hagen, Bergly & Arnevik, 2019; Stavro, Pelletier & Potvin, 2013). For alcohol addicts, executive function deficits affect their ability to adapt to the social environment, resulting in behavioral planning and regulation disorders, the inability to reject immediate rewards, and the inability to feel, understand, and regulate emotions (Pepe et al., 2022; Carbia et al., 2021).

Given current Rosstat statistical data, which indicate an increase in alcohol-related mortality in Russia by 6.3 % between 2020 and 2021 and an extraordinary (30 %) increase in death rates due to overdoses of psychoactive substances, and taking into account data on the impact of the COVID-19 pandemic on alcohol consumption worldwide (Peshkovskaya, 2021; American Psychological Association, 2021), the alcohol-related situation and its consequences can be exacerbated during the waves of the pandemic (Cai et al., 2023; Pollard, Tucker & Green, 2020). Since impairment in executive cognitive

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functions is an important determinant in the structure of addictive behavior, with a direct impact on the ability to abstain from alcohol consumption and maintain a long-term remission (Elton, Garbutt & Boettiger, 2021; Galkin & Bokhan, 2021), executive function research can provide new data on the specific characteristics of alcohol-associated cognitive changes. Thus, this **study aims** to investigate specific characteristics of executive cognitive functions in subjects with different experiences of alcohol consumption.

## Method

A total of 244 subjects with different alcohol consumption experiences participated in the study, including 78 participants with safe alcohol consumption (0-6 points in the AUDIT alcohol dependence screening test; the subjects were not diagnosed with alcohol dependence and were not consulted by a narcologist) and 166 participants diagnosed with alcohol dependence (F10.2 according to ICD-10; the diagnosis was made in the 4th department of the Clinic of the Mental Health Research Institute, Tomsk). All participants in the study were men of similar age and education, which is important in the study of executive cognitive functions (Table 1).

**Table 1**

*Study sample*

Parameter	Participants with safe alcohol consumption	Alcohol-dependent participants	p-value
Age	43.72 ± 7.55	44.82 ± 6.89	0.428
Education	secondary vocational education	secondary vocational education	–

We examined executive functions using validated and verified assessment tools which were implemented in computerized versions based on the Cognitive Symphony (Russia) (The Cognitive Symphony is a digital platform developed by Tomsk State University, certificate of state registration No. 2022684316, December 13, 2022) – the global ‘gold standard’ for assessing cognitive functions:

- A modified version (Ivanitsky, Strelets, Korsakov, 1984); (Slavutskaya, Lebedeva, Karelin, & Omel'chenko, 2020) of the Go/No-Go task (Donders, 1969) was used to assess the function of cognitive control, including the control of response inhibition.
- A modified version (Zvereva, Khromov, Sergienko, & Koval'-Zaitsev, 2017) of the Simon Test, which is a simple non-verbal version of the Stroop interference method (Simon & Wolf, 1963; Hommel, 1993) was used to assess attention.

- A modified version (Polunina & Davydov, 2004) of the Wisconsin Card Sorting Test was used to assess the function of cognitive control and cognitive flexibility (Grant & Berg, 1948; Nyhus & Barcelo, 2009). The Wisconsin Test assesses the ability to maintain and change cognitive attitudes, as well as the ability to use feedback (Peshkovskaya & Myagkov, 2020). The uniqueness of this test is that it enables the assessment of cognitive functions that are least involved in performing general intelligence tests and most prefrontal tests.
- Corsi Block-Tapping Test (Corsi, 1972; Kessels, van Zandvoort, Postman, Kapelle, de Hand, 2000; Galkin et al., 2020; Galkin et al., 2019) was used to assess working memory. In the group of alcohol-dependent subjects, cognitive function data were also supplemented by information on the duration of the disease, the duration of remission, and the number of treatment courses.

Statistical analysis was carried out using STATISTICA 12.0. The differences between groups were evaluated using the Mann-Whitney U test. The contribution of individual factors to the variation of cognitive parameters in alcoholism was assessed using the multiple linear regression method.

The study was approved by the ethics committee of the Mental Health Research Institute, Tomsk National Research Medical Center (TNRMC) of Russian Academy Sciences (RAS) and implemented in accordance with the Russian Federation legislation and international regulations on scientific research involving human subjects, including the Helsinki Declaration. All participants signed a written consent to participate in the study.

## Results

An analysis of differences in the parameters of executive functioning of individuals with different alcohol consumption experiences showed that all alcohol-dependent subjects had worse scores in executive cognitive functioning compared to the study participants with safe alcohol consumption. Thus, alcohol-dependent subjects had (a) significantly worse scores in cognitive control associated with a large number of inhibition errors ( $p = 0.0001$ ) associated with impaired inhibition processes and an erroneous response to a red signal (No-Go) in the Go/No-Go Test; (b) attention disorders resulting in switching errors – an indicator of the rigidity of the attentive function when switching between stimuli in the Simon Test ( $p = 0.026$ ); (c) reduction in cognitive flexibility associated with attitude errors – performing sorting in an irrelevant category ( $p = 0.006$ ) and perseverations (direct repetition of previous sorting patterns under changed conditions) in the Wisconsin Card Sorting Test ( $p = 0.040$ ); (d) and lower working memory capacity ( $p = 0.044$ ), which is a measure of the patient's last correct block sequence recall in the Corsi Test, compared to healthy participants (Table 2).

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**Table 2**  
*Differences in executive functions in subjects with different alcohol consumption experiences, Mann-Whitney U test with continuity correction*

Cognitive domain	Indicator	Safe alcohol consumption	Alcohol dependence	p-value
Cognitive control	Inhibitory errors	2.42 ± 1.9	7.14 ± 3.56	0.0001
	Reaction errors	1.04 ± 1.28	2.15 ± 2.3	0.055
Attention	Switching errors	1.44 ± 1.15	7.35 ± 6.99	0.026
	Attitude errors	13.56 ± 4.21	18.94 ± 7.71	0.006
Cognitive flexibility	Perseverations	7.24 ± 3.66	12.0 ± 4.72	0.040
Working memory	Capacity	5.04 ± 1.27	4.2 ± 1.67	0.044

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Since alcohol-dependent participants showed significantly lower scores in executive functioning compared to the participants in the study who practiced safe alcohol consumption, multiple regression analysis was performed to determine the contribution of individual parameters to executive functioning in alcohol-dependent participants. The duration of alcohol dependence, the duration of remissions, the number of treatment courses, and the rate of progression to alcohol dependence were assessed (Table 3).

**Table 3**  
*Contribution of indicators to the variation in executive function parameters in alcohol-dependent subjects, multiple regression analysis*

Parameter	Working memory,	Cognitive control		Attention, switching errors	Cognitive flexibility	
	Capacity	Inhibitory errors	Reaction errors		Perseverations	Attitude errors
	*	**	***	****	*****	*****
Duration of alcohol dependence	-0.04	-0.05	<b>-0.10</b>	-0.07	-0.01	-0.01
Number of treatment courses	0.04	-0.08	0.02	-0.08	-0.07	-0.07
Duration of last remission	-0.09	-0.05	0.08	-0.10	0.03	0.02
Maximum duration of remission	0.07	0.07	-0.04	0.10	0.01	0.04
Rate of progression to alcohol dependence (progrediency)	<b>-0.10</b>	0.02	<b>0.12</b>	-0.04	<b>-0.08</b>	<b>-0.10</b>

**Note.** The table shows significant parameters, \* Multiple R 0.252, F 2.230, p = 0.002559; \*\* Multiple R 0.340, F 4.291, p < 0.0000001; \*\*\* Multiple R 0.322, F 3.799, p < 0.0000001; \*\*\*\* Multiple R 0.295, F 3.128, p = 0.000015; \*\*\*\*\* Multiple R 0.324, F 3.841, p < 0.0000001; \*\*\*\*\* Multiple R 0.342, F 4.341, p < 0.0000001.

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Consequently, the decline in cognitive control and cognitive flexibility functions in alcohol-dependent subjects was associated with the duration of alcohol dependence (all  $p < 0.01$ ), and the high rate of progression to alcohol dependence contributes to the vulnerability of working memory ( $p = 0.002559$ ).

## **Discussion**

The study established specific characteristics of executive functioning in subjects with different alcohol consumption experiences, which manifest themselves in the increase in inhibition errors in the implementation of cognitive control functions in the group of alcohol-dependent subjects. The result indicates a lack of inhibition processes in alcohol dependence and the vulnerability of cognitive control in general (Galkin, Bokhan, 2023; Trusova, Berezina, Gvozdetskiy & Klimanova, 2018). At the same time, the study participants with safe alcohol consumption did not show an increase in perseverations (errors associated with the direct repetition of previous patterns under changed conditions) when performing the Wisconsin Card Sorting Test compared to the alcohol-dependent subjects, which indicates impaired cognitive flexibility in alcohol dependence and is obviously associated with the rigidity of cognitive processes observed in addictions (Peshkovskaya, Bokhan, Mandel & Badyrgy, 2022; Spindler et al., 2021).

The vulnerability of attention interference and working memory is also associated with unsafe alcohol consumption impact on executive cognition. At the same time, factors such as alcohol dependence progression rate and dependence duration contributed to executive functions impairments, particularly in working memory, cognitive flexibility, and cognitive control.

## **Conclusion**

The issue of unsafe alcohol consumption is of global social importance as it affects employed and economically active population (Formánek, Krupchanka, Mladá, Winkler & Jones, 2022; Kuznetsova, 2020; Voevodin, Peshkovskaya, Galkin, & Belokrylov, 2020).

The study results showed that vulnerability of executive functions in alcohol-dependent individuals is associated with the duration of alcohol abuse in years and alcohol dependence progression rate. The results obtained provide a basis for preventive and targeted measures aimed at reducing executive cognition vulnerability both in healthy people and in people with problematic alcohol consumption.

## **Final conclusions**

- Performance outcomes in executive functions tasks varied among individuals with different alcohol consumption experiences.

- Executive functions were significantly more vulnerable and impaired in people with alcohol dependence compared to those in people with safe alcohol consumption.
- Cognitive control errors and cognitive flexibility errors were associated with years of alcohol dependence duration in people with diagnosed alcohol dependence.
- The rate of alcohol dependence progression contributed to vulnerability of working memory in people with diagnosed alcohol dependence.

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## Conflict of Interest Information

The author has no conflicts of interest to declare.