

Cognitive dysfunctions in patients with alcohol dependence

Katarzyna Nowakowska, Karolina Jabłkowska, Alina Borkowska

Summary

Aim. Assessment of cognitive functions connected with prefrontal cortex activity and the intensity of depression symptoms in patients with alcohol dependence after discontinuation of alcohol use and after, at least, one year of abstinence.

Subjects and methods. Eighty-eight (88) patients with alcohol dependence were evaluated. In 51 subjects, an assessment was performed directly after discontinuation of alcohol drinking and in 37 subjects after, at least, one-year of abstinence. The control group consisted of 30 healthy persons, matched for age, sex and education with patients of the experimental group. The intensity of alcohol addiction was assessed, using the SADD and MAST scales, while intensity of the depression symptoms with the Beck Depression Inventory. Neuropsychological assessment included the Wisconsin Card Sorting Test (WCST) and the N-back test for different aspects of working memory and executive function estimations.

Results. In comparison to healthy subjects significant disturbances of working memory and executive functions were noted in patients with alcohol dependence, both with short-term and long-term abstinence. No significant differences were observed between the patients with short-term and long-term abstinence on the performance on neuropsychological tests, except better results of non-perseverance errors, obtained by the patients with long-term abstinence. Longer duration time of alcohol addiction correlated with the worse performance of neuropsychological tests, while higher level of education improved performance of those tests. The intensity of depression did not correlate with the level of cognitive impairment in the neuropsychological tests.

Conclusions. The obtained results indicate core and enduring cognitive deficits, connected with disturbances in prefrontal cortex activity in patients with alcohol addiction.

alcohol dependence / cognitive dysfunctions / depression

INTRODUCTION

Alcohol dependence is a chronic disease, in the picture of which, structural and functional disorders of the brain play an important role, resulting in disturbances of various cognitive function

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areas. Neuroanatomical and functional changes of the brain most often affect the prefrontal cortex of the brain and the hippocampus, i.e., the structures directly associated with memorisation processes and cognitive and emotional data processing. Parsons et al. [1], when examining patients with a many-year period of alcohol addiction, found significantly reduced blood flow rates, together with glucose metabolism disturbances in the prefrontal cortex, in structures of the limbic system and in the cerebellum, as well as decreased numbers and/or sizes of neurons plus features of glia hypertrophy in

the hippocampus and in the frontal cortex with a reduced number of neuronal connections in these brain structures. The changes, which occur within the prefrontal cortex, the hippocampus and the cerebellum, are, basically, fixed in character, and not decreasing after drinking discontinuation [2, 3].

Neuropsychological studies indicate progressive disturbances of cognitive functions, mainly with regards to memory and the, so-called, frontal functions, in the majority of patients with the alcohol dependence syndrome. [1, 4, 5, 6, 7]. These disturbances are responsible for disorders in the working memory and affect executive functions, planning and solution of complex problems or undertaken decisions. These disorders constrain the possibilities of flexible changes of action strategies, reduce behaviour control and suppress psychosocial adaptation abilities [4, 5, 8, 9, 10].

The studies, as reported in this paper, aimed at evaluating the working memory and executive functions, associated with functions of the brain prefrontal cortex, and the enhancement of depression features in alcohol-addicted persons, either immediately after alcoholic trance or after a longer period of stable abstinence.

SUBJECTS AND METHODS

Subjects

The study involved eighty-eight (88) patients with alcoholic disease (67 male and 21 female) from the city of Łódź, and the towns of Pabian-

ice and Żyrardów, at the age between 21 and 58 years (the mean age: 43 ± 9 years), treated in an inpatient environment and at an outpatient clinic of addiction therapy. The diagnosis of alcohol dependence was obtained, following the ICD – 10 Classification. Only those patients were included into the study in whom no other serious psychic or neurological diseases had been identified.

The experimental group was divided into two subgroups:

- Subgroup 1: fifty-one (51) patients, immediately after alcoholic trance, (13 women, 38 men), who had drunk liquor in an amount of, at least, 5 “standard drinks” a day for, at least, three consecutive days within two weeks before the study. The standard drink was defined as 360 ml of beer, 120 ml of wine or 37 ml of vodka.
- Subgroup 2: 37 persons (8 women and 29 men), who had maintained full abstinence for, at least, one year before the study.

The control group included 30 normal persons (7 women and 23 men), matched by sex, age and education to the alcohol-dependent patients. None of the controls had overused alcohol or suffered from any serious somatic, psychic or neurological disease.

Table 1 presents demographic characteristics of the group of patients with alcohol dependence and of healthy subjects.

Table 1. Demographic characteristics of the studied groups of alcohol-addicted and healthy persons. The mean values + SD

	Addicted persons n = 88	Healthy persons n = 30
Age (years)	43.1 + 8.9	42.5 + 8.0
Sex (number; group %)		
women	N= 21 ; 24%	N = 7; 23%
men	N= 67 ; 76%	N = 23; 77%
Education (years)	11.6 + 2.3	12.3 + 3.0

Statistically insignificant differences

Methods

1. Psychometric evaluation

The evaluation of depressive symptom intensity was performed on the basis of clinical examinations and according to the Beck Depression Inventory (BDI) [11]. It was accepted that any result above 13 indicated depression [12].

The depth of alcohol addiction was assessed by the MAST [13, 14] and the SADD scales [15, 16, 17].

2. Neuropsychological evaluation

In the neuropsychological evaluation, various tests were applied, estimating different aspects of working memory and executive functions.

- The Wisconsin Card Sorting Test (WCST) for the evaluation of working memory and executive functions in Heaton's computer version [18]. The following test parameters were evaluated:

- the perseverance error percent (PE%), indicating a tendency towards repetitions of erroneous reaction, certain rigidity of thinking,
- the non-perseverance error percent (N-PE%), indicating a tendency toward chaotic, incidental reactions,
- the number of correct categories (CC), which stands for the index of effective thinking,
- the percent of reactions, compliant with logical concept (conc.%), reflecting the ability to maintain the logical principle of reaction, as

well as the ability of exercising both experience and new data,

- the number of attempts necessary to configure the first category (1st cat.), providing an index of logical concept formulation ability.

- N-back test in Coppola's computer version [19] for evaluation of simple, visual working memory and coordination abilities. The test consists in a 27-fold display of digits (2, 4, 6, 8), which appear on the monitor screen in 1.8 s intervals, while each of them is presented for 200 ms. The examined person is asked to – as quickly as possible – press the key of the digit, which has just appeared on the screen (the 0-back version), then the key of the digit, which preceded the actually displayed stimulus (the 1-back version) or two digits before the actually displayed stimulus (the 2-back version). In the present study, the 0-back and the 1-back version of the test were applied. The percent of correct reactions and the time of reactions are also assessed here.

RESULTS

Table 2 presents the results of the Beck Depression Inventory and the results of neuropsychological tests, performed in the studied groups.

The alcohol-addicted persons presented with more intensive features of depression in the Beck Depression Inventory, when compared with the group of healthy persons. Both groups of persons with alcoholic addiction obtained worse results in the WCST test performance, except

Table 2. Intensity of depression symptoms in the Beck Depression Inventory (BDI) and the results of neuropsychological tests in alcohol-addicted persons with short- and long-term abstinence, as well as in healthy persons. The mean values + SD.

	Addicted persons with short-term abstinence n = 51	Addicted persons with more than one year abstinence n = 37	Healthy persons N = 30
BDI	19.6 + 9.2**	5.3 + 5.6*##	2.1 + 1.7
WCST PE	17.9 + 9.6**	17.7 + 12.1**	7.5 + 2.3
WCST N-PE	19.5 + 11.9**	13.9 + 9.2 *#	8.4 + 2.2
WCST CC	3.9 + 2.0**	4.4 + 2.1**	5.9 + 0.3
WCST conc. %	51.2 + 24.7**	59.7 + 24.3**	80.6 + 5.2
WCST – Cat. 1.	18.4 + 22.6	19.7 + 27.2	11.4 + 0.9

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N-back test			
1-back % of correct react.	76.2 + 25.0**	78.3 + 23.0**	92.4 + 232.5
1-back reaction time	987.3 + 395.2**	1064.6 + 316.5**	657.6 + 336.7

Significant differences vs. healthy persons * p<0.05; **p<0.001

Significant differences between the group of alcohol-addicted persons with short-term abstinence and the group of alcohol-addicted persons with more than one year abstinence #p<0.05, ##p<0.001

the first category sorting time, as well in both subscales of the n-back (1-back) test. It is an evidence for the fact that alcohol-addicted persons, regardless of how long their abstinence duration is, present with considerable disorders of the frontal functions - the working memory and the executive functions.

A comparison of both groups with alcohol dependence demonstrates that patients with short-term abstinence periods presented with a significantly higher intensity of depression features in the Beck Depression Inventory and obtained worse results in the WCST-NP performance than persons after long-term abstinence, while neither other WCST parameters nor n-back test performance revealed any significant improvement. It may be evidence that frontal dysfunctions in alcohol-addicted persons are rather fixed in character and the time period of abstinence has no effect, regarding either their reduction or elimination.

Table 3 presents correlations, observed between the patients' age, education, and addiction time periods, the intensity of depression symptoms and the results of neuropsychological tests.

The higher age of the examined patients was associated with the significantly higher number of perseverance errors in the WCST test, most strongly connected with lesion of the prefrontal cortex of the brain. It may then indicate that the effectiveness of the organ undergoes certain impairment, while there is a tendency towards more rigid thinking and lower flexibility of reactions.

Persons with more years of education studies presented with better results, regarding all the WCST parameters, except the number of cards necessary to sort the 1st category. Those persons obtained lower indices of perseverance and non-perseverance errors, correctly sorted more categories and had a higher percent of answers, conformable with the logical concept. It seems then that better education may be a protective factor, regarding the alcohol-induced lesions of the frontal functions, as observed in alcoholism.

The time period of addiction correlated with performance outcomes of WCST, P and CC tests and, at the level of statistical tendency, with the WCST conc.%. The longer the addiction period, the more perseverance errors were made by the examined persons. They also sorted fewer cate-

Table 3. Correlations between the age, education, addiction duration and the enhancement of depression symptoms in the Beck Depression Inventory (BDI) and addiction intensity and the results of neuropsychological tests in the group of 88 alcohol-addicted persons. R-Spearman's.

	N-back		WCST				
	% of correct reactions	Reaction time	PE	N-PE	CC	Concentration%	Category 1
Age	-0.03	0.17	0.24*	-0.04	-0.16	-0.11	0.13
Education	0.03	0.05	-0.25*	-0.25*	0.26*	0.25*	0.04
Addiction duration	0.05	0.06	0.22*	0.13	-0.22*	-0.20 (t)	0.19
Abstinence duration	0.06	0.07	-0.04	-0.25*	0.11	0.16	-0.07

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BDI	-0.09	0.07	0.05	0.07	-0.05	-0.06	-0.003
MAST	0.03	0.02	0.11	0.01	-0.05	-0.06	0.01
SADD	-0.02	-0.12	0.07	0.20(t)	-0.06	-0.10	0.15

* $p < 0.05$

gories and presented with a lower index of answers, conformable with logical concept. It may be evidence for enhancing disorders of executive functions in long-addicted persons. In turn, the time period of abstinence correlated only with results of the WCST NP test, where the persons with long-term abstinence scored better results. The time period of abstinence was, however, of no significance for outcomes of the other neuropsychological tests, what favours the view that disorders of the frontal functions are fixed, remaining unchanged regardless of the abstinence period.

The results in the Beck Depression Inventory did not correlate with neuropsychological test performance in the studied group of patients, indicating that the intensification of cognitive function disturbances, observed in alcohol-addicted persons, remains independent of the degree of depression symptoms. Neither was any correlation demonstrated between the intensity of addiction symptoms in the MAST and SADD scales and the results of neuropsychological tests, except the small correlation, observed between the higher score in the SADD scale (t) and the higher percent of non-perseverance errors in WCST.

DISCUSSION

It has been demonstrated in this study that enhanced disorders of the frontal functions – the working memory and executive functions – are observed in persons with alcohol-dependence. Alcohol addicted patients obtained significantly lower scores in the tests, which evaluate these processes, in comparison with sex-, age- and education-matched healthy persons. It confirms the observations of other authors, who report disorders of the working memory and cognitive functions, i.e., the processes, associated with the

functionality of the brain prefrontal cortex [7, 9]. Authors from the University of Texas, following the results of the Wisconsin Card Sorting Test (WCST) and of verbal efficacy tests, stated that a better score, regarding those abilities, could be a predictive factor for therapy effectiveness, administered to change drinking habits [9].

As it appears from our studies, cognitive function disturbances were similar in either group of the examined patients, i.e., those with short and long abstinence period. No statistically significant differences were found in the WCST or n-back test performance between those groups of patients, except the level of non-perseverance errors, associated mainly with the concentration process functionality. In patients with longer abstinence periods, the index of non-perseverance errors was lower, which may indicate beneficial changes, mainly with regards to concentration processes, so important in the functionality of the central executive system. Unfortunately, our results indicate that disorders of the frontal functions do not undergo any improvement in the course of the abstinence period duration. It means that the changes are fixed in character and present at various stages of the alcoholic disease.

The above observation was confirmed by a correlation analysis, in which it was demonstrated that the time period of abstinence maintenance was not correlated with improvement of cognitive functions, except the improvement, observed with regards to non-perseverance errors in the WCST. An association was also observed in the study between the addiction time period and poorer performance of the WCST and n-back tests. The persons with longer addiction time obtained worse results in the WCST test, regarding the number of perseverance errors, which may be evidence for some rigidity of reactions and thinking, reaction repeatability and lower behaviour flexibility, as well as the scope

of property sorted categories, which in turn shows worse effectiveness of thinking.

The to-date's results of studies, performed in a group of patients with alcoholic addiction, did not bring any unequivocal answer to the question, whether disturbances of the cognitive functions, associated with the prefrontal cortex functionality, are transient, depending on clinical factors, or fixed.

Some authors maintain that the time period of abstinence preservation may be connected with improvement of the cognitive functions [3, 20, 21], however, this assumption is not confirmed in results of other studies. Following the results of American authors, it can be stated that neurobiological changes in the central nervous system, resulting from chronic intoxication, get only partially moderated, what may be connected with but a fragmentary improvement of the cognitive skills, which however, do not attain their pre-morbid levels [22]. Other authors make a point of the observation that only some patients, who maintain long-term abstinence, present some improvement regarding their frontal functions. It may be connected with individual predispositions with regards to pre-morbid efficiency of the central nervous system or with the dose of consumed alcohol [23, 24]. Some French authors have found that alcohol-induced disorders of the cognitive functions result from progressive brain lesion and, in some patients, even in those who maintain abstinence, they not only do not improve but may even attain the level of alcoholic dementia [25].

In our studies, we have shown a relationship between higher education (a higher number of completed education studies) and the higher level of executive functions. It may be evidence that higher education is of protective significance, regarding frontal function disorders.

However, no significant relationship was found between the intensification of depression symptoms and the enhancement of frontal function disorders in the examined patients, despite the results of studies on patients with depression, which reveal a clear relationship between depression and the degree of disorders of working memory and executive functions [26, 27]. Perhaps, in persons with alcohol addiction, there is a different mechanism of frontal dysfunction and depression. Ueckerman et al. [12] obtained

similar data, stating that frontal dysfunction - although very significant in alcohol-addicted persons - bears no direct relationship with the occurrence of depressive disorders. Also Rosenbloom et al. [7] assume that disturbances of executive function, associated with dysfunction of the frontal cortex of the brain, reveal slight correlation with mood changes (dysphoria).

CONCLUSIONS

1. When compared with healthy subjects, persons with alcohol addiction show significant disorders of various aspects of the working memory and executive functions.
2. Persons with short- and long-term abstinence showed a similar degree of frontal dysfunction, beside a higher efficacy of attention-dependent processes in persons with long-term abstinence, which may indicate a fixed character of these disorders.
3. The disease duration was associated with the worse efficacy of frontal functions, while higher education with better performance of all the tests.
4. The intensity of depression features was not related to the enhancement of cognitive function disorders in the studied groups.

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