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Decision-making in opioid-dependent individuals using the Iowa Gambling Task

La toma de decisiones en dependientes de opiáceos mediante la Iowa Gambling Task

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Summary

Decision-making impairments have been highlighted in opioid-dependent individuals using the Iowa Gambling Task (IGT). The objective of this study was to assess decision-making under uncertainty in opioid-dependent subjects. The sample included 64 abstinent opioid-dependent individuals under treatment and 48 control subjects. Group equivalence was analyzed considering age, gender and educational variables. In both groups, most subjects showed borderline performance, followed by disadvantageous performance and advantageous performance. Both groups showed a preference for low punishment frequency decks (B and D). In both groups, education and gender do not account for IGT performance, and learning differences in the IGT could be in part attributable to cognitive functions as assessed by the MoCA. Opioid- dependent individuals and the control group showed no significant differences in performance.

Keywords: Decision-making, Iowa Gambling Task, opioid dependence, punishment frequency

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Resumen

En individuos dependientes de opiáceos se evidenció deterioro en la toma de decisiones utilizando el Iowa Gambling Task *(IGT). El objetivo de este estudio es evaluar la toma de decisiones en condiciones de incertidumbre en los sujetos dependientes de opiáceos. La muestra incluye 64 individuos dependientes de opiáceos abstinentes en tratamiento y 48 sujetos control. Se analizó la equivalencia de los grupos teniendo en cuenta las variables edad, género y educación. En ambos grupos, la mayoría de los sujetos mostraron un desempeño* borderline, *seguido de desempeño desventajoso y desempeño ventajoso. Ambos grupos demostraron una preferencia para las barajas de baja frecuencia de castigo (B y D). En ambos grupos, la educación y el género no contribuyen en el desempeño de IGT, y las diferencias de aprendizaje en el IGT pueden ser en parte atribuibles a las funciones cognitivas evaluadas por el MoCA. Los individuos dependientes de opiáceos y el grupo control no mostraron diferencias significativas en el rendimiento.*

Palabras clave: Toma de decisiones, dependencia de opiáceos, I*owa Gambling Task*, frecuencia de castigo.

Decision-making in opioid-dependent individuals using the Iowa Gambling Task The Iowa Gambling Task (IGT) (Bechara, Damasio, Damasio, & Anderson, 1994) simulates real-life decision-making in situations under uncertainty with respect to the consequence, i.e., reward or punishment. The task consists of a game in which the subject must choose cards from four different decks (A, B, C, D) in 100 trials to win as much money as possible or to avoid losing. Gains and losses follow a predefined reward and punishment scheme. Every time a subject selects a card an immediate monetary gain is awarded, although for some cards this reward is immediately followed by punishment. Decks A and B provide the highest rewards and also the worst punishments. These are considered disadvantageous because in the long run the money penalties exceed the rewards and provide a less advantageous balance. Decks C and D provide lower rewards, but also lower losses. These are considered advantageous because the long-term rewards surpass the penalties and offer a more advantageous balance. Therefore, the most effective strategy for winning money in the task is to consistently select more cards from decks C and D than from decks A and B. However, this objective can only be accomplished if subjects learn the long-term pattern of rewards and penalties for each deck.

Substance dependence can be defined as a paradigm of the decision-making paradox: "the substance use is continued despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by the substance..." (DSM-IV-TR; American Psychiatric Association, 2000, p. 197). In fact, decision-making studies using IGT on substance-dependent individuals (alcohol, cannabis, cocaine, methylenedioxymethamphetamine and opioids) point to a disadvantageous performance (e.g., Bechara & Damasio, 2002; Bechara, Dolan, & Hindes, 2002; Le Berre *et al.*, 2014), which is directly involved in dependence development and maintenance (Verdejo-García, Pérez-García, & Bechara, 2006). In this case, the "somatic marker model of addiction" (Verdejo-García *et al.*, 2006) has been used to explain the difficulties substance-dependent individuals have both in decision-making with IGT as well as in daily life. Impairment in decision- making could be due to a deficit in emotional signals (somatic markers) that anticipate the results of an action and guide towards the selection of the most advantageous response (e.g., Bechara & Damasio, 2002; Bechara *et al.*, 2002). Thus, substance dependence can be defined as "…a condition in which the person becomes unable to choose according to long-term outcomes" (Bechara, Noel, & Crone, 2006, p. 227).

However, there is "…evidence that decision-making performance differs between the type of substance used" (Ersche & Sahakian, 2007, p.

324). Studies in former opioid-dependent individuals are scarce. This could be explained by the fact that most research is US-based, where opioid use is significantly lower than in Europe. Indeed, according to the United Nations Office on Drugs and Crime (2011), in North America 25 % of treatment demands stem from opioid use, and 28% are related to cocaine use. In Central and Western Europe, 46.9 % of treatment requests are motivated by opioid use and 11.6 % by cocaine use. This high prevalence of opioid use in Europe is associated with an elevated harmfulness potential, reflected in a high rate of treatment demand (United Nations Office on Drugs and Crime, 2011). This underlines the importance of studying decision-making processes in opioid-dependent individuals. Some studies specifically investigating decision-making with IGT on opioid-dependent individuals were conducted in subjects on maintenance treatment. Under these conditions they showed worse performance than control groups (Petry, Bickel, & Arnett, 1998; Rotheram-Fuller, Shoptaw, Berman, & London, 2004). Nevertheless, since the studies were conducted in subjects undergoing maintenance treatment, IGT performance could be attributed to the effects of opioid agonists.

Maintenance programs show that buprenorphine-maintained individuals performed better than methadone-maintained individuals, and not differently than drug- free controls (Pirastu *et al.*, 2006). Studies with IGT in abstinent opioid users were conducted in the United Kingdom (Passetti *et al.*, 2011) and in countries with a high prevalence of heroin addiction, such as Bulgaria (Vassileva *et al.*, 2007), Iran (Hassani- Abharian & Tabatabaei-Jafari, 2011) and China (Li *et al.*, 2013; Zhang *et al.*, 2011). Some studies using IGT on abstinent opioid-dependent individuals and polysubstance abusers with a marked subjective preference for heroin showed poorer performance in decision-making compared to controls (Passetti *et al.*, 2011; Verdejo-García, Perales, & Pérez-García, 2007). Moreover, this deficit in decision-making in opioid addicts can predict the outcomes of treatment and abstinence from illicit drugs at follow-up (Passetti *et al.*, 2011). However, the severity of opioid drug dependency was not associated with differences in decision-making (Hassani-Abharian & Tabatabaei-Jafari, 2011).

Other studies show that substance-dependent individuals can have different patterns of IGT decision (Mellentin, Skøt, Teasdale, & Habekost, 2013), with some showing similar performance to the control group (Adinoff *et al.*, 2003; Zorlu, Demir, Polat, Kuserli, & Gülseren, 2013). These results have been observed since early studies (Bechara & Damasio, 2002; Bechara *et al.*, 2002) where a large variability in control group performance has been seen, with 37 % of the subjects showing disadvantageous performance. Such results are supported by studies showing an absence of homogeneity in the performance of subjects from the general public, with a high percentage of poor performance and absence of learning (Caroselli, Hiscock, Scheibel, & Ingram, 2006; Steingroever, Wetzels, Horstmann, Neumann, & Wagenmakers, 2013).

Most studies using the IGT focused on performance differences between clinical and control groups, and the proportion of deterioration in each group was not often presented (Hassani-Abharian & Tabatabaei-Jafari, 2011; Li *et al.*, 2013; Vassileva *et al.*, 2007; Verdejo-García, Perales, & Peŕez-García, 2007; Zhang *et al.*, 2011).

Performance classification also differs between studies. Initially advantageous performance was defined as [(C + D) - (A + B)] > 0 and disadvantageous performance as [(C + D) - (A + B)] < 0 (Bechara, Damasio, Tranel, & Anderson, 1998; Bechara, Tranel, & Damasio, 2000; Denburg, Tranel, & Bechara, 2005), with zero score considered as random behavior (Dalgleish *et al.*, 2004; Denburg *et al*, 2006) and values that do not deviate significantly were classified as borderline (Dalgleish *et al.*, 2004; Denburg *et al.*, 2006). In other works (Bechara *et al.*, 2002; Bechara & Damasio, 2002), the value 10 was adopted as cut-off point, since it was the maximum score achieved by patients with orbitofrontal lesions (Bechara *et al.*, 2001; Verdejo-García, Aguilar de Arcos, & Pérez-García 2004). Later it was defined as disadvantageous performance a score less than or equal to -18, borderline performance a score between -17 and 17, and advantageous performance a score greater or equal to 18 (Bakos, Denburg, Fonseca, & Parente, 2010).

As far we know, the only study on opioid-dependent individuals that presents percentages of deterioration assumes as disadvantageous performance the negative range and provides 40 % deterioration in methadone-maintained individuals group, 22 % buprenorphine-maintained individuals and 29% in the control group (Pirastu *et al.*, 2006).

Another aspect is the distinction between "advantageous" and "disadvantageous" decks on which the assessment of performance is based in most studies (Caroselli *et al.*, 2006). This could cause other differences between decks to be overlooked. For instance, besides differences in reward and punishment magnitudes, decks also differ in the frequency of punishments and rewards. Regarding punishment frequency, decks B ("disadvantageous") and D ("advantageous") have low punishment frequency (net gain in 90% of the trials), whereas A ("disadvantageous") and C ("advantageous") are high punishment frequency decks (net gain in 50 % of the trials).

Some subjects in control groups seem to value the frequency of positive results over the amount of money (gained or lost), so they prefer decks B and D (e.g., Caroselli *et al.*, 2006; Lin, Chiu, Lee, & Hsieh, 2007; Steingroever *et al.*, 2013; Upton, Kerestes, & Stout, 2012). Additionally, healthy and non-healthy subjects tend to have a specific preference for deck B, called the "prominent deck B" phenomenon (Lin *et al.*, 2007), as reported in several studies (Lin *et al.*, 2007; Steingroever *et al.*, 2013), including studies in opioid-dependent individuals (Upton *et al.*, 2012).

Thus, although some of the research conducted with IGT in opioid-dependent individuals has focused on abstinent individuals, results are still unclear and insufficient. Therefore, the main objective of this study is to compare the performance on IGT in opioid-dependent individuals with 5-9 days of abstinence with an equivalent control sample. Our hypothesis is that opioid-dependent individuals performed worse and have a higher percentage of deterioration in decision-making.

METHODS

Participants and procedures

The sample consisted of 64 opioid-dependent individuals who did not fulfill criteria for dependence or abuse of other substances according to the DSM-IV-TR (2000), admitted as inpatients for a closed-regimen detoxification program at the Coimbra Detoxification Unit of the Institute on Drugs and Drug Addiction. Exclusion criteria were: presence of cognitive impairment; diagnosis of other lifetime Axis I psychiatric disorders and Axis II personality disorders according to the DSM-IV-TR (2000); HIV/AIDS infection; primary or secondary neurological disease and intelligence estimate lower than 70 (DSM-IV-TR, 2000). The criteria were confirmed by laboratory findings, medical and psychological assessment, according to the European Monitoring Centre for Drugs and Drug Addiction protocol. The collected information was confirmed by clinical history as recorded in the Multidisciplinary Information System of the Institute on Drugs and Drug Addiction and by the information collected during interviews with the family and companions at the time of admission. The data on substance use and agonist treatment characteristics are summarized in Table 1.

After acute opioid withdrawal symptoms (Kleber, 2007), assessment was conducted between abstinence days 5 and 6 on heroin- and buprenorphine-dependent subjects, and between days 8 and 9 on methadone-dependent subjects. Opioid- dependent individuals were medicated according to the current therapeutic administration protocol in the institution (Table 1).

The control group (n = 48) was recruited by public notice and the same exclusion criteria were applied. In addition to these exclusion criteria, individuals who had used psychoactive substances were also excluded, except those who occasionally consume alcohol and/or tobacco. Both groups consisted of Caucasian subjects. There were no significant differences in age (minimum and maximum age of 18 and 47 years in dependent individuals, and 20 and 49 years in the control group), gender and education in the two groups (Table 2).

The study complied with the ethical guidelines for human experimentation stated in the Declaration of Helsinki, and was approved by the Clinical Board of the Institute on Drugs and Drug Addiction. Every subject signed an informed consent after the research objectives and participation conditions had been explained. No subject was rewarded for collaborating.

Table 1
Self-reported substance use history and medication

	Opioid-dependent group *(N = 64)*
	M (SD)
Age at onset of opioid use	19.31 (4.34)
Years of opioid use *	14.16 (6.67)
Medication † (dose range, mg/day)	
Clonidine	[0.45, 0.6]
Etilefrine	[5, 20]
Diazepam	[10, 40]
Mirtazapine‡ or	15
Trazodone ‡	150
Tramadol chlorhydrate and/or	[100, 400]
Butylscopolamine bromide	[10, 20]

Note: * Time elapsed since the first use of opioid; † Medication used within 24 hours before testing; ‡ Used as a hypnotic the night before testing.

Table 2
Demographics, cognitive functioning and intelligence

	Opioid-dependent group *(N = 64)*	Control group *(N = 48)*						
	M (SD)	*M (SD)*	$\chi^2(1)$	*t*(110)	*p*	95% CI	*Cohen`s d*	□
Age*	33.47 (6.48)	33.44 (8.08)		0.02	.982	[-2.70, 2.76]	<0.01	
Education*	9.73 (2.51)	10.52 (2.54)		1.64	.105	[-1.74, 0.17]	-0.31	
Gender (% male)	89.1%	77.1%	2.92		.088			0.16
MoCA score	26.31 (2.36)	26.75 (2.38)		-0.97	.336	[-1.34,0.46]	-0.19	
Vocabulary score WAIS III	11.80 (2.37)	11.15 (2.87)		1.31	.191		0.25	
Block Design score WAIS III	8.97 (2.18)	10.52 (2.71)		-3.36	< .001	[-2.47, -0.64]	-0.63	
Intelligence estimate	102.20 (10.49)	105.24 (13.76)		-1.33	.187	[-7.58, 1.50]	-0.25	

Note: CI = Confidence interval; * Years; Significance levels were set at p < .05, two-tailed.

Instruments

Cognitive function was assessed using the Portuguese version of the Montreal Cognitive Assessment (MoCA) (Freitas, Simões, Alves, & Santana, 2011). This included the assessment of executive functions, visuospatial abilities, short-term memory, language, attention, concentration, working memory and temporal and spatial orientation.

The Wechsler Adult intelligence Scale - Third Edition (WAIS-III), Vocabulary and Block Design subtests (Wechsler, 2008) were used to estimate intelligence, as calculated by the deviation quotient formula (Tellegen & Briggs, 1967).

Decision-making was assessed by means of an electronic version of the IGT adapted for the euro and the Portuguese language. This version is based on the IGT (Bechara *et al.*, 1994) in terms of schedules of reinforcement and does not change the quantitative value of the original version in dollars, since currency exchange differences are irrelevant. Detailed instructions were provided (Bechara, Damasio, Damasio, & Lee, 1999). The position of decks (A, B, C, D) on the screen is spatially random to prevent a location bias in deck selection; punishments are unpredictably distributed within 10-trial blocks. The subject may make up to 100 selections from the same deck. The application provides information on gains and losses, as well as a balance update after each move. Each card selection is followed by an emoticon: happy when winnings exceed losses and sad in the opposite situation.

All statistical analyses were performed using IBM SPSS Statistics 20. The Alpha level was set at $p < .05$ (two-tailed) for all analyses. In the repeated measures ANOVA, the Greenhouse-Geisser or the Huynh-Feldt correction was used when violation of the assumption of sphericity was noticed. Assumptions of linearity, multicollinearity and homoscedasticity of data were verified for simple linear regression analysis estimates. The effect size was assessed by Cohen`s d, phi(□) and partial eta-squared ($\eta\rho^2$).

RESULTS

The cognitive and intellectual function assessment is summarized in Table 2. There were no significant differences between the groups in the Vocabulary test, intelligence estimates, and MoCA scores. However, opioid-dependent individuals have significantly lower Cube test outcomes (Table 2).

The assessment of performance in the IGT followed the formula [(C + D) - (A + B)], which corresponds to the total sum of choices from the advantageous decks minus the total sum of choices from the disadvantageous decks (Bechara *et al.*, 1994), and shows no significant differences between groups (Table 3).

Performance was classified according to the criterion of Bakos *et al.* (2010), with scores of -18 or less regarded as disadvantageous, those ranging from -17 to 17 as borderline, and those of 18 or more as advantageous. In both groups, most subjects showed borderline performance, followed by disadvantageous performance and advantageous performance (Table 3). As recommended by Dunn *et al.* (2006), mean values obtained from the [(C + D) - (A + B)] formula were compared with a zero score, which is considered as random behavior (Denburg, Recknor, Bechara, &Tranel, 2006). The score in the opioid-dependent individuals, $t(63) = -3.23$, $p = .002$, 95% CI [-13.80, - 3.26], $d = -0.40$, was significantly lower than zero. On the contrary, in the control group scores did not differ significantly from zero, $t(47) = -1{,}67$, $p = .101$, 95% CI [-14.23, 1.31], $d = -0.24$.

Choices per deck were analyzed and a 2 (group) x 4 (deck) repeated measures ANOVA was performed. We noted no effect of the group x deck interaction, $F(2.74, 301.07) = 0.11$, $p = .941$, $\eta\rho^2 < 0.01$. However, there is a significant main effect of decks, $F(2.74, 301.07) = 46.17$, $p < .001$, $\eta\rho^2 = 0.30$, and a group effect, $F(1,110) = 4.19$, $p = .043$, $\eta\rho^2 = 0.04$. Mean pairwise comparisons using the Bonferroni adjustment showed significant differences among deck pairs, with B > C, B > D, B > A, D > C, and D > A ($p < .001$). No significant differences were noted between decks C and A ($p = 1.000$). Both groups showed a preference for low frequency punishment decks (B and D).

Subsequently, choices from the decks grouped by the low (B + D) and high (A + C) punishment frequency criterion (Table 3) were analyzed. The 2 (punishment frequency) x 2 (group) repeated measures ANOVA showed a significant main effect of punishment frequency, $F(1, 110) = 96.77$, $p < .001$, $\eta\rho^2 = 0.47$, and a group effect, $F(1,110) = 4.19$, $p = .043$, $\eta\rho^2 = 0.04$. Both groups preferred low punishment frequency decks (B and D), but opioid-dependent individuals choose such decks more often (Table 3). There was no significant effect of the "punishment frequency" x groups interaction, $F(1, 110) = 0.05$, $p = .827$, $\eta\rho^2 < 0.01$.

Comparing the performance using the formula [(B + D) - (A + C)] (which shows choice according to adoption of the low punishment frequen-

Table 3
IGT performance in opioid-dependent group and control group

	Opioid dependent group (N=64)	Control group (N=48)						
	M (SD)	M (SD)	χ2	t(110)	p	95% CI	Cohen`s d	□
Total score [(C+D) - (A+B)]	-8.53 (21.11)	-6.46 (26.76)		-0.46	.648	[-11.04, 6.89]	-0.09	
Classification of performance %			0.95		0.621			0.09
Disadvantageous ≤ -18	37.5%	31.3%						
Borderline [-17, 17]	53.1%	54.2%						
Advantageous ≥ 18	9.4%	14.6%						
Total sum [(B+D)	62.23 (12.28)	60.29 (19.30)						
Total sum (A+C)	37.77 (12.28)	34.71 (15.67)						
Total sum [(B+D) - (A+C)]	22.83 (23.69)	23.83 (27.68)		-0.21	.837	[-10.64, 8.63]	-0.04	

Note: CI = Confidence interval; Significance levels were set at p < .05, two-tailed.

cy criterion) did not demonstrate significant differences between the groups (Table 3).

Learning evolution was assessed by means of a block calculation (Bechara *et al.*, 1999), dividing performance into five blocks of 20 trials each, based on the formula [(C + D) - (A + B)]. In the repeated measures ANOVA, 5 (block) x 2 (group) did not show a significant main effect of blocks, $F(4, 440) = 1.31$, $p = .267$, $\eta\varrho^2 < 0.01$, of groups, $F(1,110) = 0.21$, $p = .648$, $\eta\varrho^2 < 0.01$, or of the block x group interaction, $F(4, 440) = 2.27$, $p = .061$, $\eta\varrho^2 = 0.02$.

Simple linear regression analyses were conducted to ascertain whether gender, education, MoCA and intelligence estimate could account for the IGT performance. This showed that gender and education are not predictors for scores in the IGT based on the formula [(C + D) - (A + B)]. For gender, in the opioid-dependent individuals, $\beta = -0.15$, $F(1,62) = 1.50$, $p = .225$, and in the control group, $\beta = 0.04$, $F(1,46) = 0.07$, $p = .791$. For education, in the opioid-dependent individuals, $\beta = 0.09$, $F(1, 62) = 0.54$, $p = .467$, and in the control group, $\beta = 0.14$, $F(1,46) = 0.92$, $p = .344$. In the opioid- dependent subjects, MoCA was demonstrated to be a performance predictor, $\beta = 0.29$, $F(1,62) = 5.63$, $p = .021$, R^2adj.= 0.07, but not in the control group, $\beta = -0.14$, $F(1,46) = 0.95$, $p = .336$. Intelligence estimates did not account for the total IGT performance in the opioid-dependent individuals, $\beta = 0.22$, $F(1,62) = 3.21$, $p = .078$, nor in the control group, $\beta = 0.21$, $F(1,46) = 2.04$, $p = .161$.

DISCUSSION

In the IGT performance calculated by the formula [(C + D) - (A + B)], we have noticed that both the opioid-dependent individuals and the control group mostly show borderline behavior, according to the Bakos *et al.* (2010) criterion, associated with a low rate of advantageous performance. This lack of difference between groups had already been noted in previous studies, namely in abstinent cocaine-dependents (Adinoff *et al.*, 2003), abstinent alcohol-dependents (Zorlu *et al.*, 2013) and in subjects undergoing a maintenance program with buprenorphine (Pirastu *et al.*, 2006). Adinoff *et al.* (2003) justified the lack of difference in the high performance variability within groups, which was also seen in our study. However, in opioid-dependent individuals such performance is not attributable to random behavior (Denburg *et al.*, 2006), because it is significantly lower than zero, meaning an effective risk choice preference.

Another hypothesis explaining the absence of differences is that the sample was limited to medically healthy, abstinent, dependent subjects with no other psychiatric disturbances (Adinoff *et al.*, 2003), the same exclusion criteria we applied in our study. In the study by Zorlu *et al.* (2013), too, the absence of differences in IGT performance between "pure" alcohol-dependent individuals and the control group was justified by the absence of psychiatric comorbidity, and it was considered that the earlier studies could have had limitations in controlling this variable.

Vassileva *et al.* (2007) noted that abstinent psychopathic heroin addicts made significantly more disadvantageous choices than non- psychopathic subjects. Moreover, some differences were noted in the evolution of IGT performance between subjects with substance use disorder without associated psychopathologies and subjects with substance use disorder associated with antisocial personality disorder (Mellentin *et al.*, 2013). Thus, while subjects with substance use disorder showed slow, but steady learning during the task, subjects with substance use disorder associated with antisocial personality disorder showed initial improvement, but their performance declined markedly in the last 40 trials (Mellentin *et al.*, 2013). As pointed by Ersche and Sahakian (2007, p. 325) "...accumulating evidence indicates that drug abuse per se not mediate decision-making on the IGT but it may act as a moderator, aggravating existing decision-making impairments". Our belief is that psychopathology and personality disorders may be more likely to account for differences between groups than substance dependence.

Another aspect that does not help to clarify differences between groups is the publications' bias found in a meta-analysis study on the neuropsychological consequences of opioids (Baldacchino, Balfour, Passetti, Humphris, & Matthews, 2012). This bias is expressed by a higher probability of research with statistically significant positive results being published (Baldacchino *et al.*, 2012).

The results in the control group are lower than expected, but in line with observations by other authors (Caroselli *et al.*, 2006; Steingroever *et al.*, 2013). In these studies, the general population showed no homogeneity in performance, with a high percentage of poor performance and low learning levels.

Another finding in our study is the preference of all subjects for low punishment frequency decks (B and D), which was previously reported in other studies (e.g., Caroselli *et al.*, 2006; Lin *et al.*, 2007; Steingroever et al., 2013; Upton *et al.*, 2012). However, opioid-dependent individuals choose such decks more often. This preference shows the importance of gain-loss frequency rather than long-term outcomes (Lin, Chiu, & Huang, 2009; Lin, Song, Lin, & Chiu, 2012). As Caroselli *et al.* (2006) have noted, the attractive power of a deck depends more on the previous reinforcement frequency than on the magnitude of reward.

In our study, the low rate of advantageous performance could be explained by the absence of payment, which was not considered for practical and ethical reasons regarding the dependent subjects, but it may have been something of a deterrent. However, despite some controversy as to the effect on performing the task using actual money, it has been found that using real reinforcement decreases result variability (Bowman & Turnbull, 2003) and leads to a lack of difference between the control group and cocaine abusers (Vadhan, Hart, Haney, van Gorp, & Foltin, 2009). Regarding payment, the optimal situation to assess the decision-making style would require individuals to invest their own money and really lose or win (Areias, Paixão, & Figueira, 2013). Thus, when participants are gambling, influenced by payment, they are always in the realm of winning because, no matter how much they lose, from an ethical point of view no experimental situation allows them to leave the situation losing money, i.e., the result will never be negative (Areias *et al.*, 2013). Therefore, it seems that conditions which apparently bring the IGT closer to a real-life situation, i.e., payment conditional on gambling results, seem to distort the nature of the situation somehow, because the subjects have the prospect of winning, but are never in a situation of a real loss (Areias *et al.*, 2013). Furthermore, according to the prospect theory (Kahneman & Tversky, 1979), when the reference point is defined such that the result is perceived as a potential gain, individuals tend to be risk averse. From this point of view, it would seem that making payment conditional on performance may induce an advantageous performance (Areias *et al*., 2013). This raises the issue of the IGT's status as a psychological assessment tool, because in the absence of actual payment subjects may see the task as a game in which they have nothing to win or lose and so have little inclination to follow the instructions and win as much money as possible. This hypothesis is consistent with our results, which suggest that performance in the control group is characterized by low investment in performing the task, which translates into slower learning than expected.

Another explanation for the performance we have observed are the transcultural differences in decision-making in the IGT (Bakos *et al*., 2010), reinforced by an occurrence of such differences in perception of and attitudes in the face of risk (Wang & Fischbeckb, 2008; Weber & Hsee, 1998).

In both groups, education does not account for IGT performance. Previous studies report conflicting results for this question. For instance, Evans, Kemish, and Turnbull (2004) have noted that subjects with more years of education showed a significantly lower performance in the last two blocks in a version of the IGT (Bechara *et al*., 1994) using real money. The authors explained these results based on an education effect which would discourage decision-making, supported by emotion-based mechanisms. Meanwhile, normative data obtained from a sample of 932 adults (although collected with a different IGT version) showed that educational level only contributed 3.6 % of variance in the IGT scores (Bechara, 2007).

Differences in the IGT could be in part attributable to cognitive functions as assessed by the MoCA, as the simple linear regression analyses suggest. The relation between the IGT performance and cognitive functions and intelligence is controversial; although some studies find that higher IQ scores predicted better IGT performance (Demaree, Burns, & Dedonno, 2010), most studies point to the independence of the results (cf. for review, Toplak, Sorge, Benoit, West, & Stanovich, 2010). However, comparison of the studies is not without problems, since various measures have been used.

Gender was not shown to be a predictive variable of the IGT score. A literature review on the influence of gender on the IGT yields conflicting results. Although most studies with young people and adults indicate that gender has no effect (Davis *et al*., 2008), including normative studies on the IGT (Bechara, 2007), other research has shown that men and women perform differently (Goudriaan, Grekin, & Sher, 2007).

In conclusion, there were no significant differences in choice patterns between opioid-dependent individuals and the control group. Both groups demonstrated a preference for low punishment frequency decks (B and D). In both groups, education does not account for IGT performance, and learning differences in the IGT could be in part attributable to cognitive functions as assessed by the MoCA. Finally, gender was not shown to be a predictive variable of the IGT score.

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