Theory of Mind Deficits Following Acute Alcohol Intoxication

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ABSTRACT

Acute alcohol consumption is associated with socially inappropriate behaviour. Such behaviour could in part reflect the potential of alcohol to interfere with social cognition. In this experiment we tested the hypothesis that acute alcohol consumption by regular, heavy social drinking young adults would compromise an aspect of social cognition, namely theory of mind (understanding intentions, emotions, and beliefs). Participants who had consumed 6 – 8 units of alcohol showed specific impairments on two theory of mind tests: identification of faux pas and emotion recognition. This result suggests that alcohol consumption could lead to social problems secondary to difficulties in interpreting behaviour the behaviour of others due to theory of mind impairments.

Key Words: prefrontal, theory of mind, executive, alcohol, faux pas, Reading the Mind in the Eyes Test, intoxication.

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INTRODUCTION

There is a well established relationship between acute alcohol intoxication and inappropriate social behaviour. For example, Kershaw [1] claims that misuse of alcohol is a factor in 40% of all assaults. Alcohol consumption is also related to an increased prevalence of accidents, it being implicated in 20-30% of all accidents [2], and with other problematic behaviours such as sexual risk taking [3,4] It should be noted, however, that alcohol consumption does not invariably lead to increased aggression. For example, Mitchell et al., [5] have shown that acute alcohol intoxication can result in reduced pro-violent attitudes and induce an increased sense of conviviality.

The mechanisms by which acute alcohol intoxication can result in problematic social behaviour are not fully understood. High doses of alcohol result in a general depression of neural activity across the brain [6,7]. At more modest doses the effects of alcohol on prefrontal functioning can be seen in poor executive performance. For example, moderate alcohol consumption has been shown to impair performance on prefrontal based executive tasks including planning, impulsivity, response inhibition and verbal fluency [8,9,10]. In everyday life executive functions allow us to control our impulses, plan our actions, and hold in mind our goals. Disruption of any of these processes may well lead to socially inappropriate behaviour.

The negative effects of alcohol on social behaviour could potentially also result from disrupting theory of mind (ToM). ToM, an aspect of social cognition, refers to thinking about mental states, such as beliefs or desires and making inferences about intentions. The precise brain mechanisms subserving ToM remain a matter of contention [11,12,13,14]. However, it is generally accepted that ToM deficits will result following dysfunction of the prefrontal cortex, especially the orbitofrontal cortex, and the amygdala [15,16,17].

Much of the interest in ToM has grown out of developmental psychology where the focus has been on the age at which different facets of ToM are attained. Understanding that the mind represents the world, as evidenced by tests such as the false belief task [18] emerges around 4 years of age [19]. To pass the task one needs to acknowledge that someone can hold a belief that does not accurately represent the world, for example, someone who did not see a bar of chocolate moved from the cupboard to a drawer, will most probably believe it remains in the cupboard. ToM also involves understanding emotional aspects of mental states: both 'simple' identification of people's emotion based on outwardly visible facial expressions and more complex inference of others' emotional experiences. Difficulty understanding emotional mental states is especially likely to lead to socially inappropriate behaviour and so this study focussed on tests of these aspects of ToM, namely the faux pas test and the "Reading the Mind in the Eyes test".

The faux pas test employs vignettes in which a character unintentionally says something that is awkward or hurts the feelings of another character. For example, on visiting a friend's new home the protagonist criticises the curtains, assuming they

belonged to the previous occupant and unaware that they have just been bought. To pass the task a participant must identify that something inappropriate has been said and explain why it is inappropriate. To do this they must understand the mental state of the protagonist: that she is unaware of a fact or acts on the basis of a mistaken belief. This is a more challenging task than the false belief test as it involves spontaneously thinking about beliefs and intentions, and attributing relatively complex emotional states based on these mental states. It is solved by typically developing children at around 9 to 11 years [17]. Studies of neurological patients have shown the reliance on the frontal lobe to solve the faux pas task. Thus, patients with orbitofrontal lesions fail the task [17] as do patients with frontal variant frontotemporal dementia [15] despite the latter patients having relatively normal executive function. Difficulties in resolving instances of faux pas in real life would be expected to lead to misunderstandings and potentially, conflicts.

Another commonly used test of a component of ToM is the "Reading the Mind in the Eyes Test" (RME test). This test differs from the false belief and faux pas tasks in that it does not necessitate an understanding of other people's mental states as representations of the world. Rather it requires the recognition of emotions which are based on mental states. It has been claimed that this test can reveal subtle mind reading deficits in adults with autism [20], (but see [21]). Participants are shown photographs of the eye region of a face and asked to choose which of 4 words most accurately describes what the person is thinking or feeling. Unlike the faux pas test, the RME test makes little demand on executive functions. Patients with frontal variant frontotemporal dementia [15], as with the faux pas test, show deficits on the RME task. Difficulties in recognising the emotions of others based on their mental states

might be expected to be associated with misinterpretations of the desires and intentions of others and this in turn could lead to social conflict.

The current paper reports an experiment in which the effects of acute alcohol intoxication in regular heavy social drinking young adults on ToM functioning were examined. It was hypothesised that acute alcohol consumption would result in ToM deficits as a result of its actions on the neural circuits that support this vital aspect of social cognition. The RME and faux pas test were used to assess ToM functioning so as to tap both emotional and cognitive aspects of ToM. A simple test of executive function was also run in order to check that the dose of alcohol consumed had compromised prefrontal functioning. Testing took place during a social event rather than in a laboratory in order to increase ecological validity of the experiment.

Methods

Ethical Considerations

This experiment was conducted as a part of final year undergraduate research projects. Ethical approval was granted by the Ethical Review Committee, School of Psychology, University of Birmingham. Participants were recruited on the basis that they regularly drank heavily, and their drinking was typical for the population (see [22]). Although formal data were not collected there was no reason to think that our participants met the criteria for alcohol use disorder, nor that they were taking other drugs. Participants while sober, prior to the evening of testing, were interviewed with respect to their regular drinking habits and informed consent obtained. It was made clear that the experimenters were not encouraging the participants to drink and that testing would only occur during an evening when the alcohol would have been consumed as a result of a prearranged social engagement. A debriefing was given on a separate occasion when participants were sober and issues relating to excessive alcohol consumption were raised.

Design

A within subjects design was used with alcohol intoxication being the independent variable. Thus, each participant was tested in both an intoxicated and sober state with the order of condition being counterbalanced. The dependent variables were scores on tests of executive function and ToM.

Measures

1. Tests of Executive Functioning

General executive function was tested using the FAS Test that measures verbal fluency (see 23). In this test the participant was asked to say as many words as s/he could think of beginning with F in 60 seconds. The procedure was repeated with the letter A and then S. Performance on this test is known to be impaired by alcohol consumption. Scanning studies have shown that the alcohol induced detriment in performance is associated with a lack of activation in anterior left dorsolateral prefrontal cortex [24].

2. ToM Tasks

Two ToM tasks were used, "The Faux Pas Recognition Test" (Adult Version) devised by Stone et al., [17] and the "Reading the Mind in the Eyes Test" taken from Baron-Cohen et al., [25]. The order of ToM tasks was counter balanced.

The Faux Pas task used 10 vignettes in each test session, (taken from Stone et al., [17] and Gregory et al., [15]) 5 of which included an incidence of faux pas. The other 5 vignettes were control vignettes which described a social interaction in which no faux pas occurred. Each vignette was read once by the experimenter. Participants were asked, "Did someone say something they shouldn't have?" Two non-social factual questions assessing comprehension and understanding of the vignette were then asked. For example, in a story about buying curtains for a new apartment the questions were "In the story, what had Jill just bought?" and "How long had Jill lived in this apartment?" If the participant had declared that nothing inappropriate was said, they progressed to the next vignette. If the participant had declared a faux pas 5 questions further assessed this: "Who committed the faux pas?", "Explain why the character shouldn't have said it", "Why did they say it?", "Did the character know

that they were saying something that they should not have said?" and "How would person Y have felt?" New vignettes were used in the second test session, counterbalanced between participants.

In the RME task 18 photographs of the eye region of faces (9 male/9 female) were presented in each test session. Each photograph was accompanied by 4 words, one of which captured the mental state being expressed. Participants selected the word they felt best described the emotion being expressed. For each correctly identified mental state the participant scored 1 point (maximum score 18 points). New photographs were used in the second test session, counterbalanced between participants.

Participants

20 undergraduate students, or recent graduates (7 female) aged 21 $\pm$ 1.1 years participated. All were regular heavy social drinkers and would have consumed alcohol on the evening of the test session irrespective of participating in the experiment.

Procedure

Participants were tested once they had consumed a set amount of alcohol. For male participants this was 8 units, for female participants it was 6 units. Testing took place within 2 hours of the start of drinking. Testing in the alcohol condition took place in a bar of the participant's choice. Testing in the sober condition took place in the participant's home. Although this meant that we could not control environmental conditions, the tests used do not require special conditions and there is no reason to think that participants' performance would have been unduly affected.. In the sober

condition, participants were required not to have consumed alcohol for 24 hours prior to testing. In each testing session participants completed the FAS word fluency test followed by the ToM tasks. The order of the faux pas recognition task and the RME task were counterbalanced.

RESULTS

Statistical Analysis

Data were analysed using t tests where data were suitable (FAS and RME) and Wilcoxon Signed Rank tests where non-parametric analysis was required (Faux Pas). We set α at .05.

1. FAS Word Fluency Task (test of executive function)

Participants generated significantly fewer words in the alcohol (Mean = 42.9, S.E. = $\pm$ 1.77) than in the sober condition (Mean = 55.2, S.E. = $\pm$ 2.63), $t(19) = 8.24$, $p < 0.01$ with a 23.3% reduction in performance.

2. Performance of ToM tasks

Faux Pas

In the sober condition accurate identification of faux pas in test vignettes was almost at ceiling. However, participants were less likely to identify faux pas correctly in the alcohol condition. Consumption of alcohol was associated with a deterioration of performance of about 10.1%. The difference in performance was significant (Wilcoxon signed rank test $Z = -2.89$, $p = .004$, See table 1).

Performance on the non-social factual questions was near ceiling in both the alcohol and sober conditions. A Wilcoxon signed rank test showed there to be no significant difference between the two conditions, $N = 20$, $Z = -0.142$, $p = .887$).

On a few occasions (18 out of 400) participants judged that a faux pas had occurred in a control vignette when in fact it had not. There was no significant

difference in this false alarm rate between conditions (Wilcoxon signed rank test Z = -1.64, p = .102)

Because participants demonstrated good comprehension of the vignettes (as assessed in the non-social questions), we examined their performance on the supplementary questions. These questions were asked if a participant stated that a vignette contained a faux pas. Performance on these supplementary questions is shown in table 2 expressed as a percent correct responses (as the number of questions asked of each participant varied according to how many examples of faux pas they correctly spotted). Scores for each of the 5 questions were lower in the alcohol condition compared to the equivalent score in the sober condition. A series of Wilcoxon signed rank tests showed each of the comparisons to be significant.

RME Task

Performance on the RME task was also impaired following alcohol consumption with scores in the alcohol condition (Mean = 13.9, S.E. = .49) being approximately 10% lower than in the sober condition (Mean = 15.4, S.E. = .34). A paired sample t-test showed this difference was significant, t(19) = 3.4, $p < 0.01$. Performance on the task was impaired in the alcohol condition, yet remained clearly above chance (25% correct).

DISCUSSION

The relatively modest amount of alcohol consumed by the participants was sufficient to compromise executive function as shown by the impairment on the FAS word fluency test. This implies that the dose of alcohol was sufficient to compromise some aspects of prefrontal function. The dose of alcohol was also sufficient to result in impairments on ToM as indicated by poor scores on the RME and Faux Pas tests. Participants were impaired on identifying when a faux pas had occurred and also performed poorly when explaining faux pas that were identified. These deficits occurred even though the participants were able to accurately answer the non-social comprehension questions associated with the faux pas vignettes and did not make an excessive number of false alarms when faux pas did not occur. Thus, although executive performance was impaired in the alcohol condition participants were able to comprehend the factual aspects of the faux pas vignettes. This implies that elements of non-social cognition had not been dramatically affected by the alcohol consumption. This therefore indicates that alcohol may result in a relatively specific impairment on mentalising and theorising about the actions of others.

Alcohol could potentially affect specific processes underpinning social cognition. If so, we might expect to see deficits on ToM tasks, but not on other similarly complex tasks. An alternative possibility is that ToM might be impaired because alcohol affects more general processes (such as executive function) because, by its very nature, ToM involves complex organisation and processing of information. In this case we would expect participants who had consumed alcohol to also be impaired on similarly complex reasoning tasks (such as counterfactual thinking, the

ability to imagine how things might have been otherwise, which we know is related to theory of mind developmentally, see Riggs, Peterson, Robinson et al, [26]). The fact that the participants in these studies performed poorly on both the faux pas test and executive function task may indicate that the latter explanation is more likely. However, it should also be noted that the participants showed deficits on the RME test which is thought to make little demand on executive functions. This implies that acute alcohol consumption can induce a relatively specific impairment on ToM functioning.

Regardless of whether the alcohol induced ToM deficit reflects a specific impairment, or a more general problem in complex reasoning, this deficit in social cognitive capabilities would be expected to have consequences for functioning in everyday life. Social drinking would be expected to be associated with poorer understandings of the emotions and intentions of others. Acute alcohol intoxication is associated with many undesirable social effects including the expression of aggressive and violent behaviours. The emergence of these behaviours can be attributed to the alcohol inducing a state of impulsivity as a product of loss of behavioural inhibition secondary to prefrontal dysfunction [10,27]. The data presented here, however, suggest that the problems of alcohol induced impulsivity could be aggravated by deficits in ToM functioning. Similarly Hoaken, Shaughnessy, and Pihl [28] concluded that aggression associated with acute alcohol consumption might result from executive cognitive dysfunction rather than being intrinsically related to increased impulsivity

A limitation of the current study was that it is not possible to know whether our participants had neuropathological damage as a consequence of long-term alcohol

abuse. Consequently, the deficits seen following acute alcohol consumption may reflect an interaction between intoxication and longer-term damage.

These observations show how alcohol consumption in our regular heavy social drinkers can lead to a breakdown in social cognition. This can leave the social drinker vulnerable to misinterpretation of social cues which could contribute to inappropriate social behaviour.

REFERENCES

1 Kershaw C, Budd T, Kinshott G, Mattison J, Mayhew P, Mayhill A: The 2000 British Crime Survey for England and Wales. Home Office, Statistical Bulletin 2000; 18:1-153.

2 Honkanen R: Alcohol in home and leisure activities. Addiction 1993; 88:939-944.

3 Abbey A, Zawacki T, Buck PO, Clinton AM, McAuslan P: Sexual assault and alcohol consumption: what do we know about their relationship and what types of research are still needed? Aggression and Violent Behaviour 2004; 9:271-303.

4 Thompson JC, Kao TC, Thomas RJ: The relationship between alcohol use and risk-taking sexual behaviors in a large behavioral study. Preventive Medicine 2005; 41:247-252.

5 Mitchell IJ, Rutherford V, Wrinch KAJ, Egan V: Paradoxical effects of alcohol intake in a convivial social setting on attitudes to violence', Addiction Research & Theory 2008; 15:1-11.

6 Giancola PR: Executive functioning: A conceptual framework for alcohol-related aggression. Experimental and Clinical Psychopharmacology 2000; 8:576-597.

7 Lyvers M: “Loss of Control” in alcoholism and drug addiction. A neuroscientific interpretation. Experimental and Clinical Psychopharmacology 2000; 8:225-249.

8 Peterson JB, Rothfleisch J, Zelazo PD, Pihl RO: Acute Alcohol-Intoxication and Cognitive-Functioning. Journal of Studies on Alcohol 1990; 51:114-122.

9 Weissenborn R, Duka T: Acute alcohol effects on cognitive function in social drinkers: their relationship to drinking habits. Psychopharmacology 2003; 165:306-312.

10 George S, Rogers RD, Duka T: The acute effect of alcohol on decision making in social drinkers. Psychopharmacology 2005; 182:160-169.

11 Apperly IA, Samson , Chiavarino C, Humphreys GW: Frontal and Temporo-Parietal Lobe Contributions to Theory of Mind: Neuropsychological Evidence from a False-Belief Task with Reduced Language and Executive Demands. Journal of Cognitive Neuroscience 2004; 16:1773-1784.

12 Perner J, Aichhorn M, Kronbichler M, Staffen W, Ladurner G: 'Thinking of mental and other representations: The roles of left and right temporo-parietal junction'. Social Neuroscience 2006; 1:245-258

13 Aichhorn M, Perner J, Weiss B, Kronbichler M, Staffen W, Ladurner G: Temporo-parietal junction activity in theory of mind tasks: falseness, beliefs, or attention. J. Cog. Neuroscience 2009; 21:1179-1192.

14 Saxe R, Kanwisher N:. People thinking about thinking people: The role of the temporoparietal junction in ‘‘theory of mind’’. NeuroImage 2003; 19:1835-1842.

15 Gregory C, Lough S, Stone S, Erzinclioglu S, Martin L, Baron-Cohen S, Hodges JR: Theory of mind in patients with frontotemporal dementia and Alzheimer’s Disease: Theoretical and practical implications. Brain 2002; 125:752-764.

16 Rowe AD, Bullock PR, Polkey, CE, Morris, RG: Theory of mind' impairments and their relationship to executive functioning following frontal lobe excisions. Brain 2001; 124:600-616.

17 Stone VE, Baron-Cohen S, Knight RT: Frontal lobe contributions to Theory of Mind. Journal of Cognitive Neuroscience 1998;10:640-656

18 Wimmer H, Perner J Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children’s understanding of deception. Cognition 1983; 13:103-128.

19 Wellman HM, Cross D, Watson J: Meta-analysis of theory-of-mind development: The truth about false belief. Child Development 2001; 72: 655-684.

20 Baron-Cohen S, Wheelwright S, Hill J, Raste Y, Plumb I: The "Reading the Mind in the Eyes" test revised version: A study with normal adults, and adults with Asperger Syndrome or high-functioning Autism. Journal of Child Psychology and Psychiatry 2001; 42:241-251.

21 Back E, Ropar D, Mitchell P: Do the eyes have it? Inferring mental states from animated faces in autism. Child Development 2007; 78:397-411.

22 Gill, JS: Reported levels of alcohol consumption and binge drinking withinthe UK undergraduate student population over the last 25 years. Alcohol and Alcoholism 2002; 37: 109-120

23Tombaugh TN, Kozak J & Rees L: Normative data stratified by age and education for two measures of verbal fluency: FAS and animal naming. Archives of Clinical Neuropsychology 1999; 14: 167-177

24 Wendt PE, Risberg J: Ethanol reduces rCFB Activation of left dorsolateral prefrontal cortex during a verbal fluency task. Brain and Language 2001; 77:197-215.

25 Baron-Cohen S, Ring HA, Wheelwright S, Bullmore ET, Brammer MJ, Simmons A, Williams SCR: Social intelligence in the normal and autistic brain: an fMRI study. European Journal of Neuroscience1999; 11:1891-1898

26 Riggs KJ, Peterson DM, Robinson EJ, Mitchell P: Are errors in false belief tasks symptomatic of a broader difficulty with counterfactuality? Cognitive Development 1998; 13:73-90.

27 Colder CR, Chassin L: Affectivity and impulsivity: Temperament risk for adolescent alcohol involvement. Psychology of Addictive Behaviors 1997; 11:83-97.

28 Hoaken PNS, Shaughnessy VK, Pihl RO: Executive cognitive functioning and aggression: Is it an issue of impulsivity? Aggressive Behaviour 2003; 29:15-30.

***Table 1**: Effect of alcohol intoxication on faux pas identification, means (± S.E.s)*

	Correct recognition faux pas presence (max score = 5)	Correct recognition faux pas absence (max score = 5)	Non-social Comprehension (max score = 20)
Sober	4.95 (± 0.05)	4.50 (± 0.17)	19.6 (± 0.18)
Alcohol	4.45 (± 0.10)	4.23 (± 0.18)	19.5 (± 0.44)

***Table 2**: Effect of alcohol intoxication on the detailed understanding of the correctly identified instances of faux pas*

	Mean percent correct *(± S.E.s)*			
	No alcohol	Alcohol	Wilcoxon Z	*p*
who committed	98.0 (± 1.39)	84.3 (± 3.47)	-2.80	.005
why committed	98.0 (± 1.39)	84.5 (± 2.88)	-3.07	.002
intention	98.0 (± 1.39)	83.5 (± 3.18)	-3.00	.003
accidental/deliberate	97.0 (± 1.63)	83.3 (± 3.94)	-2.80	.005
resulting emotions	99.0 (± 1.00)	87.5 (± 2.37)	-3.13	.002