Blood alcohol concentration is negatively associated with gambling money won on the Iowa gambling task in naturalistic settings after controlling for trait impulsivity and alcohol tolerance

Lyvers, Michael; Mathieson, Nicole; Edwards, Mark S.

Published in:
Addictive Behaviors

DOI:
10.1016/j.addbeh.2014.10.008

Blood Alcohol Concentration is Negatively Associated with Gambling Money Won on the Iowa Gambling Task in Naturalistic Settings After Controlling for Trait Impulsivity and Alcohol Tolerance

Abstract

Acute alcohol intoxication has been found to increase perseverative errors on the Wisconsin Card Sorting Test, a well known neuropsychological index of prefrontal cortical functioning, in both laboratory and naturalistic settings. The present study examined the relationship between levels of alcohol consumption at campus drinking venues and performance of the Iowa Gambling Task (IGT), another neuropsychological test designed to assess prefrontal cortex dysfunction, after controlling for potential confounding variables including habitual alcohol intake (as a proxy for alcohol tolerance), trait impulsivity, and everyday executive functioning. The 49 participants of both genders aged 18 to 30 years were recruited at the relevant venues and showed a broad range of blood alcohol concentrations (BACs) from virtually zero (.002%) to .19%. After controlling for demographic variables, habitual use of alcohol and illicit drugs, and frontal lobe related behavioural traits including impulsivity and disinhibition, BAC negatively predicted gambling money won on the last two trial blocks of the IGT. Trait impulsivity and habitual alcohol use were also significant predictors. Results are discussed in terms of acute effects of alcohol on brain systems and the behavioural consequences of such effects on decision making.

Alcohol intoxication has been found to acutely disrupt performance on a well known neuropsychological test sensitive to prefrontal cortical functioning in both laboratory and naturalistic bar settings (Lyvers & Maltzman, 1991; Lyvers & Tobias-Webb, 2010). On the Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, Kay & Curtis, 1993), the percentage of perseverative errors – i.e., persisting with a previously correct but currently inappropriate sorting response – increases under the influence of alcohol. Of the many performance measures yielded by the WCST, this is the measure that is most selectively sensitive to prefrontal cortical injury as compared to posterior cortical injury or non-brain-injured neurotypical controls (Mountain & Snow, 1993). The present study examined performance of another neuropsychological test of prefrontal cortical functioning, the Iowa Gambling Task (IGT; Bechara, 2007), in relation to blood alcohol concentration (BAC) of intoxicated bar patrons and attendees at a campus party. Whereas the WCST has been found to be most sensitive to dorsolateral prefrontal dysfunction, performance on the IGT is most sensitive to ventromedial prefrontal dysfunction (Glasher et al., 2012). Nevertheless significant correlations have been found between WCST perseverative errors and IGT performance on the later trial blocks in normal controls (Brand, Recknor, Grabenhorst & Bechara, 2007), suggesting that IGT performance should be similarly affected by alcohol intoxication as the WCST, at least on the later trial blocks.

The IGT can detect deficits in cognitive and emotional processing following damage to orbitofrontal/ventromedial prefrontal cortex in brain injured patients (Bechara, Damasio, Damasio & Anderson, 1994; Bechara, Tranel & Damasio, 2000). The IGT provides $2000 of play money and requires participants to choose cards from four decks for 100 trials, with the aim of making the most money. For each decision participants are informed that they will receive a reward - which stays constant for each deck - and possibly a penalty, which varies. Two of the decks contain cards that yield larger rewards, however they also run the risk of a large penalty and thus are considered risky decks. The other two decks contain cards with smaller rewards but also have a much smaller penalty, and are most advantageous in the long run. Those with orbitofrontal/ventromedial prefrontal cortex damage tend to consistently choose from the risky decks more often than neurotypical controls, thereby earning less money overall (Bechara, 2004; Bechara et al., 1994). The IGT has since been found to detect similar deficits in those diagnosed with schizophrenia (Shurman, Horan, & Nuechterlein, 2005) and substance disorders (Barry & Petry, 2008).

Bechara, Damasio, Tranel, and Damasio (1997) examined skin conductance responses (SCRs) in patients with prefrontal cortex injury and neurotypical controls as the participants performed the IGT. Neurotypical individuals showed anticipatory SCRs immediately prior to choosing from the risky decks, even when they were not consciously aware that those decisions were risky. By contrast this psychophysiological response was not seen in those with prefrontal cortex damage. The IGT can thus be considered an index of emotion based decision making, where neurotypical individuals are able to learn from previous trials and make more advantageous decisions based on internal emotional cues from their learning history. Such learning based on error monitoring appears to be deficient in those with prefrontal injury, a type of deficit that may also be present in normal individuals under the influence of alcohol and which may promote riskier or otherwise poorer decision making under the influence of alcohol. For example, Euser, vanMeel, Snelleman and Franken (2011) used the Balloon Analogue Risk Task (BART; Lejuez et al., 2002) to determine the impact of acute alcohol intoxication on risky decision making. The study found that consumption of alcohol decreased effective use of reinforcement history to predict future gain or loss. The BART and the IGT thus appear to test similar aspects of decision-making, and indeed, performance on these tasks has been found to be significantly correlated (Upton, Bishara, Ahn & Stout, 2011), at least in participants who were low in trait impulsiveness.

Balodis, MacDonald and Olmstead (2006) conducted a laboratory investigation comparing individuals who had consumed a moderate dose of alcohol (calculated to achieve a peak BAC of .08%) to sober individuals on performance of the IGT. They did not find a significant difference between intoxicated and sober individuals on the IGT, although there was a non-significant trend for poorer performance on the later trial blocks by those who had consumed alcohol. Interestingly, Brand et al. (2007) concluded that only performance on the last trial blocks of the IGT reflects decision making based on prior learning, as learning of response contingencies occurs during the earlier blocks of trials. This was also found for the WCST, such that a second run of the test reduced variability due to initial rates of learning, with the result that the test is rendered more sensitive to prefrontal cortex injury or alcohol intoxication when conducted a second time – i.e., after the correct sorting strategy has been learned (Lyvers & Maltzman, 1991). For this reason, and also given that only scores for the later trial blocks were found to correlate with WCST performance in the Brand et al. study, the present study focused solely on monetary gain in the last two IGT trial blocks. Further, Balodis et al. examined net scores (i.e., selections from advantageous decks minus selections from disadvantageous decks), whereas in the present study gambling money won was the performance index of interest given the naturalistic context of the study, and also given the well-known association between alcohol consumption and gambling (e.g., Welte, Barnes, Wieczorek, Tidwell & Parker, 2001).

A major limitation of the Balodis et al. (2006) study was the lack of control for trait factors that might influence both IGT performance and response to a moderate alcohol dose, such as habitual alcohol consumption levels (tolerance), impulsivity (e.g., Franken, van Strien, Nijs & Muris, 2008) and inherent executive cognitive functioning. For example, trait impulsivity was recently found to influence IGT performance on the later trials in a non-clinical sample (Upton et al., 2011), and the Barratt Impulsiveness Scale (BIS-11; Patton, Stanford & Barratt, 1995) was found to predict performance on another neuropsychological test of prefrontal cortical functioning, the D-KEFS Tower Test (Lyvers, Basch, Duff & Edwards, 2014). Moreover, in the latter study BIS-11 was found to be related to habitual alcohol consumption such that higher impulsivity scores were significantly associated with higher scores on the Alcohol Use Disorders Identification Test (AUDIT; Babor, Higgins-Biddle, Saunders, & Monteiro, 2001). Positive relationships have also been found between BIS-11 and scores on the Frontal Systems Behavior Scale (FrSBe; Grace & Malloy, 2011), an index of behavioural signs of frontal lobe dysfunction in everyday life (Lyvers, Duff, Basch & Edwards, 2012). Given such evidence, habitual alcohol consumption as measured by AUDIT, trait impulsivity as measured by BIS-11, and everyday frontal systems functioning as measured by FrSBe were covariates in the present investigation. Illicit drug use was also assessed using the Drug Use Disorders Identification Test (DUDIT; Berman, Bergman, Palmstierna & Schlyter, 2005), an instrument comparable to the AUDIT, given that use of illicit drugs has also been found to be significantly associated with frontal lobe related traits and behaviours (Lyvers, Jamieson & Thorberg, 2013) and thus might also be expected to influence IGT performance. Finally, Balodis et al. (2006) examined only one moderate BAC manipulation in relation to IGT performance and thus could not detect effects which may be present at higher BACs. The present study examined a broad range of BAC in intoxicated bar patrons and students at a campus party, including much higher BACs than those reported by Balodis et al. The primary prediction was that gambling money won on the last two trial blocks of the IGT would be significantly negatively predicted by BAC after controlling for the other factors described above.

Method

Participants

Participants were recruited between 9^{00} pm and 11^{30} pm at a university bar and campus party. For ethical reasons only individuals who were not obviously intoxicated were asked to participate; that is, those who appeared drunk or otherwise behaved inappropriately were not approached. No incentive was offered for participation. Criteria for inclusion in the present study were age between 18 and 30 years inclusive; at least occasional alcohol consumption; non-smoking (as smoking has been associated with cognitive functioning; Almeida et al., 2011; Lyvers, Maltzman & Miyata, 1994); BAC below .20% (due to consent related issues); and minimal use of illicit drugs, such that those who said they used illicit drugs more than once a month on average, or had used illicit drugs in the 48 hours prior to completing the study, were excluded. In addition, data for participants were removed if their AUDIT or DUDIT scores were suggestive of substance dependence (Babor et al., 2001; Berman et al., 2005). After removal of 32 cases from the dataset for one or more of the above reasons or for incomplete questionnaire data, failure to follow task instructions or after identification as multivariate outliers, the final sample consisted of 49 participants (33 females and 16 males) ranging in age from 18 to 30 years (M = 21.0 years, SD = 2.64), with 94% reporting that they were current university students. Of the final sample, 30 were recruited at the university bar and 19 at a campus party; there were no significant differences between those recruited at the two locations on any variable in the study as shown by group comparisons using chi-square tests and analyses of variance, thus the data from these two sources were combined. The Bond University Human Research Ethics Committee (BUHREC) approved this study prior to data collection and in accordance with this all participant information remained anonymous.

Materials

AlcoQuant© 6020. The AlcoQuant®6020 was used to test the BAC of participants. It is an Australian Standard Certified Alcohol Breathalyser AS3547 Type II, with certificate number SMKH21861. Certification indicates that the breathalyser meets validity requirements for the performance and testing of reusable alcohol breathalysers. As per certification standards, accuracy is better than +/- 10%. The breathalyser allows unlimited testing for six months, after which it ceases to function and recalibration is required. The breathalyser was calibrated prior to data collection by the manufacturer. To evaluate BACs, individuals were required to blow into a disposable mouth piece and the AlcoQuant®6020 then indicated BAC to three decimal places. BACs were measured before and after completion of the IGT in order to best estimate BAC during IGT performance by taking the average of the two measurements.

Demographic Information Battery. This questionnaire consisting of 9 items was used to assess characteristics of the sample and to determine whether a participant's data should be excluded from analysis. Participants were asked their gender (male or female), age, education level, student status, whether they drink alcohol, smoke cigarettes or use illicit drugs, and frequency and recency of illicit drug use.

Frontal Systems Behaviour Scale (FrSBe; Grace & Malloy, 2001). The FrSBe was designed to identify and assess executive functioning problems and behavioural disturbances due to frontal lobe dysfunction or damage. The scale was initially developed for a clinical population such that post-injury patients are required to answer each question twice, once regarding behaviour before injury and the other for present behaviour. The FrSBe has since been found to be a valid measure of behaviours related to prefrontal functioning in non-clinical samples and therefore in the present study participants were only required to provide answers based on their current situation (Spinella, 2007). The FrSBe has 46 self-report items with each item scored on a 5 point Likert-type scale indicating the frequency of the behaviours in question; the final 14 items are reverse scored. Higher scores indicate more behaviour problems symptomatic of frontal lobe deficit. The scale takes 10 to 15 minutes to administer. There are three subscales, Apathy, Executive Dysfunction and Disinhibition. The

Apathy scale includes items such as “I only speak when spoken to,” and reverse scored items such as “Do things without being requested to do so.” Executive Dysfunction items include “Repeat certain actions or get stuck on certain ideas,” and reverse scored items such as “Am able to plan ahead.” Disinhibition items include ‘Swear’ and reverse scored items such as “Get along well with others.” The present study used total scale scores as an index of everyday frontal systems functioning.

Alcohol Use Disorders Identification Test (AUDIT; Babor et al., 2001). The AUDIT was designed to assess risky and harmful drinking patterns in both clinical and community settings. It is a 10 item self-report scale with higher scores indicating higher levels of problematic drinking. Items 1 to 3 assess frequency of alcohol consumption and are rated on a 4 point Likert-type scale. Items include “How often do you have a drink containing alcohol?” with answers ranging from 0 (*never*) to 4 (*4 or more times a week*); “How many drinks containing alcohol do you have on a typical day when you are drinking?” ranging from 0 (*1 or 2*) to 4 (*10 or more*); and “How often do you have six or more drinks on one occasion?” ranging from 0 (*never*) to 4 (*daily or almost daily*). Items 4-8 assess the consequences of alcohol use and include “How often during the last year have you had a feeling of guilt or remorse after drinking?” These items are scored from 0 (*Never*) to 4 (*Daily or almost daily*). Items 9 and 10 are assessed on a 3 point scale and indicate harmful use and concern from others, e.g., “Have you or someone else been injured as a result of your drinking?,” with possible answers 0 (*no*), 2 (*Yes, but not in the last year*) and 4 (*Yes, during the last* year). The scale takes approximately 2 minutes to complete.

Scores are obtained by adding the responses for each item and range from 0 to 40. Scores above 7 suggest hazardous drinking, scores of 16 or higher suggest harmful drinking and a score of 20 or more may suggest alcohol dependence (Babor et al., 2001). In a review of studies between 2002 and 2007 the AUDIT showed high internal consistency reliability

(Reinert & Allen, 2007). The AUDIT has demonstrated convergence with the Michigan Alcoholism Screening Test (MAST; Selzer, 1971) and predictive validity with alcohol-related physical and social problems (Dawe, Loxton, Hides, Kavanagh & Mattick, 2002).

Drug Use Disorders Identification Test (DUDIT; Berman et al., 2005). The DUDIT was designed to assess illicit drug taking behaviour in adults and is very similar to the AUDIT. It is an 11 item self-report scale with higher scores indicating increased likelihood of illicit drug-related problems. Questions 1 to 9 are scored on a 5-point scale. Questions 1 to 3 indicate the frequency of drug taking behaviour. For question 1, "How often do you use drugs other than alcohol?" and 2, "Do you use more than one type of drug on the same occasion?" participants rate from 0 (*never)* to 4 *(4 times a week or more often).* Question 3 indicates the amount of drugs taken per day, from 0 *(0)* to 4 *(7 or more).* Items 4 to 9 include "How often are you heavily influenced by drugs?" and are rated from 0 (*Never)* to 4 (*Daily or almost every day*). Items 10 and 11 are scored on a 3 point scale, 0 (*No),* 2 (*Yes, but not over the past year*) and 4 (*Yes, over the past year*) and indicate harmful use and concern from others, e.g., "Have you or anyone else been hurt because you used drugs?" Scores are obtained by adding the total of all items and range from 0 to 44. Scores of above 6 for men and above 2 for women suggest substance abuse, and scores of 25 or above for both sexes suggest drug dependence (Berman et al., 2005). The scale takes approximately 2 minutes to complete. Voluse, Fioia, Sobell, Dum, Sobell and Simco (2012) tested the psychometric properties of the DUDIT with outpatient drug abusers, residential drug abusers and alcohol abusers without other drug abuse problems and found high internal consistency reliability.

Barratt Impulsiveness Scale -Version 11 (BIS-11; Patton et al., 1995). The BIS-11 is a 30-item self-report scale designed to measure trait impulsiveness in clinical and non-clinical adult populations. All items are rated on a 4-point Likert-type scale from 1

(*Rarely/Never*) to 4 (*Almost Always/Always*). Items include “I do things without thinking” and reverse scored items such as “I concentrate easily.” There are 11 reverse scored items. Each item response is summed to yield a total impulsivity score which can range between 30 and 150, with higher scores indicating higher levels of impulsivity. The scale takes 5-10 minutes to complete.

Patton et al. (1995) found a reliable second order three-factor structure with factors labelled attentional impulsiveness, motor impulsiveness and non-planning impulsiveness. The BIS-11 total score is a reliable measure of impulsivity and has strong internal consistency and temporal stability for test-retest at one month (Stanford et al., 2009). The latter authors suggested that a cut-off score of 72 indicates a highly impulsive individual. Further, concurrent validity has been indicated such that highly impulsive individuals as measured by BIS-11 were more than twice as likely to have shoplifted an item over $10 and to have been involved in self-mutilation, and the BIS-11 has also shown convergence with other measures of impulsiveness (Stanford et al., 2009).

Iowa Gambling Task (IGT; Bechara, 1994). The IGT was designed to assess individuals with deficits in affective decision making due to damage to the prefrontal cortex, especially the ventromedial prefrontal cortex (Bechara, 2004). The Psychological Experiment Building Language (PEBL) computerised test battery version was used to minimise both procedural and scoring errors that arise from hand scoring and to ease administration of the task, as the computer version was found to be comparable to the manual version (Bechara, Tranel & Damasio, 2000). An Acer Travelmate 8572T computer with Windows 7 Professional interface was used to run the IGT.

In the IGT, participants are initially presented with $2000 of play money and are instructed to try to make as much money as possible. They are asked to choose cards from four decks for 100 trials and are not told how many trials they have or when the test will finish. Each time a participant chooses a card from a certain deck they get a reward (increase in play money) with the possibility of also receiving a penalty (loss of money). The penalty can be bigger than the reward, leading to an overall loss on that trial. They are informed that they may switch between decks as often as they like and that they should continue to play until they are informed of their final score. Money is made by continuously choosing cards from the most advantageous decks, however they are not told which decks these are. On each trial participants are provided feedback as to their overall net position. Two of the decks are disadvantageous decks as they have larger immediate rewards but also have larger penalties, leading to an overall loss of money. The other two decks yield smaller rewards but much smaller penalties and therefore are more profitable over the course of the trials. Participants who more often choose from disadvantageous decks will therefore earn less play money than those who choose more cards from advantageous decks. For scoring Bechara (2007) recommends that the data be divided into five blocks of 20 trials each, such that Block 1 consists of the first 20 trials, Block 2 of trials 21 to 40 and so on until Block 5 which is trials 81 to 100. Brand et al. (2007) concluded that only the decisions made on the later trials of the IGT assess risky decision-making, as by the final blocks individuals have a greater chance of interpreting the risks given that they have had the opportunity to test all the decks and experience the corresponding rewards and punishments. Brand et al. found that only decisions made on the later blocks were correlated with risky or flawed decisions on the Game of Dice Task (GDT; Brand et al., 2005) and the WCST. Thus in the present study, the outcome measure of interest was gambling money won in the final two blocks of 20 trials each. As discussed previously above, gambling money won was the performance measure of choice as it was most congruent with the naturalistic context of the present study as an index of the potential effects of alcohol on gambling behaviour.

Split-half reliability was found for the IGT in a substance dependent population by assessing odd versus even numbered trials, and the test was shown to be even more reliable when only assessing the later trials (Monterosso, Ehrman, Napier, O'Brien & Childress, 2001). Validity has been supported through convergent studies where performance in the later trial blocks of the IGT was significantly correlated with other neuropsychological tests of frontal lobe related executive function such as the WCST (Brand et al., 2007). The IGT has been shown to differentiate those with frontal lobe damage from neurotypical controls (Fellows & Farah, 2005). Interestingly, Fukui, Murai, Fukuyama, Hayashi and Hanakawa (2005) found that IGT performance was correlated with brain activity in the medial prefrontal cortex during risky decisions (i.e., choosing from the disadvantageous decks).

Procedure

Potential participants were approached at a university bar and campus party between 9^{00} pm and 11^{30} pm. They were given a brief explanation of the study as an examination of the effects of alcohol on decision making, including information about the time required to complete all aspects of the study. Those who agreed to participate were led to a quiet, private, adjoining room. Participants were presented with an explanatory statement to read, and were asked for their consent to use their anonymous data in the study. They were told that they could not consume any more alcohol for the duration of testing and were given a cup of water to rinse their mouths with for an accurate BAC reading. Following that, the participant was presented with the Demographic Information Battery, FrSBe, BIS-11, AUDIT and DUDIT and asked to complete all questions. Immediately thereafter, BAC was recorded using the AlcoQuant® 6020. Participants were then instructed that for the IGT they would be given $2000 of play money and the aim was to gamble to win as much play money as possible. They were told they could do this by picking from one of four decks on the computer for multiple trials. They were further informed that each deck had a certain reward but there is also the possibility of a penalty, and that they could keep track of their winnings from a scale on the screen. They were told they could change between decks as often as they wished. Participants were then asked to read the instructions on the screen and to choose from the decks until the program told them to stop, at which point they were advised of their final score in play money. A second BAC reading was taken and participants were thanked and released. The total time required for participation was approximately 30 min for each participant.

Results

The average of the two BAC readings taken from participants immediately before and immediately after IGT performance showed a broad range from virtually zero (.002%) to .19%, with a mean BAC of .06% (*SD* = .05). Intercorrelations among the continuous measures are shown in Table 1. As can be seen in the table, the self-report scales were significantly intercorrelated in expected ways, consistent with previous research findings in both student and community samples (e.g., Lyvers, Duff et al., 2012; Lyvers, Onuoha et al., 2012). That is, BIS-11 impulsivity scores were highly positively correlated with the frontal lobe dysfunction index FrSBe, and both BIS-11 and FrSBe were significantly positively correlated with AUDIT. BAC was significantly positively correlated with AUDIT and DUDIT but only approached significance (p = .08) for gambling money won in the final two trial blocks of the IGT, which was not significantly correlated with any other variable.

Hierarchical linear regression was conducted on gambling money won in the final two IGT trial blocks. Table 2 shows the unstandardized (B) and standardized (β) coefficients for each predictor at each step. Demographic variables gender, age and education level were entered in the first step, with the model nonsignificantly accounting for 6.4% of the variance in play money won, $F(3, 44) = 1.01$, $p = .40$. Substance use variables AUDIT and DUDIT were entered in the second step, nonsignificantly explaining a further 1% of variance, F

change(2, 42) = .22, $p = .81$. Trait variables BIS-11 and FrSBe were entered at step 3, accounting for an additional 13% of variance, *F change*(2, 40) = 3.21, $p = .05$. Only when BAC was entered at the final step did the overall model become significant ($p < .05$), explaining a further 15% of the variance, *F change*(1, 39) = 9.21, $p = .004$, with the final model accounting for 35% of total variance overall, $R = .60$, $R^2 = .35$, $F(8, 39) = 2.67$, $p = .02$. In the final model, BAC, BIS-11 and AUDIT were significant predictors (see Table 2).

Discussion

As expected, after accounting for the influences of habitual alcohol consumption (as a proxy for alcohol tolerance) and relevant trait variables on performance of the IGT, BAC was a significant negative predictor of gambling money won in the final two trial blocks in a sample largely comprised of university students. BIS-11 impulsivity scores also negatively predicted IGT performance, whereas the AUDIT index of habitual alcohol consumption was a positive predictor in the final model, presumably reflecting an influence of alcohol tolerance given the positive correlation of AUDIT scores with BAC. In other words, habitual heavy drinkers with higher levels of tolerance both consumed more alcohol and were more resistant to the adverse effects of alcohol on cognition in this sample. Note that a causal influence of alcohol on IGT performance, though strongly suggested by the current findings, cannot be assumed given the correlational nature of the study; only a suitable laboratory experiment manipulating BAC at multiple levels, and which takes into account the influences of trait impulsivity and habitual alcohol consumption, can properly address the issue of causation. Furthermore the generalisability of the present findings is limited given that 94% of participants were young adults attending university.

The present results partially parallel those of Lyvers and Tobias-Webb (2010), who found that alcohol intoxication was associated with an increase in the percentage of perseverative errors on the WCST in 86 patrons recruited from three different bars. An interesting difference, however, was that in the previous study neither AUDIT nor BIS-11 predicted WCST performance, whereas in the present study AUDIT and BIS-11 were both significant predictors in the final model. The participant sample of the Lyvers and Tobias-Webb study was different in several respects: although the age range was the same, BIS-11 scores were virtually identical in mean and SD, and average BAC of drinkers was very similar (.07% in their study versus .06% in the present study), there were slightly more males (56%) than females in their sample (versus 33% males in the present sample), AUDIT scores ranged up to 34 with a mean of 13.72 (versus ranging up to 22 with a mean of 10.10 in the present study), and one third of their sample were non-students (versus only 3% of the present sample). Such differences in samples might for unknown reasons account for the different findings of the two studies concerning the influences of the AUDIT and BIS-11 on neuropsychological test performance, but it is also possible that the IGT is inherently more sensitive than the WCST to trait impulsivity (e.g., Franken et al., 2008; Upton et al., 2011). In any case the present findings were consistent with predicted negative influences of both trait impulsivity and acute alcohol intoxication on IGT performance. However, the index of frontal lobe related executive functioning in everyday life, the FrSBe, was not related to IGT performance in the present study, contrary to expectations. This outcome was nevertheless very similar to the findings of Lyvers, Basch et al. (2014), who reported that the BIS-11, but not the FrSBe, significantly predicted performance on the D-KEFS Tower Test, another neuropsychological index of frontal lobe related executive cognition.

On the WCST, the ability to shift strategies when reinforcement contingencies change – as inversely measured by perseverative errors – is impaired by acute alcohol intoxication (Lyvers & Maltzman, 1991; Lyvers & Tobias-Webb, 2010), consistent with a depressant effect of alcohol on the dorsolateral prefrontal cortex. On the IGT, alcohol intoxication may diminish the ability to learn to ignore large immediate payoffs that are sometimes accompanied by large losses in favour of a more conservative strategy where smaller immediate payoffs lead to greater long term gains. Such a behavioural effect of alcohol would be consistent with acute impairment of ventromedial prefrontal cortical functioning (Bechara, 2004; Bechara et al., 1994). The present finding that trait impulsivity also impacted IGT performance is consistent with the previous findings of Upton et al. (2011) for the IGT as well as the recent finding by Lyvers, Basch et al. (2014) that BIS-11 scores negatively predicted performance on another frontal lobe task, the D-KEFS Tower Test, which can be disrupted by lateral prefrontal lesions (Yochim et al., 2009). Based on their own findings as well as other published work (see Toplak et al., 2013), Lyvers, Basch et al. concluded that the BIS-11 is unusual among self-report scales in predicting variance on neuropsychological tests of frontal lobe related executive cognitive functioning.

A common theme across the reported acute alcohol effects on performance of the IGT and WCST is that in both cases the alcohol-related deficit may reflect a difficulty in error monitoring, such that those who are intoxicated on alcohol - like those who have suffered prefrontal cortical injury - are less responsive to error signals in comparison to signals of reward. In this regard, alcohol is well known to potentiate the impact of rewarding stimuli on the subcortical dopaminergic reward system innervating prefrontal cortex (Wise, 1998) and to exert an anxiolytic action via potentiation of GABA mediated inhibition in the amygdala (Nie et al., 2004). Alcohol also inhibits prefrontal cortex activity more than other brain regions at typical doses, presumably via both dopaminergic and GABAergic mechanisms (Lyvers, 2000). Any or all of these brain effects of alcohol are plausibly responsible for the observed relationship of alcohol intoxication to IGT and WCST performance. However, as noted above, although both laboratory and naturalistic studies have confirmed an effect of alcohol on WCST performance, the present naturalistic study, while indicating a significant relationship of BAC to IGT performance, does not permit causal inferences to be conclusively made despite controlling for trait variables that were expected to influence both alcohol consumption and IGT performance. Despite such controls, some unknown variable not taken into account in the present study could conceivably promote heavier drinking while also interfering with IGT performance, leading to a spurious relationship. The results of the present study are nevertheless consistent with an acute effect of alcohol intoxication on IGT performance, which by contrast was not found in the controlled laboratory experiment by Balodis et al. (2006). Potentially relevant differences between the two studies include (1) the use of a single moderate BAC manipulation of .08% by Balodis et al. compared to a broad range of BAC in the present study, including much higher BACs than those examined by Balodis et al., and (2) their lack of control for trait factors that are likely to influence IGT performance as well as response to alcohol, such as impulsivity (e.g., Franken et al., 2008) and habitual alcohol consumption levels (tolerance), which were taken into account by the present investigation. As noted above, however, only a suitably controlled laboratory experiment can resolve the issue of causation.

The findings of the present study suggest that performance of the IGT, a neuropsychological test sensitive to ventromedial prefrontal cortical functioning, may be altered by acute alcohol intoxication under naturalistic conditions once other relevant factors are taken into account. Unlike changes in social behaviour linked to alcohol, disruption of cognitive functioning by alcohol is not subject to alcohol expectancy effects (Hull & Bond, 1986; Lyvers & Maltzman, 1991), thus alcohol expectancy cannot account for the present results. Instead, the present findings for the IGT are consistent with the notion that alcohol increases responsiveness to rewards and/or decreases responsiveness to punishments via pharmacodynamic actions on specific brain systems. Such actions of alcohol likely underlie the widely reported impacts of alcohol intoxication on decision making in everyday life, perhaps rendering risky behaviours more likely in situations where competing approach and avoidance response tendencies are present – as when gambling with real money, or when an opportunity for risky sex presents itself (e.g., Lyvers, Cholakians, Puorro & Sundram, 2011). The fact that many casinos serve free alcoholic drinks is thus hardly surprising. Both the gambling industry and those seeking short term sexual liaisons have long known about the effects of alcohol on decision making, but lately science may be catching up.

References

Almeida, O. P., Garrido, G. J., Alfonso, H., Hulse, G., Lautenschlager, N. T., Hankey, G. J., & Flicker, L. (2011). 24-Month effect of smoking cessation on cognitive function and brain structure in later life. *Neuroimage*, *55*, 1480-1489. doi:10.1016/j.neuroimage.2011.01.063

Babor, T. F., Higgins-Biddle, J. C., Saunders, J. B., & Monteiro, M. G. (2001). *The alcohol use disorders identification test. Guidelines for use in primary care.* Geneva: World Health Organization.

Balodis, I.M., MacDonald, T.K., & Olmstead, M.C. (2006). Instructional cues modify performance on the Iowa Gambling Task. *Brain and Cognition, 60*, 109–117. doi:10.1016/j.bandc.2005.05.007

Barry, D., & Petry, N. M. (2008). Predictors of decision-making on the Iowa Gambling Task: Independent effects of lifetime history of substance use disorders and performance on the trail making test. *Brain Cognition, 66*, 243-252. doi:10.1016/j.bandc.2007.09.001

Bechara, A. (2004). The role of emotion in decision-making: Evidence from neurological patients with orbitofrontal damage. *Brain and Cognition, 55*, 30-40. doi:10.1016/j.bandc.2003.04.001

Bechara, A. (2007). *Iowa Gambling Task professional manual*. Lutz, FL: Psychological Assessment Resources.

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, *50*, 7-15. doi:10.1016/0010-0277(94)90018-3

Bechara, A., Damasio, H., Tranel, D., & Damasio, A. R. (1997). Deciding advantageously before knowing the advantageous strategy. *Science, 275,* 1293-1295. doi:10.1126/science.275.5304.1293

Bechara, A., Tranel, D., & Damasio, H. (2000). Characterization of the decision-making deficit of patients with ventromedial prefrontal cortex lesions. *Brain*, *123*, 2189-2202. doi:10.1093/brain/123.11.2189

Berman, A.H., Bergman, H., Palmstierna, T., & Schlyter, F. (2005). *Drug Use Disorders Identification Test (DUDIT) manual*. Stockholm: Karolinska Institute.

Brand, M., Fujiwara, E., Borsutzky, S., Kalbe, E., Kessler, J., & Markowitsch, H. J. (2005). Decision-making deficits of korsakoff patients in a new gambling task with explicit rules: Associations with executive functions. *Neuropsychology*, *19*, 267. doi:10.1037/0894-4105.19.3.267

Brand, M., Recknor, E. C., Grabenhorst, F., & Bechara, A. (2007). Decisions under ambiguity and decisions under risk: Correlations with executive functions and comparisons of two different gambling tasks with implicit and explicit rules. *Journal of Clinical and Experimental Neuropsychology*, *29*, 86-99. doi:10.1080/13803390500507196

Dawe, S., Loxton, N. J., Hides, L., Kavanagh, D J., & Mattick, R. P. (2002). *Review of diagnostic screening instrument for alcohol and other drug use and other psychiatric disorders (second edition)*. Canberra, Australia: Publications Production Unit Commonwealth Department of Health and Ageing.

Euser, A. S., van Meel, C. S., Snelleman, M., & Franken, H. A. (2011). Acute effects of alcohol on feedback processing and outcome evaluation during risky decision-making: an ERP study. *Psychopharmacology, 217*, 111-125. doi:10.1007/s00213-011-2264-x

Fellows, L. K., & Farah, M. J. (2005). Different underlying impairments in decision-making following ventromedial and dorsolateral frontal lobe damage in humans. *Cerebral cortex*, *15*, 58-63. doi:10.1093/cercor/bhh108

Franken, I.H., van Strien, J.W., Nijs, I., & Muris, P. (2008). Impulsivity is associated with behavioral decision-making deficits. *Psychiatry Research, 158*, 155-163. doi: 10.1016/j.psychres.2007.06.002.

Fukui, H., Murai, T., Fukuyama, H., Hayashi, T., & Hanakawa, T. (2005). Functional activity related to risk anticipation during performance of the Iowa Gambling Task. *NeuroImage, 24*, 253-259. doi:10.1016/j.neuroimage.2004.08.028

Gläscher, J., Adolphs, R., Damasio, H., Bechara, A., Rudrauf, D., Calamia, M., Paul, L.K., & Tranel, D. (2012). Lesion mapping of cognitive control and value-based decision making in the prefrontal cortex. *Proceedings of the National Academy of Sciences, 109*, 14681-14686. doi: 10.1073/pnas.1206608109

Grace, J., & Malloy, P. F. (2001). *Frontal Systems Behavior Scale. Professional manual*. Lutz, FL: Psychological Assessment Resources.

Heaton, R. K., Chelune, G. L., Talley, J. L., Kay, G. G., & Curtis, G. (1993). *Wisconsin Card Sort Test (WCST) manual revised and expanded*. Odessa, FL: Psychological Assessment Resources.

Hull, J.G., & Bond, C.F. (1986). Social and behavioral consequences of alcohol consumption and expectancy: A meta-analysis. *Psychological Bulletin, 99*, 347-360.

Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J. B., Ramsey, S. E., Stuart, G. L., Strong, D.R., & Brown, R. A. (2002). Evaluation of a behavioral measure of risk taking: the Balloon Analogue Risk Task (BART). *Journal of Experimental Psychology: Applied*, *8*, 75-84. doi: 10.1037/1076-898X.8.2.75

Lyvers, M. (2000). "Loss of control" in alcoholism and drug addiction: A neuroscientific interpretation. *Experimental and Clinical Psychopharmacology*, *8*, 225-249.

Lyvers, M., Basch, V., Duff, H., & Edwards, M.S. (2014). Self-reported impulsivity predicts

D-KEFS Tower Test performance in university students. *Applied Neuropsychology: Adult*, in press.

Lyvers, M., Cholakians, E., Puorro, M., & Sundram, S. (2011). Alcohol intoxication and self-reported risky sexual behavior intentions with highly attractive strangers in naturalistic settings. *Journal of Substance Use, 16,* 99-108. doi: 10.3109/14659891.2010.495819

Lyvers, M., Duff, H., Basch, V., & Edwards, M. (2012). Influences of rash impulsiveness and reward sensitivity on risky drinking in university students: Evidence of mediation by frontal systems. *Addictive Behaviors*, *37*, 940-946.

Lyvers, M., Jamieson, R., & Thorberg, F.A. (2013). Risky cannabis use is associated with alexithymia, frontal lobe dysfunction and impulsivity in young adult cannabis users. *Journal of Psychoactive Drugs, 45*, 394-403**.**

Lyvers, M., & Maltzman, I. (1991). Selective effects of alcohol on Wisconsin Card Sorting Test performance. *British Journal of Addiction, 86*, 399-407.

Lyvers, M., Maltzman, I., & Miyata, Y. (1994). Effects of cigarette smoking and smoking deprivation on Wisconsin Card Sorting Test performance. *Experimental and Clinical Psychopharmacology, 2,* 283-289.

Lyvers, M., Onuoha, R., Thorberg, F.A., & Samios, C. (2012). Alexithymia in relation to parental alcoholism, everyday frontal lobe functioning and alcohol consumption in a non-clinical sample. *Addictive Behaviors*, *37*, 205-210.

Lyvers, M., & Tobias-Webb, J. (2010). Effects of acute alcohol consumption on executive cognitive functioning in naturalistic settings. *Addictive Behaviors, 35,* 1021-1028.

Monterosso, J., Ehrman, R., Napier, K. L., O'Brien, C., & Childress, A. R. (2001). Three decision-making tasks in cocain-dependent patients: do they measure the same construct? *Addiction, 96*, 1825-1837. doi:10.1080/09652140120089571

Mountain, M.A., & Snow, W.G. (1993). Wisconsin Card Sorting Test as a measure of frontal pathology: A review. *Clinical Neuropsychologist, 7,* 108-118.

Nie, Z., Schweitzer,P., Roberts,A.J., Madamba,S.G., Moore,S.D., & Siggins, G.R. (2004). Ethanol augments GABAergic transmission in the central amygdala via CRF1 receptors. *Science, 303*, 1512-1514.

Patton, J. H., Stanford, M. S., & Barratt, E. S. (1995). Factor structure of the Barratt Impulsiveness Scale. *Journal of Clinical Psychology, 51*, 768 - 774.

Reinert, D. F., & Allen, J. P. (2007). The Alcohol Use Disorders Identification Test: An update of research findings. *Alcoholism: Clinical and Experimental Research, 31*, 185 – 199. doi:10.1111/j.1530-0277.2006.00295.x

Selzer, M.L. (1971). The Michigan Alcoholism Screening Test: The quest for a new diagnostic instrument. *American Journal of Psychiatry, 127*, 1653-1658.

Shurman, B., Horan, W. P., & Nuechterlein, K. H. (2005). Schizophrenia patients demonstrate a distinctive pattern of decision-making impairments on the Iowa Gambling Task. *Schizophrenia Research, 72*, 215-224. doi:10.1016/j.schres.2004.03.020

Spinella, M. (2007). Measuring the executive regulation of emotion with self-rating scales in a nonclinical population. *Journal of General Psychology, 134*, 101-111. doi:10.3200/GENP.134.1.101-111

Stanford, M. S., Mathias, C. W., Dougherty, D. M., Lake, S. L., Anderson, N. E., & Patton, J. H. (2009). Fifty years of the Barratt Impulsiveness Scale: An update and review. *Personality and Individual Differences, 47*, 385-395. doi:10.1016/j.paid.2009.04.008

Toplak, M.E., West, R.F., & Stanovich, K.E. (2013). Do performance-based measures and ratings of executive function assess the same construct? *Journal of Child Psychology and Psychiatry, 54,* 131-143. doi:10.1111/jcpp.12001

Upton, D. J., Bishara, A. J., Ahn, W. Y., & Stout, J. C. (2011). Propensity for risk taking and trait impulsivity in the Iowa Gambling Task. *Personality and Individual Differences*, *50*, 492-495. doi:10.1016/j.paid.2010.11.013

Voluse, A. C., Gioia, C. J., Sobell, L. C., Dum, M., Sobell, M. B., & Simco, E. R. (2013). Psychometric properties of the Drug Use Disorders Identification Test (DUDIT) with substance abusers in outpatient and residential treatment. *Addictive Behaviours, 37*, 36-41. doi:10.1016/j.addbeh.2011.07.030

Welte, J., Barnes, G., Wieczorek, W., Tidwell, M.C., & Parker, J. (2001). Alcohol and gambling pathology among U.S. adults: Prevalence, demographic patterns and comorbidity. *Journal of Studies on Alcohol and Drugs, 62,* 706-712.

Wise, R.A. (1998). Drug-activation of brain reward pathways. *Drug & Alcohol Dependence, 51,* 13-22.

Yochim, B.P., Baldo, J.V., Kane, K.D., & Delis, D.C. (2009). D-KEFS Tower Test performance in patients with lateral prefrontal cortex lesions: The importance of error monitoring. *Journal of Clinical and Experimental Neuropsychology, 31,* 658-663. doi:10.1080/13803390802448669

Table 1. Intercorrelations between age, average blood alcohol concentration (BAC), IGT money won in last two trial blocks, and AUDIT, DUDIT, BIS-11, and FrSBe total scores (see text for details of measures).

	AUDIT Total	DUDIT Total	BIS Total	FrSBe Total	Average BAC	IGT Gain Score
Age	-.22	.05	-.03	-.10	.09	-.06
AUDIT Total		.26	.34*	.33*	.44**	.04
DUDIT Total			.14	.38**	.37**	.08
BIS-11 Total				.67***	-.01	-.23
FrSBe Total					.15	-.06
Average BAC						-.26

* $p < .05$

** $p < .01$

*** $p < .001$

Table 2. Hierarchical regression on IGT money won in last two blocks (see text for abbreviations).

	Variable	B	β	*t*	R^2 Change
Step 1	(Constant)	357.57		0.47	.06
	Gender	-254.25	-.19	-1.24	
	Age	-20.22	-.08	-0.49	
	Education	205.34	.16	0.96	
Step 2	(Constant)	184.90		0.21	.01
	Gender	-233.94	-.17	-1.09	
	Age	-19.38	-.08	-0.45	
	Education	226.69	.18	1.03	
	AUDIT Total	9.74	.07	0.46	
	DUDIT Total	9.73	.05	0.33	
Step 3	(Constant)	1188.91		1.21	.13
	Gender	-354.82	-.26	-1.69	
	Age	-19.11	-.08	-0.46	
	Education	344.43	.27	1.58	
	AUDIT Total	28.34	.21	1.31	
	DUDIT Total	7.18	.04	0.24	
	FrSBe Total	1.89	.06	0.28	
	BIS Total	-23.61	-.44	-2.13*	
Step 4	(Constant)	957.58		1.06	.15**
	Gender	-372.23	-.28	-1.94	
	Age	11.26	.05	0.29	
	Education	241.84	.19	1.20	
	AUDIT Total	56.36	.42	2.58*	
	DUDIT Total	26.62	.14	0.94	
	FrSBe Total	4.03	.13	0.65	
	BIS Total	-30.33	-.56	-2.93**	
	Average BAC	-6494.07	-.48	-3.03**	

* $p < .05$

** $p < .01$