Individual differences in the response to forgone payoffs: An examination of high functioning drug abusers

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Abstract:

This study evaluates the effect of forgone payoffs in decision-making tasks used for studying individual differences. We investigate whether the disclosure of forgone payoffs (defined as payoffs associated with un-chosen alternatives) has selective effects for drug abusers. Evidence suggests that drug abusers are hypersensitive to signals of positive reward. Accordingly, because the forgone payoffs of risky high-variability options include rewarding outcomes, this may create a distraction and lead drug abusers to make more risky choices. In a controlled experiment, we examined the behavior of high-functioning drug abusers and healthy controls using the Iowa gambling task. The results showed that in a forgone payoff condition, drug abusers made more risky choices. The results demonstrate that adding information about forgone payoffs can be useful for studying individual differences, and that studying individual differences can be valuable in evaluating the effects of forgone payoffs.

Keywords: drug abuse, decision making, adaptive behavior, memory

An experimental method that has recently been used to examine decision processes in drug abusers is the Iowa gambling task (Bechara, Damasio, Damasio, & Anderson, 1994). In this task players make a series of choices from four decks of cards (See Table 1; and see Figure 1). These choices lead to monetary gains and losses. Each choice leads to a gain, and sometimes these gains are coupled with simultaneous losses. The player's goal is to accumulate payoffs across trials. Two of the decks are disadvantageous in this respect, having higher positive payoffs (of $1) but also higher risks, leading to a net loss. Good performance is achieved by avoiding these decks, and instead choosing the two alternative decks. These alternative decks lead to a net win using lower positive gains ($0.5) with smaller magnitude losses.

The Iowa task was originally used to characterize behavioral changes in patients with lesions in the ventromedial (VM) area of the frontal lobe. VM-lesioned patients are unable to learn to avoid making disadvantageous choices, and consequently perform poorly in the task (see Bechara et al., 1994; Bechara & Damasio, 2002; Bechara, Dolan, & Denburg et al., 2001). Studies examining chronic users of strongly or moderately addictive substances have indicated similar differences between substance abusers and non-abusers in gambling task behavior. Chronic users of addictive substances, such as cocaine and heroine, fail to learn to avoid disadvantageous decks, and their behavior is similar to VM patients (Bartzokis et al., 2000; Bechara et al., 2001; Grant, Contoreggi, & London, 2000; Petry, Bickel, & Arnett, 1998). For example, Bechara and his colleagues (2002) examined substance dependent individuals who were undergoing treatment for either alcohol or stimulant (metamphetamine or cocaine) abuse. The results showed that a significantly higher proportion of substance abusers (61% vs. only 32.5% of normal controls) performed within the range of the VM patients, whereas the rest performed within the range of normal controls.

Examinations of the behavior of relatively high functioning drug abusers in the gambling task have produced equivocal results. High functioning drug abusers are defined as individuals with high substance use levels and/or substance use problems identified by self-report on substance use questionnaires, but who have not received a formal substance abuse diagnosis, have not been treated, and who remain either employed or in school. In Petry's (2001) study, substance abusers (mostly alcohol abusers) performed as well as non-abusers (see also Mazas, Finn, & Steinmetz (2000) unless they were also diagnosed as pathological gamblers. A study by Stout, Rock, Campbell, Busemeyer, & Finn (2004) found that male college students who abused (various) drugs and/or alcohol, but were relatively high functioning, performed worse than the non-drug abusing male controls. Yet in this study, female college students, who had similar drug abuse patterns to men, actually performed better than their comparison group. Finally, Lejuez et al. (2003) reported no difference between student drug abusers and non-abusers in the gambling task performance.

The mixed pattern of the results suggests two likely explanations. First, the gambling task may be ineffective for detecting effects associated with relatively mild substance abuse (Lejuez et al., 2003; see also Hinson, Jameson, & Whitney, 2002). A second possibility is that in the gambling task, the outcomes from the disadvantageous high-risk decks are not salient enough to attract high-functioning drug abusers. This implies that the gambling task could be improved so that it would better capture specific behavioral tendencies of relatively milder or higher functioning substance abusers.

For the current study, we modified the gambling task to increase the salience of positive payoffs from the disadvantageous decks by using forgone payoffs. Decision-making tasks used for studying individual differences typically include choice-contingent feedback, i.e., players are only shown the outcomes of their selections. For example, in the Iowa gambling task (Bechara et al., 1994), selection of a card from a given deck reveals the payoff only for that card, whereas the payoffs from non-selected decks remain hidden. An alternative condition, called forgone payoffs, is a type of feedback that is not choice-contingent, but instead shows payoffs from both the chosen and unchosen alternatives. In other words, players see what they could have gotten had they made other choices. This type of payoff has not been typically used in investigations of individual differences. However, studies of choice behavior and experimental economics have extensively studied forgone payoffs, which have been shown to have clear effects on learning processes (see e.g., Camerer & Ho, 1999; Capra, Goeree, Gomez, & Holt, 2002; Cheung & Friedman, 1997; Mookherjee & Sopher, 1994; Nyarko & Schotter, 2002; Stahl & Wilson, 1994). The goal of the present paper is to examine whether forgone payoffs have differential outcomes for specific clinical populations, and in particular, for high-functioning drug abusers. We predicted that forgone payoffs would lead to more risky choices on the part of drug abusers.

Forgone payoffs can increase the choice of risky alternatives (Grosskopf, Erev, & Yechiam, 2003; Haruvy & Erev, 2001)[1]. Drug abusers are known to make riskier choices in real-life circumstances, an effect which has been revealed in laboratory choice behavior studies (described above). Therefore, forgone payoffs may be one of the environmental characteristics that lead to risk taking behavior in drug abusers.

As a demonstration of the effect of forgone payoffs on risk taking behavior, consider a Decision Maker (DM) who is asked to choose repeatedly from the four decks of the Iowa task without prior knowledge of the payoffs associated with the options. One disadvantageous deck leads to relatively high losses in 50% of the cards, with no losses in the remaining 50% of the cards (this deck is labeled Disadv50). In the second disadvantageous deck 10% of the cards contain a very high loss, and 90% have no loss (this deck is labeled Disadv10). These two decks lead to an equal net loss (of 25 cents per trial on average). Good performance is achieved by avoiding these decks, and instead choosing the two alternative decks (labeled Adv50 and Adv10). These alternative decks lead to a net win (of 25 cents) using lower positive gains with smaller magnitude losses. Let us assume that the DM starts by exploring each option, choosing it a couple of times, and this results in a loss in decks Disadv50 and Disadv10. The DM therefore decides to choose Adv10. If no forgone payoffs are available, then the most salient positive outcome from repeated choices will be the gain of 50 cents from option Adv10. However, if

[1] This effect is predicted under a general family of learning models called belief-based learning models (see e.g., Mookherjee & Sopher, 1994). These models incorporate foregone payoffs into the information updating procedure. It is also predicted under a reinforcement learning model that assumes a diminishing exploration period of forgone options (see Grosskopf et al., 2003).

forgone payoffs are available, then in each trial it is likely (p=.95) that either option Disadv50 or Disadv10 will yield a gain of $1 without any losses. This can tempt the DM to revert back to Disadv50 or Disadv10. The effect of forgone payoff in this situation has been termed the "big eyes effect" since the relatively high yield in unchosen options leads the player to imagine that these options might be more rewarding (Haruvy & Erev, 2001). When choices from the more risky options (high gain with rare large loss) are made repeatedly, the big eyes effect has been found to diminish, as if the DM comes to understand that although tempting, these options are risky (Grosskopf et al., 2003).

Theories of the behavior of high-functioning drug abusers in choice tasks (e.g., Brown. 1998; Finn, 2002; Gorenstein & Newman, 1980; Vogel-Sprott et al., 2001) suggest that drug abusers may be hypersensitive to signals of reward. In drug abusers, signals of reward may carry larger weight over signals of potential risk due to stronger appetitive processes and weaker disinhibitory mechanisms. According to some accounts (see review in Finn, 2002), the response to such signals is moderated by memory processes, including the capacity to resist distraction and maintain the activation of items in working memory.

In tasks with choice-contingent feedback regarding payoffs, it may be relatively easy to resist distraction from risky options (such as option A in the example above), because the positive reward signals of risky options can be avoided simply by not selecting these options. Accordingly, moderate drug abusers may display behavior that is similar to that of healthy controls. However, in tasks with forgone payoffs, the higher positive outcomes of risky options are constantly salient. As a result, the motivational processes that make risky alternatives attractive may be relatively hard to resist. Thus, this is a case where forgone payoffs may selectively affect the responses of drug abusers, and in particular, amplify their choice of risky alternatives. In the present study, we examined this effect in the Iowa gambling task.

The present paper follows with a controlled experiment to examine our prediction that foregone payoffs would be associated with relatively more risky choices in drug abusers. The discussion section examines the implications of the findings for the use of cognitive tasks in the study of individual differences.

Experiment

We examined the effect of forgone payoffs by creating an alternate version of the gambling task, and then compare the altered version to the standard version using a between subject design. The primary manipulated variable was the disclosure of forgone payoffs. In the standard condition (partial disclosure), we used the typical gambling task in which choices lead to payoff information only for the deck selected. We compared this to a forgone payoff condition (full disclosure), in which choices were followed by payoff information for all of the possible choices. Also unlike the original version, neither condition placed constraints on the order of the payoffs (see Clark & Robbins, 2002). The negative payoffs were randomly calculated for each choice from a deck independently. Accordingly, the risk level was equal in each choice from a particular deck.

Our hypotheses focused on the effects of forgone payoffs on decks Disadv10 and Disadv50 choices, because these reflect the magnitude of risk seeking behavior. These disadvantageous decks offer immediate positive outcomes that, if presented in a salient way (foregone payoffs), may be more tempting for high functioning drug abusers. We predicted that the effect of foregone payoffs in drug abusers would be strongest in Disadv10 because in this deck, nine out of ten cases lead to high and positive payoffs. In contrast, in Disadv50, only 50% of the cases have high positive payoffs, whereas the other 50% are also coupled with a loss. In line with the diminishing big eyes effect, the effect of full disclosure was expected be strongest at the beginning of the task.

The study also used a secondary manipulation which magnified the size of the payoffs of the disadvantageous decks. In the baseline payoff condition (low payoff), the disadvantageous decks (Disadv50 and Disadv10) had the exact wins/losses as the original version run by Bechara et al. (1994), divided by 100 (see Table 2). In the high payoff condition, the payoffs (wins and losses) were also divided by 100 from the original task, but were multiplied by a constant factor of 1.5 to increase the magnitude of payoffs in comparison to the baseline payoff condition within this study. We expected that the higher positive payoffs would be more salient and therefore lead to increased choices of risky decks in drug abusers.

Method

Participants

One hundred and sixty-two men and women between the ages of 18 and 35 were recruited through flyers posted around the Indiana University - Bloomington campus and in local bars. This resulted in a sample of 82 drug abusers and 80 control participants. Using a scripted telephone screening interview, we excluded volunteers who admitted: a) recent head injury; b) current use of prescribed psychotropic medication; c) psychosis; d) non-native English speakers; or, e) prior participants in our decision studies. Classification of participants into the drug abuse group (DRUG) was made on the basis of a score of 5 or more in the Michigan Alcohol Screening Test (MAST; Selzer, 1971), or a score of 4 ore more in the Drug Abuse Screening Test (DAST; Skinner, 1982; see also Justus, Finn, & Steinmetz, 2001), or exceedingly high rates of alcohol or drug use (above the 90th percentile in our sample). Of the 82 participants classified as drug abusers, 42 were classified in the DRUG group on the basis of both tests, 19 were classified based on the MAST, and only 14 were categorized based on the DAST. Seven of the participants were classified on the basis of high alcohol use only (more than 17.5 alcoholic drinks per week), and four only on the basis of high rates of drug use (used drugs 4 days a week or more). The remaining 80 participants were classified as controls (CTRL). We requested that participants refrain from drinking alcohol or ingesting drugs for 12 or more hours prior to testing, and all participants demonstrated 0% breath alcohol levels using a breathalyzer (Alcosensor III, Intoximeters, Inc., St. Louis, MO) at the initiation of testing. All participants gave written informed consent.

Participant Demographics (see Table 3). The participants' average age was 22 years. About 85% of the participants were students in the Bloomington campus, with the DRUG group (13.59 ± 1.75) being slightly less educated than the CTRL group (14.36 ±

1.73; t(160) = 2.84, $p < .01$). The proportion of males to females was slightly higher in the DRUG condition: 43% males in the CTRL condition, and 56% males in the DRUG condition (χ^2 (1)= 2.99, $p<.1$). The estimated IQs were not significantly different between the groups (Shipley Institute of Living Scale, 1939; t(160) = 1.84, NS).

Substance Use Assessment (see Table 3). For the DRUG group, both men and women reported higher alcohol intake per week (t(81.56) = 3.86, $p < .01$) and a higher frequency of drug use (t(80.4) = 10.52, $p < .01$), as well as more severe problems with substance use (MAST: t(86.91) = -7.75, $p < .01$; DAST: *t*(81.95) = 8.53, $p < .01$) than the CTRL group. Men in the DRUG group reported more problems with alcohol use than female drug abusers (t(80) = 2.68, $p < .01$), and on average, had a larger amount consumed in one occasion (t(48.9) = 2.59, $p < .05$). However, men and women did not differ in their frequency of alcohol or drug usage, or DAST scores.

Personality Assessment (see Table 3). We administered several psychodiagnostic assessments that have been shown to have relevance to substance abuse. To assess social deviance, we used the Psychopathic Deviate subscale of the Minnesota Multiphasic Personality Inventory 2-antisocial section (MMPI-2; Hathaway, 1989) and a checklist of symptoms taken directly from the antisocial personality section of the Diagnostic Interview Schedule, Version IIIA (DIS; Robins et al., 1985). Additionally, we assessed impulsivity using the impulsivity subscale of the Eysenck impulsivity/venturesomeness scale (Eysenck et al., 1985) and the Multidimensional Personality Questionnaire (MPQ; Tellegen & Waller, 2000) subscales for self control and harm avoidance. Participants in the DRUG group were found to have significantly different scores in all of the measures, as detailed in Table 3. Note, however, that the average level of the DRUG group in the Eysenck impulsivity scale and MPQ subscales was below the level of chronic drug abusers, as studied, for example, in Finn et al., (2002).

Measures and Apparatus

Simulated Gambling Task. We used a computerized version of the Iowa gambling task developed by Bechara et al. (1994). Images of four card decks, labeled A, B, C, and D (corresponding to Disadv50, Disadv10, Adv50, and Adv10) were displayed horizontally and ‘face down’ on a monitor controlled by a desktop computer running Windows 98, 2nd edition (Microsoft, Seattle, WA). Participants were instructed to make a series of selections from the decks using the mouse, and to try to win as much money as possible. They received a $20.00 credit at the start of the task and were informed that their winnings would be paid at the end of the session so long as they continued until the game was completed (150 trials). Gains and losses were shown on two tally bars at the top of the display, the top one revealing the cumulative net win/loss, and a second bar below indicating the win/loss for the most recent selection (See Figure 1).

Design

Using a 2 × 2 × 2 between subjects design, we examined how disclosure and payoff magnitude conditions affected the number of choices from decks Disadv10 and Disadv50 in the two studied populations. It was predicted that the effect of forgone payoffs would be stronger (a) for drug abusers; (b) in the high payoff version; and (c) in the beginning of the task (per Grosskopf et al., 2003). Note that because we compared the first and second half of the task (both including 75 observations) the sampling distribution of the choice proportion is approximately normal. To further normalize the proportions we conducted the statistical analysis using logit transformations ($\text{Logit}(p) = \ln [p/(1-p)]$).

For the disclosure manipulation, one condition (Partial Disclosure) was consistent with the original Iowa task. When a card was selected, only the payoff for the card selected was shown. In contrast, to examine the effects of forgone payoffs, in the Full Disclosure condition, when a card was selected, the payoffs were shown for all four cards. Thus, in the Full Disclosure condition, the actual win/loss was shown for the card selected, as well as showing all wins/losses that could have occurred with unselected decks (forgone payoffs).

For the payoff magnitude manipulation, we used typical payoff magnitudes applied in the Iowa task. That is, for the Lower Payoff condition, each card was associated with a win of either $1.00 (decks Disadv50 and Disadv10) or $0.50 (decks Adv50 and Adv10). In addition, some cards were also associated with losses. Table 2 describes the revised wins and losses in the two decks. The actual losses in Disadv50 had a small error factor (2 (p=.2), 2.5 (p=.3), 3 (p=.2), and 3.5 (p=.3), averaging in 2.5). The losses in Adv50 also likewise had a small error factor (0.25 (p=.5), 0.5 (p=.25), 0.75 (p=.25), averaging in 0.5). The average payoff was a net loss of $2.50 across ten selections for the disadvantageous decks, and a net gain of $2.50 across ten selections for the advantageous decks. For the High Payoff condition, the wins and losses associated with the advantageous decks were one and a half times higher (see Table 2). Accordingly, the average payoff was a net loss of $3.75 across ten selections for the disadvantageous decks.

Procedure

Participants were studied in the laboratory individually for approximately two hours, completing the questionnaire based assessments of drug and alcohol use and personality, and then a single run of the simulated gambling task. Following study completion, participants were paid in cash $7.00 per hour and whatever monetary bonuses they had earned in association with their performance.

Results

Figure 2 shows the effect of the disclosure of forgone payoff on proportion of selections from the two disadvantageous decks in drug abusers and controls. Note that because the payoff size manipulation did not lead to any significant results, we pooled the two payoff size conditions in all subsequent analyses.

As indicated in Figure 2, on average, more selections were made from disadvantageous Deck Disadv10 than from Deck Disadv50 ($t(161) = 12.41$, $p < .001$, Cohen's $d = 1.42$) and more selections were made from advantageous Deck Adv10 compared to Deck Adv50 ($t(161) = 5.04$, $p < .001$, Cohen's $d = 0.59$). This is consistent with previous studies showing that decision makers tend to underweight negative rare payoffs in repeated small choices (Barron & Erev, 2003). In the present task, this leads to more selections from decks Dis10 and Adv10, where the probability of a negative payoff is .1

Although there may be some dependence between the choices from the two decks Disadv50 and Disadv10, we focused on the choice of these two decks separately because of the assumption that rare and very high negative outcomes (in Disadv10) would be associated with a stronger effect of forgone payoffs. To examine the strength of the actual dependence, we examined the correlation between the choices of the different decks. The correlation matrix (see Table 4) indicates that the association between these two decks was medium ($r = 0.45$, $p<.01$). Accordingly, we also examined the mutual effect of forgone payoffs on both disadvantageous decks. Note that the correlation between the low frequency disadvantageous deck (Disadv10) and the low frequency advantageous deck (Adv10) was negative ($r=-0.21$, $p<.01$), thus, the correlation matrix supports the usage of specific decks rather than examining the high frequency (Disadv50, Adv50) versus low frequency (Disadv10, Adv10) decks.

Effect of disclosure

The Disadv10 deck (disadvantageous, losses incurred in 10% of the selections). We initially focused on the effect of the manipulation on Disadv10 selections, which is presented on the right hand side of the figure. It was predicted that the difference between the DRUG and CTRL group in the Full Disclosure condition would be largest for this deck. Unexpectedly, *without* forgone payoffs, participants in the DRUG group showed substantial learning (not to choose from Disadv10). That is, they chose Disadv10 37% of the time in the first block of 25 trials and 23% in the last block (a decrease from 9.3 to 5.8 choices on average). In contrast, in the Full Disclosure condition, the difference in Disadv10 choices between the first and last blocks of trials was much smaller (a mere 2% difference). The controls were less affected by forgone payoffs, and in the Full disclosure condition they started with 41% selections of Disadv10 in the first block and ended with 33% in the last block (a decrease from 10.3 to 8.3 choices on average). Thus, in the final block of trials the drug abusers chose more frequently from Disadv10 only in the Full Disclosure condition (38%, higher than the CTRL group average of 33%). The interaction of time by drug use by disclosure was significant ($F(1,158) = 5.95$, $p < .05$; Cohen's $F = 0.18$, a medium effect size).

Therefore, the DRUG group was affected more by the forgone payoffs, leading to more selections from the disadvantageous deck. However, whereas we did find an adverse effect of forgone payoff in the DRUG group, we did not find the expected diminishing big eyes effect. Rather, the effect of forgone payoffs in the DRUG group appeared to be initially small and to strengthen over time.

The Disadv50 deck (disadvantageous, losses incurred with 50% of the selections). In a secondary set of analyses, we examined selections from Disadv50, for which we had predicted that the DRUG group would show an initial positive effect of forgone payoffs. In line with this prediction, in the Full Disclosure condition participants in the DRUG group chose Disadv50 22% of time in the first block of 25 trials compared to 16% in controls, whereas in the Partial Disclosure condition the initial choice proportions were similar (18% for both groups). Therefore, the proportion of Disadv50 choices in the Full Disclosure condition was 26% *higher* than in the Partial Disclosure condition in the DRUG group, whereas in the CTRL group it was 11% *lower*.

The predicted interaction of time by drug use and disclosure was significant ($F(1,158) = 2.75$, $p < .05$, one sided; Cohen's $F = 0.12$). Thus, in this group forgone payoffs led to an initial big eyes effect that was apparent in the DRUG group but not in the CTRL group.

Aggregating decks. Note that the most common approach in analyzing the Iowa is aggregating the two disadvantageous decks. If we examine the aggregated measure in the present framework (group × disclosure × time) the interaction is marginally significant ($F(1,158) = 3.13$, $p < .1$; Cohen's $F = 0.13$) [2]. Yet examining this aggregated measure may mask group effects because of the markedly different dynamics that occur with different loss frequencies in the deck pairs. Specifically, as indicated above, the effect of forgone payoffs develop differently in the two decks. When the losses were more frequent (Disadv50), the big eyes effect diminished with experience. In contrast, when losses were infrequent (Disadv10), the big eyes effect was enhanced with experience. Furthermore, this enhancement of the big eyes effect occurred partially because under the Partial Disclosure condition, drug abusers learned better *not* to choose from Disadv10.

[2] It is interesting to note that participants in the DRUG group under the Full Disclosure condition had the lowest monetary outcome for the experiment ($29.6); lower than the average payoff of this group in the Partial Disclosure condition ($32.2). The outcomes for participants in the CTRL group were higher ($31.5 in the Full Disclosure condition and $33.3 in the Partial Disclosure condition).

Effect of gender

An examination of gender differences in the choice of the two disadvantageous decks reveals no significant differences in Disadv50 choices. Women had more Disadv10 selections in the second half of the task than men did ($t(145) = 2.00$, $p < .05$; Cohen's $d = 0.17$) but the differences were small, with the men selecting this deck 31.2% of the time compared to 37.6% of the time in women. As indicated above, there was a small difference in the gender distributions of the two conditions. Given the gender effect observed here, we included gender as a covariant in the ANOVA analyses described in the previous section. The results replicate the effects described above (for conciseness, these results are not detailed).

Relationship to personality tests

In addition to comparing the two conditions, we examined the association between personality tests and selections from the two disadvantageous decks. Following our main hypothesis of a different effect in the two disclosure conditions, these correlations were conducted separately for the Partial and Full Disclosure conditions. The only significant result was that higher levels on the Harm Avoidance subscale of the MPQ were associated with a larger number of selections from Disadv10 in the Partial Disclosure condition ($r(79) = 0.30$, $p < .01$). It may be that because the Disadv10 deck is associated with lower frequencies of negative payoff, especially in the Partial Disclosure condition, it would come to be preferred by individuals who are harm avoidant or anxious about loss. Given this single finding, though, it seems that the personality tests were not sensitive enough for predicting the decisions of high functioning individuals with mild drug abuse problems (for similar results, see e.g., Fein, Klein, & Finn, 2004)

Discussion

The findings of the present study indicate that the impact of forgone payoffs was greater for the DRUG group than for the CTRL group. Furthermore, whereas the preferences of the DRUG group were markedly different when the negative payoffs occurred frequently (and were of lower magnitude) than when they occurred infrequently (and were of higher magnitude), the impact of forgone payoffs in the DRUG group was similar across different frequencies. In both cases, forgone payoffs led to more risky choices on the part of high-functioning drug abusers. This discussion examines the implications of these findings to the design of cognitive tasks that tap risk-taking behavior, and in the understanding of decision-making styles in individuals who abuse drugs.

Whereas the finding of poor decision-making in drug abusers is fairly well-known, the current study reveals a unique facet to these findings. That is, there is a common belief that providing additional information to decision makers can only improve their choices. This was formulated by Garner (1974) as the general tendency for redundant information to result in either no change or an improvement in performance level. However, in contrast to this common belief, our findings show that drug abusing college students did not consistently use knowledge of negative payoffs to reduce their risk. This finding increased of risky behavior even in the presence of forgone payoffs is consistant with the results of recent studies, especially in the field of experimental economics, which show that, paradoxically, adding information can lead to less rational choices (see Haruvy & Erev, 2001; Grosskopf et al., 2003). In the so-called big eyes effect, decision makers are drawn to potentially large outcomes of high-variability or risky options. These are constantly displayed in a forgone payoff condition. Thus, increased information about a high risk can increase the choice of risky options.

Note that the present study also showed that there are differences in the impact of forgone payoffs on drug abusers' choices under different risky reward structures (the two disadvantageous decks). As predicted, the effect of forgone payoffs in the high frequency (and lower magnitude) deck, Disadv50, were apparent in the initial part of the task and diminished as decision makers gathered experience. The size of the effect was stronger for the Disadv10 deck, as we had predicted. Yet this effect was different than we observed for Disadv50 because in the standard task condition, drug abusers learned more rapidly not to choose from Disadv10 (for similar findings see Stout et al., 2004). Accordingly, they actually made fewer risky choices than controls. However, forgone payoffs eliminated this learning and had a lasting negative effect on drug abusers' choices, yielding more risky choices on the part of drug abusers in the full disclosure condition.

One possibility to account for this long-term effect of forgone payoffs on drug abusers' choices is that forgone payoffs may have an entrapment effect (see Yechiam & Busemeyer, 2004). Drug abusers may be drawn to select from Disadv10 when its forgone payoffs are salient. In the first few selections from Disadv10 this experience tends to be safe. Safe experiences are known to lead to underweighting of negative rare events (Barron & Erev, 2003). That is, there may be a decrease in the salience of the rare losses associated with Disadv10 selections following a brief safe experience with this deck. An alternative explanation for the long-term effect is that the presence of information about gains embedded in forgone payoffs could distract drug abusers from paying attention to the rare loss information. In addition, the presence of information about actual negative payoffs may lead to a reduction in the avoidance of these outcomes as if, perhaps, knowing the negative payoffs may be less intimidating or anxiety-producing than imagining potential unknown negative payoffs.

The present study thus extends the understanding of the big eyes effect, showing that it may be magnified by particular psychological or neurobiological factors. First, the study demonstrates that forgone payoffs can selectively lead to increased risky behavior on the part of drug abusers. Secondly, and unexpectedly, in drug abusers the presence of forgone payoffs can have long lasting effect on risk taking behavior. Within the context of drug abuse research, this idea is consistent with the possibility that drug abusers have heightened sensitivity to signals of positive outcomes (see Finn, 2002 for a review), which predicts a big eyes effect in drug abusers.

Relationship to previous findings

Note that the task performance in the standard Iowa task (Partial Information condition here) did not yield significant group differences between high functioning drug abusers and controls. Although this finding replicates recent results (Lejuez, 2004) it also contradicts previous findings showing that drug abusers had poorer performance in the task (e.g., Bechara et al., 2001). This difference is elucidated by the fact that the drug abusers who participated in the present study were relatively high functioning and had shorter drug use durations. That is, compared to previous studies that examined adults of age 30-50 (e.g., Bechara et al., 2001), they were primarily college students who were at least functional enough to be enrolled in classes.

Still, an alternative possibility that accounts for the different findings is the fact that the task used by Bechara et al. (2001; see also Bechara et al., 1994) employed a single sequence of cards (losses). Thus, it is possible that the original findings were driven by the effect of a specific order of cards.

Methodological implications

The findings of this study show the value of a more detailed consideration of selection patterns in the Iowa gambling task than that typically undertaken in studies of drug abuse and other clinical populations. The difference between advantageous and disadvantageous selections, collapsed across the high and low frequency loss conditions, often fails to reveal significant group effects. In fact, collapsing the four decks for analysis as advantageous versus disadvantageous decks is the traditional approach to analyzing the gambling task (Bechara et al., 1994).

However, previous studies of choice behavior have revealed distinct patterns associated with rare negative outcomes such as those that occur in the Disadv10 deck, and with more frequent negative outcomes, such as those that occur in the Disadv50 deck (see e.g., Barron & Erev, 2003). Similarly, this study shows that in the Iowa gambling task, a consideration of the Disadv50 and Disadv10 decks separately can lead to the identification of significant individual differences which may bear out as important ways of characterizing clinical populations. In particular, whereas forgone payoffs led to more risk taking on the part of drug abusers in both decks, the behavioral patterns of drug abusers were different. For example, the effect was long lasting in Disadv10 and appeared in the initial part of the task in Disadv50. Future studies should examine the robustness of this finding.

Conclusions:

The results of the current study can be considered in terms of their value for understanding decision making processes in general, as well as for their implications about decision making within drug abusers. First, and more generally, the results point to the value of considering individual differences when studying decision-making processes. The finding of individual differences in the effect of forgone payoffs on decision making indicates that whereas there may be general principles regarding the impact of information on additional choices, there are important potential modifiers of the impact of such information. Improved understanding of individual differences and environmental effects on decision making may well foster a movement toward more solid empirical foundations for prevention and interventions directed towards drug abuse.

For example, our findings may suggest that some individuals may be differentially affected by observations of positive outcomes of drugs (e.g., getting “high”, more comfortable socially). The sources of these individual differences may be of importance in public health and may include possibilities such as clinical diagnoses, personality, and neurobiological factors. The foregone payoff condition in the laboratory experiment is conceptually related to real world social learning from the outcomes of others. A drug abuser can observe the frequent enjoyment that his or her friends are having, without directly experiencing the enjoyment. This may partly be responsible for drawing or enticing an individual to begin abusing drugs.

More specifically, the present results show a unique facet of the decision making style of drug abusers, the heightened sensitivity to forgone payoffs. These results suggest that future studies using the gambling task may benefit from greater attention to the features of task structure, and from exploring task manipulations that can increase the usefulness of the task for understanding the decision making of drug abusers.

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Table 1: The Iowa gambling task with the original payoff scheme (Bechara et al., 1994).

Deck	Wins	Losses	Description
Disadv50	100 every card	Every other card: 150, 200, 250, 300, 350	Disadvantageous: Risky
Disadv10	100 every card	1250 every 10 cards	Disadvantageous: Risky, delayed
Adv50	50 every card	Lose 50 every other card	Advantageous: Safe
Adv10	50 every card	Lose 250 every 10 cards	Advantageous: Safe, delayed

Table 2: The revised gambling task used in the Low and High payoff conditions of the present study.

	Low payoff		High Payoff	
Deck	Wins	Losses	Wins	Losses
Disadv50	$1.00 every card	.5 to lose $2.50	$1.50 every card	.5 to lose $3.75
Disadv10	$1.00 every card	.1 to lose $12.50	$1.50 every card	.1 to lose $18.75
Adv50	$0.50 every card	.5 to lose $0.50	$0.50 every card	.5 to lose $0.50
Adv10	$0.50 every card	.1 to lose $2.50	$0.50 every card	.1 to lose $2.50

<u>Table 3</u>: Use of addictive substances in the high functioning drug abuse group and the control group (standard deviations appear in parenthesis).

Variable	DRUG	CTRL
Demographics		
Age	21.8 (3.55)	21.7 (3.81)
Education	13.6 (1.75)**	14.4 (1.69)
IQ (Shipley)	107.9 (8.91)	109.8 (9.52)
Gender	46 M, 36 F	34 M, 46 F
Substance Use Assessment		
Raw score on the MAST	9.94 (9.72)**	1.47 (1.84)
Raw score on the DAST	10.37 (10.69)**	0.26 (0.81)
Total number of days subject drinks alcohol	3.74 (2.04)**	1.17 (1.27)
Maximum consumed in one occasion	14.96 (21.41)**	3.89 (4.0)
Total number of drinks per week	33.79 (71.54)**	3.23 (4.16)
Total types of drugs used per week	.95 (0.99)**	.025 (0.16)
Total number of days subject uses drugs	3.67 (3.11)**	.025 (0.16)
Personality tests		
MMPI – Psychopathic Deviate	20.61 (4.82)**	18.45 (4.00)
Anti-social symptoms (DIS score)	4.38 (4.31)**	1.46 (2.11)
Eysenck – Impulsivity	8.93 (4.51)**	5.65 (4.06)
MPQ – Self control	11.33 (6.03)**	16.09 (5.83)
MPQ – Harm avoidance	14.37 (4.36)**	16.38 (5.83)

** = $p<.01$

Table 4: Average proportions of choices from the four decks (Disadv50, Disadv10, Adv50, and Adv10) and inter-correlations between selections (*df* = 162 for all effects).

	Average choice proportion		Inter-correlations between decks		
	First half	Second half	Disadv50	Disadv10	Adv50
Disadv50	16%	13%	1.0		
Disadv10	39%	34%	0.45**	1.0	
Adv50	19%	20%	0.07	0.08	1.0
Adv10	27%	32%	-0.18*	-0.21**	0.01

** = p<.01; * = p<.05

Table 5: Results of the ANOVA for the differences between the proportion of selections from the two disadvantageous decks in the Partial and Full Disclosure conditions ($df = 1{,}158$ for all effects).

	Disadv50 Deck			Disadv10 Deck		
	MS_e	*F*	Cohen's *F*	MS_e	*F*	Cohen's *F*
Between						
Group	12.3	2.68	0.13	0.13	0.03	0.01
Disclosure	6.32	1.38	0.09	0.06	0.02	0.01
Group × Disclosure	0.26	0.06	0.02	6.25	1.59	0.10
Within						
Time	47.1	33.01**	0.45	12.0	18.28**	0.33
Time × Group	3.17	2.23	0.11	0.07	0.10	0.02
Time × Disclosure	0.81	0.57	0.05	0.47	0.71	0.06
Time × Group × Disclosure	3.93	2.75*	0.12	3.90	5.95*	0.18

** = $p<.01$; * = $p<.05$

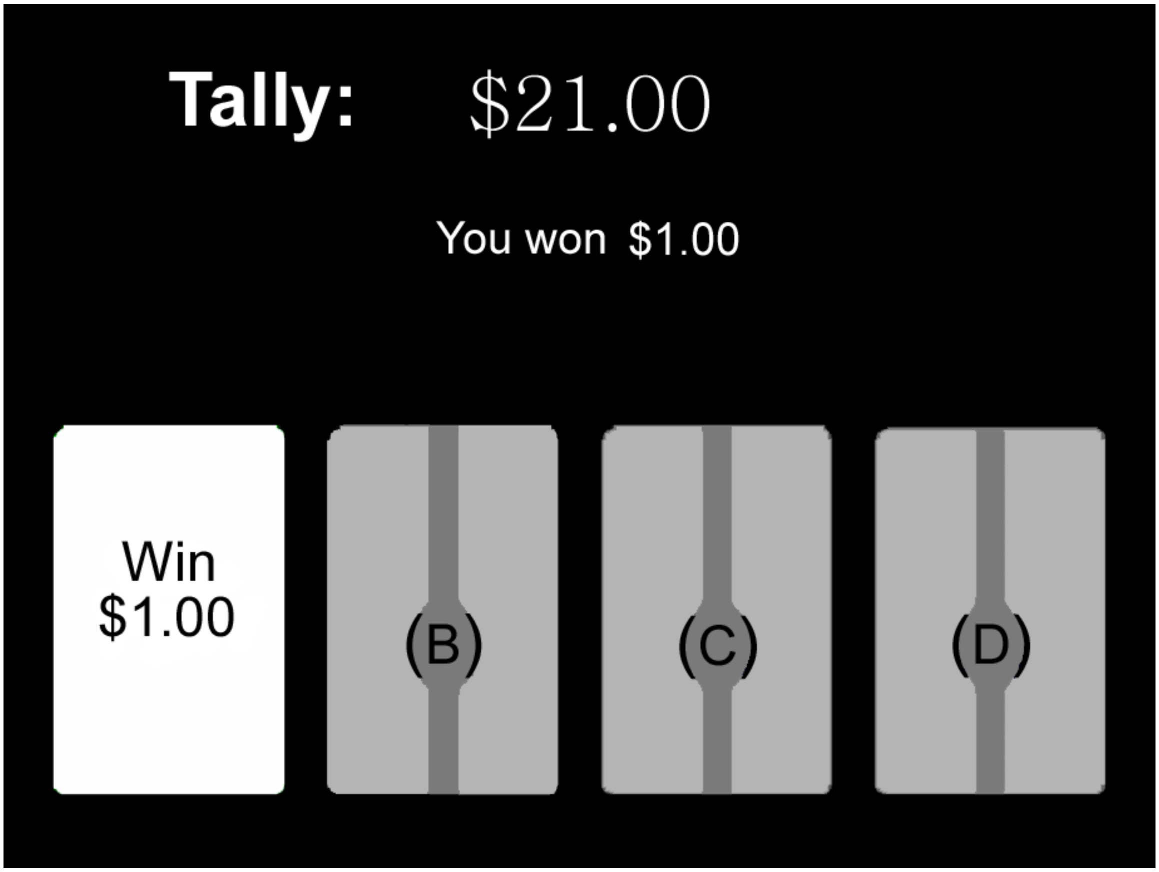

Figure 1: A screen shot from the simulated Iowa task.

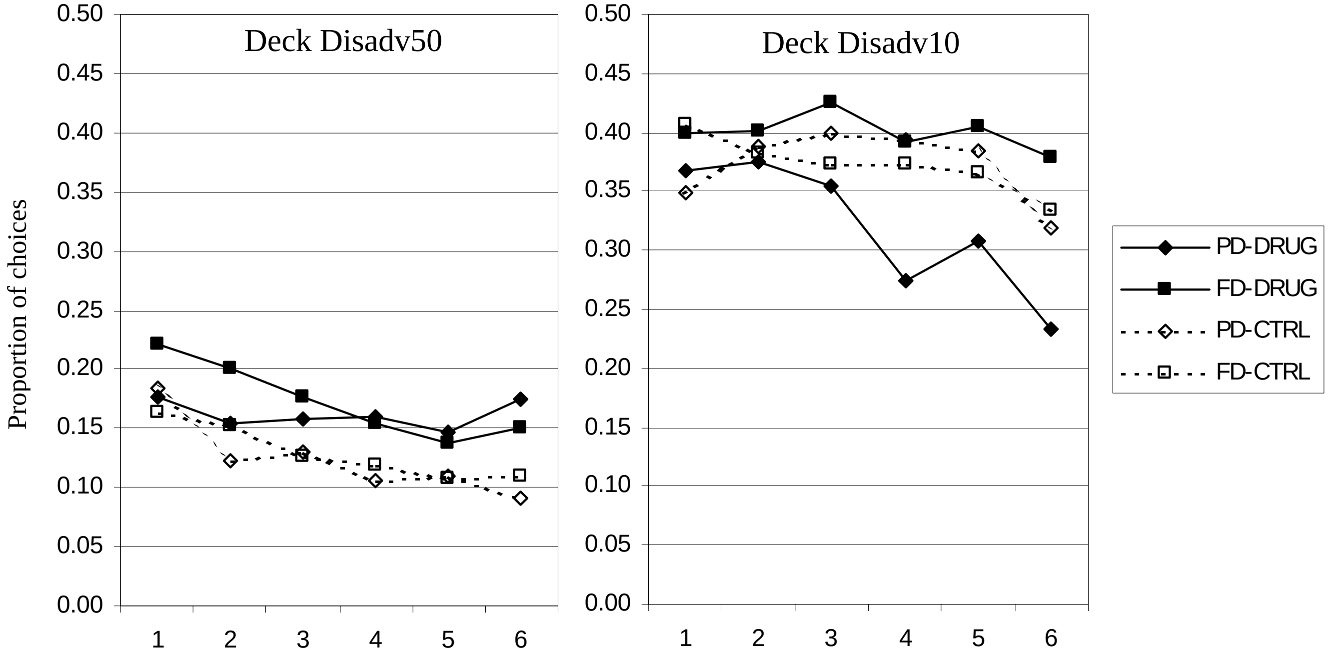

Figure 2: Proportions of selections from the two disadvantageous decks (Disadv50 and Disadv10) as a function of time (6 blocks of 25 trials) in the experimental conditions: Partial Disclosure (PD) versus Full disclosure (FD), and controls (CTRL) versus drug abusers (DRUG).