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Binge drinking and sex: effects on mood and cognitive function in healthy young volunteers

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Abstract

This study compared the mood and cognitive performance of male and female teetotal and binge drinking students. The binge drinkers had significantly lower self-ratings of trait anxiety and depression and of state alertness at the time of testing than did the teetotallers. The females had significantly higher ratings of trait and state anxiety, but there were no Sex × Bingeing interactions on mood. The binge drinkers made significantly fewer correct responses in a test of sustained attention and recalled fewer line drawings. There was a significant Sex × Binge interaction in a spatial recognition task because the male, but not the female, binge drinkers were slower to make correct responses. Males performed better than females in both the spatial and pattern recognition memory tasks. There were three tests of executive function. In a spatial working memory task, males performed better than females, but there were no effects of binge drinking. There were no effects in a test of mental flexibility. However, in a test of planning, the binge drinkers were significantly slower than the teetotallers were. Thus, compared with a group of teetotallers, the binge drinkers had lower trait anxiety and depression and poorer performance in tests of sustained attention, episodic memory and planning ability.

Keywords: Alcohol; Binge drinking; Attention; Memory; Executive function; Planning ability

1. Introduction

Surprisingly, only 30–60% of adult alcoholics have been found to have neuropsychological impairments (Grant et al., 1984). Drinking variables, such as amount consumed and duration of drinking, cannot account for the cognitive deficits of alcoholics, and Parsons and Stevens (1986) suggested that they might be related to the number of withdrawal episodes. Several studies suggest that the pattern of drinking is an important factor. Hunt (1993) suggested that the risk of developing brain damage was greater in binge drinkers, and Wechsler et al. (1994) found that alcohol-related problems were related to a pattern of binge drinking. Glenn et al. (1988) found that the number of withdrawals was linked to poor memory in adult alcoholics. Alcohol-dependent adolescents had significant impairments of long-term nonverbal memory that was linked to the number of withdrawals, especially in boys.

A decade ago, we surveyed the drinking and lifestyle habits of 774 medical and dental students in London (File et al., 1994). One third of the male students in Years 1–3 were drinking above the government guidelines of safe drinking (>21 units/week), and 12–22% of the female students drank >15 units/week. By the fifth year, the percentage of males drinking >21 units/week had risen to 59%. In the group of male students identified as drinking at dangerous levels (>40 units/week), there was a clear pattern of binge drinking, with 100% of them drinking >10 units on one or more occasions per week and at least half of their total alcohol intake occurring at weekends. Of this group, 65% had been physically hurt or had hurt others as a result of their drinking, and 30% drank at lunchtime more than once a week. In recent years, there has been an increase in the incidence of binge drinking, and this has been particularly marked in young women (Office for National Statistics, London, 2002). In a recent study, Weissenborn and Duka (2003) compared student bingers and nonbingers and found

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that the bingers showed significantly worse performance in a test of spatial working memory and in a pattern recognition task. No other differences in cognitive performance were found. The purpose of the present study was to compare the mood and cognitive performance of a group of teetotal students with that of a group of binge drinkers and to determine whether there were any sex differences. The cognitive test battery included tests of sustained attention, memory and executive function.

In addition to government definitions of binge drinking, we calculated binge scores as defined by Townshend and Duka (2002) on the basis of the information 'drinks/h', 'times being drunk in the last 6 months' and 'percentage of time getting drunk when going out', as extracted from the Alcohol Use Questionnaire (AUQ; Mehrabian and Russell, 1978). This binge score is derived from the relationship between alcohol intake and drinking patterns and thus provides an overall view of habitual alcohol use. For example, a participant with a high binge score may have a similar weekly intake of alcohol with those with a lower binge score but would consume the majority of the alcohol in a single session. In a study of 61 university students, Townshend and Duka (2002) found that the relationship between these 'binge scores' and alcohol intake showed little correlation (r=.23; n.s.), whereas a highly positive correlation (r=.58; P<.01) was seen between number of drinks/h and the amount of alcohol consumed, indicating that the binge score is unrelated to the amount of alcohol drunk. As bingeing behaviour may be a key factor for increased alcohol dependency and cognitive impairment (Hunt, 1993; Stephens, 1995), it is important to distinguish between alcohol intake and patterns of drinking.

Table 1
Testing schedule

	Testing schedule
Pretest session	Consent form
	Exclusion questionnaire
	HAD
Testing session	CANTAB practice—IDED, SOC, SWM
	NART
	Word list
	Bond and Lader mood rating scale
	Alcohol and caffeine questionnaire
	AUQ
	IDED
	SOC
	Spatial working memory
	Spatial recognition memory
	Pattern recognition memory
	Word list recall
	Line drawing recall
	PASAT

2. Methods

The test order is given in Table 1.

2.1. Participants

Student volunteers (aged 18–23 years) were recruited from the undergraduate population at King's College London to take part in an experiment on the cognitive effects of Gingko biloba, for which they were paid £10. Participants gave written informed consent. The study was approved by the King's College Research Ethics Committee. All the students were first tested undrugged, before the start of the Ginkgo or placebo treatment. On the basis of replies to the AUQ and weekly diaries of their last week's and a typical week's alcohol consumption, we identified a group of teetotal students (six males and seven females). A group of binge drinkers (nine males and five females) was identified following the UK government definition of binge drinking, i.e., consuming 10 units (8 g alcohol, e.g., half an imperial pint of beer or a 12.5 ml glass of wine) on a single occasion (Broomfield et al., 1999), and the frequently used U.S. definition of >5 drinks/occasion for males and >4 drinks/occasion for females (Wechsler et al., 1995), and also on the basis of their binge scores extracted from the AUQ (individual score $\geq$ 24; Townshend and Duka, 2002). All participants were fluent in English, and a measure of verbal IQ was taken using the National Adult Reading Test-revised version (NART-R; Nelson and Willison, 1991).

2.2. Mood ratings

The Hospital Anxiety and Depression Scale (HAD; Zigmond and Snaith, 1983) was completed prior to the start of the test session and measures trait anxiety and depression because the questions refer to 'how you usually feel'. Self-ratings of mood state were assessed using the Bond and Lader (1974) visual analogue rating scales. For the mood scales, each item consisted of a pair of opposite adjectives separated by a 100-mm line. The participant indicated how they felt at the time by placing a perpendicular mark at the appropriate place along each line. Three independent factors, measuring alertness, well-being and anxiety, can be extracted from these scales. These scales were completed after about 10 min of testing, just after the presentation of the line drawings and word list (see Table 1).

2.3. Cognitive tasks

2.3.1. Sustained attention

The Paced Auditory Serial Addition Test (PASAT) was used to measure sustained attention (Spreen and Strauss, 1991). This involved adding together successive pairs of digits read from a list of 61 numbers, presented at different speeds from one digit every 2.7 s to one every 1.2 s. This is a difficult test to master, and the first two tape speeds (2.7 and 2.0 s) were used as practice. The two fastest speeds, 1.6 and 1.2 s, were used to assess performance. The total number of correct responses (maximum 60) was recorded for each of these two trials.

2.3.2. Tests of episodic memory

2.3.2.1. Recall tests of long-term memory. There were two recall tests of long-term episodic memory. The first involved the presentation of 20 line drawings of common objects. The participants were asked to recall as many as possible after a period of 25 min. The second test involved the presentation of a list of 36 words. The participants were asked to recall as many as possible after a period of 25 min.

2.3.2.2. Pattern and spatial recognition memory. This task employs a delayed match to sample paradigm, taken from the Cambridge Neuropsychological Test Automated Battery (CANTAB, CeNeS, Cambridge), which measures recognition memory for visual patterns and spatial location (Morris et al., 1987). For the pattern recognition test, the participants are presented with a series of geometric patterns presented sequentially for 3 s. The participants are then presented with two geometric patterns, one of which is familiar from the previous set. The participants are required to touch the familiar pattern. The percentage of correct responses and the time taken to perform a correct response were recorded. For the spatial recognition test, participants were presented with empty boxes at different locations on the screen. They were then presented with two boxes, one of which is positioned in a location previously shown. The participants are required to touch the box positioned at a previously seen location. The percentage of correct responses and the time taken to correctly respond were recorded.

2.3.3. Tests of executive (frontal lobe) function

2.3.3.1. Spatial working memory. This is a self-ordered search task also from the CANTAB test battery, which requires participants to search through a spatial array of boxes to collect tokens hidden inside. At any one time, there will be one single token hidden. The key instruction is that once a blue token has been found inside a box, then, that box will never be used again to hide a token. There are trials of four, six and eight boxes. Errors (between-search) are recorded when a box from which a token has been taken is revisited. A ‘‘strategy score’’ is also obtained, and a higher score indicates a poorer strategy.

Table 2
Mean (± S.E.M.) age (years), verbal IQ, body mass index (BMI), number of cigarettes smoked/day and daily caffeine intake (cups/day) of male and female teetotallers and binge drinkers

	Teetotallers		Bingers	
	Male ($n=6$)	Female ($n=7$)	Male ($n=9$)	Female ($n=5$)
Age	20.3 ± 0.6	21.4 ± 0.4	21.8 ± 0.3	21.0 ± 0.8
Verbal IQ from NART	102.7 ± 1.9	104.6 ± 2.4	108.0 ± 2.3	105.4 ± 2.8
BMI	22.9 ± 1.0	21.5 ± 0.8	23.5 ± 0.9	22.1 ± 1.1
Number of cigarettes/day	0.3 ± 0.3	1.7 ± 1.7	1.3 ± 1.1	2.2 ± 2.0
Daily caffeine intake (cups)	3.9 ± 1.3	2.1 ± 0.6	3.6 ± 0.7	4.0 ± 1.6

Table 3
Mean (± S.E.M.) alcohol intake (units typical week and units last week), total score on AUQ, number of times drunk in past 6 months, percentage of time getting drunk when drinking, number of drinks/h and binge drinking scores of male and female bingers

	Bingers	
	Male ($n=9$)	Female ($n=5$)
Alcohol intake—typical week (units)	22.0 ± 4.6	15.6 ± 3.2
Alcohol intake—last week (units)	22.0 ± 4.9	19.4 ± 7.9
AUQ total	58.7 ± 5.0	49.6 ± 5.1
Number of times drunk in past 6 months	23.6 ± 4.6	15.4 ± 3.9
Percentage time drink get drunk	42.6 ± 9.9	34.0 ± 13.2
Number of drinks/h	2.9 ± 0.3	3.4 ± 0.7
Binge drinking score (Townshend and Duka, 2002)	43.6 ± 5.4	35.8 ± 4.8

2.3.3.2. Mental flexibility. The IDED test, taken from the CANTAB, is a test of rule learning, reversal and shifting and provides a measure of mental flexibility, which is controlled by the frontal cortex (Owen et al., 1991). A series of pairs of patterns were presented on a computer screen, and the task was to learn the rule that determined which pattern was correct. Once the rule was correctly learned, this rule was reversed or shifted. The time taken to complete each stage was recorded, along with the total number of trials and errors to complete the task.

2.3.3.3. Planning ability. Planning ability was measured using the Stockings of Cambridge (SoC) test from the CANTAB, which has also been shown to be a measure of frontal lobe function (Owen et al., 1990). The computer screen displayed two sets of three coloured balls that could be housed in three stockings. The task was to move the balls in the lower part of the screen so that the pattern exactly matched that shown in the upper part. Response times are recorded during the performance. Dependent variables in this task were the minimum number of moves to complete the task, the time to initiate a move (initial thinking or planning time) and the time it takes to perform the solution (subsequent thinking time).

2.4. Statistics

The data from the cognitive tests were analysed by one-tailed t tests, with the directional hypothesis that the binge drinkers would have a poorer performance. A priori power estimates for our sample size ranged from 0.87 to 0.90. The results of the t tests are presented only when they reached significance. In addition, the mood scores and the cognitive data were analysed with two-way analyses of variance (ANOVA), with bingeing as one factor (teetotal vs. binge) and sex as the second. This allows the determination of whether alcohol bingeing has different effects on cognition in males and females (shown by a significant Binge × Sex interaction), as well as an assessment of sex differences (shown by a main effect of sex) and alcohol bingeing (shown by a main effect of bingeing). A priori power estimates for these analyses were 0.88. When the error scores were not normally distributed, they were analysed by Mann–Whitney U tests. To determine whether there was any relationship between the speed of responding and the accuracy of responses in the spatial recognition memory task, Pearsons Product–Moment Correlation coefficients were calculated.

3. Results

3.1. Volunteer characteristics

It can be seen from Table 2 that the four groups did not differ in age [$F(1,23) = 1.8$, n.s.], verbal IQ, BMI, smoking or caffeine intake ($F < 1.0$ in all cases, n.s.).

3.2. Alcohol consumption

Table 3 shows that the male and female binge drinkers did not differ significantly in their typical weekly alcohol consumption ($F < 1.0$, n.s.), their previous week's consumption ($F < 1.0$, n.s.) or in their binge drinking score [$F(1,12) = 1.4$, n.s.].

3.3. Mood ratings

3.3.1. Hospital anxiety and depression scale

The female students had significantly higher anxiety ratings than did the males [$F(1,23) = 18.4$, $P < .0001$], and the teetotal students had significantly higher anxiety than did the binge drinkers [$F(1,23) = 5.0$, $P < .04$], but there was no Sex × Bingeing interaction ($F < 1.0$, n.s.; see Fig. 1).

The teetotal students had higher ratings of depression than did the binge drinkers [$F(1,23) = 5.6$, $P < .03$], but there were no significant sex effects or Sex × Bingeing interaction ($F < 1.0$ in both cases, n.s.; see Fig. 1).

3.3.2. Bond and Lader mood ratings

The female students had higher ratings on the state anxiety factor than did the males [$F(1,23) = 5.5$, $P < .03$], but there were no significant effects of binge drinking [$F(1,23) = 1.9$, n.s.] or Sex × Binge interaction ($F < 1.0$, n.s.; see Fig. 1). The

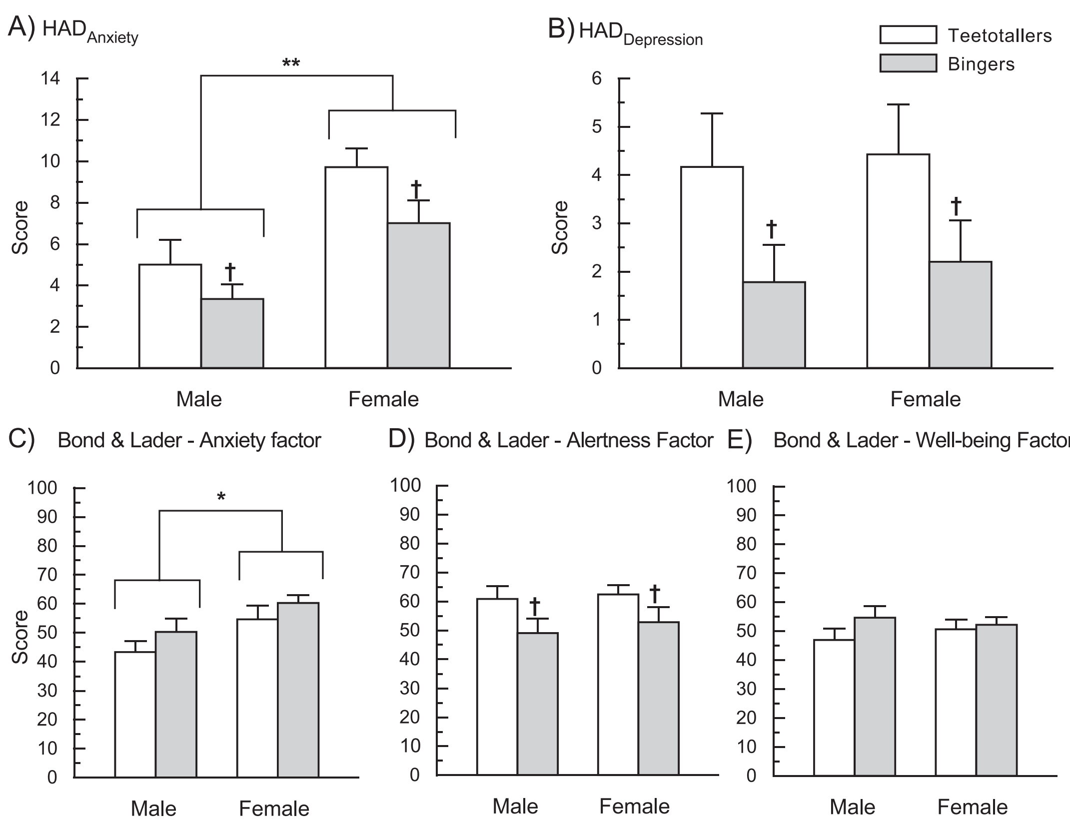

Fig. 1. Mean (± S.E.M.) HAD anxiety (Panel A) and depression scores (Panel B), Bond and Lader mood ratings of anxiety (Panel C), alertness (Panel D), and well-being (Panel E) for male and female teetotallers and binge drinkers. †$P < .05$ significant difference between teetotallers and bingers. * $P < .05$, ** $P < .001$ significant sex difference.

binge drinkers had significantly lower ratings on the state of alertness factor than the teetotallers did [$F(1,23) = 4.9$, $P < .04$], but there was no significant sex effect or Sex × Binge interaction ($F < 1.0$ in both cases; see Fig. 1). There were no significant effects on the factor of well-being [$F(1,23) < 1.4$ in all cases, n.s.; see Fig. 1].

3.4. Cognitive tests

3.4.1. Sustained attention

Binge drinkers made significantly fewer correct responses in the two hardest stages of the PASAT ($t = 1.7$, $P < .05$; $t = 2.2$, $P < .02$). This was confirmed by the two-way ANOVA [$F(1,23) = 4.2$, $P = .05$], but there was no effect of sex or Sex × Binge interaction ($F < 1.0$ in both cases, n.s.; see Fig. 2A).

3.4.2. Episodic memory

3.4.2.1. Recall tasks of long-term memory. The binge drinkers recalled significantly fewer line drawings than did the teetotallers ($t = 1.8$, $P = .04$). The two-way ANOVA also showed an effect of binge drinking [$F(1,23) = 3.3$, $P = .08$], but there was no significant sex effect or Sex × Bingeing interaction ($F < 1.0$ in both cases, n.s.; see Fig. 2B]. There were no significant effects in the word recall task [$F(1,23) < 1.0$ in all cases; n.s.; see Table 4].

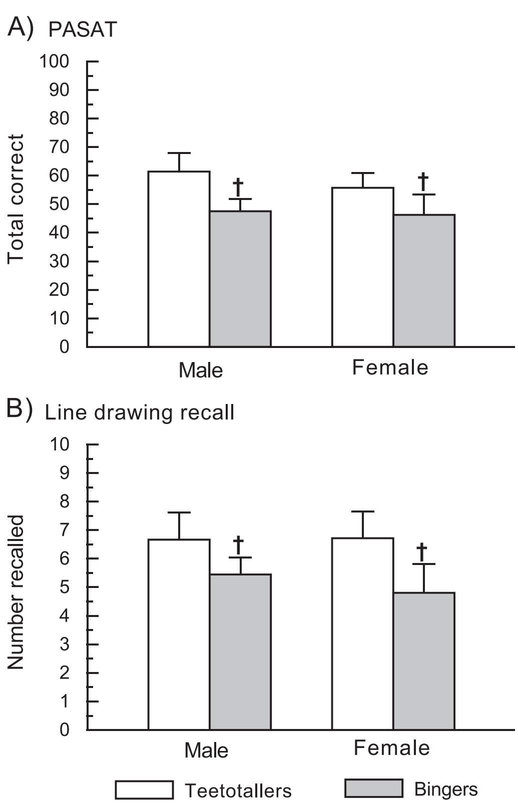

Fig. 2. (A) Mean (± S.E.M.) total correct (out of 120) on PASAT test for male and female teetotallers and binge drinkers and (B) mean (± S.E.M.) total number of line drawings recalled. †$P < .05$ significant difference between teetotallers and binge drinkers.

Table 4
Mean (±) number of words and line drawings correctly recalled, percentages of correct responses in pattern and spatial recognition memory, mean latencies for correct responses in recognition memory tests, total errors made between searches and errors made between searches in the eight-box test of spatial working memory for male and female teetotallers and binge drinkers

	Teetotallers		Bingers	
	Male ($n = 6$)	Female ($n = 7$)	Male ($n = 9$)	Female ($n = 5$)
Long-term memory				
Word recal	7.3 ± 2.0	4.9 ± 1.3	7.8 ± 1.9	7.6 ± 1.9
Line drawing recall	6.7 ± 1.0	6.7 ± 0.9	5.4 ± 0.6	4.8 ± 1.0
Pattern recognition memory				
Percent correct (%) *	95.8 ± 2.6	89.3 ± 4.8	94.5 ± 2.2	83.2 ± 6.1
Mean correct latency (ms)†	1623 ± 92	2152 ± 118	1859 ± 108	2324 ± 342
Spatial recognition memory				
Percent correct (%)*	90.8±4.5	70.7±1.3	84.4±5.2	67.6±14.4
Mean correct latency†	1921±234	2391±203	2086±100	1712±98
Spatial working memory				
Between-search errors (Total) *	11.8 ± 2.7	18.4 ± 5.2	8.6 ± 2.4	22.2 ± 8.1
Between-search errors (eight boxes) *	9.3 ± 2.8	14.4 ± 4.6	5.3 ± 1.7	17.0 ± 5.1
Strategy	31.7 ± 1.6	31.3 ± 2.2	26.2 ± 1.8	32.2 ± 1.5

* $P < .05$ significant sex difference, see text for details.
† $P < .05$ significant Sex × Binge interaction, see text for details.

3.4.2.2. Pattern recognition memory. There was a significant sex effect on the percentage of correct responses in the pattern recognition task, with males performing better [$F(1,23) = 5.2$, $P = .03$], but no effect of binge drinking or Sex × Binge interaction ($F < 1.0$ in both cases, n.s.; see Table 4). There was also a significant effect of sex on the latency to make correct responses, with males being faster [$F(1,23) = 9.1$, $P < .01$], but no effect of sex or Sex × Binge interaction ($F < 1.5$ in both cases, n.s.).

3.4.2.3. Spatial recognition memory. There was also a significant effect of sex on the percentage of correct responses in the spatial recognition task, with males performing better [$F(1,23) = 7.5$, $P = .01$], but no effects of binge drinking or Sex × Binge interaction ($F < 1.0$ in both cases). However, there was a significant Sex × Binge interaction for the latency to make correct responses [$F(1,23) = 6.2$, $P = .02$], with binge-drinking males having a slower response time than teetotal males do, whereas binge drinking females had a faster response time than teetotal females do (see Table 4). The groups showed some interesting differences in the relationship between accuracy and speed of responding in this task. The binge drinking females showed a high positive correlation ($r = .80$) because the scores were either slow, but accurate or fast and inaccurate.

The female teetotallers also showed a positive correlation, but in this group, the correlation was less strong (.48). The males all showed good performance in this task, but whereas the male bingers showed little relationship between speed and accuracy (r=.2), male teetotallers showed a strong negative correlation ($r = -.71$) because those who had the highest accuracy were also the fastest.

3.4.3. Tests of executive function

3.4.3.1. Spatial working memory. Over the whole task, the female students made significantly more errors of revisiting a location from which a token had been taken on a previous trial [between-search errors $F(1,23) = 4.9$, $P < .04$; see Table 4]. This was particularly marked for the most difficult eight-box task [$F(1,23) = 5.6$, $P < .03$]. There were no effects of binge drinking or Sex × Bingeing interactions ($F < 1.0$ in all cases, n.s.). There were no significant effects on the strategy used in this task [$F(1,23) < 2.7$ in all cases, n.s.; see Table 4].

3.4.3.2. Mental flexibility. There were no significant effects on this task, except for the number of errors made in the extradimensional shift stage, in which male binge drinkers made fewer errors than the male teetotallers (Mann–Whitney, $z = 2.0$, P=.04; see Table 5).

3.4.3.3. Planning ability. There was a significant effect on the initial thinking (planning) time, with binge drinkers being significantly slower than teetotallers were on the two-, four- and five-move problems ($t = -2.1$, $P < .03$; $t = -2.4$, $P < .02$; $t = -2.3$, $P < .02$, respectively). The two-way ANOVA also showed an effect of binge drinking [$F(1,23) = 5.8$, $P < .025$; see Fig. 3]. There were no significant effects of sex or Sex × Binge interaction ($F < 1.0$ in all cases). There were no significant effects on the subsequent thinking times, i.e., the times to complete the task after the initial move or on the problems solved in the minimum moves, although there was a tendency for the males to perform better [$F(1,23) = 3.0$, $P < .10$; see Table 5].

3.4.4. Bingeing or high alcohol?

To try to separate the effects of binge drinking from the level of alcohol consumption, we divided our binge drinkers into two groups according to their typical alcohol consumption. Those in the lower half had < 18 units/week of typical alcohol consumption (two males, three females), and those in the higher half had >20 units/week (five males, two females). These two groups of course differed significantly in their typical alcohol intake [$F(1,12) = 22.6$, $P < .0001$], but did not differ in their binge scores ($F < 1.0$, n.s.; see Table 6). The groups also differed in their self-ratings of well-being, with the high alcohol group scoring significantly higher [$F(1,12) = 8.3$, P=.01]. The groups also differed significantly in their mean latencies to respond correctly in the spatial recognition task [$F(1,12) = 4.8$, P=.05]. However, they did not differ significantly on any of the other cognitive measures for which differences had been found between binge drinkers and teetotallers [see Table 5; $F(1,12) < 4.3$ in all cases, n.s.].

Table 5
Mean (± S.E.M.) scores of male and female teetotallers and binge drinkers for measures in the IDED and SoC tests

	Teetotallers		Bingers	
	Male (n=6)	Female (n=7)	Male (n=9)	Female (n=5)
IDED				
Completed stage errors	7.7 ± 1.1	11.7 ± 3.2	13.0 ± 1.2	9.6 ± 1.2
Completed stage trials	59.7 ± 4.1	68.6 ± 11.1	68.6 ± 3.0	67.2 ± 4.8
Pre-EDS errors	4.8 ± 0.7	11.9 ± 3.9	7.9 ± 1.4	6.6 ± 0.4
EDS errors	10.8 ± 4.6	2.6 ± 0.7	3.6 ± 1.3	7.2 ± 4.5
Stages completed	8.3 ± 0.4	8.0 ± 1.0	9.0 ± 0.0	8.6 ± 0.4
Total errors (adjusted)	24.5 ± 9.8	37 ± 24.0	13.0 ± 1.2	19.6 ± 9.1
Total trials (adjusted)	93.0 ± 17.3	119 ± 41.6	77.3 ± 3.0	87.2 ± 16.2
Latencies (ms)				
Simple discrimination	1021 ± 88	1547 ± 206	1333 ± 178	1692 ± 474
Simple reversal	956 ± 123	1160 ± 223	1348 ± 239	875 ± 48
Compound discrimination I	1199 ± 139	1554 ± 196	1669 ± 144	1529 ± 111
Compound discrimination II	1019 ± 105	1157 ± 156	1156 ± 92	1245 ± 50
Compound reversal	971 ± 99	1027 ± 129	1110 ± 88	1103 ± 127
ID shift	940 ± 77	1119 ± 124	1213 ± 87	1067 ± 33
ID reversal	864 ± 32	953 ± 84	1024 ± 80	920 ± 73
ED shift	1062 ± 102	1285 ± 127	1271 ± 66	1183 ± 143
ED reversal	979 ± 58	1152 ± 100	1075 ± 50	1106 ± 75
Stockings of Cambridge				
Subsequent thinking time (ms)				
Two-move problem	77.2 ± 58.7	37.9 ± 37.9	27.0 ± 27.0	104.3 ± 97.1
Three-move problem	29.7 ± 29.7	259 ± 217	137 ± 82.8	70.2 ± 39.0
Four-move problem	630 ± 239	869 ± 238	1101 ± 402	735 ± 143
Five-move problem	401 ± 152	470 ± 216	896 ± 310	469 ± 211
Tasks completed in minimum moves	9.0 ± 1.0	7.4 ± 0.3	8.2 ± 0.6	7.4 ± 0.8

4. Discussion

The students in the present study were mainly third year students, and whilst the typical weekly alcohol consumption of the males was similar with the mean found 10 years ago, the intake in the female students in the present study is about 2.5 times higher. Although this could be an artefact of the small sample in the present study, the indication of increased alcohol consumption in female binge drinkers is in agreement with findings in a recent survey by the Office for National Statistics, London (2002). The level of caffeine consumption was similar with that found 10 years ago, but the incidence of smoking was much lower.

With only the two groups studied, we are unable to say whether the mood differences are primarily due to the teetotal or to the binge drinking group, or whether changes in both groups contribute to the results. The interpretation of the mood differences may be further complicated by the

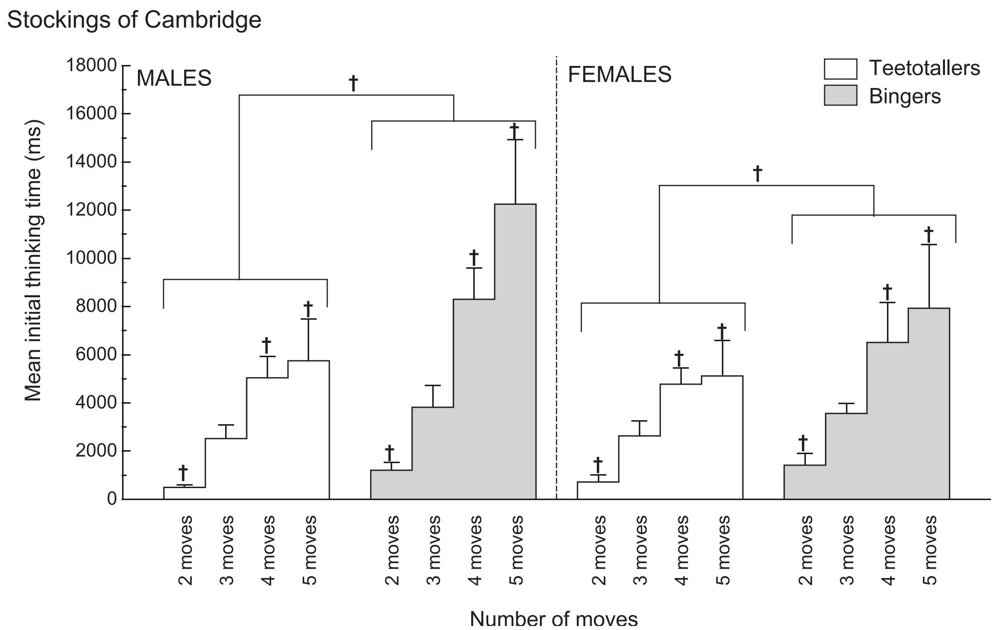

Fig. 3. Mean (± S.E.M.) initial thinking time (planning) time for male and female teetotallers and binge drinkers in the 2, 3, 4, and 5 move tasks of the stockings of Cambridge test.[†]$P < .05$ significant difference between teetotallers and binge drinkers.

groups differing in the percentage of students with an Asian background (85% in the teetotal group, 21% in the binge group). To see whether the mood differences reflected the ethnicity, rather than the intake of alcohol, we compared all of the Asian students with the non-Asians. No significant differences were found in the HAD anxiety and depression scales [$F(1,23) < 2.6$; n.s. in both cases] or in the states of anxiety or alertness factors [$F(1,23) = < 0.4$; n.s. in both cases]. Randall et al. (2004) studied teetotal, low and moderate drinking groups of students, but unfortunately, it is not possible to compare the HAD scores across the two studies because the Randall et al. (2004) study excluded students with scores >11 on either measure. Unfortunately, it does not help to address the issue of ethnicity because 90% of the students in the Randall et al. (2004) study were British Asians. However, compared with both the drinking groups, Randall et al. (2004) found that the teetotal group responded with greater increases in bodily symptoms of anxiety to the stress of cognitive testing. It is therefore possible that teetotallers are characterised by a greater likelihood of anxiety responses.

Because the binge drinkers had lower self-ratings of typical anxiety and depression than did the teetotallers, the poorer cognitive performance in the binge drinking group cannot be attributed to impaired mood. It is possible that reduced alertness contributed to the impairments observed, but this would not have produced a specific pattern of deficits and would have been most evident in the very lengthy test of mental flexibility. As the participants were asked to refrain from consuming alcohol the day before the test session, it is unlikely that the poorer test performance could be entirely attributed to the immediate aftermath of a binge drinking session. Compared with the group of teetotallers, our binge drinkers had cognitive impairments in the PASAT, planning and episodic memory tasks. Performance in the PASAT relies on sustained attention, working memory and ability to ignore interfering items. The latter two are executive functions, thus, it would seem possible that it is

Table 6
Mean (± S.E.M.) scores for binge drinkers divided into low and high typical alcohol consumption

	Low alcohol ($n = 7$)	High alcohol ($n = 7$)
Alcohol intake—typical week (units)	10.4 ± 1.9	29.0 ± 3.4***
Binge drinking score	43.3 ± 5.3	38.4 ± 5.9
Bond and lader		
Anxiety	50.9 ± 5.2	56.8 ± 4.1
Well-being	47.5 ± 2.9	59.9 ± 3.2 *
Alertness	51.2 ± 4.9	49.6 ± 5.8
Spatial recognition memory		
Percent correct (%)	84.3 ± 5.8	72.5 ± 11.0
Mean correct latency (ms)	1787 ± 111	2119 ± 105 *
Stockings of Cambridge		
Initial thinking time (ms)		
Two-move problem	1340 ± 381	1209 ± 390
Three-move problem	3409 ± 906	4036 ± 824
Four-move problem	6643 ± 1333	8674 ± 1540
Five-move problem	8879 ± 2717	12522 ± 2925
PASAT (number correct)	44.1 ± 4.7	49.9 ± 5.8

* $P < .05$ compared with the low-alcohol group.
*** $P < .001$ compared with the low-alcohol group.

mainly executive function that is impaired by binge drinking. We did not find impairments in the spatial working memory task, although Weissenborn and Duka (2003) did find that performance in this task was impaired in binge drinkers. The difference could be because of the much higher level of performance of our male students (the students in Weissenborn and Duka, 2003 study made three times as many errors in the eight-box task as our male students). It would therefore seem that at least two frontal lobe functions may be impaired by binge drinking, working memory and planning. It is interesting that it is these particular two tasks of frontal function that were found to be impaired in Korsakoff alcoholics (Joyce and Robbins, 1991). In alcoholics, cortical damage is particularly severe in the frontal lobes (Volkow et al., 1992; Kril et al., 1997), and loss of muscarinic cholinergic receptors have been found especially in the frontal cortex (Freund and Ballinger, 1988). The results of the present study and that of Weissenborn and Duka (2003) suggest that impaired frontal lobe function may occur even at an early age in binge drinkers.

Because our study compared teetotallers with binge drinkers, we cannot be certain that the differences we found were due to the pattern of drinking rather than the actual alcohol consumption. Our subanalysis comparing the higher and lower typical alcohol consumption groups of the binge drinkers attempted to address this question. This suggested that the finding that male binge drinkers had impaired performance in the spatial recognition task could be the result of a higher alcohol consumption, rather than the pattern of bingeing per se. When Weissenborn and Duka (2003) compared bingers and nonbingers with similar levels of alcohol consumption, they did not find differences in this task. Furthermore, in a study by Randall et al. (2004), where the effects of alcohol intake on tasks of sustained attention (RVIP) and planning (SoC) were investigated, no differences were found between the performance of the teetotal group and that of a group of drinkers with the same weekly alcohol intake as our binge drinkers, but who did not have a pattern of bingeing. We found no other cognitive differences between the higher and lower alcohol intake groups. This, together with the results of Weissenborn and Duka (2003), suggests that it may be the pattern of binge drinking, rather than the alcohol intake per se, that is responsible for the impaired frontal function.

Our results do not allow a determination of causality. It is plausible that a low level of anxiety is one factor predisposing towards binge drinking, but the possibility that binge drinking has an anxiolytic effect cannot be excluded. Likewise, it is plausible that binge drinking results in poorer cognitive performance, and indeed, this was our hypothesis and the conclusion of Weissenborn and Duka (2003). However, the possibility that impaired attention and executive function contribute to the pattern of binge drinking cannot be excluded.

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References

Bond AJ, Lader M. The use of analogue scales in rating subjective feelings. Br J Med Psychol 1974;47:211–8.

Broomfield K, et al. Alcohol consumption and alcohol problems among women in European countries. Institute for Medical Informatics, Biostatistics and Epidemiology. Berlin: Free University; 1999.

File SE, Mabbutt PS, Shaffer J. Alcohol consumption and lifestyle in medical students. J Psychopharmacol 1994;8(1):22–6.

Freund G, Ballinger WE. Loss of cholinergic muscarinic receptors in the frontal cortex of alcohol abusers. Alcohol Clin Exp Res 1988;12(5):630–8.

Glenn SW, Parsons OA, Sinha R, Stevens L. The effects of repeated withdrawals from alcohol on the memory of male and female alcoholics. Alcohol Alcohol 1988;23(5):337–42.

Grant I, Adams K, Reed R. Aging, abstinence and medical risk factors in the prediction of neuropsychological deficit among long-term alcoholics. Arch Gen Psychiatry 1984;41:710–8.

Hunt WA. Are binge drinkers more at risk of developing brain damage? Alcohol 1993;10(6):559–61.

Joyce EM, Robbins TW. Frontal lobe function in Korsakoff and non-Korsakoff alcoholics: planning and spatial working memory. Neuropsychologia 1991;29(8):709–23.

Kril JJ, Halliday GM, Svoboda MD, Cartwright H. The cerebral cortex is damaged in chronic alcoholics. Neuroscience 1997;79(4):983–98.

Mehrabian A, Russell JA. A questionnaire measure of habitual alcohol use. Psychol Rep 1978;43:803–6.

Morris RG, Evenden JL, Sahakian BJ, Robbins TW. Computer-aided assessment of dementia: comparative studies of neuropsychological deficits in Alzheimer-type dementia and Parkinson's disease. In: Stahl SM, Iversen SD, Goodman EC, editors. Cognitive neurochemistry. Oxford: Oxford University Press; 1987. p. 21–45.

Nelson HE, Willison JR. Restandardisation of the NART against the WAIS-R. Windsor: NFER-Nelson; 1991.

Office for National Statistics. Living in Britain: results from the 2002 General Household Survey, London, TSO; 2002.

Owen AM, Downes JJ, Sahakian BJ, Polkey CE, Robbins TW. Planning and spatial working memory following frontal lobe lesions in man. Neuropsychologia 1990;28:1021–34.

Owen AM, Roberts AC, Polkey CE, Robbins TW. Extra-dimensional versus intra-dimensional set shifting performance following frontal lobe excisions, temporal lobe excisions or amygdalo–hippocampectomy in man. Neuropsychologia 1991;29:993–1006.

Parsons OA, Stevens L. Previous alcohol intake and residual cognitive deficits in detoxified alcoholics and animals. Alcohol Alcohol 1986;21(2):137–57.

Randall DC, Elsabagh S, Hartley DE, File SE. Does drinking have effects on mood and cognition in male and female students? Pharmacol Biochem Behav 2004;78:629–38 [in this issue].

Spreen O, Strauss E. A compendium of neuropsychological tests: administration norms and commentary. Oxford: Oxford University Press; 1991.

Stephens DN. A glutamatergic hypothesis of drug dependence: extrapolations from benzodiazepine receptor ligands. Behav Pharmacol 1995;6(5 and 6):425–46.

Townshend JM, Duka T. Patterns of alcohol drinking in a population of young social drinkers: a comparison of questionnaire and diary measures. Alcohol Alcohol 2002;37(2):187–92.

Volkow ND, Hitzemann R, Wang GJ, Fowler JS, Burr G, Pascani K, et al. Decreased brain metabolism in neurologically intact healthy alcoholics. Am J Psychiatry 1992;149(8):1016–22.

Wechsler H, Davenport A, Dowdall G, Moeykens B, Castillo S. Health and behavioural consequences of binge drinking in college: a national survey of students at 140 campuses. JAMA 1994;272:1672–7.

Wechsler H, Davenport A, Dowdell G, Rimm EBA. Gender-specific measure of binge drinking among college students. Am J Public Health 1995;85(7):982.

Weissenborn R, Duka T. Acute alcohol effects on cognitive function in social drinkers: their relationship to drinking habits. Psychopharmacology (Berl.) 2003;165(3):306–12.

Zigmond AS, Snaith RP. The hospital anxiety and depression scale. Acta Psychiatr Scand 1983;67:361–70.