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THE EFFECT OF 0.1-0.25 MG/DM³ OF BREATH ALCOHOL CONCENTRATION ON COGNITIVE FUNCTIONS IN ALCOHOL NONDEPENDENT YOUNG ADULTS

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Summary. Alcohol dependency has been connected to altered brain activity and cognitive decline. However, data regarding the influence of acute and low-to-moderate alcohol use on cognition are inconsistent. The aim of the study was to assess the influence of 0.1-0.25 mg/dm³ of breath alcohol concentration (BrAC) on cognitive functions such as attention, perception, psychomotor speed and visual-spatial functions, in 50 young alcohol nondependent adults. We observed a worsening in focus attention measured with Cross Apparatus following the consumption of a given dose of alcohol. We also revealed the occurrence of learning effect in measures of attention and psychomotor speed. However this effect was significantly weakened in participants who were intoxicated in the first testing. We concluded that the studied concentration of alcohol may have a negative effect on focused attention and ability to benefit from previous experience which are crucial for complex behaviours, such as driving.

Key words: alcohol, attention, reaction time, general perceptual ability, spatial perception

Introduction

Excessive alcohol use and alcohol dependency has for many years been linked to the occurrence of structural and functional changes in the brain, mainly in the prefrontal cortex (Tarter, 1975; Gilman et al., 1996; Ratti et al., 2002; Oscar-Berman et al., 2004; Dirksen et al., 2006) the dorsomedial nucleus of thalamus connected to the basal ganglia (Tarter, 1975), and the area of the hippocampus, limbic structures and cerebellum (Harris et al., 1999; Beresford et al., 2006; Marinkovic et al., 2009).

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Symptoms of structural and functional abnormalities of the brain include deficits of cognitive functions. The earlier studies have reported no reduction in general intelligence of alcohol-dependent persons, particularly on scales in which the verbal factor is dominant (Tarter, 1975, 1980; Parsons, 1987). Nonetheless, more detailed studies of cognitive processes have revealed deterioration in cognitive plasticity, problem-solving ability, visual-motor coordination, verbal and non-verbal abstraction, and also in memory and learning (Cala et al., 1978; Tarter, 1980; Bergman, 1985; Miller, 1985; Nicolás et al., 1993; Beatty et al., 1996; Nixon, Bowlby, 1996).

Most researchers have concentrated on the effects of long-term alcohol consumption. The literature best describes the effects of alcohol dependency in the form of deficits in executive functions (Sullivan et al., 1993; Nowakowska, Jabłkowska, Borkowska, 2007). A comprehensive evaluation of these in alcohol-dependent patients indicated disturbances of planning, working memory, response inhibition and multitasking (Kopera, Wojnar, Szelenberger, 2010). The tool most commonly used to evaluate executive functions is the Wisconsin Card Sorting Test (WCST). Research revealed that alcohol-dependent persons performed WCST worse than healthy controls (Lyvers, Malzmann, 1991; Sullivan et al., 1993; Nowakowska, Jabłkowska, Borkowska, 2007). They also exhibited disturbances of motor perceptual functions in relation to the location of stimuli and reaction times. Also frequently observed were deficits of visual-spatial functions, such as visual search, mental rotation, constructional praxis. With regard to memory and learning, research indicated significant disturbances of short-term and long-term memory, non-verbal episodic memory, and learning of visual-spatial material (Kopera, Wojnar, Szelenberger, 2010).

Another field of research is the direct effects of alcohol consumption. The mechanism by which alcohol affects the brain is still not fully understood. According to earlier studies based on resting-state neuroimaging, the consumption of alcohol was connected with an increase in blood flow (rCBF) in the frontal and temporal areas (Sano et al., 1993). However, the latest resting-state fMRI study (Zheng et al., 2015) indicated that alcohol influenced brain functions in healthy persons in the area of the upper frontal gyrus, cerebellum, hippocampus and basal ganglia, and in the structures of the right internal capsule. Alcohol also weakened functional connections in the default mode network (DMN) (Raichle, 2001). Neuroimaging during simulation of car driving (Meda et al., 2009; Rzepecki-Smith et al., 2010) revealed that relatively large doses of alcohol (1.0‰) were linked with the changes in patterns of activity in cortical and subcortical circuits, i.e. the frontal-temporal-basal ganglia and the cerebellar circuits. Also, a study of brain activity during the performance of a Go/No Go task, evaluating the function of attention control (Anderson et al., 2011), demonstrated a decrease of brain activity in the cerebellum and basal ganglia.

Changes in the neurofunctional connections and activity of specific areas of the brain may be the basis of cognitive dysfunctions occurring immediately after the consumption of alcohol. Among the cognitive processes disturbed under the influence of an acute (single-instance) alcohol intoxication, the most commonly listed are processes of attention, learning, short-term memory, working memory, cognitive control, information processing, decision-making and visual-motor coordination, as well as reaction times (Holloway, 1995; Dougherty et al., 2000; Moskowitz, Fiorentino, 2000; Schulte et al., 2001; Weissenborn, Duka, 2003; Marczinski et al., 2005; Abroms, Gottlob, Fillmore, 2006; Fillmore, 2007).

The quality and depth of cognitive deficits and dysfunctional behavioural reactions following alcohol consumption are linked to the blood alcohol concentration, BAC (Kinney, Leaton, 1996). In the case of cognitive functions, adverse effects following an acute alcohol intoxication were observed at BAC of 0.05-0.1‰ for divided attention, 0.2-0.3‰ for sustained attention (Kopera, Wojnar, Szelenberger, 2010), 0.4-0.5‰ for perception, 0.4‰ for visual functions and psychomotor speed (Moskowitz, Fiorentino, 2000). Moreover, some studies have shown women to be more sensitive than men to the effects of alcohol, and thus to the deterioration of cognitive functioning under the influence of alcohol. These differences widened with an increase in the quantity of alcohol consumed (for review see: Mumenthaler et al., 1999). It has been found that not only the dose of alcohol and the sex, but also such factors as a level of task practice (Tarter et al., 1971), and even expectation of a deterioration in performance after moderate alcohol intake, may change the pattern of the cognitive functioning of persons after an acute alcohol intoxication (Fillmore, Vogel-Sprott, 1995).

Cognitive dysfunctions following alcohol consumption may be a serious problem not only in the context of the functioning of the individual, but also in social perspective. The consequences of these disturbances are particularly dangerous in the case of driving. Legally permitted BAC for drivers vary significantly between countries, and range from 0.0‰ to 1.00‰ (ICAP, 2002).

Most studies carried out to investigate drivers' cognitive performance following alcohol consumption concerned levels above the permitted BAC of the country in question, usually more than 0.5‰. In Poland there were very few such studies, and most data relating to the adverse effect of alcohol on driving ability are based on analysis of police data (Wiergowski, 2012). For example, in 2000-2006 between 13.6% and 16.3% of the total number of road accidents in Poland involved persons classed as intoxicated. The number of fatalities per 100 accidents caused by intoxicated road users was higher by 1-2 persons than the number of fatalities per 100 accidents caused by persons not classed as intoxicated (Kin-Dittmann, 2007).

Our study aimed to assess, in experimental model, the relationship between 0.1 to 0.25 mg per dm^3 of breath alcohol content, BrAC (in Poland, the equivalent of 0.2-0.5‰ of BAC) and cognitive functions such as attention, perception, psychomotor speed and visual-spatial functions, in alcohol-nondependent persons. The studied range of BrAC is the range defined in Polish law as a "state after alcohol consumption", in which the driving of vehicles constitutes a criminal misdemeanour.

Material and methods

Participants

Fifty alcohol-nondependent volunteers aged 25±3.356 years participated in the study. The sample was selected randomly, and recruitment was carried out by means of an announcement on a social networking website. Alcohol dependency was excluded on the basis of an interview according to ICD-10 criteria. The sex variable was controlled by the inclusion in the sample of the same number of women (25) and men (25). A clear majority of the group were persons who had completed high-school (24) and university-level education (23). One subject had completed a vocational school, and two had completed technical education. All of the subjects gave their informed consent for participation in the study. The study was conducted at the Institute of Psychology of Kazimierz Wielki University in Bydgoszcz. The study was approved by Institute's Research Ethics Committee.

Methods

The following research methods were used:

1) *d2 Test of Attention (Brickenkamp, 2003) in Polish adaptation of Dajek (2003).* It measures perceptual ability and attention parameters such as concentration (focused attention), impulsiveness and inattentiveness. The test uses A4 sheets on which 14 rows of 47 letters are printed. These consist of 16 different combinations of the letters *d* and *p* with one, two, three or four extra marks. The subject's task is to find and cross out the letter *d* with two marks. The time for performance of the task is limited to 20 seconds for each of the 14 rows. In the d2 test, concentration is interpreted as the continuous selection of stimuli, focusing, speed and ability to direct the attention selectively to important internal or external stimuli – that is, remaining detached or not paying attention to irrelevant stimuli. The index of concentration (d2_ZK) is the difference between the numbers of letters correctly and incorrectly crossed out. Perceptual ability is understood as the ability to notice and distinguish the features of stimuli. The index of general perceptual ability (d2_WZ-B) is the difference between the number of all crossed out letters and number of errors. Impulsiveness is defined as the tendency to make "false alarm" errors, and inattentiveness as the tendency to make omission errors.
2) *AT Smart Systems Cross Apparatus (CA).* This tool is used to test a subject's attention and visual-motor coordination. The device evaluates the speed of psychomotor reaction, the accuracy of perception and speed of decision-making under pressure of time, tiredness or stress. The apparatus has 49 buttons placed at equal intervals in 7 columns and 7 rows. On the edges of the matrix are LEDs which indicate that a given row or column is active. The equipment is designed for use by both left- and right-handed subjects. Testing can be carried out in two modes:
    a) Forced mode (FoM), in which the researcher sets the speed of the test, and the device illuminates, at an even pace, successive combinations of stimuli consisting of one active diode in a particular column and one in a particular

row. The subject's task is to keep up with the device and to press the appropriate buttons at the point of intersection between the active column and the active row. In this mode the apparatus counts the correct responses and mean reaction time.

b) Free mode (FrM), in which the apparatus generates an identical sequence of active diodes as in forced mode, except that in this case the rate of changes is determined by the subject's speed of reaction. In this mode the device calculates the total time of administration and the number of errors.

It is suggested that subject's performance on this task reflects on his or her behaviour in a real difficult situation on the road, in which perceptual speed and immediate appropriate reactions are of extremely high importance (Rotter, 2003).

3) *AT Smart Systems Stereometer (St).* This device tests the subject's spatial perception by evaluating the ability to estimate distances. The device used in this study is a reproduction of Dufour's stereometer, and is fully compatible with its methodology. It fulfils the quality requirements for testing at a distance of 4 metres. The apparatus has a mechanism of three moving rods, illuminated by a screen with controlled luminous intensity, which can be programmed for testing in two modes: with the outside rods moving (middle rod at 0 mm, both outside rods at +100 mm and then at –100 mm) or with the middle rod moving (both outside rods at 0 mm, middle rod at +135 mm and then at –135 mm). The result is the sum of distance in both modes [(m1, m2) sum].

4) *AT Smart Systems Reaction Time Tester (RTT).* This device is used to evaluate the speed and evenness of the subject's psychophysical reaction to light and sound stimuli of various frequencies. It enables the testing of simple and complex reactions. In the testing of a complex reaction, the subject must also demonstrate the ability to distinguish and identify stimuli and to map them to specific ways of acting. The device can be programmed to emit three light stimuli and two sound stimuli. It has five built-in programs which correspond to the programs recommended by Polish Road Transport Institute (Rotter, 2003). Using this test we measured number of errors and mean reaction times for simple (SR) and complex (CR) conditions.

Procedure

Each subject completed the D2 Test of Attention and performed set of tasks on the driver testing devices recommended by Polish Road Transport institute: the Cross Apparatus (free mode – number of variables 49; forced mode – number of variables 49, rate 50/min), the Stereometer (outside rods moving, programs 1 and 2), and the Reaction Time Tester (simple reaction – reaction with the right foot to every stimulus, number of stimuli 30, program 2; complex reaction (differentiated) – reaction with the right foot to a red light and with the right hand to a yellow light, while avoiding reacting to other stimuli, number of stimuli 30, program 2; complex reaction (choice) – reaction with the right foot to a red light, with the right hand to a yellow light, with the left foot to a green light and with the left hand to a sound, number of stimuli 30, program 2.

Participants performed the tests twice – once when sober, and once when under the influence of alcohol. In the latter case to reach the BrAC of 0.1-0.25 mg/dm^3, participants consumed a quantity of alcohol determined on the basis of their sex, weight and height . The content of BrAC of was measured using a certified semiconductor breathalyser, 30 minutes after finishing drinking, when the alcohol concentration is highest; and also after the end of the test. After performing the tests the subjects remained at the laboratory in the presence of the researcher until they were completely sober, or else were provided with safe transport to their home.

To diminish the learning effect, a three-week interval was left between the first and second series of tests, and the subjects were divided into two groups:

a) Group 0 – tested first without alcohol (noALC), and secondly with alcohol (ALC),
b) Group 1 – tested first with alcohol (ALC), and secondly without alcohol (noALC).

All statistical analysis were performed using STATISTICA 12.0. licenced package.

Results

At the first stage of analysis, the performance of cognitive tasks in sober state and after alcohol consumption was compared using Student's *t*-test for dependent variables. We found sum of error in free mode measured by Cross Apparatus which is one of considered parameters of focus attention to be significantly higher in the participants under influence of alcohol. The analysis did not reveal any other effect of alcohol consumption on the level of focused and selective attention, the level of general perceptual ability, the efficiency of spatial perception or psychomotor reaction times (table 1).

Next, we correlated the level of BAC before and after testing with all cognitive parameters using *r*-Pearson test and found no significant relationship between those variables (mean BAC before testing was: 0.450‰ ± 0.068‰ and mean BAC after testing was: 0.439‰ ± 0.072‰).

Table 1. The cognitive performance in a somber state and after alcohol consumption

Measure	noAlc		Alc		t – test	p – value
	M	*SD*	*M*	*SD*		
Focused attention						
d2_ZK	195.880	36.781	198.340	39.349	-0.447	0.657
CA_FoM sum of correct responses	40.460	6.777	40.920	7.085	-0.426	0.672
CA_FrM sum of errors	0.940	1.058	1.480	1.776	-2.179	0.034
RTT_SR sum of errors	0.140	0.452	0.080	0.274	0.903	0.371
Selective attention						
RTT_CR sum of errors	1.680	1.362	1.860	1.429	-0.796	0.430
General perceptual ability						
d2_WZ-B	486.540	72.243	490.580	73.516	-0.422	0.675
Spatial perception						
St_(m1,m2) sum (mm)	85.380	63.364	71.920	69.973	1.399	0.168
Psychomotor reaction time						
RTT_SR mean reaction time (s)	0.343	0.053	0.340	0.047	0.461	0.647
RTT_CR mean reaction time (s)	0.469	0.063	0.473	0.063	-0.432	0.667
CA_FoM mean reaction time (s)	0.646	0.077	0.654	0.094	-0.534	0.595
CA_FrM total time (s)	50.260	7.730	50.374	6.485	-0.098	0.922

$p < 0.05$

CA_FoM – Cross Apparatus_Forced Mode, CA_FrM – Cross Apparatus_Free Mode, RTT_SR – Reaction Time Tester_Simple Reaction, RTT_CR – Reaction Time Tester_Complex Reaction, St_(m1,m2) – Stereometer_(mode 1 and 2)

Since in previous reports a learning effect, or else effect of familiarity with the testing situation in the repeated measurement was often observed, leading to an improvement in the results obtained in the second measurement, at the next step of analysis we assessed whether and how that effect was influenced by the consumption of alcohol. The tests were organised in such a way that at the second measurement one-half of the study group was under the influence of alcohol, while the other half was sober. Consequently, analysis of variance with repeated measurements and qualitative predictors was applied. The first of the qualitative predictors was the consumption of alcohol in the first vs. the second measurement. The second qualitative predictor, in accordance to previous research reports, was taken to be the sex of the subject.

The analysis showed the presence of a learning effect for the **focused attention**. The indicator of focused attention in the D2 Test of Attention (d2_ZK) increased significantly between the first and second measurements: $F(1.46) = 155.451$, $p < 0.001$, $\eta 2p = 0.772$ (figure 1). However, this effect proved to be independent of whether alcohol was consumed at the first or the second measurement: $F(1.46) = 2.151$, $p < 0.149$, $\eta 2\mathrm{p} = 0.045$; and of sex: $F(1.46) = 0.833$, $p = 0.366$, $\eta 2p = 0.018$.

An analogous situation was found in the case of the number of correct responses in testing using the Cross Apparatus (CA_FoM sum of correct responses), where the results improved significantly in the second measurement: $F(1.46) = 18.252$, $p < 0.001$, $\eta 2p = 0.284$ (figure 2), independently of whether alcohol was consumed at the first or the second measurement: $F(1.46) = 0.005$, $p = 0.946$, $\eta 2p = 0.0001$, and independently of sex: $F(1.46) = 3.449$, $p = 0.070$, $\eta 2p = 0.070$.

The learning effect was also observed in sum of errors measured by free mode in Cross Apparatus (CA_FrM sum of errors) $F(1.46) = 7.173$, $p = 0.010$, $\eta 2p = 0.135$. The learning effect did not depend on the subject's sex: $F(1.46) = 0.061$, $p = 0.806$, $\eta 2p = 0.001$, although it proved to be dependent on whether alcohol was consumed at the first or second measurement: $F(1.46) = 7.782$, $p = 0.008$, $\eta 2p = 0.145$ (figure 3). In the group of participants who did not consume alcohol at the second measurement, we revealed the significant decrease in the number of errors in that measurement. Such difference has not occurred in the subjects who in the first measurement were sober while intoxicated with alcohol during second measurement.

In case of last measures of focused attention (RTT_SR sum of errors) we found no change under the influence of repeated measurement: $F(1.46) = 0.398$, $p = 0.531$, $\eta 2p = 0.009$. However these results cannot be considered credible due to the very low changeability of this parameter in both measurements (90% in the first measurement and 92% in the second measurement of participants committed no error).

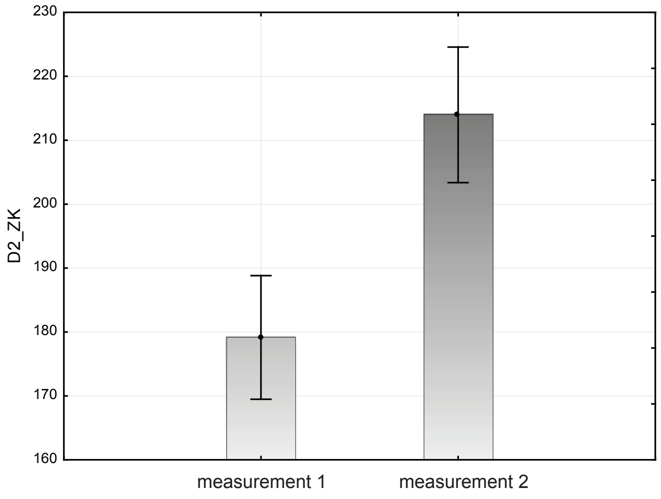

Figure 1. Performance on D2 Test of Attention (D2_ZK) in first and second measurement

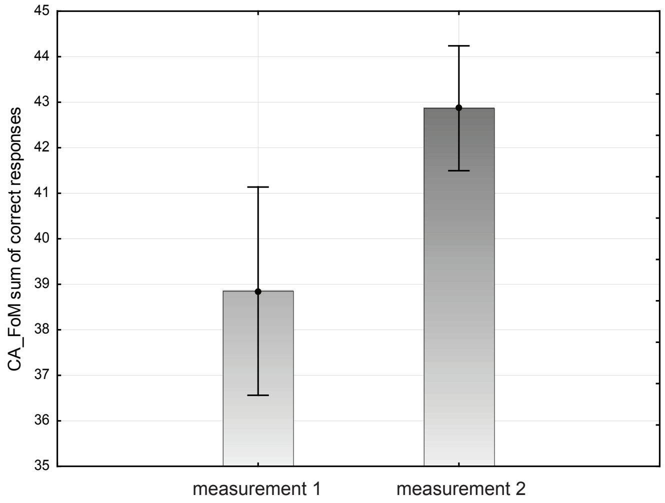

Figure 2. Performance on Cross Apparatus (CA_FoM sum of correct responses) in first and second measurement

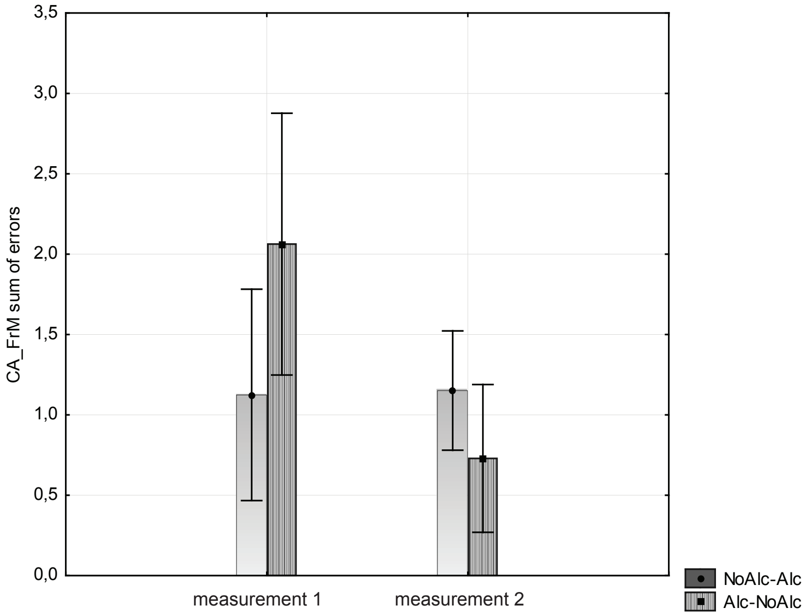

Figure 3. Performance on Cross Apparatus (CA_FrM sum of correct responses) in both measurement, in the groups which were under influence of alcohol in the first and second measurement respectively

The level of **selective attention** measured by sum of errors for complex reaction in Reaction Time Tester (RTT_CR sum of errors) did not change under the influence of repeated measurement: *F*(1.46) = 0.367, *p* = 0.548, *η2p* = 0.008, independently of whether alcohol was consumed at the first or second measurement: *F*(1.46) = 0.367, *p* = 0.548, *η2p* = 0.008, and independently of sex: *F*(1.46) = 0.016, *p* = 0.00, *η2p* = 0.0003. However these results cannot be considered credible due to the very low changeability of this parameter in both measurements (94% of participants in the first measurement, while 92% in second measurement achieved 90% of correct responses, i.e. made 3 errors).

The **general perceptual ability** assessed by WZ-B parameter in d2 Test of Attention (d2_WZ-B) increased significantly between the first and second measurements: *F*(1.46) = 151.134, *p* < 0.001, *η2p* = 0.767 (figure 4). The effect of repeated measurement was not dependent on whether alcohol was consumed at the first or second measurement: *F*(1.46) = 2.517, *p* = 0.119, *η2p* = 0.052; or on sex: *F*(1.46) = 0.108, *p* = 0.744, *η2p* = 0.002.

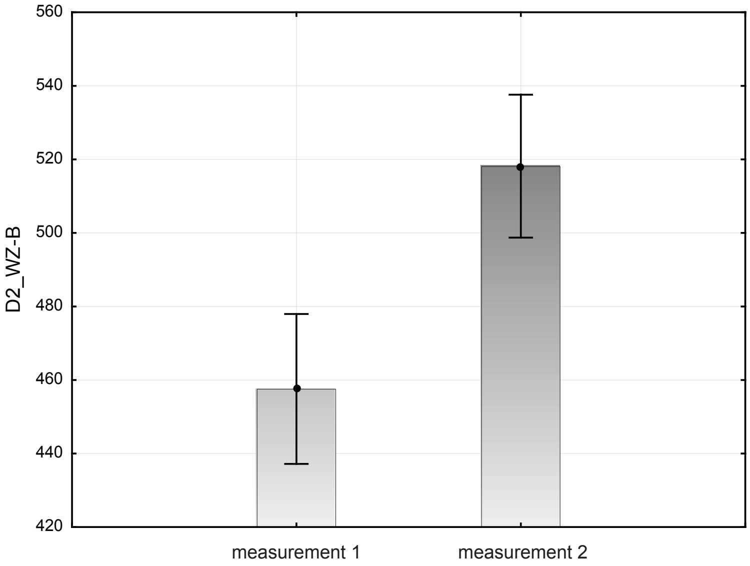

Figure 4. Performance on D2 Test of Attention (D2_WZ-B) in first and second measurement

No learning effect was observed in the case of the efficiency of **spatial perception**: assessed by sum of distance deviations in both modes (m1 and m2) in Stereometer: *F*(1.46) = 0.039, *p* = 0.843, *η2p* = 0.001, independently of when the alcohol was consumed (measurement 1 vs. measurement 2): *F*(1.46) = 1.232, *p* = 0.273, *η2p* = 0.026, and independently of the subject's sex: *F*(1.46) = 1.296, *p* = 0.261, *η2p* = 0.027.

As regards to the **psychomotor reaction times**, repeated measurement was found to produce a significant improvement in total time on the Cross Apparatus in free mode (CA_FrM total time): *F*(1.46) = 110.193, $p < 0.001$, $\eta 2p = 0.705$. The learning effect did not depend on the subject's sex: *F*(1.46) = 0.523, $p = 0.473$, $\eta 2p = 0.011$, although it proved to be dependent on whether alcohol was consumed at the first or second measurement: *F*(1.46) = 4.640, $p = 0.036$, $\eta 2p = 0.092$. The total reaction time decreased significantly at the second measurement, the decrease being greater in the case of those subjects who did not consume alcohol at that measurement (figure 5).

For the second indicator of psychomotor reaction time measured by Cross Apparatus – mean reaction time in forced mode (CA_FoM mean reaction time) the learning effect has not been revealed *F*(1.46) = 0.118, $p = 0.733$, *eta* = 0.002; independently of subject's sex *F*(1.46) = 1.398, $p = 0.243$, *eta* = 0.029 and alcohol consumption *F*(1.46) = 3.514, $p = 0.067$, *eta* = 0,071.

Similarly, the mean time for simple and mean time for complex reactions in Reaction Time Tester (RTT_SRT mean reaction time and RTT_CRT mean reaction time), did not change as a result of repeated measurement: *F*(1.46) = 0,521, $p = 0{,}474$, *eta* = 0.011 and *F*(1.46) = 1.236, $p = 0.272$, $\eta 2p = 0.026$ respectively. It was observed independently of when the alcohol was consumed: *F*(1.46) = 0.275, $p = 0{,}602$, *eta* = 0.006 (RTT_SRT mean reaction time) and *F*(1.46) = 0.458, $p = 0.502$, $\eta 2p = 0.010$ (RTT_CRT mean reaction time),, and independently of sex: *F*(1.46) = 1.192, $p = 0{,}281$, *eta* = 0.025 and *F*(1.46) = 0.078, $p = 0.781$, $\eta 2p = 0.002$, respectively.

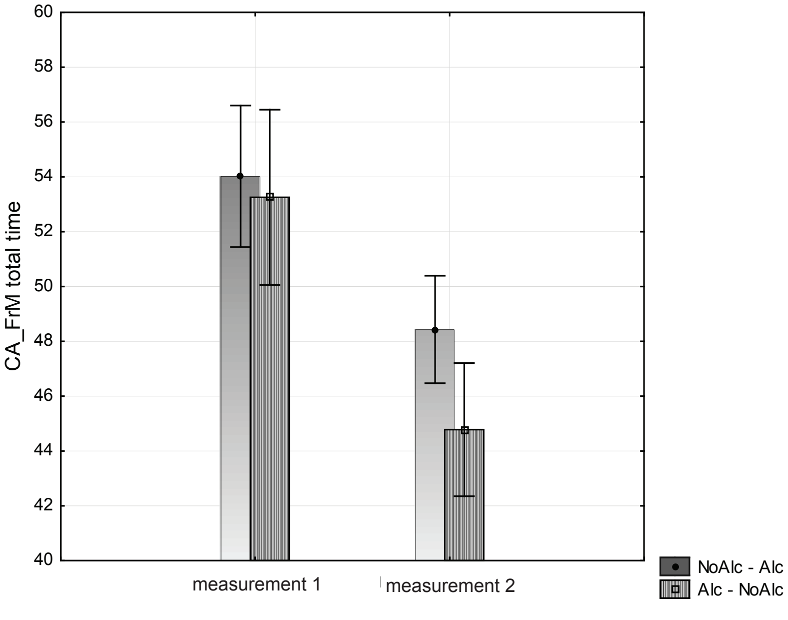

Figure 5. Performance on Cross Apparatus (CA_FrM total time) in both measurement in the groups which were under influence of alcohol in the first and second measurement respectively

Discussion

The detrimental effects of alcohol consumption on human brain and behavior have been studied extensively for many years. However, the most often the research focused on the effects of long-term alcohol dependency. To date, very few studies have concentrated on the influence of acute, low-to-moderate alcohol intoxication on cognition, especially in young alcohol nondependent adults. Our study aimed to assess such a relationship. We have used an experimental model to observe the effect of 0.1-0.25 mg/dm^3 of BrAC (in Poland equivalent of 0.2-0.5 of BAC) on cognitive functions reported to be alcohol-sensitive and also to be critical for complex behaviors, such as driving. Therefore, we used methods recommended by Polish Road Transport Institute for psychological assessment of drivers (Rotter, 2003).

In the first step of analysis we compared the performance of participants on cognitive tasks in alcohol-free state and following alcohol intoxication. We observed their efficiency in five cognitive domain: focused attention, selective attention, general perceptual ability, spatial perception and psychomotor reaction times. The results revealed the difference only in one parameter which assess focused attention. Participants made more errors in free mode on Cross Apparatus following alcohol consumption compared to their performance in sober state. This measure of focused attention is to large extent connected with a psychomotor coordination, thus it may be most sensitive to even minor changes in the level of performance, especially in free mode in which the presentation of stimuli is not at an even pace which requires larger involvement of attention. We also correlated the level of BAC before and after testing with results of all applied tests and found no relation between those parameters. Based on previous reports (Koelega, 1995; Moskowitz, Fiorentino, 2000; Ogden, Moskowitz, 2004; Kopera, Wojnar, Szelenberger, 2010) we expected the alcohol to influence all selected cognitive domains in dose-dependent pattern. However, our group consisted of young alcohol adults in whom the influence of alcohol on cognition may be slighter than in older adults. The period of early adulthood in developmental psychology is associated with the highest efficiency in different cognitive domains (Gurba, 2011) which may compensate the negative impact of alcohol on cognition. In addition, the results of Sklar et al. (2014) have revealed the interactions between alcohol and age, suggesting that older adults may be more susceptible to the effects of alcohol on some aspects of driving performance. Moreover, alcohol-induced cognitive impairment was demonstrated to some extent to be time-dependent, and is greatest during periods of sleepiness, i.e. the early afternoon and after midnight (Koelega, 1995). Our study was conducted during daytime and the participants declared not to be sleepy or tired prior to testing. Furthermore, our study group consisted of alcohol nondependent persons in whom the alcohol-induced cognitive impairment has been shown to be slighter than in those who are "bingers" (Weissenborn, Duka, 2003).

The other field of our observation in the study was the influence of alcohol on learning effect. The repeated measurement using neuropsychological tools has been demonstrated to produce an occurrence of learning effect which needs to be controlled in the diagnosis of cognitive performance (Valdez, Ramírez, García,

2012) The results of our study has also confirmed this phenomenon. We found three parameters to improve in the second testing, independently of alcohol intake and subject's sex. Two of them were the measures of focused attention (d2_ZK and CA_FoM sum of correct responses) and one was a measure of general perceptual ability (d2_WZ-B). Moreover, in the case of two other parameters we observed learning effect to be influenced by alcohol consumption. In participants who were under influence of alcohol in the first measurement with Cross Apparatus in free mode, the learning effect was weakened. In the second testing the decrease in total time of performance and sum of errors was smaller than in the individuals who were sober in the first measurement and intoxicated in the second one. It appears that alcohol intake in the first testing adversely affected the ability to use prior experience in the second measurement of focused attention and psychomotor speed.

The learning process is based on explicit and implicit memory (Schacter 1987; Kirsner 1998). The study of Duka, Weissenborn and Dienes (2001) has shown that alcohol received prior to encoding reduced awareness of implicitly retrieved material. They also observed state-dependent retrieval effects on explicit memory. For explicitly retrieved information, recollective experience benefited from same drug state, whereas familiarity benefited from different drug state between encoding and retrieval. Moreover, Weissenborn and Duka (2000) found that in the case of encoding under influence of alcohol intoxication, alcohol may provide an internal or independent context to assist additional cues in retrieval process. Based on these findings we hypothesized that in our study the learning effect could be influenced by different drug state between first and second measurements or by alcohol-induced changes in encoding during first testing.

In conclusion, our study has revealed that 0.1-0.25 mg/dm^3 of BrAC may lead to worse performance on focused attention task and decreased ability to benefit from previous experience in area of attention and psychomotor speed in young alcohol nondependent adults. These deficits may be critical while driving. We understand that our results obtained as an effect of testing in laboratory do not translate directly into efficiency of driving under the influence of alcohol dose tested. The laboratory setting did not take into account the real threats and cognitive demands that may appear on the road while driving. These results, however, allow to confidently look at the legal restrictions in Poland relating to permissible BAC for drivers and believe that compliance with these regulations increases the level of road safety.

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WPŁYW 0,1-0,25 MG/DM^3 ALKOHOLU W WYDYCHANYM POWIETRZU NA FUNKCJE POZNAWCZE U MŁODYCH DOROSŁYCH NIEUZALEŻNIONYCH OD ALKOHOLU

Streszczenie. Uzależnienie od alkoholu prowadzi do zmian w aktywności mózgu i zaburzeń poznawczych, jednakże dane dotyczące wpływu spożywania niskich do umiarkowanych dawek alkoholu na funkcjonowanie poznawcze są niespójne. Celem badania była ocena wpływu 0,1-0,25 mg/dm^3 stężenia alkoholu w wydychanym powietrzu na funkcje poznawcze, takie jak: uwaga, percepcja szybkości psychomotorycznej i funkcji wzrokowo-przestrzennych u 50 młodych nieuzależnionych od alkoholu dorosłych. Wyniki wykazały pogorszenie w zakresie koncentracji uwagi mierzonej aparatem krzyżowym po spożyciu badanej dawki alkoholu. Ujawniły one także występowanie efektu uczenia się w zakresie testów do badania uwagi i szybkości psychomotorycznej. Efekt ten był jednakże znacząco osłabiony u uczestników, którzy byli pod wpływem alkoholu w pierwszym badaniu. Uzyskane rezultaty wskazują, że badane stężenie alkoholu może mieć szkodliwy wpływ na koncentrację i zdolność do korzystania z wcześniejszych doświadczeń, które są kluczowe dla złożonych zachowań, takich jak prowadzenie pojazdów mechanicznych.

Słowa kluczowe: alkohol, uwaga, czas reakcji, ogólna zdolność spostrzegania, percepcja przestrzenna

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