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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

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HIGHLIGHTS

- Iowa Gambling Task performance was negatively influenced by alcohol.
- Trait impulsivity also negatively influenced performance.
- Testing was done on intoxicated bar and party patrons.
- Alcohol may increase responsiveness to cues of reward.
- Alcohol may reduce responsiveness to error cues.

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ABSTRACT

Introduction: 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.
Method: 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.
Results: 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.
Conclusions: 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.

1. Introduction

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 the 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 (Gläscher 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

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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, Damasio, Damasio & Anderson, 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, van Meel, 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 the 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 the 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, Recknor, Grabenhorst and Bechara (2007) concluded that only the 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, MacDonald and Olmstead (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, Bishara, Ahn & Stout, 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, in press). 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, 2001), 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 the 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, MacDonald and Olmstead (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.

2. Method

2.1. 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 ages 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 h 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, Higgins-Biddle, Saunders & Monteiro, 2001; Berman, Bergman, Palmstierna & Schlyter, 2005). After the 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,