ORIGINAL ARTICLE

Neuropsychological assessment of impulsive behavior in abstinent alcohol-dependent subjects

Avaliação neuropsicológica do comportamento impulsivo de sujeitos dependentes de álcool em abstinência

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Abstract
Objective: *Poor impulse control is thought to be one of the characteristics of alcohol addiction. The capacity to remain abstinent may be linked to cognitive bias related to three dimensions of impulsivity: motor, non-planning, and attentional impulsivity. The aim of this study was to evaluate the neuropsychological profile related to these impulsivity dimensions in alcohol-dependent patients within 15 -120 days of abstinence.* ***Method:*** *We compared 31 alcohol-dependent patients to 30 matched healthy controls regarding their performances on the Continuous Performance Task, the Iowa Gambling Test, and the Wisconsin Card Sorting Test, each of which is thought to tax primarily one of the three dimensions of impulsivity just outlined.* ***Results:*** *When compared to controls, alcohol-dependent patients presented more commission errors on the Continuous Performance Task; made more disadvantageous choices on the Iowa Gambling Test; and made more perseverative errors on the Wisconsin Card Sorting Test. There was no significant correlation between performance on these tests and the length of abstinence.* ***Conclusion:*** *These results suggest that deficits related to motor, non-planning and attentional components of impulsivity exist in alcohol-dependent patients, in the period immediately after acute alcohol withdrawal. These results may help guide interventions designed to prevent the risk of relapse in alcohol-abstinent patients.*

Descriptors: *Alcoholism; Abstinence; Impulsive behavior; Cognition; Neuropsychology*

Resumo
Objetivo: *O controle deficiente dos impulsos é considerado uma das características da dependência do álcool. A capacidade de permanecer abstinente pode estar ligada a viés cognitivo relacionado a três dimensões da impulsividade: motora, de atenção e por falta de planejamento. O presente estudo objetivou avaliar o perfil neuropsicológico relacionado a estas dimensões da impulsividade em pacientes dependentes de álcool em 15 a 120 dias de abstinência.* ***Método:*** *Nós comparamos o desempenho de 31 pacientes dependentes de álcool a 30 controles saudáveis na* Continuous Performance Task, *no* Iowa Gambling Test *e no* Wisconsin Card Sorting Test, *que são considerados testes capazes de avaliar primariamente as citadas dimensões de impulsividade.* ***Resultados:*** *Em relação aos controles, o grupo pacientes dependentes de álcool cometeu mais erros de comissão na* Continuous Performance Task*; fez escolhas menos vantajosas no* Iowa Gambling Test *e mais erros perseverativos no* Wisconsin Card Sorting Test*. Não houve correlação significativa entre o desempenho nestes testes e o tempo de abstinência.* ***Conclusão:*** *Estes resultados sugerem que há déficits relacionados aos componentes da impulsividade (motores, atencionais e por não-planejamento) em pacientes dependentes de álcool, no período imediatamente após a fase aguda de retirada do álcool. Estes resultados podem ajudar a guiar intervenções para impedir o risco do recaída em pacientes em curto período de abstinência de álcool.*

Descritores: *Alcoolismo; Abstinência; Comportamento impulsivo; Cognição; Neuropsicologia*

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Introduction

Impulsivity or poor impulse control, defined as a behavior performed with little or inadequate forethought, is thought to be associated with addiction, including alcohol addiction.[1] It is suggested that impulsivity plays a role, along with related features such as poor decision-making and loss of willpower, as well as affective aspects, in a complex process that results in clinical descriptions in which subjects take alcohol despite their awareness of its negative consequences.[2] It remains unclear, however, whether this impulsivity arises as a consequence of long-term drug exposure, or it predates drug consumption, thus rendering individuals more vulnerable to addiction.

Impulsivity, however, is not a unitary phenomenon. For instance, Barratt separated impulsive behavior into three components: motor (action without thinking), attentional (lack of focus on the task at hand), and non-planning (orientation towards the present, rather than to the future).[3] This classification presents some convergence on Bechara's model[4] that also argues for the existence of three types of impulsivity, each one analogous to Barratt´s proposition (see also Malloy-Diniz et al.).[5]

Different approaches, including objective and subjective measures, have been used to evaluate the different aspects of impulsivity among many psychiatry disorders.[2-6] Some authors have proposed that behavioral measures may have the advantage of being more sensitive to transient changes in impulsivity, as well as being more amenable to repeated administration.[7] As such, these behavioral measures of impulsivity may be more useful during both the assessment and treatment phases of disorders related to impulsivity. Thus, different paradigms have been used to measure different component processes related to impulsivity. For example, motor impulsivity has been assessed by rapid response inhibition paradigms, such as the continuous performance task (CPT), which measures the ability to suppress dominant, automatic or pre-potent responses. In the CPT, impulsive responses may be defined as a response to any stimulus other than the target (i.e. a commission error).[2,7]

Non-planning impulsivity, on the other hand, has been assessed by reward-punishment paradigms such as the Iowa gambling test (IGT). In the IGT there is a choice between 1) a high immediate reward, but with relatively increased risk for higher future punishment, and 2) a relatively lower immediate reward, but with relatively lower future punishment.[2,7,8] Although this task involves several aspects of decision-making, it taps into non-planning impulsivity when the subject chooses smaller-sooner gains instead over a larger-later reward that comes from the overall gain.[4] It should be noted, however, that this paradigm is related, but not the same, to the classic delay-discounting task in which the subject is presented with choices between immediate rewards versus parametrically varied delays to reward deliveries.[7]

Attentional impulsivity may be assessed by tasks requiring shifting attention from one perceptual dimension to another, such as the Wisconsin Card Sorting Test (WCST). Performance in this kind of task may be impaired by difficulties in shifting attention and behavior, which could be related to the difficulty to avoid drug-related thoughts, or to establish new patterns of social behavior during the early phases of abstinence.[2]

According to Marlatt and Gordon,[9] after the acute initial period of abstinence, when the risk for relapse is highest, due to physical withdrawal and craving, impulsivity may play a major role in promoting relapse during that period. This period is critical because, while reinserting on habitual daily activities, subjects may face situations in which they used to drink as a behavioral strategy to cope with difficulties (e.g.: social stress). Furthermore, subjects may be exposed to alcohol or to any other situation where they have to make a decision between abstinence or relapse.

Although it is largely accepted that impulsivity plays a key role in alcohol addiction and relapse, it remains unclear whether specific sub-facets of impulsivity (e.g., motor, non-planning, or attentional) are the most critical, or are related to each other, since, to our knowledge these sub-facets were never assessed together in alcohol-dependent patients. The main objective of our study was to address this question, and evaluate the neuropsychological profiles related to impulsivity in a group of alcohol-dependent patients within 15-120 days of abstinence. We also examined whether impulse control changes over time during an abstinence period by comparing patients with shorter abstinence time (i.e. 15-30 days) to patients with longer abstinence time (i.e. 60-120 days).

Method

1. Participants

We assessed 31 alcohol-dependent patients (5 women and 26 men) recruited from the day-hospital service of a public hospital (IPSEMG) in Belo Horizonte, Brazil. The diagnosis was made based on DSM-IV criteria using a structured interview (MINI-PLUS).[10] The mean alcohol-use time during life span was nearly 30 years and the mean alcohol-dependence time was nearly 10-15 years. The patients were heavy users (more than 51 alcohol units per week for men and 31alcohol units per week for women). We also assessed 30 healthy controls (10 women and 20 men) recruited from local advertisements. They were also submitted to MINI-PLUS to identify exclusion criteria.

We excluded participants with a current substance-related disorder other than alcohol or tobacco, current major depressive disorder or manic/hippomanic episode, a history of psychotic disorder, obsessive-compulsive disorder, impulse control related disorders such as pathological gambling, borderline personality, attention-deficit/hyperactivity disorder or eating disorders, or a lifetime history of traumatic brain injury/vascular brain disorder. We did not exclude patients on benzodiazepine or antidepressant use, in order to bring test conditions near to real-world practice. These assessments were made by a psychiatrist. Furthermore, for the purposes of this study we included only participants who presented scores greater than, or equal to, the 25th percentile on the Raven Progressive Matrices – General Scale, according to the Brazilian normatization;[11] educational level above 7 years of formal education, and ages between 18 and 60 years. This strategy aimed at preventing from confounding effects such as low intelligence, poor education, and incomplete development of executive functions, or age-related cognitive decline, which could interfere with test comprehension or performance. In order to compare groups according to intelligence level, we used Raven's raw scores.

All participants were free of alcohol use for at least 15 days, and at most 120 days before inclusion in the study. All patients were customers of the local day-hospital service and were under group psychotherapy for relapse prevention, which warrants a good control over occurrence of relapses. Abstinence was determined by self- and family-report collected daily and weekly, respectively. The Local Ethics Review Committee had approved the study protocol. All participants signed informed consents before participating in this study. They were not paid for their participation.

2. Instruments

1) Continuous Performance Task

We used a version of this task (CPT-II), in which the subject has to press a spacebar when any letter (except for the letter X) appears on screen.[12] A commission error occurs when the subject presses the spacebar when an X letter appears on the screen, thus reflecting a failure to inhibit a pre-potent motor response. Commission errors were used to evaluate motor impulsivity.

2) Iowa Gambling Task

We used a computerized version of the Iowa Gambling Task (IGT).[13,14] Briefly, subjects have to choose one card at a time from four available decks (A, B, C, and D). The task requires the subjects to make 100 choices (100 trials), and in each trial subjects may win or lose a certain amount of money. While receiving instructions for the game subjects are told that some decks are more advantageous than others, but they do not know which decks are better. After each choice, subjects receive a feedback on the computer screen telling them how much money they won or lost. Through this feedback, subjects have to avoid decks that yield high immediate gains but lead to larger future losses (decks A and B) and choose the decks that lead to a small immediate gain but avoid substantial losses along the task (decks C and D). One hundred choices were divided into five blocks of twenty choices each. This kind of register is important to verify changes in the pattern of choices along the task. For each block we used the formula: (number of Deck C choices + number of Deck D choices)-(number of Deck A choices + number of Deck B choices). A net score for each block as well as a total score was obtained. In our study, the performance in the IGT was used to assess non-planning impulsivity.

3) Wisconsin Card Sorting Test

In the Wisconsin Card Sorting Test (WCST),[15-17] subjects are presented with two decks of 64 cards each. They are instructed to match the cards to four key cards and they have to discover the matching principle based on feedback from the examiner. As soon as subjects make ten corrects answers they are considered to have completed one category and the matching principles change. Subjects have to adapt their strategy based on feedback from the examiner. The variables used to measure shift attention were the number of perseverative errors. Perseverative errors occur when the subject gives an answer suited to the previous learned strategy. Non-perseverative errors were used as a control measure not related to attention set-shift. On the version used in this study, only one deck is presented to the subject. This version has the advantage of a shortened administration time with the retention of original task demands. In our study, the short version of computerized Wisconsin Card Sorting Test[18] was used to measure set-shifting ability and perseverative behavior, which are related to attentional impulsivity.

A trained neuropsychologist (L.M-D.) administered the tests in a quiet laboratory and in a standardized sequence: CPT-IGT-WCST. This sequence took nearly 40 minutes and was the same used in Malloy-Diniz et al.[5] with the addition of WCST at the end.

3. Statistical analysis

In order to compare the individuals, we used descriptive statistics (mean and standard deviation), t test for continuous data, and χ^2 for categorical data (e.g. gender). We also used the Pearson coefficient analyses to verify correlations between the measures of the alcohol-dependent patients. The level of significance was set at $p < 0.05$. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS version 12.0).

Results

The alcohol-dependent group (ADG) was not different from controls regarding gender, age distribution, and years of education. The level of intelligence, as measured by the Raven Progressive Matrices, was also not different between groups (Table 1).

The neuropsychological impulsivity assessment revealed significant differences between ADG and controls on the three tests that were used. On the CPT, there was an increase in the number of commission errors made by ADG relative to controls. On the IGT, there was a difference between groups in the net scores from the second, the fourth and the fifth block, as well as the total net score; the number of advantageous choices made by the ADG was smaller than that of controls in these blocks. On the WCST, the ADG made more perseverative errors than controls. The number of non-perseverative errors did not differ between ADG and controls. These results are presented in Table 1.

Table 1 - Comparison of sociodemographic characteristics and test performance between short-term abstinent alcohol-dependent (n = 31) subjects and healthy controls (n = 30)

	AD subjects	Controls	Significance (t test)	
	Mean ± SD	Mean ± SD	t	p
Age	48.97 ± 6.1	46.93 ± 8.3	1.089	0.281
Education (years)	10.55 ± 2.6	11.07 ± 4.0	-0.594	0.555
Gender	26 males, 5 females	20 males, 10 females	1.65*	0.235*
Raven Progressive Matrices	41.55 ± 7,5	41.79 ± 6,0	-0.139	0.890
CPT-II commissions errors	11.65 ± 5.6	7.17 ± 4.6	3.387	0.001
IGT block 1	0.26 ± 4.5	0.21 ± 5.2	0.041	0.967
IGT block 2	-1.45 ± 6.0	1.97 ± 5.5	-2.308	0.025
IGT block 3	2.00 ± 6.7	4.62 ± 8.2	-1.364	0.178
IGT block 4	-2.71 ± 3.7	5.4 ± 7.6	-5.224	< 0.001
IGT block 5	2.94 ± 4.1	6.86 ± 8.0	-2.354	0.023
IGT-net score	1.03 ± 14.6	19.10 ± 22.7	-3.699	< 0.001
WCST (perseverative errors)	14.74 ± 7.8	10.52 ± 6.8	2.233	0.029
WCST (non-perseverative errors)	17.45 ± 11.6	14.17 ± 6.7	1.352	0.183

* χ^2

In ADG we found no significant correlation between commission errors in CPT and performance in any block of IGT or perseverative errors in WCST. Also, there is no significant correlation between performance in IGT and in WCST.

Pearson coefficient analyses showed no correlation between days of abstinence and performance in any of the tests. Performance of patients with shorter abstinence (i.e. 15-30 days, 20 subjects) was not different of performance of patients with longer abstinence (i.e. 60-120 days, 9 subjects).

Discussion

Our study evaluated the performance of abstinent alcohol dependents in three construct dimensions of impulsivity, namely: motor, non-planning and cognitive by means of three neuropsychological tests, namely CPT, IGT and WCST, respectively. Our results showed impairment in all three tests related to controls. This impairment cannot be ascribed to a general cognitive deficit since the performance on the Raven Progressive Matrices did not differ from controls. Nevertheless, we cannot exclude the possibility that some factors that may cause cognitive impairment (e. g. benzodiazepine use or hepatic disease) may have had some influence on the results. It should be noted, however, that only a small portion of the patients was on benzodiazepine use and none had clinical evidence of hepatic disease.

Some studies have assessed impulsivity by means of performance in neuropsychological tests in alcohol-abstinent subjects. Bjork et al. have showed that abstinent inpatients with 28 days length of hospitalization on average made significantly more commission errors than controls in a five-digit variant of the CPT.[19]

In two studies with delay-discounting tasks, decision-making tasks that may be conceptually similar to the IGT, in short-term abstinent alcoholics showed more preference for small, immediate reward over large, delayed reward than did controls.[20-21] Performance on the IGT has been shown to be impaired even in long-term abstinent alcohol abusers as demonstrated in patients with a mean of 6 months[22] to 6.5 years of abstinence.[23]

In patients undergoing detoxification, performance on all measures of the WCST was impaired in the first evaluation (mean of 4 days of abstinence). However, non-perseverative errors, but not perseverative errors, improved in the follow-up assessment (nearly 2-3 months).[24] In contrast, Goudriaan et al.[25] did not find difference between alcohol-dependent patients who had been abstinent for a period of 3-12 months and controls on any measures of the WCST.

Studies with non-abstinent alcohol subjects have also shown impairment in performance relative to controls on the IGT[20,26,27] (but see[28,29]) and the WCST, as well as other set-shifting types of tasks.[26,29]

In sum, results from the literature are in accordance with ours to the extent that most of them showed impairments among alcohol-dependent subjects on behavioral tests that assess motor, non-planning and cognitive/attention dimensions of impulsivity. Reports of normal performance on the IGT in alcohol-dependent subjects could be, at least partially, due to a particularly restrictive inclusion criteria, as Hildebrandt et al.[29] included only patients without any memory impairment and Fein et al.[28] only alcohol-dependent young adults who were treatment-naïve.

Of note, our study was the first to assess the three impulsivity dimensions in the same patients. Our results show that there are no significant correlations when we compare the variables of one test to the variables of the other tests. This seems compatible with the hypothesis that the tests used are related to different portions of prefrontal cortex (PFC). Commission errors in CPT and inhibitory processes involved in WCST seem to be related to infero-lateral PFC function.[30,31] The absence of significant correlation between commission errors in CPT and variables of WCST in our sample may be due to the fact that performance in WCST may depend more heavily on functions related to dorsolateral portions of PFC (e.g., heavy load of working-memory, cognitive shift), which could be also affected in the patients.[32,33]

Several authors have shown that performance in decision-making tasks depends on normal functioning of more ventromedial portions of PFC and may be separable from those requiring executive functions linked to more dorsal-lateral portions of PFC.[34-36] Subjects with impaired decision-making may have normal, or even superior, dorsolateral prefrontal functions, such as working-memory, for example. On the other hand, severe impairment in dorsolateral PFC may influence decision-making.[2,37,38] In our sample, although patients showed impairment in both dorsolateral and ventromedial prefrontal related tasks, the deficits seem to occur independently.

Our study focused on a critical time period after detoxification since all patients were within 15 days and 120 days of abstinence. In this period, patients usually overstep the acute detoxification phase, when they usually have a closer monitoring and an unusual profile of daily functioning, and try to reinsert themselves in their own way of life. Hence, this is a period when the mechanisms of impulse control may play a critical role. Our results are in accordance with the hypothesis that alcohol-dependent patients in abstinence may have difficulty to: 1) inhibit a shift in attention from an alcohol signal, (e.g. an alcoholic beverage bottle), which is related to attentional impulsivity, 2) make a wise decision in order to avoid immediate reward (e.g. drinking alcohol) and gain the delayed, larger reward (e.g. remaining abstinent), which is related to non-planning impulsivity, 3) inhibit pre-potent motor response (e.g. to hold the bottle and drink), which is related to motor impulsivity. Further, impairment on one impulsivity dimension is independent of impulsivity in another dimension. Hence, our results may help to orient the development of tools for prognosis, as well as interventions (e. g. behaviour psychotherapy) designed to ameliorate the cognitive profile related to impulsivity in order to prevent the risk of relapse in alcohol-dependent patients.

It is well-known that chronic alcohol abuse is linked to prefrontal cortex dysfunction, which includes impairment in impulse control.[39] Our study design did not allow us to state whether the impulsivity seen in our patients is due to the chronic effect of alcohol in the brain or to a trait that precedes (and perhaps facilitates) alcohol use or both. However, since our results showed no correlation between days of abstinence and performance in any of the tests, it is possible that impulsivity in abstinent patients, whatever its etiology be, is a stable risk factor, and alcoholics may always be at high risk of relapse, even after prolonged and successful period of abstinence.

However, several shortcomings from our study should be noted. First, although we have a good patient follow-up, we did not use any laboratory measure to assure abstinence. Second, we did not control for past depressive episode or drug use/abuse, which are conditions that may affect test performance. Third, our sample is small thus further controlled trials with larger samples and account for these shortcomings are required to confirm our data. Longitudinal studies that focus on the relationship between the performance in tests of impulsivity and incidence of relapse are also advisable.

Disclosures

Writting group member	Employment	Research grant[1]	Other research grant or medical continuous education[2]	Spekear's honoraria	Ownership interest	Consultant/ Advisory board	Other[3]
João Vinícius Salgado	Instituto Raul Soares, Universidade FUMEC	---	---	---	---	---	---
Leandro Fernandes Malloy-Diniz	UFMG	---	---	---	---	---	---
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Susana Silva Costa Abrantes	Universidade FUMEC	---	---	---	---	---	---
Daniel Fuentes	FMUSP	---	---	---	---	---	---
Antoine Bechara	University of Iowa	---	---	---	---	---	---
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** Modest*
*** Significant*
**** Significant. Amounts given to the author's institution or to a colleague for research in which the author has participation, not directly to the author.*
Note: FMUSP = Faculdade de Medicina da Universidade de São Paulo; UFMG = Universidade Federal de Minas Gerais.
For more information, see Instruction for authors.

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