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Binge drinking, reflection-impulsivity and unplanned sexual behaviour: Impaired decision-making in young social drinkers.

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32 **Abstract**

33 *Background.* The repeated pattern of heavy intoxication followed by withdrawal from alcohol
34 (i.e., ‘binge drinking’) has been found to have substantial adverse effects on prefrontal neural
35 systems associated with decision-making and impulse control. Repeated binge drinking has
36 been linked to risky and unplanned sexual behaviour, however few studies have examined the
37 role of impulsivity and related cognitive processes in understanding this association. The aim
38 of this study was to examine the relationship between binge drinking, ‘reflection-impulsivity’
39 (deficits in gathering and evaluating information during decision-making), alcohol-related
40 expectancies and unplanned sexual behaviour in a sample of university students.

41 *Methods.* Ninety-two university students completed the Alcohol Use Questionnaire (AUQ) to
42 measure alcohol intake and binge drinking. Two groups (low binge, high binge) were
43 generated from the AUQ data. The Information Sampling Task (IST: Cambridge Cognition
44 Ltd.) was used to measure reflection-impulsivity; the Alcohol Expectancy Questionnaire
45 (AEQ) for alcohol outcome expectancies; and an Unplanned Sexual Behaviour questionnaire,
46 which asked about the number of unplanned sexual events.

47 *Results.* When compared with the low-binge drinking group, the high-binge drinkers had
48 significantly more unplanned sexual encounters and were impaired on the IST, reflection-
49 impulsivity task. They scored higher on the alcohol expectancy factors of Sociability, Risk
50 and Aggression, Negative Self-perception, and in particular Liquid Courage. In a regression
51 analysis, number of unplanned sexual encounters, binge drinking score, and Liquid Courage
52 were all significantly related.

53 *Conclusions.* These results support the role of binge drinking in reduced impulse control and
54 decision-making deficits. The findings indicate that heavy binge drinkers demonstrate
55 impairments on an impulse control task similar to that observed in dependent samples and
56 this may be a factor in understanding the negative behavioural consequences associated with
57 excessive alcohol use.

58 **Keywords:** Binge-drinking, reflection-impulsivity, expectancies, unplanned sexual behaviour,
59 Information sampling task.

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63 1. Introduction

64 Binge drinking has been defined as the consumption of five or more drinks for men and four
65 or more drinks for women within two hours (Courtney & Polich, 2009) and represents a
66 particularly problematic, yet highly prevalent pattern of consumption amongst young adults
67 (e.g., Archie et al., 2012; Courtney & Polich, 2009). Specifically, a range of studies have
68 indicated that the binge drinking pattern is associated with numerous adverse psychological
69 and health related outcomes (e.g., Carlson et al., 2010). For example, binge drinkers are more
70 at risk of alcohol-related problems relating to impulsive behaviour, drink driving, alcohol
71 dependence, unplanned and risky sexual behaviour, and associated health, social and
72 economic consequences (Miller et al., 2007; Orchowski et al., 2012; Wechsler et al., 2000).

73 Of particular concern is that the binge pattern of consumption appears to have deleterious
74 effects on neural functioning (Lopez-Caneda et al., 2013; Maurage et al., 2012). That is, the
75 repeated pattern of heavy intoxication followed by withdrawal from alcohol has been found
76 to have substantial adverse effects on prefrontal neural systems associated with decision-
77 making and inhibitory control (Hermans et al., 2012; Maurage et al., 2012), a finding
78 consistent with studies into the neurotoxic effects of illicit drugs (e.g., Goldstein & Volkow,
79 2011; Jenstch & Taylor, 1999). Thus, neurobiological evidence suggests that not only is
80 binge drinking problematic due to the amount of alcohol consumed but more so due to the
81 specific pattern of intense use in a short period of time (Hermans et al., 2012).

82 However, from a methodological perspective, disentangling overall quantity of consumption
83 from drinking pattern presents a difficult task. In an attempt to discriminate between
84 different drinking patterns, Maurage et al. (2012) compared three drinking groups and a
85 control group on specific event related potentials (ERPs) pertaining to cognition and decision
86 making. Two of the drinking groups consumed the same overall amount of alcohol per week
87 (15-29 units) but, critically, differed in terms of consumption frequency. Specifically, the

88 'moderate binge' group consumed 5-12 drinks in 2-3 drinking sessions, whilst the 'daily
89 drinkers' consumed 3-5 drinks in 5-7 drinking sessions. A third drinking group 'intense
90 binge' comprised individuals who consumed over 30 drinks per week and were included to
91 examine the effects of overall quantity of use. Findings indicated that, when compared to the
92 daily drinkers, the moderate binge group displayed significant neural deficits as assessed by
93 the ERPs (Maurage et al., 2012). Thus, despite reporting the same overall weekly
94 consumption as the daily drinkers, the moderate binge drinkers were characterised by
95 impairments in neural functioning. This finding provides support for the proposal that the
96 binge *pattern* of alcohol consumption may have particular ramifications for specific neural
97 processes. Indeed, these results are in accordance with broader evidence demonstrating the
98 deleterious effects of excessive substance use on prefrontal areas responsible for decision
99 making, inhibitory control and impulsivity (Dawe et al., 2007; Duka et al., 2004; Jentsch &
100 Taylor, 1999; Hermans et al., 2012; Townshend & Duka, 2005).

101 Thus, the finding that repeated intense alcohol consumption affects prefrontal neural systems
102 responsible for impulse control (e.g., Jentsch & Taylor, 1999; Cardenas et al., 2007;
103 Goldstein & Volkow, 2011) is consistent with findings from studies implicating impulsivity-
104 related personality traits as correlates of drinking behaviour (e.g., Dawe et al., 2007;
105 VanderVeen et al., 2013). Interestingly, measures of impulsivity have also shown to
106 prospectively predict early experimentation with alcohol (e.g., McGue et al., 2001; Tarter et
107 al., 2004) and evidence also indicates that chronic use exacerbates impulsivity by impairing
108 neural systems responsible for impulse control in a similar manner to that seen in patients
109 with prefrontal cortex lesions (orbitofrontal area; e.g., Bechara & Damasio, 2002; Verdejo-
110 Garcia & Bechara, 2008). Taken together, these findings suggest that impulsivity is a
111 particularly relevant individual difference variable in understanding both the development
112 and maintenance of binge drinking behaviour (e.g., Gullo & Dawe, 2008). That is, a

113 heightened trait level of impulsivity may confer a predisposition toward excessive alcohol use
114 (McGue, et al., 2001; Tarter et al., 2005) and ongoing chronic consumption may further
115 exacerbate impulsive behaviour (e.g., de Wit, 2009) and thus increase binge drinking by
116 damaging neural systems responsible for impulse control (Balodis et al., 2010; Clark et al.,
117 2009; Jenstch & Taylor, 1999).

118 However, evidence indicates that impulsivity is a multidimensional construct (see Evenden,
119 1999) and various definitions have been proposed as relevant to understanding drinking
120 behaviour. Most studies have primarily focused on conceptualisations pertaining to rashness
121 (i.e., spur of the moment behaviour, disregard for negative consequences) and/or reward
122 sensitivity (i.e., increased sensitivity to and approach toward appetitive stimuli; Franken,
123 2002; Gullo et al., 2010, Kambouropoulos & Staiger, 2007). Of interest to the present
124 investigation however is a relatively unstudied aspect of impulsiveness which may be of
125 particular relevance to the study of binge drinking. Specifically, ‘reflection impulsivity’
126 (Kagan, 1966), deficits in the gathering and evaluation of information during the decision
127 making process (Solowij et al., 2012) may be critical to understanding the binge pattern of
128 consumption and associated negative consequences.

129 Indeed, using a behavioural task specifically designed to measure the ability to gather and
130 evaluate all available information (e.g., Information Sampling Task – IST; Cambridge
131 Cognition Ltd.), significantly reduced reflection has been found in chronic cannabis users
132 (Clark et al., 2009), and in current users of amphetamines and opioids (Clark et al., 2006).
133 Similarly, Lawrence et al. (2009) found that alcohol dependent individuals displayed
134 significantly lower levels of reflection on the IST relative to a sample of healthy control
135 participants. Fewer studies have examined the relationship between reflection impulsivity and
136 binge drinking, however the available evidence indicates that binge drinkers also display
137 deficits in inhibitory control on similar behavioural tasks (e.g., Henges & Marczyński, 2012;

138 Townshend & Duka, 2005). Thus, while limited, evidence suggests that a reduced capacity to
139 reflect may be an important factor in facilitating binge drinking and thus may help to explain
140 associated alcohol related negative consequences. To date however, few studies have
141 specifically assessed the role of reflection impulsivity in binge drinking and related adverse
142 behavioural consequences amongst young adults.

143 A potentially serious behavioural consequence of heavy drinking behaviour, which would
144 appear to be related to impulsivity, is an increased likelihood of unplanned sexual behaviour
145 (e.g., Bersamin et al., 2012; Orchowski et al., 2012; Poulin & Graham, 2001). For example,
146 in one study, Bersamin et al. (2012) reported that the number of times University students
147 reported being drunk was positively associated with frequency of sex with strangers.
148 Similarly, studies have found positive associations between drinking and unplanned sex (e.g.,
149 Corbin & Fromme, 2002), however, others have reported only inconsistent evidence
150 regarding this relationship (Veles-Blasini, 2008). Interestingly, the available evidence
151 implicates alcohol and sex related beliefs and expectancies as potentially important factors in
152 predicting sexual behaviour following excessive alcohol use (Brown & Vanable, 2009;
153 Orchowski et al., 2012). For example, Orchowski et al. (2012) reported that the belief that
154 alcohol would facilitate 'liquid courage' was significantly associated with 'regretted' sexual
155 behaviour following alcohol use amongst University students. These findings suggest that
156 students who expect alcohol to increase assertiveness are more likely to have engaged in
157 sexual behaviour that is perhaps unplanned and thus later regretted.

158 However, while there are numerous studies examining alcohol use and 'risky sexual
159 behaviour' (e.g., Brown & Vanable, 2007; Cooper, 2002) few studies have attempted to
160 explore potential explanations for the link between binge drinking and unplanned sexual
161 behaviour. Whilst the decision to engage in risky sexual behaviour can be a purposeful
162 planned action, *unplanned* sexual behaviour resulting from alcohol use is, it can be argued, a

163 qualitatively different behavioural outcome, probably more closely associated with
164 impulsivity. That is, individuals with high levels of impulsivity who binge drink may be
165 particularly likely to engage in *unintended* sexual behaviour due to a heightened tendency
166 toward ‘spur of the moment’ behaviour (e.g., non-planning; Whiteside & Lynam, 2001; see
167 also, Eysenck et al., 1987). Reflection impulsivity may be a particularly important variable in
168 this context as a reduced capacity to evaluate all available information effectively may be a
169 critical contributing factor to unintended and unplanned behaviour resulting from excessive
170 alcohol use. However, to date no studies have specifically examined the relationship between
171 reflection impulsivity, binge drinking, expectancies, and unplanned sexual behaviour.

172 Thus, the purpose of this study was to assess reflection impulsivity, expectancies, and
173 unplanned sexual behaviour in a sample of University students. A sample of ‘high-binge’
174 drinkers (median split: > 28.5 on the ‘binge drinking score’ derived from the Alcohol Use
175 Questionnaire; Mehrabian & Russell, 1978) were compared to a group of ‘low-binge’
176 drinkers on a validated behavioural index of reflection impulsivity (IST; Cambridge
177 Cognition Ltd.) and completed self-report measures of alcohol-related expectancies and
178 unplanned sexual behaviour. The hypotheses tested were that, a) high-binge drinkers would
179 display significantly lower levels of reflection as indexed by the IST when compared to low-
180 binge drinkers; b) high-binge drinkers would report significantly higher levels of unplanned
181 sexual behaviour relative to the low-binge drinkers; c) compared to low-binge drinkers, high-
182 binge drinkers would hold significantly more positive expectations regarding the effects of
183 alcohol; and d) drinking behaviour and alcohol-related expectancies (particularly liquid
184 courage) would significantly predict levels of unplanned sexual behaviour and IST-reflection
185 impulsivity.

186

187 **2. Materials and Methods**

188 **2.1 Participants**

189 Ninety five young, healthy volunteers who described themselves as social drinkers answered
190 an advertisement to take part in a study looking at the relationship between drinking patterns,
191 mood, and unplanned sexual behaviour. Volunteers with a history of neurological diseases,
192 drug or alcohol dependence were not included in the study. Self-reported alcohol intake for
193 the previous 24 hours was asked for and participants who had drunk more than 6 drinks on
194 the previous day were excluded. The criteria excluded 3 participants, 2 males and 1 female,
195 leaving a total of 92 participants (43 male and 49 female) between the ages of 18 and 34
196 (mean 22.3 SD 4.46).

197 **2.2 Measures**

198 *2.2.1 Alcohol Use Questionnaire (AUQ)*

199 A quantity-frequency, beverage-specific index of alcohol consumption for the previous 6
200 months was obtained using a revised version of the Alcohol Use Questionnaire (AUQ;
201 Mehrabian & Russell, 1978). The revised questions, by determining brands of liquor, allow
202 for actual alcoholic content (percentage volume) of drinks to be assessed. Participants were
203 asked to estimate the number of drinking days, the usual quantity consumed and the pattern
204 of drinking. The AUQ has previously been shown to be a reliable measure of drinking
205 quantity and drinking pattern (Townshend & Duka, 2002). *Binge drinking score:* A ‘binge
206 drinking’ score was calculated for all participants on the basis of the information given in
207 items 10, 11 and 12 of the AUQ [Speed of drinking (average drinks per hour); number of
208 times being drunk in the previous 6 months; percentage of times getting drunk when drinking
209 (average)] (Mehrabian & Russell, 1978). For this study two groups were created above and

210 below the median (28.5) of the binge drinking score (46 'high-binge' scorers, 46 'low-binge'
211 scorers, see Table 1).

212 2.2.2 Alcohol Expectancy Questionnaire (AEQ)

213 Based on the Comprehensive Effects of Alcohol Questionnaire (CEOA; Fromme et al, 1993),
214 the AEQ is a 38-item questionnaire, which assesses positive and negative expected effects of
215 alcohol consumption. There are seven expectancy factors, four positive (sociability, tension
216 reduction, liquid courage and sexuality), and three negative (cognitive and behavioral
217 impairments, risk and aggression, and negative self-perception).

218 2.2.3 Sexual Behavior Questionnaire:

219 This questionnaire was created specifically for the study and consisted of 16 questions around
220 sexual behavior, decision making, impulsivity and regret. The questions of relevance to this
221 paper were Q1 'Approximately how many times have you ever engaged in unplanned sexual
222 activity with non-partners or strangers?' Possible answers were 'never, once, 2 – 5 occasions,
223 6 – 10 occasions, 11 or more occasions.' Q12 'Generally, how would you rate yourself as a
224 decision maker?' Answers were on a 5 point scale from 'very bad' to 'very good'. Q13
225 'Generally, would you describe yourself as an impulsive person?' Answers were on a 5 point
226 scale from 'not at all impulsive' to 'very impulsive'.

227

228 2.2.5 Reflection Impulsivity: Information Sampling Task (IST; CANTAB Cambridge Cognition 229 Ltd.).

230 The IST measures reflection impulsivity on two sets of ten trials. Twenty five grey boxes are
231 presented on a 5x5 matrix with two coloured squares displayed beneath. The two squares
232 beneath are of different colours. When respondents touch any of the grey squares they turn to
233 one of the two colours displayed beneath and remain that colour for the duration of each

234 individual trial so there is no working memory requirement to the task. Participants are asked
235 to decide which colour is in the majority, basing their decision on the boxes revealed.

236 The IST has 2 conditions, Fixed Win (FW) and Decreasing Win (DW). The first 10 trials are
237 played in the FW condition with a win of 100 points for a correct choice and 100 points
238 deducted for a wrong choice, regardless of the number of boxes opened. In the FW condition
239 subjects are informed that they can open as many boxes as they choose before making their
240 decision. When they are ready to decide their decision is indicated by touching the box
241 beneath which corresponds with their majority colour choice. At this point they are informed
242 whether they have made a correct decision or not and awarded or deducted points
243 accordingly. In the second, DW condition, participants begin with 250 points but their score
244 decreases by 10 points for each box opened. Their score reduces by 100 points for an
245 incorrect choice, regardless of when they make their decision. Performance on the task is
246 measured by the number of boxes opened, the proportion of correct choices, the number of
247 incorrect responses, and the time taken to make a decision.

248

249 **2.3 Procedure**

250 The study was approved by the University of West London Psychology Ethics Sub-
251 committee. All volunteers gave their informed consent and were compensated for their time
252 with a £10 Amazon voucher. All procedures were conducted in a dedicated research
253 laboratory at the University of West London. Participants completed a brief demographics
254 questionnaire followed by the AEQ. The IST was then completed followed by the AUQ and
255 finally the sexual behaviour questionnaire.

256

257 **3. Results**258 *3.1 Demographics*

259 Table 1 shows the demographic data for the drinking pattern groups and separately for males
 260 and females. The high-binge drinking group drank more units per week [$t(90)=4.90$, $p <$
 261 0.001] and first became drunk at an earlier age [$t(88)=3.31$, $p < 0.001$]. There was also a
 262 significant but small difference between the ages of the groups with the low-binge drinking
 263 group being slightly older than the high-binge drinkers [$t(90)= 2.65$, $p = 0.01$]. High-binge
 264 drinkers smoked more cigarettes and more cannabis than the low-binge drinkers. Age, age of
 265 first getting drunk, smoking and cannabis use were entered as covariates where significant
 266 differences were found between groups.

267 [TABLE 1]

268 *3.2 Reflection Impulsivity: Information Sampling Task*

269 A repeated measures MANOVA was conducted for both the fixed and decreasing win
 270 condition to examine differences between groups on levels of reflection. There were four
 271 DVs (No. of boxes opened; P Correct [proportion correct choices]; total errors; latency) and 2
 272 groups (high-binge and low-binge). Condition (fixed win or decreasing win) was the within
 273 subject factor. There was an overall main effect of condition [$F(4,87) = 42.58$, $p < 0.001$, η^2_p
 274 $= 0.66$] and a significant condition by group interaction [$F(4,87) = 3.02$, $p = 0.02$, $\eta^2_p = 0.12$].
 275 The main effect of group was not significant ($p = 0.11$). Univariate analysis indicated
 276 significant interactions between condition and group on number of boxes opened [$F(1, 90) =$
 277 11.38 , $p < 0.001$, $\eta^2_p = 0.11$], P Correct [$F(1, 90) = 8.81$, $p = 0.02$, $\eta^2_p = 0.09$], and latency
 278 [$F(1, 90) = 7.92$, $p = 0.01$, $\eta^2_p = 0.08$]. Simple effects analysis revealed that in the fixed win
 279 condition the high-binge drinking group opened fewer boxes than the low-binge drinkers ($p <$
 280 0.001), scored lower on the mean P Correct ($p = 0.01$) and made more errors ($p = 0.04$).

281 However, in the decreasing win condition only the mean latency to respond differed between
282 groups, the high-binge drinkers were faster (see Figure 1). This effect was not significant
283 when cannabis use was entered as a covariate. All other effects remained significant after
284 controlling for age, age at first getting drunk, smoking and cannabis use.

285 [FIGURE 1]

286 *3.3 Alcohol Expectancies*

287 A multivariate analysis of variance (MANOVA) was conducted to examine group differences
288 on the 7 factors of the Alcohol Expectancy Questionnaire. The analysis revealed an overall
289 significant difference between the two drinking groups [$F(7, 84) = 2.23, p = 0.04, \eta^2_p = 0.16$].
290 Univariate tests indicated that the high-binge drinkers scored significantly higher on
291 expectations of sociability [$F(1, 90) = 6.79, p = 0.01, \eta^2_p = 0.07$], liquid courage [$F(1, 90) =$
292 $9.72, p < .001, \eta^2_p = 0.10$], cognitive behavioural impairment [$F(1, 90) = 5.46, p = 0.02, \eta^2_p =$
293 0.06], and risk and aggression [$F(1, 90) = 5.81, p = 0.02, \eta^2_p = 0.06$]. Table 2 provides means
294 and standard deviations for all seven AEQ subscales.

295 [TABLE 2]

296 *3.4 Unplanned Sexual Behaviour*

297 A one-way MANOVA was conducted to examine differences between the two binge groups
298 on the three questions drawn from the unplanned sexual behaviour scale. The analysis
299 indicated an overall difference between the groups [$F(3, 88) = 12.32, p < .001, \eta^2_p = 0.30$].
300 Specifically, when compared to low-binge drinkers ($\underline{M} = 2.13, \underline{SD} = 1.13$), the high-binge
301 drinkers ($\underline{M} = 2.98, \underline{SD} = 1.13$) reported significantly more frequent unplanned sexual
302 behaviour [$F(1, 90) = 13.03, p < 0.001, \eta^2_p = 0.13$]. Similarly, high-binge drinkers ($\underline{M} =$
303 $3.74, \underline{SD} = 1.08$) rated themselves as significantly more impulsive than the low-binge

304 drinkers ($M = 2.61$, $SD = 1.04$) [$F(1, 90) = 25.98$, $\eta^2_p = 0.22$]. There was no significant
305 difference between the groups on ratings of decision making efficacy.

306 *3.5 Associations between binge drinking, impulsivity, alcohol expectancies and unplanned*
307 *sexual behaviour.*

308 A final series of analyses were conducted to examine the relationships between binge
309 drinking, reflection impulsivity, expectancies and unplanned sexual behaviour. The variables
310 utilised in the following analyses explained the most between group variance (i.e., largest η^2_p)
311 in the preceding group difference tests. Of particular interest is the extent to which levels of
312 binge drinking and alcohol expectancies (i.e., liquid courage) predict performance on the IST
313 and rates of unplanned sexual behaviour. Thus, two hierarchical multiple regression analyses
314 were conducted. The first analysis regressed reflection (IST no. of boxes opened fixed
315 condition) onto binge score (step 1) and liquid courage (step 2). At step 1, binge score was
316 significantly and negatively associated with IST-reflection, accounting for 4.4% of the
317 variability, $R = 0.21$, [$F(1, 90) = 4.19$, $p < 0.05$]. Liquid courage was entered into the
318 analysis at step 2 (AEQ-LC) and accounted for an additional 4.3% of the variance, [$F_{\text{change}}(1,$
319 $89) = 4.16$, $p < 0.05$].

320 The second analysis examined the predictive relationship between binge drinking, liquid
321 courage and unplanned sexual behaviour. At step 1, binge score was significantly associated
322 with unplanned sexual behaviour, accounting for 18% of the variability, $R = 0.43$, [$F(1, 90) =$
323 19.97 , $p < 0.05$]. Liquid courage was entered into the analysis at step 2 (AEQ-LC) and
324 accounted for an additional 4.4% of the variance, [$F_{\text{change}}(1, 89) = 5.04$, $p < 0.05$]. Beta
325 weights, unstandardised coefficients and squared semi-partial correlations for both analyses
326 are presented in Table 3.

327

[TABLE 3]

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333**4. Discussion**

334 The results are generally consistent with predictions and indicate that a University sample of
335 heavy binge drinkers demonstrated impairments on a behavioural task measuring the ability
336 to gather and evaluate information during decision-making (i.e., reflection impulsivity).
337 Further, the high-binge drinking group scored significantly higher than low-binge drinkers on
338 specific alcohol-related expectancies and rates of unplanned sexual behaviour but no different
339 on a measure of mood. Interestingly, and consistent with a previous study (Orchowski et al.,
340 2012), expectations of 'liquid courage' (i.e., assertiveness) was a significant positive
341 predictor of unplanned sexual behaviour. Finally, expectations of liquid courage accounted
342 for additional unique variance in IST performance beyond binge drinking levels. Taken
343 together, these findings support previous work by highlighting the problematic nature of the
344 binge pattern of alcohol consumption (e.g., Maurage et al., 2012; Miller et al., 2007).
345 Specifically, binge drinking in this sample was associated with impairments in decision
346 making and impulse control, heightened positive expectations of drinking and elevated levels
347 of unplanned sexual activity.

348 Indeed, the reflection deficits observed in the high-binge drinking group is consistent with
349 previous work investigating IST performance in dependent drinkers (e.g., Lawrence et al.,
350 2009) and drug users (Clark et al., 2009; Solowij et al., 2012). In this sample, the binge
351 drinkers opened less boxes and made more errors (and lower proportion correct responses) in
352 the fixed win condition when compared to the low group. This finding is consistent with
353 Clark et al. (2006) who reported impaired IST performance in the fixed win condition for
354 current amphetamine and opiate users (see also Solowij et al., 2012). Thus, our findings

355 suggest that regular social drinkers who engage in repeated binge drinking episodes may be
356 as impaired as regular drug users in terms of the ability to gather and evaluate information
357 during decision making processes. It is possible that this deficit is due to the specific pattern
358 of heavy use followed by withdrawal periods that has been found to adversely affect
359 prefrontal neural systems responsible for decision-making and impulse control in both
360 alcohol and drug users (e.g., Hermans et al., 2012; Jentsch & Taylor, 1999; Maurage et al.,
361 2012).

362 This impairment in impulse control and decision-making associated with excessive alcohol
363 use (i.e., poor reflection) may manifest in a variety of problematic drinking-related cognitive
364 and behavioural consequences (e.g., Brown & Vanable, 2009). Specifically, the high-binge
365 drinking group was found to report increased levels of expectations that alcohol would
366 facilitate social cohesion, increase risk taking and aggression, increase cognitive/behavioural
367 impairment, and provide liquid courage. A particular behavioural consequence of interest to
368 this study was the relationship between binge drinking and the frequency of unplanned sexual
369 behaviour. Interestingly, both levels of binge drinking and the expectation that alcohol would
370 enhance assertiveness (liquid courage) were significant positive predictors of unplanned
371 sexual behaviour and reduced reflection. Thus, consistent with a previous study examining
372 sexual 'regret' (Orchowski et al., 2009), students who expect that alcohol will increase
373 assertiveness may be more likely to engage in impulsive unplanned sexual behaviour
374 following excessive drinking.

375 The finding linking alcohol expectancies with poor reflection is consistent with
376 neurobiological evidence indicating that positive expectancies in adolescence are related to
377 deficits in inhibitory neural processing during a go/no go task (Anderson et al., 2005). The
378 authors propose that such neural deficits may facilitate the development of maladaptive
379 positive expectancies and in turn may lead to heavier drinking behaviour (Anderson et al.,

380 2005). The finding of significantly poorer reflection in the high-binge group is therefore of
381 interest given that this is a sample of young, relatively inexperienced drinkers. Participants
382 with any history of alcoholism were excluded from the study and thus no individuals reported
383 a chronic long-term use pattern characteristic of dependent users. Despite this, our findings
384 suggest that excessive alcohol use, even at an early age is associated with the reduced
385 reflection characteristic of dependent users who suffer from prefrontal neurotoxicity (e.g.,
386 Hermans et al., 2012; Jentsch & Taylor, 1999; Maurage et al., 2012). Consequently,
387 impulsive behavioural responses such as an unplanned sexual activity resulting from alcohol use
388 may be more likely to occur (see also Solowij et al., 2012). Therefore, these findings add to
389 the growing body of evidence emphasising the deficits in inhibitory control associated with
390 binge drinking in young adults and thus further support the role of early alcohol intervention
391 techniques in emphasising the adverse consequences of alcohol-related impulsive behaviour.

392 A particular limitation of the findings pertains to the issue of directionality. The results
393 suggest that there is an association between binge drinking, impulsivity and unplanned sexual
394 behaviour but no direction can be inferred. An examination of the literature suggests that
395 heightened impulsivity during adolescence predicts earlier onset of problem drinking
396 behaviour (e.g., McGue, et al., 2001; Tarter et al., 2005). Therefore, high levels of
397 impulsivity might be a common risk factor for both binge drinking and risky sexual
398 behaviour. However, other studies have demonstrated that ongoing consumption has
399 deleterious effects on neural systems responsible for impulse control (e.g., Clark et al., 2009;
400 Jenstch & Taylor, 1999; Maurage et al., 2009). Thus, it is likely that an early predisposition
401 toward impulsive behaviour may render an individual particularly vulnerable to heavy
402 drinking which in turn may serve to further exacerbate impulsive behavioural outcomes.

403 In summary, this study contributes to the study of impulsivity and alcohol use by
404 demonstrating that unplanned sexual behaviour may be one outcome of binge drinking

405 behaviour. Thus, individuals who engage in regular binge drinking may have deficits in
406 utilising and evaluating all pieces of information during the decision making process (i.e.,
407 poor reflection) and are more likely to report unplanned sexual behaviour. Furthermore,
408 consistent with previous work (Orchowski et al., 2012), heavier binge drinkers expect that the
409 consumption of alcohol will increase assertiveness, and interestingly, this variable
410 (expectations of 'liquid courage') was also predictive of unplanned sexual behaviour.
411 Overall, the findings indicate that heavy binge drinkers demonstrate impairments on an
412 impulse control task similar to that observed in dependent samples and this may be an
413 important factor in understanding the many negative behavioural consequences associated
414 with excessive alcohol use.

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BINGE DRINKING AND REFLECTION IMPULSIVITY

598 Table 1
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Group characteristics	'Low-binge'			'High-binge'		
	Total M (SD)	Males M (SD)	Females M (SD)	Total M (SD)	Males M (SD)	Females M (SD)
Number	46	20	26	46	23	23
Age**	23.57 (5.33)	23 (5.39)	24 (5.34)	21.17 (3.01)	21.57 (3.02)	20.78 (2.97)
Alcohol units ¹ per week**	17.19 (12.54)	17.48 (15.76)	16.96 (9.71)	43.13 (33.62)	52.87 (42.26)	33.39 (18.12)
Binge drinking score**	15.04 (7.02)	13.55 (5.48)	16.19 (7.92)	61.24 (32.32)	70.26 (38.18)	52.21 (22.56)
Age of first drink	13.61 (3.04)	12.70 (3.51)	14.31 (2.43)	13.35 (2.70)	13.57 (2.86)	13.13 (2.58)
Age of first time being drunk**	16.20 (1.78)	16.26 (1.82)	16.15 (1.78)	15.04 (1.52)	15.13 (1.71)	14.95 (1.33)
Cigarette smokers** (previous 24hrs) (n)	6	1	5	23	14	9
Regular cannabis** (>3 x per week) (n)	1	0	1	13	11	2

600 ¹ One unit is 8 g of alcohol

601 ** p<0.005 differences between groups (binge drinkers and non-binge drinkers)

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611 Table 2.

Alcohol Expectancy Factors	Low-Binge (n=46) M (SD)	High Binge (n=46) M (SD)
Sociability *	27.97 (3.08)	29.48 (2.40)
Tension reduction	8.09 (1.74)	7.89 (1.80)
Liquid courage **	13.46 (2.65)	15.13 (2.50)
Sexuality	10.0 (2.66)	10.89 (2.71)
Cognitive & Behavioural Impairment *	24.96 (4.97)	27.33 (4.76)
Risk and aggression *	12.54 (3.14)	14.02 (2.73)
Negative self perception	7.45 (2.61)	7.85 (2.77)

612 * p < 0.05, ** p<0.01

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626 Table 3.

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POMS Factors	Low-Binge (n=46) M (SD)	High-Binge (n=46) M (SD)
Anxiety	0.55 (0.57)	0.47 (0.42)
Depression	0.34 (0.62)	0.18 (0.24)
Anger	0.25 (0.54)	0.21 (0.33)
Vigour	1.37 (0.90)	1.38 (0.60)
Fatigue	0.98 (0.73)	0.97 (0.70)
Confused	0.58 (0.57)	0.64 (0.50)

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BINGE DRINKING AND REFLECTION IMPULSIVITY

642 Table 4

	ΔR^2	B	SE	β	t	sr^2
<i>DV: IST-no. of boxes opened</i>						
<i>Step 1</i>	0.04*					
Binge score		-0.03	0.02	-0.21	-2.05*	0.04
<i>Step 2</i>	0.04*					
Binge Score		-0.02	0.02	-0.13	-1.20	0.01
Liquid Courage		-0.40	0.20	-0.22	-2.04*	0.04
Overall $R^2 = 0.09$, Adjusted $R^2 = 0.07$, $F(2, 89) = 4.25$, $p < .05$.						
<i>DV: Unplanned sexual behaviour</i>						
<i>Step 1</i>	0.18**					
Binge score		0.02	0.003	0.43	4.47***	0.18
<i>Step 2</i>	0.04*					
Binge score		0.01	0.004	0.34	3.43**	0.10
Liquid courage		0.10	0.05	0.23	2.25*	0.04
Overall $R^2 = 0.23$, Adjusted $R^2 = 0.21$, $F(2, 89) = 12.95$, $p < .001$.						

643 * $p < .05$, ** $p < .01$, *** $p < .001$.

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656 **Table legends**

657 Table 1. Demographic and alcohol use data for low and high binge groups.

658 Table 2. Scores on the Alcohol Expectancy Questionnaire for low and high-binge groups.

659 Table 3. Scores on the Profile of Mood States for low and high binge groups.

660 Table 4. Binge score and expectations of liquid courage as predictors of IST reflection and
661 unplanned sexual behaviour.

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682 **Figure legend**

683 Figure 1. Mean number of boxes opened (a), probability of being correct (b), errors (c) and
684 latency to open (d) for high-binge drinkers and low-binge drinkers across both the fixed-win
685 and decreasing-win conditions. Error bars represent \pm SEM.

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