

## **DECISION-MAKING AND THE IOWA GAMBLING TASK: ECOLOGICAL VALIDITY IN INDIVIDUALS WITH SUBSTANCE DEPENDENCE**

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Substance Dependent Individuals (SDIs) usually show deficits in real-life decision-making, as illustrated by their persistence in drug use despite a rise in undesirable consequences. The Iowa Gambling Task (IGT) is an instrument that factors a number of aspects of real-life decision-making. Although most SDIs are impaired on the IGT, there is a subgroup of them who perform normally on this task. One possible explanation for this differential performance is that impairment in decision-making is largely detected on the IGT when the use of drugs escalates in the face of rising adverse consequences. The aim of this study is to test this hypothesis, by examining if several real-life indices associated with escalation of addiction severity (as measured by the Addiction Severity Index -ASI-) are predictive of risky decisions, as revealed by impaired performance on different versions of the IGT. We administered the ASI and different versions of the IGT (the main IGT version, a variant IGT version, and two parallel versions of each) to a large sample of SDI. We used regression models to examine the predictive effects of the seven real-life domains assessed by the ASI on decision-making performance as measured by the IGT. We included in regression models both ASI-derived objective and subjective measures of each problem domain. Results showed (i) that several aspects of real-life functioning associated with addiction severity were moderate predictors of IGT decision-making performance; (ii) that the combined assessment of decision-making using different versions of the IGT yielded better predictive measures than assessment using isolated versions of the IGT; and (iii) that objective measures of real-life functioning were better predictors of decision-making performance on the IGT than subjective measures based on SDI's insight about their problems. These results support the notion that decision-making deficits as measured by the IGT are associated with a rise in real-life adverse consequences of addiction.

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## Introduction

One of the most important aspects of drug addiction is the persistence of drug use, despite a rise in undesirable consequences, including severe medical (contracting HIV or hepatitis), psychiatric (developing mood or personality disorders), social (loss of reputation, job, home, and family), and legal problems (going to jail). This is quite similar to patients with orbitofrontal cortex lesions in that they both show signs of impairments in judgement and decision-making, characterised by a tendency to choose the immediate reward, at the expense of severe negative future consequences. Additionally, both patients with orbitofrontal lesions and substance dependent individuals (SDIs) often deny, or are not aware, that they have a problem. This lack of awareness can also be associated with a variety of ill-considered choices and risky behaviours in real-life. Since frontostriatal systems are critically involved in executive functions, emotional regulation, and self-awareness (Stuss & Alexander, 2000), it is possible that alterations in these systems could play a role in both the decision-making deficits, and in the impaired awareness of SDIs. Therefore, it has been proposed that a decision-making impairment linked to frontostriatal dysfunction, with particular emphasis on the involvement of a dysfunctional ventromedial/ orbitofrontal cortex, may be at the core of the problem of substance addiction (Bechara et al., 2001).

Bechara and his colleagues introduced the Iowa Gambling Task (IGT) to assess decision-making in an ecologically valid fashion. A number of studies have shown that the IGT is a multidetermined task requiring a variety of cognitive and emotional functions, including affective processing of ongoing somatic feedback (Bechara & Damasio, 2002; Crone et al., 2004), working memory, response inhibition, planning, and rule detection (Bechara & Martin, 2004; Maia & McLelland, 2004; Martin et al., 2004). Therefore, decision-making as measured by the IGT involves multiple candidate mechanisms in which SDIs are frequently impaired. Furthermore, this task factors a number of aspects involved in complex real-life decisions: immediate rewards and delayed punishments, risk, and uncertainty of outcomes. Using the IGT, studies have shown that SDIs perform this task more poorly, as a group, than a matched non-drug using control group (see Bechara, 2003 for a review). Although most SDIs are impaired on the IGT, there is a subgroup of them who perform normally on this task (Bechara et al., 2001; Bechara & Damasio, 2002; Bechara & Martin, 2004). Thus the question: are there real-life factors associated with drug addiction that are predictive of risky decisions, as revealed by impaired IGT performance?

Bechara et al. (2001) argued that the impairment in decision-making is detected largely when the use of substances escalates in the face of rising adverse consequences, such as loss of job, destruction of family life and loss

of friends. In support of this notion, they demonstrated that performance on the IGT was significantly correlated with the ability of SDIs to maintain gainful employment, despite a drug or alcohol habit (Bechara et al., 2001). In this sense, a number of real-life variables other than employment, including medical, psychiatric, social and legal factors can be associated with the severity of addiction in real-life, and with poorer performance on the IGT. The relevance of chronic medical conditions for decision-making deficits was revealed in a recent study that showed that HIV+ SDIs performed significantly more poorly than HIV- on the IGT, possibly as a consequence of HIV induced frontostriatal deterioration (Martin et al., 2004). Poorer performance on the IGT has been as well associated with a number of psychiatric conditions related to addiction, including mood disorders (Clark et al., 2001), conduct/antisocial disorder (Ernst et al., 2003; Fein et al., 2004), and psychopathy (Mitchell et al., 2002; van Honk et al., 2002). Abnormal decision-making as measured by the IGT has been as well linked to aberrant behavioural patterns, including impulsive aggression (Best et al., 2002), and suicide attempts (Jollant et al., 2005). The relationship between IGT performance and severity of alcohol and drug abuse is more controversial, since some studies have shown significant correlations between dose-related measures of drug use and IGT scores (Fein et al., 2004; Rotheram-Fuller et al., 2004), while others have failed to detect this relationship (Verdejo-García et al., 2004). In contrast, the relationship between IGT performance and other real-life aspects such as family, social, and legal problems has never been explored, despite the fact that family life destruction, loss of social status and legal problems are frequently observed in SDIs.

The wide range of real-life problems associated with addiction has been traditionally assessed using the Addiction Severity Index (ASI) (McLellan et al., 1992). The ASI is a well-validated instrument that assesses seven domains in which SDIs typically have problems: medical, employment, alcohol, drug, family-social, legal, and psychiatric. Additionally, the ASI provides two different sets of valid scores that take into account (i) the individual's subjective ratings regarding the severity of his/her problem, and (ii) the interviewer ratings regarding the necessity of treatment/assistance for each domain (Alterman et al., 2001).

The aim of this study is to examine if several real-life domains associated with escalation or severity of addiction can be good predictors of decision-making. We specifically investigated the status of decision-making defined as "the ability to select the most advantageous response from an array of possible behavioural choices" (Bechara, Damasio, & Damasio, 2000). For the assessment of decision-making we used different versions of the IGT: the original version of the IGT and a variant version, where the contingencies were reversed. For each version, we have used two parallel versions,

designed to allow for repeat testing of the IGT, thus enhancing the reliability of the test measures. The aim of including multiple versions of the IGT was to achieve a broader, more reliable, and more clinically meaningful evaluation of decision-making processes. Furthermore, the use of variant versions of the IGT has provided, in the past, a way for parcelling out different processes involved in complex decision-making. More specifically, the variant version of the IGT was designed to distinguish the effects of high sensitivity to reward versus insensitivity to future consequences (both reward and punishment) on decision-making (Bechara, Tranel, & Damasio, 2000). Moreover, parallel versions of the original and variant versions of the IGT may provide a better understanding of decision-making processes across different situations, types of reinforcement, and reinforcing schedules. For the comprehensive assessment of real-life problems associated with addiction we used the ASI.

Additionally, since SDIs, as well as patients with orbitofrontal lesions, have shown signs of poor awareness of their deficits, a related aim of this study was to examine whether ASI subjective ratings, or the ASI interviewer ratings, better predicted performance on the different versions of the IGT.

We hypothesised that (i) the indices of real-life functioning associated with escalation in addiction severity will significantly predict decision-making performance as measured by the IGT; (ii) indices of real-life functioning will have a stronger predictive power when including multiple measures from the parallel versions of the decision-making tasks as opposed to using one test measure; and (iii) the interviewer ratings regarding SDIs functioning will be better predictors of decision-making performance than the subjective ratings of SDIs.

## Methods

### *Participants*

The participants for this study were 122 SDIs (64 males). Substance dependence and/or abuse were determined by a clinical interview (SCID), which uses DSM-IV criteria to diagnose Axis I disorders. Mean age for the sample was 34.2 +/- 8.8 years and mean education was 12.4 +/- 2.4 years. Participants were North Americans. The "drug of choice" for these participants included alcohol, methamphetamine, and cocaine. The number of abusers for each drug of choice is presented in Table 1. SDIs were recruited from the Mid-Eastern Center for Chemical Abuse (MECCA), a local detoxification and treatment center, and they were paid for their participation in the study in gift certificates of an hourly rate identical to that earned by healthy

comparison participants. Each SDI was tested at the end-stage of their treatment shortly before their discharge. The duration of abstinence from substance use was known in these participants based on their length of stay at MECCA. The time varied among individuals, but the minimum period of abstinence from any substance use was 15 days. Thus at the time of their testing, the SDIs were no longer in acute withdrawal or taking any medications to control withdrawal (e.g., benzodiazepines). Urine toxicology screening for opiates, stimulants, marijuana, and breathalyzers tests were conducted on these SDIs routinely, so that not only recent substance use can be ruled out, but also it is reasonable to rule out the use of substances during the entire period of abstinence. All participants provided informed consent that was approved by the appropriate human subject committees at the University of Iowa.

*Table 1.*  
Descriptive Demographics of Study Participants.

	N	Gender (M/F)	Age (years)	Education (years)	Drug of choice (numbers)			
					Alcohol	Metham- phetamine	Cocaine	Polysub- stance
Completed ABCD IGT	12	64M/ 58F	34.2 ± 8.8	12.4 ± 2.4	40	38	27	17
Completed ABCD and EFGH IGT	92	43M/ 49F	33.8 ± 8.5	12.3 ± 2.3	27	30	21	14
Completed all versions of IGT	72	33M/ 39F	33.0 ± 7.8	12.5 ± 2.4	21	25	15	11

### *Instruments*

#### Addiction Severity Index

The Addiction Severity Index (ASI) was administered to SDIs by a trained interviewer. The ASI is a semi-structured interview that assesses several different domains: medical, employment, alcohol and drug use, legal, family/social, and psychiatric (McLellan, et al, 1992). The first section of the ASI, the medical section, asks questions regarding how many times the participants has been hospitalised, and whether they have any major or chronic medical conditions. The next section, employment, asks about current work status, years of education, number of dependents, and whether the participants are currently receiving unemployment compensation or other financial

public assistance. The alcohol and drug sections of the ASI assess the severity of substance use with questions regarding the number of times using in the past 30 days, the total number of years using substances, the number of times treated for abuse, and presence of withdrawal symptoms. The legal section determines how many times the participants have been arrested and/or charged with a number of different crimes, amount of time spent incarcerated, and whether they are currently on probation or parole. The next section assesses both family and social relationships, specifically the participants' current living arrangements, marital situation, and social network. The family/social section also addresses difficulty getting along with others in social relationships (past and present) and whether the participants are currently or have ever been the victim of abuse. Finally, the psychiatric section assesses whether the participants have had any significant periods of depression, anxiety, or violent behaviour at the current time or in the past. This section also asks about past or present suicidal thoughts/actions, as well as whether participants are currently taking or have ever taken psychiatric medication for emotional or psychological problems.

The ASI generates two sets of scores for each individual. The first are the Composite Scores (CSs), which range from 0 to 1, and take into account both the subjective ratings of the participant, as well as the number of responses to objective questions asked in each section. The second set of scores is the Interviewer's Ratings (IRs), ranging from 1-9, which reflect how severe the interviewer considers the problem to be, and how necessary the treatment is for this individual, in each particular area. The CSs reflect the participant's assessment of their problems over the last 30 days, while the IRs rate the severity of both past and present problems.

### *Iowa Gambling Tasks*

#### Original version of the IGT (ABCD)

The Iowa Gambling Task (IGT) is a computerised task that is used to assess decision-making (Bechara et al., 1994; Bechara, Tranel, & Damasio, 2000). The original version of the IGT involves four decks of cards, decks A', B', C' and D'. Each time a participant selects a card, a specified amount of play money is awarded. However, interspersed amongst these rewards are probabilistic punishments (monetary losses with different amounts). Two of the decks of cards, decks A' and B', produce high immediate gains, however, in the long run, these two decks will take more money than they give, and are therefore considered to be the disadvantageous decks. The other two decks, decks C' and D', are considered advantageous, as they result in small, immediate gains, but will yield more money than they take in the long run.

When administering the IGT, participants are told that the goal of the

game is to make as much money as possible and to avoid losing as much money as possible. They are instructed that they may choose cards from any deck, and that they may switch decks at any time. Participants are also informed that some of the decks are better than others, and to win, one must avoid the worse decks and stick to the good decks.

Each game consists of 100 card choices. Net scores for the gambling task are calculated by subtracting the number of disadvantageous choices (decks A' and B') from the number of advantageous choices (decks C' and D'). Higher net scores therefore signify better performance on the task. Optimal performance on the IGT requires that participants begin to learn the contingencies in each deck as the task progresses, and to shift their strategy accordingly (choosing from advantageous decks mostly).

#### Iowa Gambling Task - variant version (EFGH)

The variant version of the IGT was also used for this study. This task involves decks E', F', G', and H'. Again, there are two advantageous decks (E' and G') and two disadvantageous decks (F' and H'). In this version of the task, each card choice results in an immediate punishment (loss of money), with delayed reward. Instructions for the participants are similar to the instructions for task ABCD, however, this time they are told that they will lose money every time they pick a card and win money once in a while.

#### Iowa Gambling Task - parallel versions

In addition to the two main versions of the IGT (original-ABCD and variant-EFGH), we also implemented four parallel versions. Tasks KLMN and QRST are parallel versions of ABCD, with immediate monetary reward and delayed punishment. We will refer to them as parallel version one of the original task-KLMN, and parallel version two of the original task-QRST. Tasks IJOP and UVWX, on the other hand, are parallel versions of EFGH, with immediate punishment and delayed reward. We will refer to them as parallel version one of the variant task-IJOP, and parallel version two of the variant task-UVWX. These tasks were designed to be slightly more difficult for the participant, in order to compensate for already having played the task previously (original version-ABCD or variant version-EFGH).

#### *Procedure*

The testing for this study took place in the Department of Neurology at the University of Iowa Hospitals and Clinics.

Each testing session lasted three to four hours, with breaks given when needed. SDIs were also invited to return to the Department of Neurology for additional sessions until testing was completed. Sessions consisted of a bat-

tery of tasks, including diagnostic measures, basic neuropsychological measures, test of executive functions, and tests of decision-making. From the overall testing battery, the target measures for the current study were the six different versions of IGT and the ASI.

During the first day of testing, SDIs were given the ASI, as well as the original version of the IGT, game ABCD. The majority of SDIs ( $n=92$ ) were also given the variant version of the IGT, game EFGH, during the first session. During the second day of testing, which generally occurred within one to four days of the first session, the four additional parallel versions of the gambling task (parallel versions one and two of the original task, KLMN and QRST, and parallel versions one and two of the variant task, IJOP and UVWX) were administered. A subset of participants ( $n=72$ ) completed these additional versions.

The demographics for the participants who played each set of gambling tasks are presented in Table 1. One-way ANOVAs showed that there were no significant differences in age and education between those SDIs that played the original version-ABCD alone and those that went on to play additional gambling tasks.

### *Variables and statistical analyses*

The aim of this study was to examine the predictive value of several measures related to real-life functioning, as assessed by the ASI, on performance in different decision-making tasks. As possible predictive variables we looked at: (a) demographic characteristics (age and education); (b) the two output measures of the ASI: the CSs for medical, employment, alcohol, drug, legal, family/social and psychiatric problems during the last 30 days (ranging 0 to 1), and the IRs for medical, employment, alcohol, drug, legal, family/social, and psychiatric problems during lifetime (ranging 0 to 9).

As dependent variables, we used the net scores of the different IGT versions. For all SDIs, we looked at performance on the individual tasks alone (original version-ABCD and variant version-EFGH). For those SDIs who had played all versions of the IGT, we also used an average of each individual's scores on all three standard IGTs (original version-ABCD, and parallel versions one and two of the original task, KLMN and QRST) as well as the three variant IGTs (variant version-EFGH, and parallel versions one and two of the variant task, IJOP and UVWX).

Since IGT performance is based on the emotional learning of an advantageous decision-making strategy, some studies have proposed that it is more reliable to examine performance during the last blocks of the task, once the participants have developed a certain strategy (Monterosso et al., 2001). Thus, we also included in our analyses a comparison that involved the net



scores from only the last 40 card picks of the IGTs.

Therefore, our dependent variables were the following: (a) the net score of all 100 picks, or the net score of the last 40 picks of the original version-ABCD; b) the net score of all 100 picks, or the net score of the last 40 picks of the variant version-EFGH; c) the sum of the net scores for ABCD & EFGH, or the sum of the net scores for the last 40 picks of these two tasks; d) the average net score of the original version-ABCD, and parallel versions one-KLMN and two-QRST of the original task, or the average net score of the last 40 picks of these three tasks; e) the average net score of the variant version-EFGH and parallel versions one-IJOP and two-UVWX of the variant task, or the average net score of the last 40 picks of these three tasks, and; f) the sum of the net scores for the original version-ABCD, parallel version one of the original task-KLMN, parallel version two of the original task-QRST, variant version-EFGH, parallel version one of the variant task-IJOP, and parallel version two of the variant task-UVWX, or the sum of the net scores of the last 40 picks of all six tasks.

To examine the influence of the predictor variables on the different dependent variables, we first carried out a stepwise regression analyses. These exploratory analyses were aimed at determining which subsets of ASI scores best explained the SDI's IGT performance. The output of the stepwise regressions provided the adjusted  $R^2$  values ( $R^2$  adj.) for each model. For each dependent variable we selected the model with highest  $R^2$  adj. value and lesser number of predictors.

In a second step, we introduced this subset of variables in a series of hierarchical multiple regression analyses in order to determine the predictive efficacy of the selected variables. The variables were introduced in consecutive sets according to the following pre-established order: (1) selected demographics, (2) selected CSs for last 30 days, and (3) selected IRs for lifetime problems. This procedure allowed us to examine the isolated contribution of each set of predictors on the dependent variables, and to examine whether the inclusion of a new set of predictors significantly improved the predictive power of the previous sets.

## Results

### *Addiction Severity Index scores for SDI*

Table 2 shows descriptive data for the ASI scores in this sample. "Alcohol" and "Drug" were the most problematic areas according to the IRs, while "Employment" and "Psychiatric" problems were the more problematic areas according to the CSs.

Table 2.  
Mean ASI CSs and IRs for sample participants.

ASI scores: Averages (Standard Deviations)														
All participants	Medical		Employment		Alcohol <sup>a</sup>		Drug <sup>a</sup>		Legal		Family-Social		Psychiatric <sup>b</sup>	
	CS	IR	CS	IR	CS	IR	CS	IR	CS	IR	CS	IR	CS	IR
ABCD (122 s.)	.25 (.31)	3.52 (2.06)	.79 (.25)	5.61 (2.11)	.18 (.21)	5.98 (2.62)	.11 (.09)	6.87 (2.19)	.19 (.21)	4.83 (1.91)	.26 (.27)	5.40 (2.15)	.38 (.23)	5.60 (2.37)
Subsample														
All versions (72 s.)	.23 (.27)	3.40 (1.78)	.80 (.26)	5.44 (2.28)	.19 (.21)	6.14 (2.53)	.11 (.09)	7.08 (2.05)	.21 (.21)	4.99 (1.74)	.25 (.25)	5.53 (2.16)	.38 (.22)	5.63 (2.27)

CS=Composite Scores (ranging 0 to 1); IR=Interviewer's ratings (ranging 0 to 9).

<sup>a</sup> CS and IR scores for Alcohol and Drug Severity include measures of frequency and duration of alcohol/drug use.

<sup>b</sup> CS and IR scores for Psychiatric problems include the evaluation of depression and anxiety.

### *Behavioural Results of Gambling Task*

Fig. 1 displays the total number of cards selected from the advantageous minus the disadvantageous decks across five blocks of 20 cards for the participants in the different versions of the IGT. As shown in Fig. 1, the SDIs began to select more cards from the disadvantageous decks across the first two blocks of the original version of the IGT (ABCD), and failed to develop an advantageous strategy across the following three blocks in which they selected approximately the same number of cards from advantageous and disadvantageous decks. SDIs performed slightly better in the variant version of the IGT (EFGH), selecting more cards from the advantageous decks from block 2 on. Nonetheless, their performance was still below the cut-off net score of 10, which characterised normal performance in previous studies.

Fig. 2 shows block-by-block average performance of SDIs in the original version-ABCD and parallel versions one-KLMN and two-QRST of the original task; in the variant version-EFGH and parallel versions one-IJOP and two-UVWX of the variant task; and in a composite score obtained from all the IGTs scores. SDIs failed to develop an advantageous strategy in the original version-ABCD and parallel versions one and two of the original task (KLMN and QRST), selecting more cards from the disadvantageous decks in blocks 1 and 5, and approximately the same number of cards from the advantageous and disadvantageous decks across blocks 2 to 4. SDIs performed slightly better in the variant version-EFGH and parallel versions one and two of the variant task (IJOP and UVWX), though they still scored below the cut-off of 10, and failed to learn an appropriate strategy, as shown by the decreased performance in blocks 4 and 5.

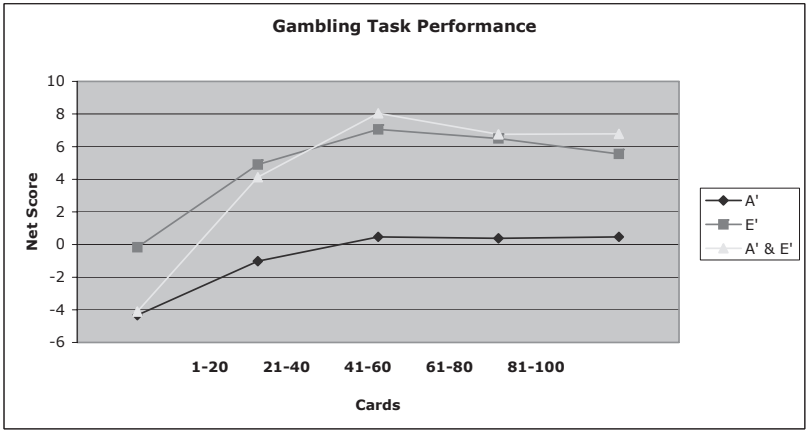


Figure 1. Mean net scores of performance on the IGT versions ABCD (A'), EFGH (E') and ABCD & EFGH (A' & E') of SDIs.

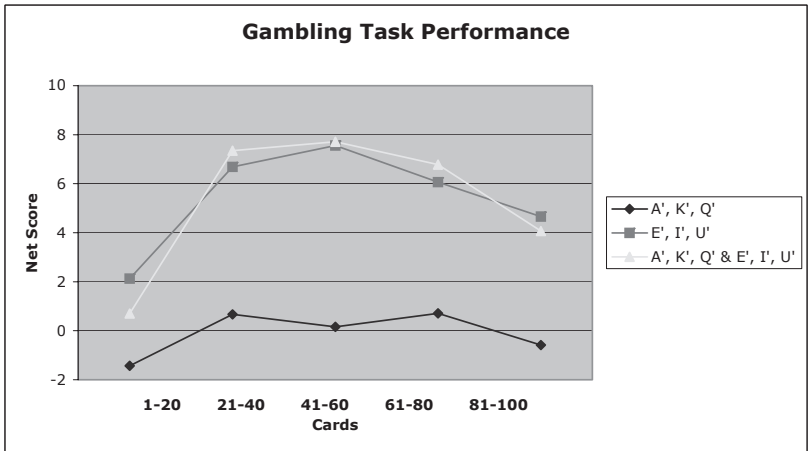


Figure 2. Mean net scores of performance on the IGT composite variables ABCD-parallel 1 and 2 (A', K', Q'); EFGH-parallel 1 and 2 (E', I', U'); and ABCD-parallel 1 and 2 & EFGH-parallel 1 and 2 (A', K', Q' & E', I', U') of SDIs.

*Exploratory stepwise regression analyses including demographics, CSs and IRs scores*

The exploratory stepwise regression analyses selected which variables (demographics, CSs, or IRs) predicted best each dependent variable (net scores from the 100 picks and the last 40 picks for each IGT or set of IGTs).

Results from the gambling task ABCD (original version) showed that age, education, and IRs for medical, alcohol, drug and legal problems were the best predictors for ABCD 100 picks (Table 3, model 1.1), explaining an 11% of the variance; while education, and IRs for medical, alcohol and legal problems were the best predictors for ABCD last 40 picks (Table 3, model 1.2), explaining 9.3% of the variance.

For gambling task EFGH (variant version), results showed that education, CSs for psychiatric problems, and IRs for employment, alcohol, and legal problems were the best predictors for EFGH 100 picks (Table 3, model 2.1), explaining a 13.1% of the variance; while education and IRs for legal and psychiatric problems were the best predictors for EFGH last 40 picks (Table 3, model 2.2), explaining a 7.5% of the variance.

With regard to the sum scores of the original version-ABCD and the variant version-EFGH (ABCD & EFGH), results showed that age, education, and IRs for drug and legal problems were the best predictors for ABCD & EFGH 100 picks (Table 3, model 3.1), explaining a 10.5% of the variance; while demographics, and IRs for medical, alcohol and legal problems were the best predictors for ABCD & EFGH last 40 picks (Table 3, model 3.2), explaining a 7.6% of the variance.

Results for the average of scores on the original version-ABCD, and parallel versions one (KLMN) and two (QRST) of the original task (ABCD-parallel 1 and 2), showed that demographics, CSs for medical problems, and IRs for alcohol and legal problems were the best predictors of "ABCD-parallel 1 and 2" 100 picks (Table 3, model 4.1), explaining a 17.3% of the variance; while education, CSs for medical and alcohol problems, and IRs for medical, alcohol, drug and legal problems were the best predictors for "ABCD-parallel 1 and 2" last 40 picks (Table 3, model 4.2), explaining a 15.2% of the variance.

For the average scores of the variant version-EFGH, and parallel versions one (IJOP) and two (UVWX) of the variant task (EFGH-parallel 1 and 2), results showed that education, CSs for medical, alcohol, legal and psychiatric problems, and IRs scores for medical, employment, legal, and family/social problems were the best predictors for "EFGH-parallel 1 and 2" 100 picks (Table 3, model 5.1), explaining 27.4% of the variance; while education, CSs for employment, alcohol, drug, legal, and family/social problems, and IRs for medical, drug, social and psychiatric problems were the best predictors for "EFGH-parallel 1 and 2" last 40 picks (Table 3, model 5.2), explaining

24.2% of the variance.

With regard to the sum scores of the original version-ABCD, parallel versions one (KLMN) and two (QRST) of the original task, variant version-EFGH, and parallel versions one (IJOP) and two (UVWX) of the variant task (ABCD-parallel 1 and 2 & EFGH-parallel 1 and 2), results showed that education, CSs for medical and legal problems, and IRs for medical, employment, alcohol and legal problems were the best predictors for “ABCD-parallel 1 and 2 & EFGH-parallel 1 and 2” 100 picks (Table 3, model 6.1), explaining a 26% of the variance; while demographics, CSs for medical and legal problems, and IRs for medical, alcohol and legal problems were the best predictors for “ABCD-parallel 1 and 2 & EFGH-parallel 1 and 2” last 40 picks (Table 3, model 6.2), explaining a 32.1% of the variance.

### *Hierarchical regression analyses including the best models of predictor variables*

Next we carried out hierarchical regression analyses to test the predictive efficacy of the different models obtained in the stepwise regressions for each dependent variable (models 1.1 to 6.2). We examined  $F$  and  $p$  values for the models (after adjusting alpha levels with the Bonferroni correction for multiple comparisons). We introduced the predictors into the regression function in the following order: (1) selected demographics; (2) selected CSs for problem areas during last 30 days; and (3) selected IRs for problem areas during lifetime. In this way we were able to examine whether the selected CSs related to problems during the last 30 days significantly improved the predictive efficacy of the demographics alone; and if the selected IRs related to lifetime problems significantly improved the efficacy of the demographics plus the CSs. Thus the critical statistics in these analyses were the improvement of  $R^2$  adj. and the change in  $F$  value after the inclusion of a new set of predictors. In order to examine possible co-linearity effects, FIV and Tolerance diagnoses were also carried out. Results are shown in Table 3.

Results for IGT ABCD (original version) showed that demographics and IRs for medical, alcohol, drug and legal problems significantly predicted ABCD 100 picks (Table 3, model 1.1), while demographics and IRs for medical, alcohol and legal problems marginally predicted ABCD last 40 picks (Table 3, model 1.2).

For IGT EFGH (variant version), results showed that education, CSs for psychiatric problems, and IRs for medical, alcohol and legal problems significantly predicted EFGH 100 picks (Table 3, model 2.1), while the model 2.2 failed to show any significant predictor for EFGH last 40 picks. Education was the most significant predictor for both EFGH 100 picks and EFGH last 40 picks, as shown by the non-significant changes in  $F$  value after

Table 3.  
 ASI (CSs and IRs) predictors of GT performance - Best predictors, % of explained variance, and p values.

Dependent Variables	Model	Demographics		Predictors		IRs (lifetime problems)		R <sup>2</sup> Adjusted	F for model	P for model
		Best Predictors	Change in F	Best Predictors	Change in F	Best Predictors	Change in F			
ABCD 100	1.1	Age, Ed	.011			Med, Alc, Dr, Leg	.035	11.0%	3.44	.004*
ABCD last 40	1.2	Age, Ed	.016			Med, Alc, Leg	.037	9.5%	3.55	.005*
EFGH 100	2.1	Ed	.004		Psych	Alc, Emp Leg	.070	13.1%	3.81	.004*
EFGH last 40	2.2	Ed	.033			Leg, Psych	.159	5.2%	2.83	.042
ABCD & EFGH 100	3.1	Age, Ed	.010			Dr, Leg	.101	10.5%	3.30	.014
ABCD & EFGH last 40	3.2	Age, Ed	.024			Med, Alc, Leg	.211	7.6%	2.50	.037
"ABCD-parallel 1 and 2" 100	4.1	Ed	.096		Med, Alc	Med, Alc, Dr, Leg	.733	15.2%	2.54	.023
"ABCD-parallel 1 and 2" last 40	4.2	Ed	.098		Med	Med, Alc, Leg	.645	17.3%	3.89	.004*
"EFGH-parallel 1 and 2" 100	5.1	Ed	.012		Med, Alc, Leg, Psych	Med, Emp, Leg, Fam/Soc	.084	27.4%	3.85	.001*
"EFGH-parallel 1 and 2" last 40	5.2	Ed	.004		Emp, Alc, Dr, Leg, Fam/Soc	Med, Dr, Fam/Soc, Psych	.037	24.2%	3.17	.003*
"ABCD-parallel 1 and 2 & EFGH-parallel 1 and 2" 100	6.1	Ed	.011		Med, Leg	Med, Emp, Alc, Leg	.548	26.0%	4.42	.001*
"ABCD-parallel 1 and 2 & EFGH-parallel 1 and 2" last 40	6.2	Age, Ed	.009		Med, Leg	Med, Alc, Leg	.234	32.1%	5.59	.000*

Note 1: CSs=Composite Scores; IRs=Interviewer's ratings; Ed=Education; Med=Medical; Emp=Employment; Alc=Alcohol; Dr=Drug; Leg=Legal; Fam/Soc=Family/Social; Psych=Psychiatric.

Note 2: \*p level<.0045

the inclusion of CSs and IRs scores.

With regard to the sum of IGTs original version-ABCD and variant version-EFGH (ABCD & EFGH), models 3.1 and 3.2 failed to significantly predict either ABCD & EFGH 100 picks or ABCD & EFGH last 40 picks. Age and education, however, were the most important predictors in both cases.

Co-linearity diagnoses showed all the predictor variables included in these analyses for ABCD, EFGH, and ABCD & EFGH were not significantly correlated, and may therefore be considered independent predictors.

Results for the average of scores on primary version-ABCD, and parallel versions one-KLMN and two-QRST of the original task (ABCD-parallel 1 and 2) showed that model 4.1 failed to significantly predict "ABCD-parallel 1 and 2" 100 picks; however, education, CSs for medical problems, and IRs for medical, alcohol and legal problems (Table 3, model 4.2) significantly predicted "ABCD-parallel 1 and 2" last 40 picks. The IRs for medical, alcohol and legal problems were the best predictors in both cases.

For the average of scores of variant version-EFGH, and parallel versions one-IJOP and two-UVWX of the variant task (EFGH-parallel 1 and 2), results showed that education, CSs for medical, alcohol, legal and psychiatric problems, and IRs for medical, employment, legal and social problems (Table 3, model 5.1) significantly predicted "EFGH-parallel 1 and 2" 100 picks; while education, CSs for employment, alcohol, drug, legal and social problems, and IRs for medical, drug, social and psychiatric problems (Table 3, model 5.2) significantly predicted "EFGH-parallel 1 and 2" last 40 picks.

For the sum net scores of the original version-ABCD, parallel versions one-KLMN and two-QRST of the original task, variant version-EFGH, and parallel versions one-IJOP and two-UVWX of the variant task (ABCD-parallel 1 and 2 & EFGH-parallel 1 and 2), results showed that education, CSs for medical and legal problems, and IRs for medical, employment, alcohol and legal problems (Table 3, model 6.1) significantly predicted performance in "ABCD-parallel 1 and 2 & EFGH-parallel 1 and 2" 100 picks; while demographics, CSs for medical and legal problems, and IRs for medical, alcohol and legal problems (Table 3, model 6.2) significantly predicted performance in "ABCD-parallel 1 and 2 & EFGH-parallel 1 and 2" last 40 picks. IRs were the best predictors in both models.

Co-linearity diagnoses detected a moderate correlation between the IRs and CSs medical predictors in all the models tested for "ABCD-parallel 1 and 2 & EFGH-parallel 1 and 2". The remaining predictors were found to be independent.

*Regression analyses including demographics, ASI item “number of days with problems” and IRs*

As shown by previous analyses (Table 3), in most of the models tested, the CSs did not show significant prediction of the dependent measures. We hypothesised that the lack of predictive power may be due to the fact that these CSs rely on the participant’s subjective report and their insight about the problems they have in each area.

We therefore carried out a new series of stepwise regression analyses, this time including, as possible predictor variables, the number of days in which the participants had experienced problems during the last 30 days in each area, instead of the CSs. This “number of days” measure is an item that is asked in each section of the ASI. The thought was that this objective measure may capture information related to problems during last 30 days (in a similar way to the CSs), better than the subjective scales, which require the subject to have an insight and awareness of the magnitude of their problems. Individual items from the ASI have been previously used for such research purposes in the literature (Makela, 2004). Thus, in this new analysis, we included as predictor variables: (a) basic demographics (age and education); (b) the number of days that the participants had experienced problems during last 30 days in each problem areas: medical, employment, alcohol, drug, legal, family/social and psychiatric; and (c) the IRs for each of areas. As dependent variables, we included the same tasks’ scores we had examined in previous analyses. After determining the best subsets of predictors for each dependent variable (models 1.1 to 6.2), we introduced these subsets in a series of hierarchical multiple regression analyses in the following order: (1) selected demographics, (2) selected number of days with problems during last 30 days; (3) selected IRs.

Table 4 shows the best subsets of predictors for each dependent variable, the single contribution of each set of new predictors included (change in  $F$ ), and the predictive efficacy ( $R^2$  adj.,  $F$  and  $p$  values) of the twelve models examined (Table 4, models 1.1 to 6.2). As hypothesised, “number of days” variables significantly improved the overall predictive efficacy of all models. All models tested, excluding model 2.2, significantly predicted performance on the different IGT versions. The proportion of variance explained by these models ranged from 16 to 36%.

## Discussion

The results of this study support the main hypothesis that decision-making, as measured by the gambling task paradigm, is associated with perfor-



Table 4. ASI (# of days and IRs) predictors of GT performance - Best predictors, % of explained variance, and p values.

Dependent Variables	Model	Demographics		Predictors		IRs lifetime problems		R <sup>2</sup> Adjusted	Statistics	
		Best predictors	Change in F	Best predictors	Change in F	Best predictors	Change in F		F for model	P for model
ABCD 100	1.1	Ed	.005	Dr, Leg	.006	Med, Alc, Leg	.031	18.4%	5.47	.000*
ABCD last 40	1.2	Ed	.004	Dr, Leg	.004	Med, Leg	.023	19.7%	5.91	.000*
EFGH 100	2.1	Age, Ed	.013	Med, Leg, Psych	.152	Med, Leg	.006	16.8%	3.83	.001*
EFGH last 40	2.2	Ed	.033	Dr	.654	Leg, Fam/Soc, Psych	.182	7.5%	1.98	.089
ABCD & EFGH 100	3.1	Age, Ed	.010	Med, Dr, Leg	.131	Leg	.024	17.2%	3.67	.003*
ABCD & EFGH last 40	3.2	Ed	.006	Med, Emp, Dr, Leg	.147	Med, Leg	.031	15.8%	3.36	.003*
"ABCD-parallel 1 and 2" 100	4.1	Age, Ed	.086	Med, Emp, Dr, Leg, Fam/Soc	.125	Med, Alc, Leg	.007	20.9%	3.05	.004*
"ABCD-parallel 1 and 2" last 40	4.2	Ed	.091	Med, Emp, Dr, Leg	.023	Med, Leg	.000	30.8%	5.43	.000*
"EFGH-parallel 1 and 2" 100	5.1	Ed	.012	Med, Emp, Alc, Dr, Leg, Fam/Soc, Psych	.390	Med, Emp, Leg, Fam/Soc	.001	29.6%	3.65	.001*
"EFGH-parallel 1 and 2" last 40	5.2	Ed	.004	Alc, Leg, Fam/Soc	.122	Med, Fam/Soc	.008	25.3%	4.79	.001*
"ABCD-parallel 1 and 2 & EFGH-parallel 1 and 2" 100	6.1	Ed	.010	Med, Emp, Alc, Dr, Leg, Fam/Soc	.073	Med, Leg, Fam/Soc, Psych	.001	32.5%	4.06	.000*
"ABCD-parallel 1 and 2 & EFGH-parallel 1 and 2" last 40	6.2	Ed	.002	Med, Emp, Alc, Dr, Leg, Fam/Soc, Psych	.251	Med, Leg, Fam/Soc	.000	36.0%	4.60	.000*

Note 1: CSs=Composite Scores; IRs=Interviewer's ratings; Ed=Education; Med=Medical; Emp=Employment; Alc=Alcohol; Dr=Drug; Leg=Legal; Fam/Soc=Family/Social; Psych=Psychiatric.  
 Note 2: \*p level<.0045

mance in a number of real-life domains in which SDIs typically have problems. These results also support the notion that decision-making deficits are detected largely by the gambling task, when the addiction is associated with a rise in adverse consequences in real-life, including severe medical, employment, family, social, and legal problems.

In a large sample of SDIs, several aspects of real-life functioning typically associated with addiction severity showed to be moderate predictors of performance on the different versions of the IGT. Interestingly, the magnitude of this prediction was modulated by two factors. On the one hand, the combined assessment of decision-making using different versions of the IGT yielded better prediction indices than assessment using isolated versions of the IGT. In this sense, the predictive effects of real-life indices improved significantly when we used a combined measure of performance on the original version-ABCD, and parallel versions one-KLMN and two-QRST of the original task as dependent variables, as opposed to the use of the original IGT score alone (from 11% to 17%). Similarly, the predictive level of real-life indices improved significantly when we used a combined measure of performance on the variant version-EFGH, and parallel versions one-IJOP and two-UVWX of the variant task as dependent variables, as opposed to using the IGT variant version-EFGH alone (from 13% to 27%). Moreover, the predictive power of real-life indices improved significantly when we used a composite score obtained from all the gambling task scores, as opposed to using the original version-ABCD and variant version-EFGH alone (from 10.5% to 32.1%). Overall, these results indicate that the combined use of different versions of the gambling task can be a good index of several aspects of real-life decision-making. The combined assessment of performance on the different versions of the IGT can be therefore regarded as an ecologically valid instrument for measuring decision-making.

On the other hand, objective measures of real-life functioning were better predictors of decision-making performance than subjective measures. This finding is supported by the fact that the ASI interviewers' ratings were better predictors of decision-making performance than the ASI composite scores, which rely largely on the individual's subjective perception concerning how bothered s/he is about problems in each domain. This may be due to the fact that individuals with substance use disorders, like patients with orbitofrontal/ventromedial lesions, frequently show poor awareness of their own deficits (Bechara et al., 2001; Dackis & O'Brien, 2002). This lack of awareness has previously been associated with poorer neuropsychological functioning, poorer achievement of addiction treatment related goals, and clinical measures of addiction denial in SDIs (Rinn et al., 2002). Furthermore, both lack of self-awareness and decision-making deficits have been associated with frontostriatal systems functioning (Stuss & Alexander,

2000). The discrepancy between the interviewers and composite scores may alternatively be due to the fact that the interviewer ratings assessed lifetime problems across ASI domains, while composite scores evaluated problems only during last 30 days. Nonetheless, this latter possibility is not consistent with the fact that inclusion of a more objective index of problems during the last 30 days (number of problem days), as opposed to the more subjective composite scores, significantly increased the prediction of the different decision-making measures. For example, the number of problem days improved the prediction of composite scores from 11% to 19% in the original version-ABCD, and from 17% to 31% in the combined score of the original version and parallel versions one and two of the original task. Therefore, it is more plausible to suggest that SDIs in this sample may be underreporting their concerns about problems associated with addiction due to poor awareness of these deficits, thus biasing the composite scores. These findings also support the validity of ASI interviewers' scores, especially in the case of trained interviewers (Alterman et al., 2001).

An important aspect of this study was to analyse which real-life indices related to addiction were specifically associated with decision-making performance as measured by different versions of the IGT. We found that medical, alcohol, drug, and legal problems were specifically and strongly associated with performance on the original version of the IGT, and its parallel versions. Thus, medical, legal and substance related problems are especially associated with decision-making performance in uncertain situations, in which an immediate reward can be followed by a delayed, more severe, penalty. This is the case of several real-life situations associated with addictive processes (Petry et al., 1998). For example, sharing drugs in a social group can be a pleasurable experience for a drug addict, and the positive reinforcing effects of this experience occur within minutes, or even seconds after drug intake. However, sharing drugs can lead to severe medical consequences in the long term, such as contracting HIV or hepatitis. In a similar fashion, robbing a bank can be a rapid and easy way of getting money to buy drugs. However, it will surely provoke important legal problems in the future. In addition to medical, substance and legal problems, employment and family/social problems were strongly associated with performance on the variant version of the IGT and its parallel versions. That is, employment and family/social problems contribute uniquely to performance on decision-making in uncertain situations in which an immediate punishment can be followed by a delayed higher reward. This is similar to several real-life employment, family, and social situations. For example, seeking employment is usually associated with aversive selection processes, interviews and frequent rejections. However, going through this process, or persistence in seeking different options, can result in the attainment of a good position in the future.

Similarly, family and social relationships are often coupled with several problems, i.e., helping friends in need, or raising children, are complicated issues involving adverse events, but they provide important support for well-being, and are extremely rewarding in the long-term.

Previous studies using the IGT showed that although SDIs, as a group, are impaired on the IGT, only a subgroup of individuals perform the task abnormally (Bechara et al., 2001; Bechara & Damasio, 2002; Bechara & Martin, 2004). The results of this study support the notion that decision-making deficits in SDIs are largely detected in the face of rising adverse consequences, such as medical, employment, familiar, social and legal problems. These results are consistent with previous findings showing that gambling task performance is associated with real-life indices, such as employment problems (Bechara et al., 2001), and severity of substance abuse (Bolla et al., 2005; Fein et al., 2004; Rotheram-Fuller et al., 2004).

Previous studies have as well shown that certain medical conditions associated with substance abuse, such as HIV, are associated with poorer decision-making performance on the IGT, possibly due to selective deterioration of the frontostriatal systems. However, the strong predictive effect of the ASI medical domain on decision-making suggests that investigations related to the severity of the medical problems associated with addiction, and the poor decision-making revealed in SDI, may go beyond chronic medical conditions to analyse those SDIs who have suffered multiple hospitalisations as a consequence of drug use. Furthermore, the moderate relationship between ASI alcohol/drug measures and decision-making performance suggests that a more comprehensive assessment of drug use patterns, including measures of peak use, abstinence duration, withdrawal symptoms, number of times in treatment, and assessment of polysubstance abuse can be better predictors of IGT performance, than standard dose-related, and duration measures (see the prediction index in Bechara et al., 2001). Furthermore, the results indicate that real-life functioning in other relevant aspects, including legal, familiar and social problems, are significantly associated with decision-making performance in the gambling task. This is consistent with previous studies showing a relationship between antisocial behaviour and ill-considered choices and risky decisions (Ladd & Petry, 2003). Moreover, the relationships revealed between family, social, or legal aspects of real-life functioning and decision-making are consistent with the essential role of orbitofrontal cortex in social cognition and behaviour (Bechara, 2002; Rolls, 2004).

It is also important to consider the possibility that the observed relationships could be accounted for by other factors. For example, increased levels of depression and anxiety are very frequent among SDIs, and these variables may modulate the relationship between real-life functioning and decision-making. Although both depression and anxiety were included in the psychi-

atric index of the ASI, and therefore we controlled for these variables in the regression models, further research using specific measures for these and other co-morbid conditions will be required to fully determine their role and influence. Furthermore, decision-making as measured by the IGT requires multiple cognitive and emotional mechanisms brought together (Bechara & Martin, 2004; Crone et al., 2004; Maia & McLelland, 2004; Martin et al., 2004). Thus, impairments of SDIs in working memory, response inhibition, or rule detection may equally play an influential role in modulating the relationships between a number of real-life aspects associated with severity of addiction.

These results, as well, raise important hypotheses for future research, involving investigations of decision-making performance in SDIs who also present with severe legal (e.g., incarceration), family-social (divorce, loss of friends), employment (repeated loss of job), and gambling problems (using the new ASI gambling subscale) (Petry, 2003). Further studies may as well explore the role of social, legal and psychiatric functioning on IGT performance in samples including SDIs with dual pathology. Alternatively, it may be equally interesting to analyse to which extent different neuropsychological indices, including decision-making measures like the ones we used, as well as working memory, impulse control, planning or rule detection measures, can predict real-life functioning in SDIs. This latter approach could have important implications for prevention and rehabilitation strategies of drug abuse.

Overall, the results of this study support the notion that several real-life domains, in which SDIs typically have problems, are associated with increased risk of impaired IGT performance among this group. Medical, alcohol, drug and legal problems are strongly associated with performance on the original paradigm of the gambling task and its parallel versions (ABCD, KLMN, and QRST), while employment and family/social problems are specifically associated with the variant paradigm and its parallel versions (EFGH, IJOP, and UVWX). This is consistent with the real-life decision situations assessed by the different tasks. These findings demonstrate that the gambling task correctly grasps important aspects of real-life functioning in SDIs, and therefore it can be considered an ecologically valid measure of decision-making in this population. An additional finding of this study was that objective measures of real-life functioning (ASI interviewers ratings and number of problem days) were better predictors of decision-making than partially subjective measures (composite scores). This finding may be associated with SDIs poorer awareness about their deficits. Finally, this study raises a number of possibilities for future research. Most previous research using the gambling task has focused on determining which specific cognitive and emotional processes are involved in performance on this task (Monterosso et al., 2001;

Bechara & Damasio, 2002; Bechara, Dolan, & Hines, 2002; Busemeyer & Stout, 2002). However, it may be equally interesting to examine which real-life problem domains are associated with performance in this task. Although not the aim of this study, it is important to mention that education showed an important predictive role on the different decision-making measures. Nonetheless, we showed that severity of ASI domains predicted decision-making performance beyond the contribution of demographic variables.

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