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# Spontaneous flexibility, attentional set shifting and cognitive control in men with alcohol dependence

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## Abstract

**Purpose:** The aim of the study was to assess spontaneous flexibility, attentional set shifting and cognitive control in alcohol-dependent men in the process of therapy in alcohol addiction treatment units, and to recognise the use of production strategies in visual-spatial mode in this clinical group.

**Methods:** A total of 72 men participated in the study, 43 were alcohol-dependent (ADS) and 29 were controls (CTR). The Ruff Figural Fluency Test (RFFT), the Color Trails Test part 2 (CTT-2) and the Montreal Cognitive Assessment (MoCA) were administered.

**Results:** The findings showed that alcohol dependence significantly impacted performance CTT-2 and RFFT, beyond and above age and education. The ADS group performed significantly worse than controls in CTT-2 and all indices of RFFT. A significant interaction effect was observed between group and task type for perseverations, with ADS patients producing fewer perseverations for the first part of RFFT compared to other parts of the test. They also used fewer production strategies than controls.

**Conclusions:** Our findings highlight that alcohol dependence specifically contributes to explaining the results in terms of reactive flexibility in the aspect of attentional set shifting, as well as spontaneous flexibility in tasks requiring the generation of unique designs in limited time. The alcohol-dependent group demonstrated poor cognitive control, as evidenced by significantly higher number of perseverations. Furthermore, an analysis of the production strategies employed by alcohol-dependent men provided important information about their control and planning capacities. These findings support the recommendation to work with cognitive stimulation in therapeutic work with this population.

**Key words:** executive functions, production strategies, perseverations.

## INTRODUCTION

Cognitive flexibility, as a crucial component of executive functions, supports various higher-order processes, such as divergent thinking, problem-solving, learning and decision making [1]. This aspect of executive functions is defined in diverse ways, with some definitions pointing out to a combination of flexibility and persistence, treated as the process that reflects the degree of task-directed maximal cognitive effort and the ability to sustain the effort over time and through distraction [2-4]. Tasks measuring flexibility require complex cognitive processes and their performance is related to mental speed [4]. Different task conditions allow for measuring two types of cognitive flexibility: spontaneous and reactive [5]. Spontaneous flexibility, related to frontal lobe functions, includes original ideation and divergent thinking while reactive flexibility engages not only frontal lobe mechanisms but also basal ganglia, and the interactions between these brain structures [6]. It concerns the ability to change strategy in response to demands, that is attentional set shifting or task-switching [7, 8]. Tasks measuring reactive flexibility are highly structured, with strictly defined requirements whereas less-constrained tasks have been used to assess spontaneous flexibility and various spontaneously used strategies [9]. In the tasks with two key requirements: optimizing novel productions while minimizing repetition, production strategies can support effective performance [10, 11]. According to Gardner *et al.* [12], these strategies may offer insights into an individual's planning, reasoning, and divergent thinking processes, although a lack of strategy use does not necessarily imply a deficit [13]. Nonverbal production strategies in figural fluency are seldom explored in the literature [10-12].

Spontaneous and reactive flexibility place different requirements on working memory and cognitive control. Reactive flexibility is essentially connected to cognitive control, while spontaneous flexibility being perceived as related to control and working memory [4, 7, 8]. Inhibitory control is crucial for divergent thinking, due to the need to stop obvious, repetitive, irrelevant responses prompted by spontaneous associations [14, 15]. Low working memory capacity may hinder successful monitoring, solution supervising, and maintenance of response sequences or self-generated cues [4]. Few studies have examined the factor structure of cognitive flexibility tests to determine overlapping cognitive abilities that contribute to cognitively flexible behaviour [8]. The results show that the nature of cognitive flexibility seems to be heterogeneous, and a single mechanism appears insufficient to explain it [7, 16].

In alcohol-dependent individuals with a history of prolonged drinking changes have been observed in the prefrontal cortex, hippocampus and cerebellum [17, 18]. Many studies suggest that these changes are persistent and may even continue after cessation of drinking. Although some studies indicate some improvements in the functioning following periods of abstinence, but other reports do not find a link between duration of abstinence and improvement in functioning [18-21]. The progressive nature of cognitive impairment associated with long-term alcohol intoxication is also indicated, potentially leading to severe cognitive deficits comparable to dementia. Decreased cognitive functioning in alcohol-dependent individuals includes deficits in memory, particularly working memory, executive functions, visual-spatial processes and visual learning [20, 22-26], distractibility, loss of inhibition, poor insight, perseverative behaviour, difficulties with impulse control [19, 27]. Executive dysfunction affecting planning, complex problem solving, behavioural control, and rigidity of functioning within established patterns are a barrier to successful rehabilitation [1, 19, 28]. Poor cognitive flexibility, indicated by difficulties in updating information for decision-making, makes abstinence difficult for alcohol-dependent individuals. Cognitive rigidity is also recognized as a predictor of addiction to psychoactive substances, including alcohol [29].

Considering all these findings, we incorporated a two-factor structure of flexibility (spontaneous and reactive), along with detailed characteristics of production strategies into the analysis of alcohol-dependent men. Despite the fact that flexibility has been shown as one of the defective areas in the functioning of alcohol-dependent individuals [18, 25, 30], these aspects of flexibility have not been incorporated into previous studies of this clinical group. A deeper analysis of nonverbal cognitive tasks strategies could contribute to a better understanding of the planning and cognitive control execution which are crucial for achieving positive therapeutic effects [19, 27, 29, 31, 32]. The study was designed to achieve three primary goals. First, to determine whether alcohol dependence uniquely contributes to spontaneous flexibility, attentional set shifting (reactive flexibility) and cognitive control irrespective of demographic variables. It was anticipated that alcohol dependence is a significant factor affecting spontaneous flexibility performance, attentional set shifting and cognitive control, regardless of demographic variables such as age and education. Second, to evaluate the cognitive functioning of alcohol-dependent individuals undergoing therapy in alcohol addiction treatment units, compared to a control group without addiction, in the range of spontaneous flexibility, attentional set shifting and cognitive control. It was assumed that alcohol-dependent individuals would demonstrate weaker capabilities in these cognitive areas compared to controls. Third, to examine the use of enumerative and rotational production strategies in visual-spatial mode. It was hypothesised that alcohol-dependent individuals use fewer production strategies than individuals without addiction and that their non-verbal tasks performance would be characterised by a lower saturation of task execution with fewer original solutions generated through production strategies.

## METHODS

### Participants

Participants included 43 men with alcohol dependence syndrome (ADS) who underwent therapy in alcohol addiction treatment units, and 29 controls (CTR) recruited in the local community who never used psychoactive substances or used them in the way that does not meet the criteria for addiction (WHO, 1992). All men from the clinical group met ICD-10 criteria for alcohol dependence. Men with ADS and controls were excluded in the preliminary screening if they had fewer than 8 years of education or a history of psychiatric condition (e.g., schizophrenia, bipolar disorder) or neurological disorders (e.g., neurodegenerative disease, stroke, multiple sclerosis). In the group of men with ADS, the mean age was 42.09 ($SD$ = 11.06), in CTR 51.28 ($SD$ = 13.30). The average years of education in ADS group was 11.28 ($SD$ = 2.30), whereas in the control group it was 13.93 ($SD$ = 2.76). Significant differences were observed between the ADS and CTR groups with respect to age ($t = -3.182; p = 0.001$) and education ($t = -4.265; p < 0.001$). In the MoCA test, men with alcohol dependence scored on average 26.12 ($SD$ = 2.63). The mean time since the first hospitalisation due to acute state caused by alcohol use was 5.84 ($SD$ = 6.00) years. All participants received information about the characteristics of the study and all signed the informed consent forms. The study was approved by the UMCS Research Ethics Committee.

### Measures

Two tests were administered to assess different aspects of cognitive flexibility. Both are timed, involving visual perception and a motor component, and require substantial working memory for successful completion [31].

The Ruff Figural Fluency Test (RFFT; Polish adaptation by Łojek and Stańczak [33]) measures non-verbal fluency and executive functions. It provides information on such cognitive abilities as flexible and divergent thinking, self-monitoring, planning strategies, the ability to flexibly shift cognitive sets in a visual-spatial context and ability to inhibit previously generated responses. It also evaluates the executive ability to coordinate processes through attention control and working memory [34, 35]. The test consists of five parts, presented sequentially, with each part containing 35 five-dot matrices. The stimulus patterns are different in each part. While parts 1, 2 and 3, use the same dot layout, parts 2 and 3 introduce distractors (additional elements are included). Parts 4 and 5 feature variation of the layout from part 1, without distracting elements. The task is to connect two or more dots in each matrix to generate as many novel designs as possible within one minute for each part without repetition. Performance on the RFFT is expressed as: (1) the total number of unique designs across all five parts (UD) indicating spontaneous flexibility; (2) the total number of repetitions, i.e. perseverative errors (PE) along with (3) the error ratio (ER), calculated as the relationship between the total number of unique designs and the total number of perseverative errors (PE divided by UD), as cognitive control indicators. Additional indices for some aspects of cognitive control were introduced: the total number of rotation strategies (RFFTrs), enumerative strategies (RFFTes), the total number of designs produced within the rotation (RFFTrsd) and enumerative strategies (RFFTesd), and the ratio of designs used in strategies (RFFTdsr, calculated by dividing the number of designs incorporated into production strategies by the number of unique designs).

The Color Trails Test (CTT; Polish adaptation by Łojek and Stańczak [36]) demands visual search, mental set switching, executive control, and motor control. It consists of two parts, with the second of them (CTT-2) being used in the study. In CTT-2 participants connect numbered circles in sequence while alternating between pink and yellow colors. Each number appears twice, once in pink and once in yellow, requiring participants to ignore distracting element, e.g., start at pink 1, avoid pink 2 to select yellow 2, skip yellow 3 to select pink 3, etc.). The time taken to complete the task serves as an indicator of reactive cognitive flexibility.

The Montreal Cognitive Assessment (MoCA) [37] is a screening tool to assess mild cognitive dysfunction, encompassing various cognitive domains: attention and concentration, executive functions, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation.

### Statistical analysis

Data were analysed using the SPSS Statistics software (version 29). To determine whether alcohol dependence distinctly contributes to the CTT-2 and RFFT performance, above and beyond the demographic variables (i.e., age and education), several hierarchical regressions were performed (using sequentially: CTT-2, RFFT UD, RFFT ER, RFFTdsr as criterion variables). Age and education were entered in the first step (model 1), and alcohol dependence in the second step (model 2). A mixed model ANOVA in scheme 2 × 5 was carried out to calculate the effects of group (alcohol dependence vs. controls) and task type (parts 1-5 of RFFT) on RFFT UD and RFFT PE. A parametric *t*-test was used to investigate the differences in CTT-2, RFFT ER, and RFFT strategies' indicators between patients with alcohol dependence and controls. The effect size for the *t*-test (Cohen's *d*) was also calculated.

## RESULTS

To determine whether alcohol dependence distinctly contributed to CTT-2 and RFFT performance hierarchical regressions were performed, using CTT-2 time, RFFT UD, RFFT ER or RFFTdsr as criterion variables (Table 1). The results of analyses, using CTT-2 or RFFT UD as a criterion, demonstrated that either age or education were independent predictors of CTT-2 and RFFT UD scores. After introducing alcohol dependence to the regression model with CTT-2 as a criterion, age remained a significant factor and alcohol dependence accounted for approximately an additional 5.6% of variance. In the regression model with RFFT UD as a criterion, once alcohol dependence was included, both age and education were still independent predictors. Nonetheless alcohol dependence explained an additional 6% of variance. These findings showed that alcohol dependence significantly contributes to performance in CTT-2 and RFFT UD. Regarding the RFFT ER and RFFTdsr scores, education but not age was an independent predictor. Nevertheless, introducing alcohol dependence factor to the regression model resulted in neither age nor education being significant predictors, but only alcohol dependence. These analyses revealed that 10% of RFFT ER and 14% of RFFTdsr variance were explained uniquely by alcohol dependence (Table 1).

The results of the present study also revealed that the ADS group performed significantly worse compared to controls in CTT-2 and all indices of RFFT. The results obtained with mixed model ANOVA showed no significant main effect of the task type on unique design number (RFFT UD; Table 2). However, there was a significant main effect of group, with poorer unique design production in ADS group, compared to CTR (Table 2). No significant

**Table 1.** The impact of demographic variables and alcohol abuse on the score of RFFT and CTT-2 (the hierarchical regression model)

| Model | | B | SE | t | p |
|---|---|---|---|---|---|
| CTT-2 | | | | | |
| Model 1 | Age<br>Education | 0.398<br>–0.287 | 0.437<br>1.987 | 3.616<br>–2.607 | < 0.001<br>0.011 |
| | $R^2_{kor}$ = 0.173, MSE = 46.03, $F$ (2,69) = 8.413, $p$ < 0.001 | | | | |
| Model 2 | Age<br>Education<br>Alcohol dependence | 0.475<br>–0.170<br>–0.282 | 0.445<br>2.142<br>12.757 | 4.235<br>–1.437<br>–2.263 | < 0.001<br>0.155<br>0.027 |
| | $R^2_{kor}$ = 0.219, MSE = 20.137, $F$ (3,68) = 7.651, $p$ < 0.001; $R^2_{chng}$ = 0.056; $F$ = 5.123, $p$ = 0.027 | | | | |
| RFFT UD | | | | | |
| Model 1 | Age<br>Education | –0.298<br>0.551 | 0.199<br>0.205 | –2.958<br>5.474 | 0.004<br>< 0.001 |
| | $R^2_{kor}$ = 0.308, MSE = 20.96, $F$ (2,69) = 16.833, $p$ < 0.001 | | | | |
| Model 2 | Age<br>Education<br>Alcohol dependence | –0.378<br>0.430<br>0.293 | 0.201<br>0.964<br>5.745 | –3.725<br>4.007<br>2.601 | < 0.001<br>< 0.001<br>0.011 |
| | $R^2_{kor}$ = 0.362, MSE = 20.137, $F$ (3,68) = 14.414, $p$ < 0.001; $R^2_{chng}$ = 0.061; $F$ = 6.764, $p$ = 0.011 | | | | |
| RFFT ER | | | | | |
| Model 1 | Age<br>Education | –0.216<br>–0.300 | 0.008<br>0.037 | –1.919<br>–2.671 | 0.059<br>0.009 |
| | $R^2_{kor}$ = 0.138, MSE = 0.862, $F$ (2,69) = 6.666, $p$ = 0.002 | | | | |
| Model 2 | Age<br>Education<br>Alcohol dependence | –0.111<br>–0.143<br>–0.380 | 0.008<br>0.039<br>0.232 | –1.001<br>–1.217<br>–3.072 | 0.321<br>0.228<br>0.003 |
| | $R^2_{kor}$ = 0.232, MSE = 0.813, $F$ (3,68) = 8.134, $p$ < 0.001; $R^2_{chng}$ = 0.102; $F$ = 9.440, $p$ = 0.003 | | | | |
| RFFTdsr | | | | | |
| Model 1 | Age<br>Education | –0.065<br>0.405 | 0.196<br>0.825 | –0.523<br>3.242 | 0.603<br>0.002 |
| | $R^2_{kor}$ = 0.128, MSE = 17.733, $F$ (2,69) = 5.260, $p$ = 0.008 | | | | |
| Model 2 | Age<br>Education<br>Alcohol dependence | –0.066<br>0.176<br>0.438 | 0.181<br>0.887<br>5.610 | –0.574<br>1.312<br>3.310 | 0.568<br>0.195<br>0.002 |
| | $R^2_{kor}$ = 0.260, MSE = 16.340, $F$ (3,68) = 7.782, $p$ < 0.001; $R^2_{chng}$ = 0.140; $F$ = 10.957, $p$ = 0.002 | | | | |

*RFFT – Figural Fluency Test, RFFT UD – unique designs, RFFT ER – error ratio, RFFTdsr – ratio of designs used in both strategies: rotational and enumerative divided by RFFT UD, CTT – Color Trails Test*

interaction between group and task type occurred (Table 2) but significant main effects of group and the task type on the number of perseverations were shown. ADS group manifested significantly more perseverative performing RFFT in comparison to CTR. The interaction effect of group and task type was significant for perseverations. Pairwise comparisons with Bonferroni test showed that ADS patients produced fewer perseverations for the first part of RFFT than for the other parts of the test ($p$ < 0.001 for part 3, 4, 5 and $p$ = 0.008 for part 2) and the second part compared to the fifth one ($p$ = 0.009). No differences between parts of the RFFT in CTR group were found.

The independent $t$-test showed that ADS men had longer reaction times on the second part of the CTT and they scored higher error ratio in RFFT than CTR group. Additionally, they had a lower RFFTdsr score than controls (Table 2).

The dependent $t$-test for variable showed that ADS men use significantly fewer strategies ($t$ = 4.458, $p$ < 0.001; $d$ = 0.680) and designs in strategies ($t$ = 4.115, $p$ < 0.001; $d$ = 0.628) in the enumeration strategy compared to the rotation one. In CTR group, no significant differences between rotation and enumeration strategies were found ($t$ = 1.020, $p$ = 0.324 for the number of strategies; $t$ = 1.863, $p$ = 0.082 for the number of designs in strategies).

## DISCUSSION

The first aim of the current study was to determine whether alcohol dependence distinctly contributes to spontaneous flexibility, attentional set shifting and cognitive control beyond or above demographic variables. The current study showed that irrespectively of age and

**Table 2.** Comparisons in RFFT indices and CTT-2 time reaction in ADS and CTR groups

| | ADS ($n$ = 43) $M$ ($SD$) | CTR ($n$ = 29) $M$ ($SD$) | Group effect | | | Type of task effect | | | Interaction effect | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $F$ | $p$ | $\eta^2$ | $F$ | $p$ | $\eta^2$ | $F$ | $p$ | $\eta^2$ |
| RFFT UD | | | | | | | | | | | |
| RFFTpart1 | 14.00 (5.35) | 18.50 (6.02) | 12.642 | 0.001 | 0.182 | 0.850 | 0.360 | 0.015 | 0.51 | 0.823 | 0.001 |
| RFFTpart2 | 13.98 (5.46) | 19.13 (4.99) | | | | | | | | | |
| RFFTpart3 | 12.84 (5.82) | 19.25 (5.93) | | | | | | | | | |
| RFFTpart4 | 14.34 (5.77) | 18.81 (4.42) | | | | | | | | | |
| RFFTpart5 | 14.79 (5.63) | 19.25 (4.39) | | | | | | | | | |
| RFFT PE | | | | | | | | | | | |
| RFFTpart1 | 8.51 (8.34) | 0.25 (0.45) | 26.215 | 0.001 | 0.315 | 11.180 | 0.001 | 0.164 | 7.990 | 0.006 | 0.123 |
| RFFTpart2 | 10.77 (9.19) | 0.38 (0.62) | | | | | | | | | |
| RFFTpart3 | 11.91 (9.34) | 0.50 (0.52) | | | | | | | | | |
| RFFTpart4 | 11.58 (0.96) | 0.56 (0.73) | | | | | | | | | |
| RFFTpart5 | 12.95 (8.67) | 0.56 (0.81) | | | | | | | | | |
| | | | $t$ | $p$ | Cohen's $d$ | | | | | | |
| CTT-2 | 114.44 (58.10) | 94.72 (34.51) | –1.803 | 0.038 | .394 | – | – | – | – | – | – |
| RFFT ER | 0.99 (1.04) | 9.07 (14.96) | 4.653 | 0.001 | 1.118 | | | | | | |
| RFFTes | 009 (0.48) | 3.31 (6.21) | –3.420 | 0.001 | –1.001 | | | | | | |
| RFFTrs | 1.37 (1.89) | 5.56 (5.32) | –4.501 | 0.001 | –1.318 | | | | | | |
| RFFTesd | 0.35 (1.88) | 7.75 (11.65) | –4.080 | 0.001 | –1.195 | | | | | | |
| RFFTrsd | 5.39 (8.13) | 22.25 (24.73) | –3.975 | 0.001 | –1.164 | | | | | | |
| RFFTdsr | 9.07 (14.96) | 31.25 (19.63) | –4.642 | 0.001 | –1.359 | – | – | – | – | – | – |

*RFFT – Figural Fluency Test, RFFT UD – unique designs, RFFT PE – perseverative errors, RFFT ER – error ratio, RFFTrs – number of rotational strategies, RFFTes – number of enumerative strategies, RFFTrsd – design number in rotational strategies, RFFTesd – design number in enumerative strategies, RFFTdsr – ratio of designs used in both strategies: rotational and enumerative divided by RFFT UD, CTT – Color Trails Test, F – repeated measures analysis of variance (RM-ANOVA) in scheme 2 (groups) × 5 (type of tasks),* $\eta^2$ *– eta squared effect size*

education, alcohol dependence is a significant contributing factor to explaining difficulties with spontaneous and reactive flexibility, cognitive control, issues with monitoring and execution of cognitive activity, and a lack of or little use of rotational and enumerative strategies. Age and education have been demonstrated to be important variables in explaining spontaneous and reactive flexibility in our study, which is comparable with prior research [38] and, though only partially, they stay in line with other studies showing that RFFT unique designs are correlated with age but not with education [39]. Our results demonstrating decreased flexibility are consistent with the previous findings [18, 25, 30] and add the analysis of flexibility components into the alcohol dependence studies, which has not been implemented. We have revealed that alcohol dependence distinctly contributes to explaining the results in terms of reactive flexibility in the aspect of attentional set shifting, and spontaneous flexibility in the range of generating unique designs in a limited time. The mechanisms of these types of flexible behavior may be determined by similar processes but differently involved in the performance of various tasks that measure spontaneous flexibility, related to divergent thinking, or reactive one, connected with the ability to effective attentional shifting between different terms of processing [7, 8, 16].

With regard to the control of cognitive task execution, restrictive for repetition, and the saturation of task execution with original solutions, generated within the rotational and enumerative strategies, our study revealed that the influence of alcohol dependence was the only significant predictor. In the literature, associations between nonverbal cognitive control, expressed in the perseverative errors in performance of figural fluency tasks and age and educational level are not clear. Izaks *et al.* [38] showed the lack of connection between perseverations and age and education in healthy adults. Van Eersel *et al.* [39] pointed out to a relationship between perseverations and age but not between perseverations and education. Our findings confirmed the negative impact of alcohol dependence on cognitive control in alcohol-dependent men [19, 27]. Nonetheless, in the present study not only the number of perseverative errors and error ratios were used to measure cognitive control but also enumerative and rotational strategies that facilitate the organizing and planning of cognitive activity.

The second aim of the study was to assess spontaneous flexibility and reactive flexibility in terms of attentional set shifting, and cognitive control in alcohol-dependent men. The results indicated that men with alcohol dependence exhibited decreased reactive flexibility, reflecting a heightened rigidity in tasks that require frequent switching between parallel data sequences. The findings are consistent with the previous studies on the assessment of attentional set-shifting in alcohol-dependent individuals [27, 30-32]. Based on Guilford's model of two-factor cognitive flexibility [5], reactive flexibility refers to switching between different dimensions or features, which is treated as attentional set-shifting. The time needed to reallocate attention from one task-set to another (the switching costs) is longer in alcohol-dependent men, even though they hardly made any mistakes performing the task. The highly structured tasks involve strictly defined rules, preventing the generation of various production strategies. Test performance is here more a response to complex demands, than creative initiation of original strategies in the course of task execution. Difficulties experienced by men in the clinical group are also revealed in the current study in terms of figural fluency, associated with the nonverbal spontaneous flexibility, i.e. generation of new visuospatial solutions under specific time limit, which is comparable to the earlier research involving this clinical group [20, 31, 40]. Patients with alcohol dependence had significantly lowered spontaneous flexibility affecting divergent thinking [7]. It means, that men from the clinical group manifested deficient attentional set-shifting and they might experience difficulties with overcoming prepotent response. Therefore, their performance did not lead to new, unique and alternative solutions. It might have, however, contributed to the stereotyped behaviour, even if the task itself was less constrained and gave the opportunity to initiate and develop strategies for solutions.

It is worth emphasizing that one of the prominent problems in the group of men with alcohol dependence was the lack of control and planning of the cognitive performance, which is expressed by an increased number of perseverative errors in relation to the number of new solutions. High number of perseverations in our group of alcohol-dependent men expresses their disturbances in disengaging attention from one aspect of the task to shift it to another. Our findings are consistent with other research reports involving this clinical group [19, 20, 27, 31, 32, 40]. One of the previous studies demonstrated that the substance abuse group had few perseverations on figural fluency, but it might be a result of the inclusion of less-alcohol-dependent individuals in the examined sample [31]. Moreover, our clinical observation data also confirm impulsivity or difficulties with initiating and sustaining activity in men with addiction. Productivity and persistence are treated as elements of spontaneous flexibility [2-4]. In alcohol-dependent participants in the current study, low effectiveness in unique design production and a lot of perseverative errors reflect poor task-directed cognitive effort and lowered ability to sustain performance over time and in spite of distractors. In the beginning of the figural fluency task performance, many alcohol-dependent men generated several unique designs, whereas in the later parts of the task a significant number of perseverations in the absence of original ideas was typically noted. This pattern of performance proves deficient persistence and spontaneous flexibility which according to Weiss *et al.* [4] precludes the effective generation of solutions. In the current study, alcohol-dependent men showed significantly lower number of perseverations in the first part , than in the subsequent parts of the test, which was not observed in control subjects. The need to maintain complex cognitive activity for a long time (following certain rules, keeping them in working memory, producing new solutions and avoiding the repetitions) is a difficult cognitive challenge for men with alcohol dependence. The growing number of perseverations is likely to be connected to the structure of the RFFT, which contains additional distracting elements or changed arrangements of the five-dot pattern in the further parts compared to the first. Therefore, low spontaneous flexibility in the demands of high cognitive effort causes the feelings of exhaustion and, as a result, an increase in stereotypical, repetitive solutions in this clinical group.

The third goal of our research was to recognise the use of enumerative and rotational production strategies in visual-spatial mode. The present study is among few that have examined the use of production strategies in figural fluency. Most studies of clinical groups do not report data for production strategies, despite suggestions available in the literature, that these indices assess cognitive operations that underlie effective figural fluency performance [10, 12, 39]. Our findings showed that individuals with alcohol dependence, compared to controls, very rarely use production strategies. As suggested by Gardner *et al.* [12], strategy use is a promising supplemental measure that may reveal useful information during neuropsychological evaluation. The implementation of strategic response seems to be related to some executive abilities, and it may be influenced by other cognitive abilities. These strategies are considered indicative of a preferred cognitive style or approach to figural fluency performance favoured by some but not all individuals. Our findings have some implications for both diagnosis and therapy. They support the recommendation to include strategic responding analysis into neuropsychological assessment, and to weigh incorporation of these data into treatment programs as cognitive flexibility and control constitute important areas of therapeutic efforts to deal with sobriety.

The present study is not without its limitations. The inclusion criteria used in this study (i.e. staying at alcohol addiction treatment units) meant that men with low-severity alcohol dependence were not included, thus the conclusions of the study should be only applied to men with moderate or serious alcohol dependence. Our control group was not well-matched in the range of age and education; men with alcohol dependence were younger and relatively worse educated than controls. For that reason, we performed hierarchical regression analyses to identify the unique contribution of alcohol dependence to measured variables regardless of age and education. In further research, we recognise the need to match the clinical and control groups better in respect of demographic variables.

## CONCLUSIONS

As this paper shows, regardless of age and education, alcohol dependence significantly reduces spontaneous and reactive flexibility in men. Poor control and deficient planning of cognitive activity lead to an increase of stereotyped and perseverative responses. These deficits, combined with weak persistence, make it difficult to effectively complete highly demanding tasks and may have implications for the effectiveness of the treatment.

Cognitive strategies, that can be helpful in tasks that require spontaneous flexibility, are rarely used by alcohol-dependent men. The implementation of strategies as measures of control and planning capacity or preferred cognitive style may contribute to developing individual therapeutic programmes for alcohol-dependent men.

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### Conflict of interest

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