NEUROCOGNITIVE ASSESSMENT OF ALCOHOL INPATIENTS DURING RECOVERY FROM ALCOHOLISM*

NEVROKOGNITIVNA OCENA ABSTINENTOV MED NJIHOVIM OKREVANJEM OD ODVISNOSTI OD ALKOHOLA

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Abstract

Objective *The aim of study was a neuropsychological evaluation of cognitive, emotional and motivational functioning of abstinent alcohol inpatients.*

Background *Alcohol dependence is characterized by a neuropsychological profile of extensive impairment in executive functions, visuospatial abilities, sociocognitive, emotional and motivational dysfunctions. A growing body of research evidence suggests that alcoholism-related structural and functional brain changes may underlay abovementioned deficits. Nevertheless, certain alcohol-related impairments are reversible with abstinence. Several studies indicated that with prolonged abstinence functional improvement in memory, visuospatial abilities, and attention occur within 3 to 4 weeks of abstinence accompanied by at least partial reversal of brain shrinkage and some recovery of metabolic functions in the frontal lobes and cerebellum, as well as with increased cortical grey matter volume.*

Methods *33 male abstinent alcohol inpatients (average abstinence: 8 weeks) and 36 healthy controls were tested on the following domains: attention (classical vs. emotional Stroop Task), working memory (spatial vs. verbal), visuospatial abilities (Benton Face Recognition Task, Line Orientation Test), emotionality (Ekman Emotional Recognition Task, Test of Emotional Styles, Beck Depression Inventory) and motivation (Behavioural Inhibition/Activation Scale).*

Results *Alcohol abstainers compared to healthy controls showed impaired attention, more depressive symptoms and overactive activation behavioural system, whereas the working memory and visuospatial tasks did not reveal significant differences between groups. A specific neuropsychological profile has been found among alcohol abstainers with suicidal history where lower emotion recognition ability and attention difficulties with emotional stimuli have been recorded.*

Conclusions *Our study demonstrated that some alcohol-related cognitive, emotional and motivational deficits can also persist to certain extent after several weeks of sobriety. Especially alcohol abstainers with suicidal history revealed a specific neuropsychological profile in this regard. Employed neurocognitive assessment proved as useful approach for clinical evaluation of alcohol abstainers functioning, since cognitive deficits have been also hypothesized to affect the efficacy of alcoholism treatment.*

Key words *neurocognitive functions; behavioural approach/inhibition system; alcohol dependence; abstinence; suicide*

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Izvleček

Namen *Namen raziskave je bil nevropsihološka evalvacija kognitivnih, emocionalnih in motivacijskih funkcij pri abstinentih od alkohola.*

Izhodišča *Za osebe, odvisne od alkohola je značilen poseben nevropsihološki profil, v katerem se odraža oškodovanost izvršitvenih in vidnoprostorskih funkcij ter disfunkcije na socio-kognitivnem, emocionalnem in motivacijskem področju. Čedalje več raziskav navaja, da so vzrok omenjenim primanjkljajem strukturne in funkcionalne možganske spremembe, povezane z učinki alkohola, ki pa so reverzibilne narave saj se lahko v obdobju abstinence deloma tudi popravijo. Različne raziskave so pokazale, da se v podaljšanem, 3 do 4-tedenskem obdobju abstinence, lahko izboljšajo spominske funkcije, vidnoprostorske sposobnosti in pozornost. Hkrati se delno popravi možganska atrofija, poveča metabolna aktivnost v frontalnem režnju in cerebelumu ter poveča volumen sivine možganske skorje.*

Metoda *33 abstinentov od alkohola (povprečna dolžina abstinence: 8 tednov) in 36 zdravih kontrol smo testirali na sledečih področjih: pozornost (besedno barvni in emocionalni Stroopov test), delovni spomin (prostorski in besedni), vidnoprostorske sposobnosti (Bentonov test prepoznavanja obrazov, Test orientacije črte), emocionalno odzivanje (Ekmanov test prepoznavanja emocij, Test emocionalnih stilov, Beckov vprašalnik depresije) in motivacija (Ocenjevalna lestvica občutljivosti motivacijskega sistema umika in nagrajevalnega motivacijskega sistema).*

Rezultati *Rezultati so pokazali pri abstinentih od alkohola okrnjeno pozornost, več depresivnih simptomov in povečano občutljivost nagrajevalnega motivacijskega sistema v primerjavi z zdravimi kontrolami. Pri nalogah delovnega spomina in vidnoprostorskih sposobnostih ni prišlo do pomembnih razlik med skupinama. Pri abstinentih od alkohola s suicidalno preteklostjo smo zabeležili poseben nevropsihološki profil, kjer je izstopala zmanjšana sposobnost prepoznavanja čustvenih izrazov in težave v pozornosti v okviru emocionalnega konteksta.*

Zaključki *Naša raziskava predstavlja izsledke nekaterih z alkoholom povezanih kognitivnih, emocionalnih in motivacijskih primanjkljajev, ki so prisotni tudi v obdobju podaljšane abstinence od alkohola. Še posebno so izraženi pri abstinentih od alkohola s suicidalno preteklostjo, kar se odslikava tudi v njihovem svojevrstnem nevropsihološkem profilu. Uporabljeni nevropsihološki instrumentarij se je izkazal kot uporaben pristop pri klinični oceni funkcioniranja abstinentov, s katerim se lahko opredeli vrste kognitivne oškodovanosti pacientov in njen vpliv na učinkovitost zdravljenja odvisnosti od alkohola.*

Ključne besede *nevrokognitivne funkcije; vedenjski pristop/inhibicijski sistem; odvisnost od alkohola; abstinenca; samomor*

Background

The brain, like most body organs, is vulnerable to injury from extensive alcohol consumption. The risk of brain damage and related neurobehavioral deficits vary from person to person and are influenced by a wide range of variables, including the amount of alcohol consumed, the onset of alcohol consumption, the duration of drinking, level of education, gender, genetic background, family history of alcoholism, etc.[1] Some of abovementioned factors that are thought to influence the causal relation between brain and behaviour have been incorporated into specific neuropsychological models in order to explain the variability in alcoholism-related brain deficits and connections with impairments in executive functions and visuospatial abilities as well with socio-cognitive, emotional and motivational functioning of alcoholics.[2–4] Three neuropsychological models prevailed in this regard, either with emphasis on dysfunction of right hemisphere, prefrontal cortex[5, 6] or throughout the brain.[7]

On the other hand, there is a considerable evidence that prolonged, excessive alcohol use is associated with an increased likelihood of cognitive impairment that can persist long after drinking cessation.[8, 9] Namely, it has been estimated that 45 % of alcohol-dependent individuals have residual deficits on neuropsychological testing after 3 weeks of abstinence, and as many as 15 % of them retain deficits after 1 year of abstinence.[10]

In general, alcohol-related cognitive impairment seemed to attenuate over time after cessation of drinking, although factors such as age, poor nutrition, and medical comorbidity diminish the extent and prolong the time course of recovery. Recovery from the alco-

hol dependence is the goal of therapy and is associated with a partial reversal of neurobehavioural deficits that occur in alcoholism. Particularly cognitive function was found to have a major influence on treatment response and therapy outcome.[11–13]
In the present clinical study we evaluated the neuropsychological performance of alcohol abstainers in comparison with the relevant control group (persons without indication of alcohol dependence in the past). The composite of the tests was employed in order to assess emotional and motivational functions expected to be affected by alcohol dependence in the following domains: motivation, mood, emotionality, social cognition, visuospatial abilities, selective attention and working memory. Some of the employed tests included verbal and nonverbal analogues as well as different emotionally valenced stimuli which are often linked with predomination of the left or right hemisphere functioning. In this respect the aim of the present study was also elucidation of some alcoholism-related brain deficits that could correspond to the dysfunction of right hemisphere.

Methods

Sample description

33 right-handed male inpatients diagnosed with alcohol dependence according to DSM-IV criteria were recruited from the University psychiatric hospital in Ljubljana after being detoxified. They had been abstinent for at least 3 weeks and were included in alcoholism treatment programme. Subjects with neurological and major psychiatric disorders were excluded from the study. Participants were provided with the full details regarding the aims of the study and the procedure to be followed and were matched for age, sex, education and handedness with 36 healthy volunteers without addiction and suicidal indications.

Instruments

Tests employed in the composite were chosen for their sensitivity to detect commonly reported neurocognitive impairments in alcohol dependence as determined from previous neuropsychological studies.[14–17] Assessment of cognitive, emotional and motivational functioning was performed with verbal, spatial and emotionally valenced stimuli in order to determine a potential neuropsychological model of alcoholism-related brain changes.

Behavioural Inhibition System/ Behavioural Activation System Scales

Behavioural inhibition/activation sensitivity was assessed with a self report measure Behavioural Inhibition System/Behavioural Activation System Scales (BIS/BAS Scales).[18] BIS/BAS Scales are comprised of 24 items with four subscales. The 7-item *BIS* scale assesses the sensitivity to environmental threats. *BAS* total scale includes three subscales: *Drive* (4 items), *Fun Seeking* (4 items) and *Reward Responsiveness* (5 items). The *Drive* scale emphasizes motivation to pursue goals, regardless of whether these goals are inherently pleasurable. The *Fun Seeking* scale reflects the impulsive pursuit of pleasure. The *Reward Responsiveness* scale describes positive responses to the occurrence or anticipation of reward. Respondents rate each item on a 4-point scale ranging from 1 (very true for me) to 4 (very false for me). Higher scores on each scale indicate greater levels of BIS/BAS sensitivity.

Test Of Emotional Styles

Test of Emotional Styles (TES)[19] was designed as a self report measure with three dimensions of emotionality: first dimension, *Responsiveness,* measures the intensity and frequency of covert emotional experience, second, *Orientation* assesses the propensity to seek out and enjoy emotional experiences, and third, *Expressiveness* describes the intensity and frequency of overt expressions of affect. Participant had to decide which one of the two paired statements best describes himself and his attitudes towards emotional expression.

Beck Depression Inventory

Beck Depression Inventory (BDI)[20] is one of the most widely used self screening instruments for assessing the severity of depression. The BDI assesses 21 symptoms and attitudes including emotional (e.g. pessimism, sense of failure), mental (suicidal ideas), behavioural (e.g. social withdrawal, indecisiveness) and body symptoms (e.g. weight loss, insomnia) in the week preceding administration. Items on both scales are rated on a 4-point scale ranging from 0 to 3.

Facial Recognition Test

Facial Recognition Test (FRT)[21] was developed to examine the ability to recognize photographs of unfamiliar human faces without involving a memory component. This task has a substantial visuospatial processing component. The test consists of three parts: matching of identical front-view photographs (a), matching of front-view with three quarter view photographs (b) and matching of front-view photographs under different lightning conditions (c). The participant was instructed to identify (by pointing to it or calling its number) presented photograph of a male or female face in a display of six photographs in a spiral bound booklet. In the b) and c) condition, participants had to locate the presented face three times, whereas in the a) condition the correct response was just one. The number of correct responses was recorded. A Short form consisting of 27 items was used and then converted into Long Form scores.

Judgement of Line Orientation Test

Judgement of Line Orientation Test (JLO)[21] was developed for assessment of visuospatial processing abilities, possibly linked with the right hemisphere deficits. The test material consists of 35 stimuli appearing in the upper part of the booklet and the same multiple-choice response card appearing in the lower part. Participant's task was to find two lines in

Table 1. *Test scores and reaction times for assessed domains in the group of alcohol abstainers and controls. (Data are presented as mean values with standard deviations (M ± SD).*

Assesed domain	Test/Variable	Controls (N = 36) M ± SD	Alcohol abstainers (N = 33) M ± SD
Personal data	Age (years)	40,44 ± 11,22	45,00 ± 1,56
	Education (years)	11,72 ± 0,31	11,88 ± 0,29
	Alcohol abuse (years)	none	13,66 ± 1,51
	Abstention (weeks)	none	8,00 ± 0,84
	Suicidality (number of suicide attempts during lifetime)	none	0,40 ± 0,76
Motivation	BIS/BAS Scale		
	BAS – Drive (score)	8,94 ± 2,747	9,67 ± 3,262
	BAS – Fun-Seeking (score)	9,19 ± 2,402	10,57 ± 2,921 (*)
	BAS – Reward (score)	14,22 ± 3,319	15,57 ± 2,622
	BAS (score)	32,38 ± 6,904	35,8 ± 6,609 (*)
	BIS (score)	18,53 ± 3,312	19,53 ± 3,17
Mood and emotinality	Beck Depression Inventory		
	Depression (score)	3,47 ± 6,46	7,83 ± 6,72 (**)
	Test of Emotional Styles		
	Expressiveness (score)	12,68 ± 5,50	12,50 ± 6,97
	Responsiveness (score)	9,88 ± 5,42	8,73 ± 5,01
	Orientation (score)	9,09 ± 4,36	10,10 ± 4,37
Social cognition	Recognition of Emotional Facial Expression (Ekman)		
	Happiness (score)	3,94 ± 0,34	4,0 ± 0,00
	Sadness (score)	3,76 ± 0,50	3,50 ± 0,68
	Fear (score)	2,79 ± 1,10	2,33 ± 1,49
	Anger (score)	3,35 ± 0,85	3,10 ± 0,13
	Surprise (score)	3,47 ± 0,62	3,37 ± 0,72
	Disgust (score)	3,18 ± 0,80	3,47 ± 0,90
	All expressions (score)	20,50 ± 2,00	19,70 ± 2,77
Visuospatial abillities	Face Recognition Task (Benton)		
	Score	46,2 6 ± 5,37	43,63 ± 9,10
	Judgment of Line Orientation (Benton)		
	Score	27,85 ± 2,97	27,13 ± 3,42
Selective attention	Emotional Stroop Task		
	Negative words (ms)	601,19 ± 101,24	671,50 ± 124,77 (*)
	Neutral words (ms)	589,03 ± 99,02	652,69 ± 117,31 (*)
	Positive words (ms)	577,94 ± 82,84	636,34 ± 117,25 (*)
	Colour Naming Stroop Task		
	XXX (ms)	615,56 ± 92,38	691,03 ± 137,55 (*)
	Congruent cues (ms)	691,56 ±114,60	716,73 ± 120,41 (*)
	Noncongruent cues (ms)	674,06 ± 111,74	747,97 ± 129,14 (*)
Working memory	Spatial N-Back Task		
	0-back (ms)	371,44 ± 54,69	349,91 ± 87,24
	1-back (ms)	423,47 ± 72,15	445,72 ± 174,05
	2-back (ms)	425,36 ± 63,53	414,00 ± 118,68
	0-back (errors score)	0,03 ± 0,17	0,09 ± 0,29
	1-back (errors score)	0,17 ± 0,38	0,88 ± 2,50 (*)
	2-back (errors score)	1,64 ± 1,93	2,39 ± 2,85
	Verbal N-Back Task		
	0-back (ms)	506,78 ± 61,78	478,18 ± 111,30
	1-back (ms)	545,19 ± 70,69	548,30 ± 155,57
	2-back (ms)	737,50 ± 202,55	681,97 ± 200,11
	0-back (errors score)	0,33 ± 0,48	0,61 ± 0,70
	1-back (errors score)	0,11 ± 0,32	0,27 ± 0,88
	2-back (errors score)	2,33 ± 1,99	1,58 ± 1,56

*, ** statistically significant differences, 2-tailed: * $p < 0,05$; ** $p < 0,01$

the response card which are in exactly the same position and point to the same direction as the lines in the upper part. The number of completely correct responses was recorded.

The Stroop Task (Colour Naming Stroop Task and Emotional Stroop Task)

The Colour Naming Stroop Task[22] is one of the most frequently used methods for examination of selective attention ability. The original Colour Naming Stroop Task has been modified in an emotional analog – Emotional Stroop Task and employed to investigate whether emotional stimuli could also produce interference. The Emotional Stroop Task is able to differentiate between groups of individuals with mood disorders, posttraumatic stress disorder, substance dependence, and control participants, providing a reliable instrument for assessing attentional bias.[23]

The Stroop Task consisted of congruent stimuli (the words red, green and blue in letters of the same colour ink, e.g., the word *blue* in blue letters) and incongruent stimuli (the same words in letters of different colour ink, e.g. the word *blue* in green letters), which were presented on a laptop. Emotional Stroop Task consisted of words with positive, negative and neutral emotional valence, selected from our previous study where emotional context of words has been tested.[17] Each trial in Colour Naming and Emotional Stroop Task consisted of 700 millisecond presentation of the stimulus, followed by a 800 second inter stimulus interval. Participants had to press the ap-

propriate key on the mouse that corresponfed with the colour in which the word on the screen was printed as quickly and as accurately as possible. A practice task was given prior to test task. Response times were recorded.

N-back Task

N-back Task[15] assesses the capacity of spatial and verbal working memory. It is often used to determine the extent of memory loss and possible frontal lobe deficits. *Spatial* N-back task measures the capacity to follow the stimulus (letter) location. *Verbal* N-back task assesses the capacity to follow the sequence of presented letters. Each test can vary in a number of subtests: 0-back, 1-back, ... *n*-back. The higher *n*-number, the larger extent of working memory is needed to successfully complete the task. In our task, the stimulus (letter) appeared on a laptop screen for 1500 milliseconds in one of the nine presented squares. The range from 0- to 2-back was used. When the presented letter corresponded to the *n*-number (0, 1 or 2), participants had to press the appropriate key on the mouse as quickly and as accurately as possible. A practice task was given prior to test task. Response times and number of errors made were recorded.

Recognition of Emotional Facial Expression

Recognition of Emotional Facial Expression Task[24] (based on Pictures of Facial Affect – PFA, Ekman) was designed to assess the skill in judgement of basic emotional reactions from facial expressions, also often used as a measure of social cognition functioning.[31, 32] 24 pictures of male and female facial expression were chosen from the PFA base, reflecting one of frequently experienced emotions: happiness, sadness, fear, anger, disgust and surprise. Each picture was presented on a laptop screen for 20 seconds. Participants had to identify the emotional expression with the aid of a list with possible emotions. Number of correctly recognised emotions was recorded.

Procedures

After signed informed consent and personal data collection the participants were assessed with a fixed-order of the following composite of the tests: the BIS/BAS Scales, TES, BDI, FRT, JLO, Emotional and Colour Naming Stroop tasks, N-back tasks and Recognition of Emotional Facial Expression Task. The last three tests were computer-administered.

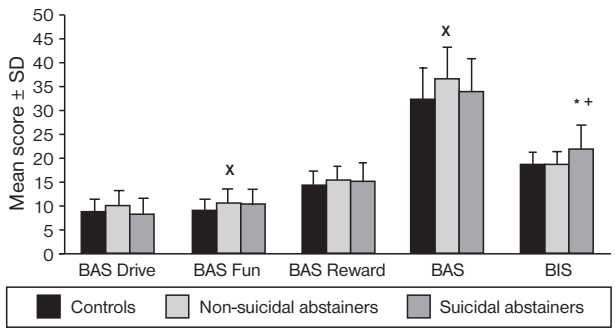
The data were analysed with Statistical Package for the Social Sciences (SPSS), version 14. Comparisons of demographic characteristics between controls and alcohol abstainers were conducted with independent-samples *t*-tests. Between-group differences for motivational, selective attention and working memory processing were examined with *t*-tests for normally distributed raw test scores and reaction times, whereas visuospatial and social cognition functioning from which data were not normally distributed were assessed with the nonparametric Mann Whitney *U* test. The group of alcohol abstainers was further divided into subgroup of non-suicidal and suicidal abstainers, in order to explore the impact of suicidal history on neurocognitive performance in abstainers. ANOVA was used to assess between-group differences. The value $p < 0,05$ was taken as an indicator of statistical significance.

Results

Group means and standard deviations of the demographic and personal data are presented in Table 1. The obtained personal data did not reveal significant differences in age and education between controls and abstainers, although controls were slightly younger than abstainers. The possible age and education impact on test performance was therefore reduced. Abstainers were abstinent for 2 months on average. Within the group of alcohol abstainers, 25 % of participants reported about previous suicidal attempts (3 participants with one, and 5 participants with two suicidal attempts). Therefore, some additional data analyses were performed in the group of alcohol abstainers in order to evaluate a potential impact of suicidal history.

Motivation

Significant differences in BIS/BAS sensitivity were found between alcohol abstainers and controls. Abstainers had higher scores on the overall BAS scale ($p < 0,05$) and on the BAS Fun Seeking Scale ($p < 0,05$) than controls (Table 1). Furthermore, non-suicidal abstainers also showed higher overall BAS sensitivity ($p < 0,05$) and higher Fun Seeking scores ($p < 0,05$) than controls. On the other hand, suicidal abstainers obtained higher BIS scores than controls ($p < 0,01$) and non-suicidal abstainers ($p < 0,01$) (Figure 1).

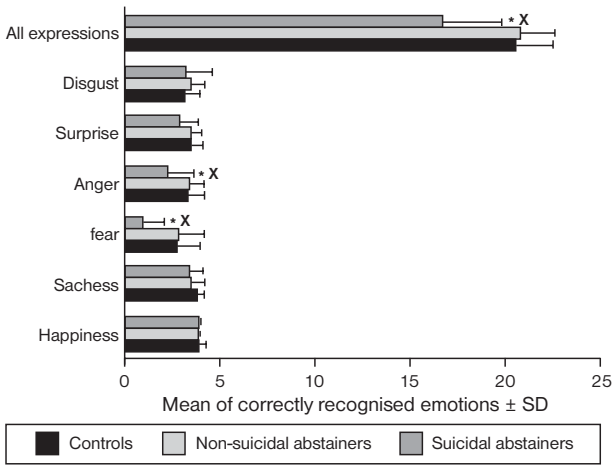


Mood and emotionality

Alcohol abstainers scored significantly higher on BDI than controls ($p < 0,01$) (Table 1). In addition, suicidal alcohol abstainers had more depressive symptoms compared to controls ($p < 0,01$) and non-suicidal abstainers ($p < 0,01$). No significant differences were found in dimensions of emotionality according to the TES results between controls and alcohol abstainers, regardless of the suicidal history. Yet the results indicated a diminished ability of directing and regulating of emotional expression among alcohol abstainers (Table 1).

Social cognition

Recognition of Emotional Facial Expression task did not reveal significant differences in recognition of basic emotional expressions between alcohol abstainers and controls (Table 1). However, significant differences did appear between subgroups of alcohol abstainers. Especially overall recognition and recognition of some negative basic emotions (fear, anger) were significantly impaired in suicidal abstainers compared to controls ($p < 0,05$) and non-suicidal abstainers ($p < 0,05$) (Figure 2).



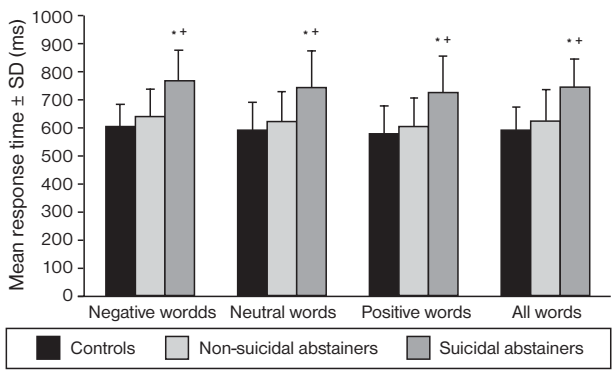
*X – significant difference between suicidal abstainers and controls at the 0.05 level; * – significant difference between suicidal and non-suicidal abstainers at the 0.05 level.*

Visuospatial abilities

Visuospatial abilities seemed preserved in the group of alcohol abstainers as well as in the subgroup of suicidal participants, as their performance did not differ significantly from controls on the Face Recognition task and Judgement of Line Orientation task (Table 1).

Selective attention

Alcohol abstainers performed significantly poorer than controls on the Emotional and Colour Naming Stroop Task with regard to the response time, which was significantly longer under all conditions of Stroop task, i.e. negative, neutral and positive words in Emotional Stroop Task and XXX, congruent and non-congruent cues in Colour Naming Stroop Task (Table 1). Additionally, inter-group comparisons revealed that alcohol abstainers spent significantly more time when responding to emotional negative valenced stimuli with regard to emotional positive valenced stimuli ($p < 0,05$). Suicidal alcohol abstainers had significantly longer latencies compared to controls ($p < 0,05$) and non-suicidal alcohol abstainers ($p < 0,05$) under all conditions of Emotional Stroop Task (Figure 3). On the other hand, performance of suicidal abstainers on Colour Naming Stroop Task did not differ significantly from the performance of non-suicidal alcohol abstainers.



Working memory

Spatial and verbal working memory ability assessed by N-back tasks did not differ between alcohol abstainers and control group. As illustrated in Table 1, alcohol abstainers had shorter latencies than controls under some conditions of N-back task (e.g. spatial N-back: 0-back, 2-back, verbal N-back: 0-back, 2-back), though between-group differences were not significant. However, it seemed that alcohol abstainers did not ensure accuracy during task as the number of errors made in this group was higher compared to controls. Despite the trend toward higher number of errors among alcohol abstainers under all conditions of N-back task, only the number of errors in spatial 1-back task was significantly higher ($p < 0,05$) compared to controls.

Discussion

Neuropsychological tests used in our clinical study were chosen for their sensitivity to detect commonly reported impairments in alcohol dependence as determined from numerous neurocognitive studies assessing executive functioning, visuospatial abilities, social cognition as well as affective and behavioural response tendencies.[2–4, 11] In recent years, there has been a considerable growth in knowledge of the processes involved in emotional and cognitive functioning regarding diverse modalities of stimuli and the different ways in which these processes might become disrupted in the human brain. Several neuroimaging and behavioural studies suggested that certain modalities of stimuli, like negative emotional context and nonverbal information predominantly activate specific neural circuits in the right hemisphere. Some of the employed tests in our study also included verbal / nonverbal stimuli and emotionally biased stimuli which are often used in clinical practice in order to estimate the possible left or right sided hemispheric impairments. Therefore we also aimed to investigate whether applied composite of tests could expose some possible alcohol-related right hemispheric deficits as it is suggested in the »right hemisphere hypothesis«. It should be noted, however, that with the use of many heterogeneous tests on relatively small sample size, we got a lot of results and there-

fore the increased likelihood to get some accidental statistically »significant« results should be considered when drawing conclusions. On the other hand, the reduced statistical power of the applied methods implies diminished chance of finding significant small differences between groups in our sample but it is possible that we would have found them in a larger one.

Our study revealed that the group of alcohol abstainers displayed higher levels of depression scores and several impairments in the motivational response tendencies and executive functions compared to control group. In addition, no significant differences between groups have been found in the visuospatial, social cognition and working memory domains nor in different dimensions of emotional styles.

In accordance with prior studies, which identified a consistent pattern of mild to moderate neurocognitive deficits in alcoholics[25, 26] our study extended those findings by further demonstrating that extensive cognitive deficits could also be detected after several weeks of cessation of drinking. Besides, they could be closely linked with emotional context and suicidal history. Within the group of alcohol abstainers nearly 25 % of persons reported earlier history of suicidal attempts. They displayed specific impairments in several assessed domains which differed from alcohol abstainers without suicidal history. Their neuropsychological profile indicated elevated depression scores, bad coping with negative emotional context, poor social cognition and attentional bias towards negatively valenced emotional cues. If the residual cognitive impairment after detoxification typically includes executive functions, learning, and memory[9, 26, 27] a patient's ability to use rehabilitative information is likely to be compromised during this period and thereby affects the prognosis for treatment success.[12] Furthermore, extensive impairment of executive functions in alcoholics has been associated with attrition from rehabilitation and higher rates of relapse,[28] as well as with social difficulties such as increased marital disruption[29] and employment failure,[30] all of which conspire toward poor treatment outcomes. Therefore during the recovery from alcoholism a special attention should be paid to alcohol abstainers with suicidal attempts.

Alcohol abstainers with suicidal history less accurately recognised emotional facial expression, especially negatively valenced emotions (anger, fear) and demonstrated increased tendencies toward withdrawal behaviour and anxiety (overactive BIS) which could be probably linked with impaired social cognition ability. Namely social cognition refers to the processes that subserve behaviour in response to the social relevant stimuli, particularly to those higher cognitive processes subserving extremely diverse and flexible social behaviours.[31] The ability to recognise the facial expression of emotion on another's face and to interpret accurately the internal state of one's interaction partner are the most relevant skills related to human communication and social cognition.[32, 33] Substance dependence is frequently associated with dysfunctions in emotional facial expression decoding processing, whereas alcohol dependence is being linked with more impairments and no improvement after months of abstinence.[34, 35] Our study did not reveal dysfunctional decoding of emotional facial expression in the group alcohol abstainers without suicidal attempts. Suicidal thinking seemed to be an important factor in this regard, since both alcohol and suicidal behaviour have been reported to correlate in many aspects of social functioning.[36] The association of alcohol dependence with suicidal behaviour is well established although complex. We found several emotional and cognitive responses that could be linked with suicidal tendencies of alcohol abstainers also after longer period of cessation of drinking. Thus suicidal behaviour could be seen as a persisting behavioural tendency toward auto-aggressiveness, which is strengthened by alcohol abuse.

A number of features like sensitiveness to negative affect, cognitive constriction, withdrawal motivational bias and affective tendencies, found in our research among suicidal alcoholics, have been often described also in some other studies dealing with suicidal state of mind.[37, 38] Suicidal thinking and alcoholism are hypothesized to strongly correlate with some motivational tendencies proposed by motivation theorists who assumed that two systems underlie much behaviour. One system is posited to manage appetitive, incentive motivation and approach behaviour. It has been referred to as a behavioural activation system – BAS,[39] behavioural approach system,[40] behavioural facilitation system[41] and approach or appetitive motivational system.[42] The other proposed system manages aversive motivation and the behaviours of avoidance and withdrawal known as the behavioural inhibition system – BIS,[40] aversive/defensive system,[43] and withdrawal motivational system.[44] Although the theories underlying the proposed motivational systems differ in several regards, most of them state that BAS is involved in the generation of positive affect and impulsiveness, whereas BIS is involved in the generation of negative affect and anxiety. The findings of our study support those theories. BIS was the only one of the BIS/BAS dimensions where link was found with suicidal history of alcohol abstainers which is in agreement with studies proposing that higher levels of behavioural inhibition sensitivity are associated with higher levels of suicidal thinking, depression and anxiety.[45–47] But none of the BAS dimensions were associated with suicidal history and they predominated only in the group of non-suicidal alcohol abstainers. This is not surprising as BAS is a temperament construct, characterized by motivational sensitivity to signals of reward. It is known that all substances of abuse have rewarding properties. According to the Gray's Reinforcement Sensitivity Theory, high BAS sensitive persons are more prone to engage in approach behaviour and experience positive affect in situations with stimuli that are associated with reward. Quite a lot of studies have indeed confirmed that BAS positively correlates with alcohol use and abuse in nonclinical and clinical populations and that elevated levels of BAS Reward Responsiveness and Fun Seeking are associ-

ated with the presence of a lifetime alcohol abuse disorder, impulsiveness and craving vulnerability.[18, 46, 48–50]

An important factor which may contribute to perceived pattern of cognitive impairment among alcohol abstainers during their recovery from alcoholism, is depression. Depression is the most frequent disorder in alcoholism; 27–69 % of all alcoholics have elevated depression scores and 15–28 % of them suffer from major depression.[3, 51] Although several studies demonstrated that depression could interfere with cognitive, emotional and motivational functioning,[47, 52–54] the potential cumulative effects of alcohol and depression have so far not been explored in detail. According to our findings some observed neurocognitive deficits in alcohol abstainers could be related to depression which substantially contributes to cognitive rehabilitation outcome. Namely, depression is often demonstrated as significant risk factor of the relapse vulnerability among individuals with alcohol dependence[55, 56] and therefore the possibility of cognitive limitations should be considered when planning treatment programmes for alcoholism. However, depression scores obtained with self-reporting inventory (like BDI) should be interpreted with caution since patient's over- or underestimating the severity of depressive symptoms could reflect rather the »reporting bias« than actual state of mood.

The presence of neuropsychological deficits in alcoholics after abstinence is not a trivial issue due to persistence of at least some deficits in a majority of abstinent alcoholics after acute detoxification and to certain extent also after prolonged period of abstinence.[8] Many studies have indicated that alcoholism-related structural and functional brain changes begin to reverse in abstinence and that brain structure is capable of repair and restructuring, though the results have not always been consistent in this regard.[57, 58] Improvement in brain function probably arises from neural repair as well as from the reorganization of brain structural networks and functional strategies.[27, 57, 59] These changes in neuroanatomy, chemistry, and neuropsychology most likely contribute to better cognitive, emotional and motivational functioning[11, 13, 25] beside successful recovery from dependence.

According to the »right hemisphere hypothesis«, the right hemisphere is more susceptible to the neurotoxic effects of alcohol, resulting in long-term deficits on measures which depend on the functional integrity of the right hemisphere, such as visuospatial processing, negative affect and / or withdrawal motivation.[5, 60–63] The behavioural data obtained in our study are only partially in line with some studies proposing that chronic use of alcohol depresses to the greater extent the right hemisphere. The length of abstinence decisively contributes to improvement in many aspects of functioning, yet the alcohol abstainers in our study demonstrated relatively preserved abilities on tasks related to the integrity of the right hemisphere. Since more studies demonstrated that alcohol inpatients recovered in several domains after a few weeks of cessation of drinking,[10, 12, 57] the impact of participant's sobriety (8 weeks on average) on some cognitive domains could also prevail in the case of our results. On the other hand, an additional data analysis which considered also a suicidal history of alcohol abstainers, revealed significant differences between the alcoholics' subgroups which are in favour of the »right hemisphere hypothesis«. Although the results obtained in our study arise from small number of suicidal alcohol abstainers and should be therefore interpreted cautiously, a group of suicidal alcohol abstainers demonstrated characteristic impairments, usually associated with the right hemispheric dysfunctions: increased behavioural inhibition sensitivity,[64–67] elevated depression symptoms,[67] impaired recognition of emotional facial expressions, particularly those expressing anger and fear[68, 69] and attention bias toward emotionally valenced words.[70, 71] This findings are consistent with the theories proposing that due to functional insufficiency of the right hemisphere a suicidal person demonstrates a compensatory shift to left hemisphere functioning and that could contribute to a suicidal state of mind. This shift manifests in cognitive constriction, low ability to generate polysemantic context, negative perception of the body, lower sensitivity to pain, difficulties in affect regulation and low openness to experience.[37, 38] However, the »right hemisphere hypothesis« is not prevalent regarding the neural substrates of alcohol addiction. Some studies suggested that alcoholism is associated with a parallel deterioration in functioning of both cerebral hemispheres. Their data showed that alcoholics exhibited both right- and left-hemisphere-type impairments with approximately equal frequency and impairments on cognitive tests that employ both verbal and nonverbal materials.[60, 63, 65, 70]

Taking into account the controversy of results emerging from several studies, their interpretations and hypotheses, further investigations are needed to examine the extent to which neurobiological causes underlie specific aspects of neuropsychological impairments in alcoholism. Future investigations should address limitations of the present study by using a larger, more diverse sample (including women) and a *follow up* approach of neuropsychological assessment in the same group of alcohol abstainers (before, during and after their treatment participation). In particular, future studies should focus on possible suicidal factors in abstainers. The topics of the dynamic interaction between affective and cognitive processes and affective personality variables (BIS/BAS) have become increasingly tractable in terms of neurobiology. In this regard future neuroimaging studies would be advisable in order to clarify the principles underlying human hemispheric specialization and neural correlates of emotional, cognitive and motivational functioning. On the whole, data from our study demonstrate that neuropsychological approach for assessment of alcohol related impairments during recovery from alcoholism is promising and could be a useful tool for evaluation of rehabilitation process and treatment planning.

Conclusions

Alcohol dependence presents a significant challenge to society and health-care services as alcoholics are not all alike. They experience different subsets of symptoms, and the disease has different origins for different people. Therefore, to understand the effects of alcoholism, it is important to consider the influence of a wide range of variables. The associated emotional and cognitive deficits are thought to affect behavioural control, therapy and liability to relapse. As it is associated with diverse changes to the brain and behaviour, clinicians must consider a variety of treatment methods to promote cessation of drinking and recovery of impaired functioning. With an optimal combination of neuropsychological observations, structural and functional brain imaging results, treatment professionals may be able to develop a number of predictors of abstinence and relapse outcomes, with the purpose of tailoring treatment methods to each individual patient.

Researchers have not yet found conclusive evidence of the general variable that can consistently and completely account for the brain deficits found in alcoholics. The most plausible conclusion is that neurobehavioural deficits in some alcoholics result from the combination of prolonged ingestion of alcohol which impairs the way the brain normally works and individual vulnerability to some forms of brain damage. Characterizing what makes alcoholics »vulnerable« remains the subject of active research.

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