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Does drinking have effects on mood and cognition in male and female students?

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Abstract

Self-ratings of mood and bodily symptoms were made by groups of IQ and education-matched male and female students [teetotal, low (2–9 units/week for both sexes; 1 UK unit = 8 g alcohol) and moderate (12–34 units/week for males; 10–24 units/week for females) drinkers], before the start and at the end of cognitive testing. Multivariate analyses of variance (MANOVAs) showed that there were significant Alcohol × Time interactions, because the teetotal group responded to the cognitive tests with greater increases in the factors of somatic anxiety and aggressive mood than did the other two groups. Thus, the teetotallers had greater ratings of anxiety, sweating, palpitations, irritability, headache, feeling angry, quarrelsome, belligerent, resentful, hostile, spiteful and rebellious. No differences were found in immediate or delayed logical memory, in verbal fluency, trails, clock-drawing or mental flexibility tests. In tests of sustained attention [rapid visual information processing (RVIP)] and planning, males performed better than females. The moderate-alcohol group performed better than the low-alcohol group in RVIP and planning (completed significantly more tasks in the minimum moves), although in the hardest parts of the latter test, they took longer in planning the initial move. In conclusion, there was no evidence that the group drinking moderate levels of alcohol had any cognitive impairment and the teetotal group responded to the cognitive tests with the greatest increases in negative mood.

Keywords: Anxiety; Executive function; Frontal lobes; Attention; Sex differences; Drinking

1. Introduction

There is a fairly large body of evidence that moderate alcohol consumption, not only can protect against coronary artery disease, but is associated with greater overall health and a reduced risk of all-cause mortality (Peele and Brodsky, 2000; Elias et al., 1999). There is also some evidence that the benefits might also extend to mood. Roberts et al. (1995) found that light drinkers (defined as 1–10 units/week for men and 1–6 units per week for women) exhibited more psychological well-being than either abstainers or heavy drinkers, although this was much more apparent for men than for women. A review of the effects of moderate alcohol consumption concluded that there was little overall evidence that there were any associated cognitive impairments (Eckardt et al., 1998). Furthermore, a more recent review has suggested that drinking in moderation (as opposed to both abstaining and drinking heavily) may actually be beneficial to both cognitive functioning and psychological well-being (Peele and Brodsky, 2000).

However, it has been reported that women are more vulnerable to the negative effects of heavy drinking, which can result in cardiovascular disease and brain shrinkage (Bond et al., 2003). Interestingly, there are some reports that the cognitive benefits associated with moderate alcohol consumption favoured women more than men. Dufouil et al. (1997) administered a varied battery of cognitive tests, which assessed attention, memory, visual and perceptive processing, reasoning, verbal fluency and psychomotor speed, to men and women with a mean age of 65 years. They

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found that women with a low to moderate alcohol consumption (defined as 2–5 drinks/day) had higher cognitive scores on most of the tests compared with nondrinkers and that this was not specific to certain cognitive domains. In men, on the other hand, there was no significant relation between alcohol intake and cognitive performance. Elias et al. (1999) found that women who consumed moderate amounts of alcohol (defined as 2–4 drinks/day) performed better on all the cognitive measures used than women who abstained. A less consistent pattern of superior performance was apparent in men, but heavy drinkers (4–8 drinks/day) did perform better than abstainers in logical memory-delayed recall and in attention and concentration.

There is some evidence that even in young volunteers, moderate levels of drinking are associated with better performance in some cognitive tasks (Bates and Tracy, 1990). The aim of the present study was therefore to determine whether there were differences in the mood or cognitive performance of groups of undergraduate male and female students with different habitual levels of alcohol consumption. The battery of tests was selected to assess memory, attention, mental flexibility, planning, verbal fluency and constructional ability.

2. Materials and methods

2.1. Subjects

Fifty healthy student volunteers (29 men and 21 women) were recruited from King's College London as part of our studies on wakefulness and cognition, which were approved by King's College Ethics Committee. Exclusion criteria were any history of psychiatric, cardiovascular or neurological illness, use of psychoactive medication, regular recreational drug use, or scores of ≥ 11 on either the anxiety or depression scales of the Hospital Depression and Anxiety Scale (HADS; Zigmond and Snaith, 1983). Volunteers were also excluded if they were colour blind (as assessed by the Ishihara cards; Ishihara, 1989), or had any major sight, hearing or movement problems. Students with more than two positive replies on the CAGE alcoholism questionnaire (Ewing, 1984), a regular consumption of more than eight cups of coffee (or ≥ 900 mg caffeine) per day, or who were familiar with tests from the Cambridge Neuropsychological Test Automated Battery (CANTAB) battery relevant to this study, were also excluded. Six subjects smoked (two in the teetotal group, one in the low-alcohol group and three in the moderate-alcohol group) and they were not asked to abstain before testing, because nicotine abstinence impairs cognitive performance in smokers (Hasenfratz and Battig, 1993; Snyder and Henningfield, 1989). Subjects were asked to abstain from alcohol the day before testing and from caffeine 3 h before the test session.

All subjects completed drinking diaries of how many units of each alcoholic beverage (red and white wine, lager, bitter, Guinness, cider or spirits) they consumed on each day of a typical week. A UK unit of alcohol is defined as 8 g of alcohol. On the basis of these replies, subjects were allocated to one of three groups: teetotallers (0 units/week, $n=11$, 8 males, 3 females); low alcohol ($n=22$, 9 males, 13 females, 2–9 units/week for both sexes) and moderate alcohol ($n=17$, 12 males 12–34 units/week, 5 females, 10–24 units/week). Two males and one female were drinking more than the UK government's guidelines of 21 units/week for women and 28 units/week for men. In addition, we looked at the pattern of drinking throughout the week and three of the males in the moderate group were drinking >10 units on a single occasion (12, 14 and 18 units), and thus would be classified as binge drinkers (Broomfield et al., 1999).

2.2. Mood ratings

Prior to cognitive testing, subjects were presented with 100-mm individual visual analogue scales, which had extremes of mood at each end, and were instructed to mark with a vertical line on each scale, the point that corresponded best with how they were feeling at that particular time. They completed rating scales of 'alertness,' 'well-being' and 'psychological anxiety' (Bond and Lader, 1974), bodily symptoms of 'somatic anxiety' (Tyrer, 1976), and 'aggressive mood' (Bond and Lader, 1986). Administration of all rating scales was repeated at the end of the testing session.

2.3. Cognitive tests

All testing was carried out in the afternoon. Some of the tests used in this study were administered on a computer and others by hand. Tasks were administered in a counterbalanced order across subjects to minimise practice and fatigue effects, except for motor screening, which was always first in the battery of cognitive tests. An estimate of premorbid verbal IQ was obtained by use of the National Adult Reading Test-II (NART-II; Nelson and Willison, 1991).

2.3.1. Computerised (CANTAB) tests

All the computerised tests were taken from the CANTAB (Cambridge Cognition, Cambridge, UK). The initial motor screening test was used to relax the subjects and to practice them in the use of the touch-sensitive screen. The scores on this test were not analysed.

2.3.1.1. Rapid visual information processing (RVIP). This is a test of vigilance (sustained attention), with a small working memory component. The test was adapted by Sahakian et al. (1989) from that of Wesnes and Warburton (1984). Subjects had to detect consecutive sequences of digits (3-5-7, 2-4-6 and 4-6-8) that appeared on the computer screen and press a pad as quickly as they could when the last digit of a target sequence was displayed. The primary outcome measures were as follows: target sensitivity (A′), response bias (B″), total false alarms (responses made outside the time

Table 1
General characteristics of the three alcohol consumption groups

	Teetotallers	Low alcohol		Moderate alcohol	
	($n=11$)	Male ($n=9$)	Female ($n=13$)	Male ($n=12$)	Female ($n=5$)
Age (years)	21.2 ± 0.4	20.3 ± 0.4	20.5 ± 0.2	20.3 ± 0.1	21.0 ± 0.6
NART verbal IQ	110.0 ± 2.0	108.4 ± 2.1	110.2 ± 1.2	108.2 ± 1.6	111.0 ± 1.1
$HAD_{Anxiety}$	4.5 ± 0.6	3.9 ± 0.9	4.1 ± 0.7	3.6 ± 0.8	3.6 ± 0.9
$HAD_{Depression}$	2.6 ± 0.9	1.2 ± 0.4	2.2 ± 0.7	1.8 ± 0.6	1.2 ± 0.2
Daily caffeine (cups)	2.0 ± 0.5	2.4 ± 0.7	2.6 ± 0.4	1.9 ± 0.5	2.8 ± 0.6
Weekly alcohol (units)	–	5.0 ± 0.9	4.8 ± 0.7	20.2 ± 2.1	15.6 ± 2.9

Values shown are means ± S.E.M.

limit of a target sequence), total misses and latency to correct detections (in milliseconds).

2.3.1.2. Intra/extra dimensional set shift (IDED). This test is similar to the Wisconsin Card-Sorting Test (WCST; Grant and Berg, 1984) and measures mental flexibility. This task is described in detail elsewhere (Owen et al., 1991). Initially, subjects were required to learn which of two shapes was correct (i.e., simple discrimination), then simple reversal (i.e., the previously incorrect shape became correct), then attend to new exemplars within the same dimension, the shape, which represented the intradimensional shift, and lastly, switch attention to the previously irrelevant dimension, the line, which was the extradimensional shift. Stages completed and number of errors were measured.

2.3.1.3. Stockings of Cambridge (SOC). This is a spatial planning task based on the Tower of London test (Shallice, 1982) and is described in detail by Owen et al. (1990). Subjects had to move the coloured balls displayed on the bottom half of the computer screen to copy an arrangement displayed on the top half of the screen. This could be done in two, three, four or five moves. Initial and subsequent thinking time (in milliseconds), as well as number of problems solved in minimum moves were scored.

2.3.2. Pen-and-paper tests

2.3.2.1. The Stroop test. The Stroop test (Stroop, 1935) is a task of selective attention and mental flexibility. This study used the Victoria version of the Stroop test, described by Spreen and Strauss (1998). Essentially, in the interference part, subjects were required to name the colour that a word was printed in rather than reading the colour word itself. Primary outcome measures were as follows: time to complete (in seconds) and total errors for each card, and Stroop interference (calculated as ratio index of the amount of time required for the difficult 'colours' card versus the simple 'dots' card).

2.3.2.2. Logical memory. This is a subtest of the Wechsler Memory Scale-Revised (Wechsler, 1987) and assesses verbal memory. Subjects were asked to recall a short story immediately after they had heard it and approximately 20 min later. The total number of 'units' recalled (out of 25) at immediate and then again at delayed recall was recorded.

2.3.2.3. Trail-Making Test (A and B). This test measures ''visual conceptual and visuomotor tracking'' (Lezak, 1983). The subjects had to connect 25 encircled numbers randomly arranged on a page, by drawing pencil lines in proper order (Part A) and then 25 encircled numbers and letters in alternating order (Part B). The times to complete Parts A and B were recorded (in seconds).

2.3.2.4. Controlled oral word association test (COWAT). This test evaluates the spontaneous production of words within a limited period of time (Spreen and Strauss, 1998). For 'letter fluency,' subjects were given 60 s for each letter to produce as many words as they could think of beginning with the letters F, A and S. For 'category fluency,' the categories were 'house animals,' 'jungle animals' and 'farm animals' and the time allowed was 60 s in total. The sums of all admissible words for the three letters and the three animal categories were recorded.

2.3.2.5. Clock drawing. This is a test of visuospatial and constructional ability (Spreen and Strauss, 1998). The subjects had to draw the face of a clock with all the numbers on

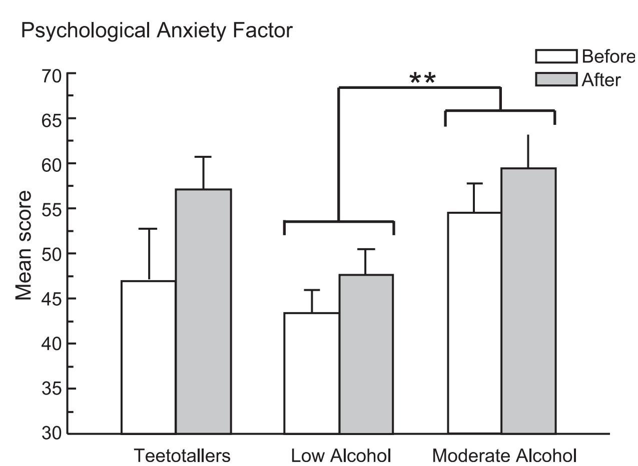

Fig. 1. Mean (± S.E.M.) ratings on the Bond and Lader factor of psychological anxiety. ** $P < .01$, significant difference between low- and moderate-alcohol groups.

it and after this, were asked to draw the hands pointing at 20 to 4. Primary outcome measures were drawing score (1–10) and time taken to complete the task (in seconds).

2.4. Statistical analysis

To compare the three groups of drinkers, the mood factors were analysed by two-way split-plot analyses of variance (ANOVAs), with the between-group factor being alcohol consumption (teetotal, low alcohol or moderate alcohol) and the repeated measure being time (before and after cognitive testing). Similar two-way multivariate analyses of variance (MANOVAs) were conducted to analyse effects on factors of somatic anxiety and aggressive mood. Where these reached significance, they were followed by ANOVAs on the individual ratings. The cognitive scores were initially analysed by one-way ANOVA, or where the data were not normally distributed or there was unequal variance between the groups, with the nonparametric Kruskal–Wallis/Mann–Whitney tests.

There were insufficient females in the teetotal group to include this group in an analysis of sex differences. However, sex differences could be analysed for the other two groups. Thus, mood was analysed by three-way ANOVAs and MANOVAs, with sex and alcohol intake as the between-group factors and time as the repeated measure. Cognitive effects were assessed with 2×2 ANOVAs, with alcohol intake (low or moderate) and sex (male or female) as factors.

Where effects reached significance, both F ratios and probability levels are given. Where results did not reach

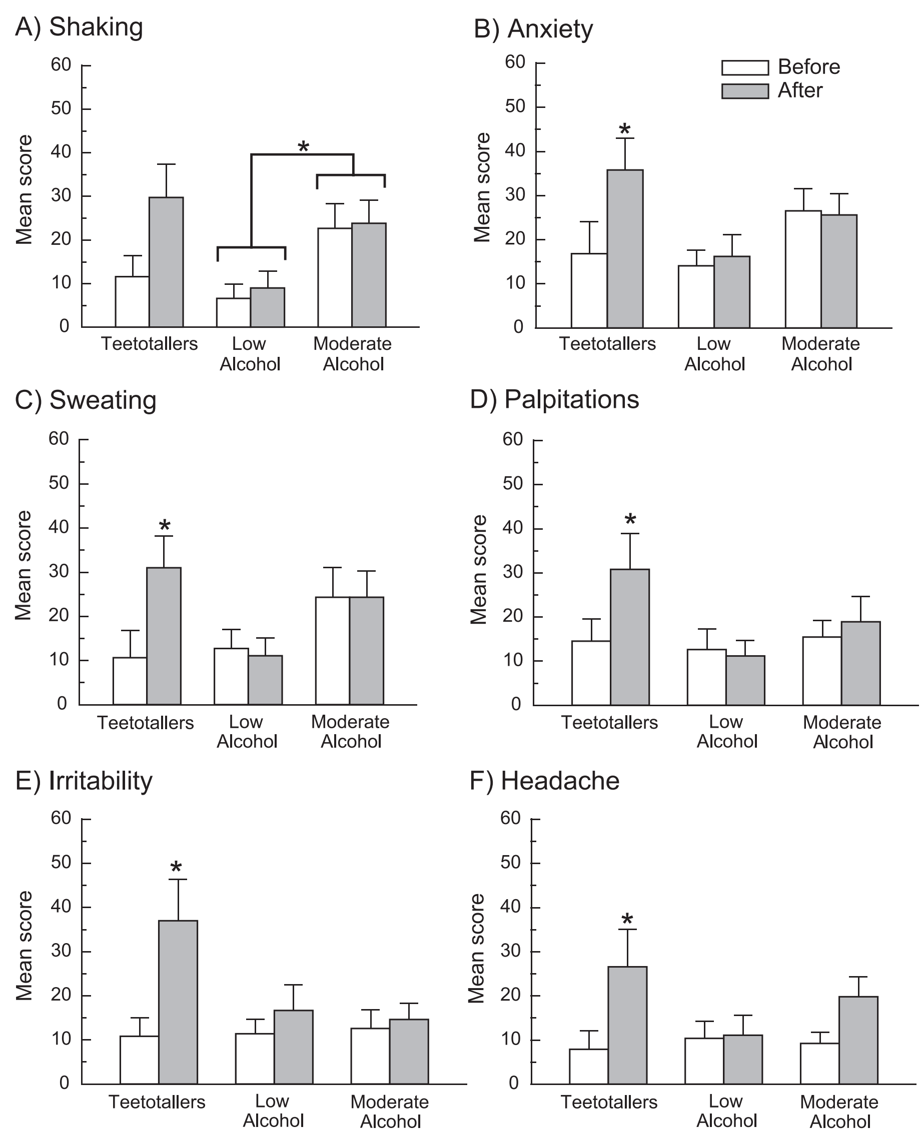

Fig. 2. Mean (± S.E.M.) ratings of somatic anxiety: shaking (A), anxiety (B), sweating (C), palpitations (D), irritability (E) and headache (F) by teetotallers, and low- and moderate-alcohol groups. Ratings were made both before and after the battery of cognitive tests. * $P < .05$, significant difference before and after testing only in teetotallers.

significance, only the F ratios are presented and nonsignificance (NS) is indicated. All data were analysed using the Statistical Package for the Social Sciences (SPSS Chicago, IL, USA) version 10.0 for Windows.

3. Results

3.1. Group characteristics

The alcohol groups did not differ significantly in IQ, HAD anxiety and depression scores or caffeine intake [in all cases, alcohol $F(2,47) < 1.0$, NS] or in age [alcohol $F(2,47) < 3.0$, NS; see Table 1]. Similarly, there were no significant sex differences in the alcohol-drinking groups [for all measures, sex $F(1,35) \leq 2.0$, NS; see Table 1].

3.2. Mood ratings

3.2.1. Bond and Lader Mood Scale

Following factor analysis, Bond and Lader (1974) isolated three independent factors from their mood rating scale. On the factor of psychological anxiety, there was a significant effect of alcohol consumption [alcohol $F(2,47) = 5.2$, $P < .01$], and post hoc tests (Bonferroni) revealed that this was due to subjects in the low-alcohol group rating themselves as feeling less anxious than subjects in the moderate-alcohol group ($P < .01$; see Fig. 1). There were no signif-

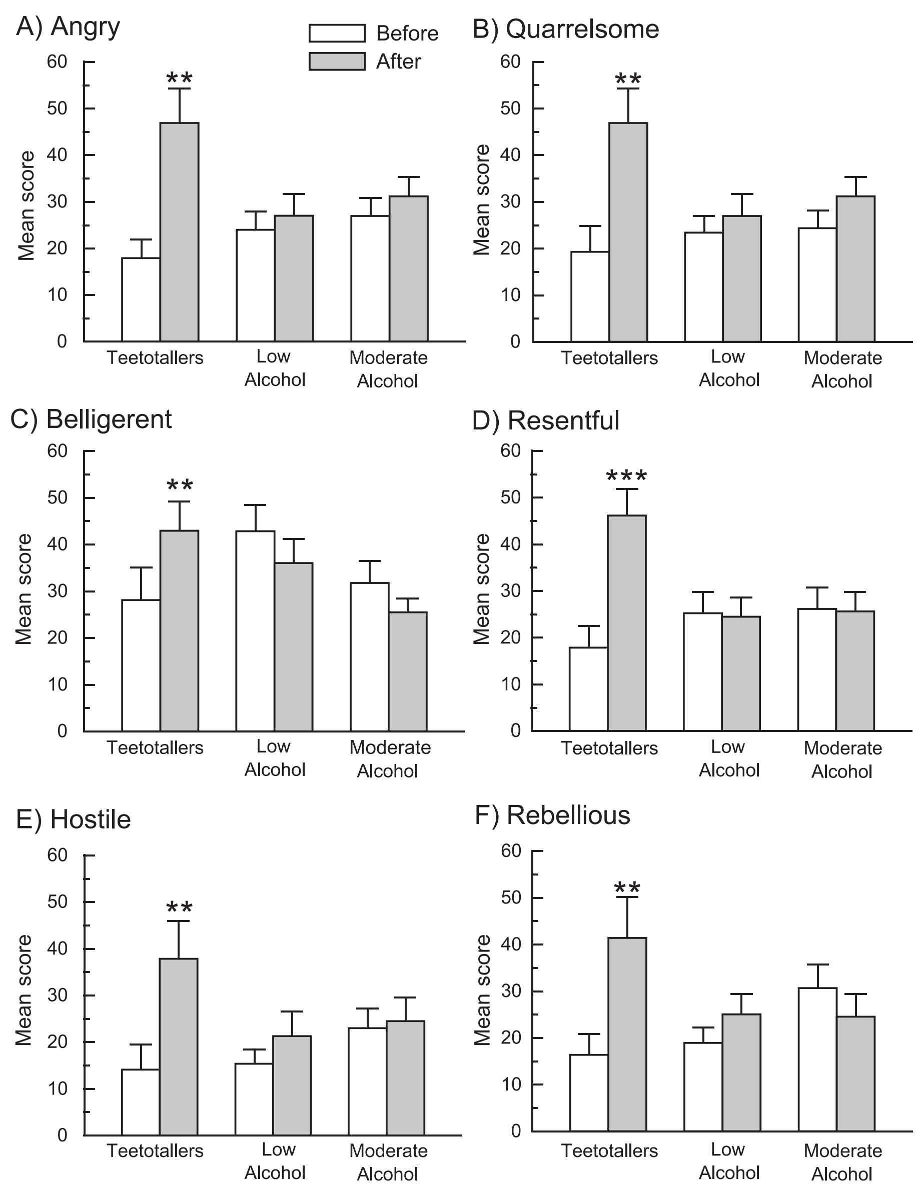

Fig. 3. Mean (± S.E.M.) ratings on individual items of aggressive mood: angry (A), quarrelsome (B), belligerent (C), resentful (D), hostile (E) and rebellious (F) by teetotallers, low- and moderate-alcohol groups. Ratings were made both before and after the battery of cognitive tests. ** $P \leq .01$, *** $P < .001$, significant Time × Alcohol interaction mainly for teetotallers.

icant effects of alcohol consumption on the factors of alertness or well-being [in both cases, alcohol $F(2,47) < 2.0$, NS; data not shown]. After testing, all subjects felt more anxious [time $F(1,47) = 6.8$, $P < .05$; see Fig. 1]. There was no significant effect of sex [in all cases, sex $F(1,35) < 2.0$, NS], and no significant Sex × Alcohol interactions [in all cases, $F(1,35) \leq 1.5$, NS].

3.2.2. Somatic anxiety

To control for intercorrelations among measures on this scale and thus to reduce the risk of false positives that might arise from a series of univariate analyses, the measures from this scale were first analysed by a MANOVA. There was a significant effect of alcohol on the somatic anxiety factor [alcohol MANOVA, $F(30,68) = 1.6$, $P = .05$]. On the individual measures, only the rating of 'shaking' showed a significant effect [alcohol $F(2,47) = 4.5$, $P < .05$], and post hoc tests showed that this was due to the low-alcohol group scoring significantly lower than the moderate-alcohol group ($P < .05$; see Fig. 2).

MANOVA also revealed a significant Time × Alcohol interaction [$F(15,33) = 2.5$, $P < .05$], and interactions were significant for several individual items: 'anxiety' [$F(2,47) = 4.0$, $P < .05$], 'sweating' [$F(2,47) = 4.3$, $P < .05$], 'palpitations' [$F(2,47) = 3.5$, $P < .05$], 'irritability' [$F(2,47) = 4.0$, $P < .05$] and 'headache' [$F(2,47) = 3.7$, $P < .05$]. The significant interactions were mainly due to the teetotal group scoring significantly higher on these items after cognitive testing (see Fig. 2).

The MANOVA analysing the data for males and females in the low- and moderate-drinking groups showed no significant effects [in all cases, $F(15,21) \leq 1.3$, NS].

3.2.3. Aggressive mood

MANOVA showed a significant Time × Alcohol interaction for aggressive mood [$F(26,70) = 1.7$, $P < .05$]. The individual items also showed several significant Time × Alcohol interactions, which were mainly due to the teetotal group scoring significantly higher after cognitive testing on ratings of 'angry' and 'quarrelsome' [$F(2,47) = 5.9$, $P = .005$, and $F(2,47) = 5.3$, $P < .01$, respectively], 'belligerent' [$F(2,47) = 4.9$, $P = .01$], 'resentful' [$F(2,47) = 10.2$, $P < .001$], 'hostile' [$F(2,47) = 5.2$, $P < .01$], 'spiteful' [$F(2,47) = 3.5$, $P < .05$] and 'rebellious' [$F(2,47) = 7.5$, $P < .005$] after cognitive testing (see Fig. 3).

There were no significant Sex × Alcohol or Time × Sex × Alcohol interactions on aggressive mood [in both cases, MANOVA, $F(13,23) \leq 1.8$, NS].

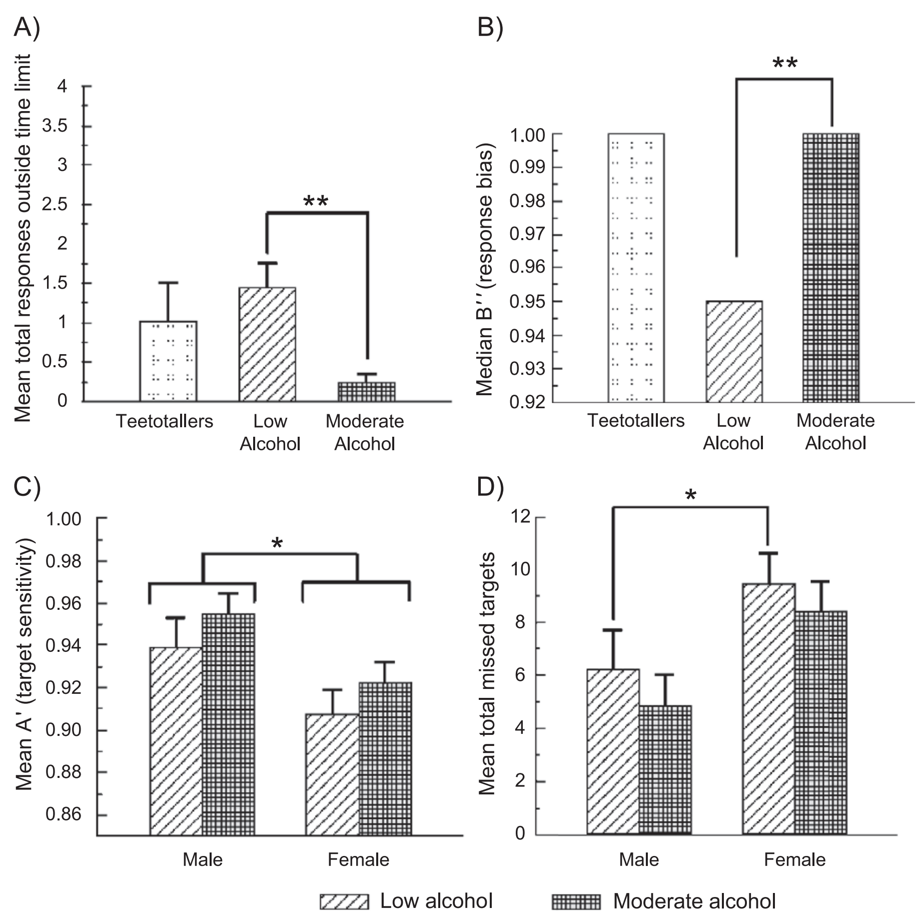

Fig. 4. Mean (± S.E.M.) responses outside time limit (A) and B″ (B) for teetotallers, low- and moderate-alcohol groups and A′ (C) and total missed targets (D) for male and female low- and moderate-alcohol groups. * $P < .05$, ** $P \leq .01$, significant difference between groups indicated.

3.3. Cognitive tests

3.3.1. Rapid visual information processing

In this test of sustained attention, there was evidence that alcohol consumption affected performance with respect to the number of responses outside the time limit [alcohol $\chi^2(2) = 10.5$, $P < .05$] and B″, a signal detection measure of response bias [alcohol $\chi^2(2) = 7.8$, $P < .05$]. Mann–Whitney tests showed that this was due to subjects in the moderate-alcohol group performing better than the low-alcohol group. Thus, the moderate-alcohol group made significantly fewer responses outside the time limit and showed a more conservative response as measured by B″ (i.e., responding less often when there was no target) than did those in the low-alcohol group ($U = 54.0$, $P < .005$; $U = 97.5$, $P = .01$, respectively; see Fig. 4A and B).

The men showed significantly greater target sensitivity, as measured by A′, and missed significantly fewer targets, than did women [sex $F(1,35) = 5.9$, $P < .05$; $F(1,35) = 6.0$, $P < .05$, respectively; see Fig. 4C and D]. There were no significant Sex × Alcohol interactions [in all cases, $F(1,35) < 2.0$, NS].

3.3.2. Stockings of Cambridge

There was a significant effect of alcohol consumption on the total number of problems solved in the minimum moves [alcohol $F(2,47) = 3.3$, $P < .05$] and post hoc tests (Bonferroni) showed that this was due to the moderate-alcohol group performing better and solving significantly more problems in the minimum number of moves than did the low-alcohol group ($P < .05$; see Fig. 5A). For the two hardest parts of the test, the four- and five-moves tests, there was also a significant effect of alcohol consumption [alcohol $\chi^2(2) = 6.4$, and $\chi^2(2) = 14.0$, respectively, $P < .05$ in both cases]. For the four-moves test, the moderate-alcohol group took significantly longer to initiate the first move than did the low-alcohol group ($U = 93.0$, $P < .01$). For the five-moves test, both the moderate-alcohol group and the teetotallers took longer than the low-alcohol group ($U = 64.5$, $P < .001$ and $U = 54.0$, $P < .01$, respectively; see Fig. 5B). Thus, although the moderate-alcohol group had the better strategy, in the harder parts of the task, they took longer to plan this strategy.

Lastly, men were significantly quicker at planning the solutions of two- and five-moves problems in the SOC task [sex $F(1,35) = 4.6$ and 4.3, respectively, $P < .05$, data not shown]. There were no significant Sex × Alcohol interactions in this test [in all cases, $F(1,35) < 3.0$, NS; data not shown].

3.3.3. Intra/extra dimensional set shift

There were no significant effects of alcohol consumption in this task [alcohol $\chi^2(2) < 4.0$, in all cases], and no significant Sex × Alcohol effects [$F(1,35) < 1.5$, NS; see Table 2].

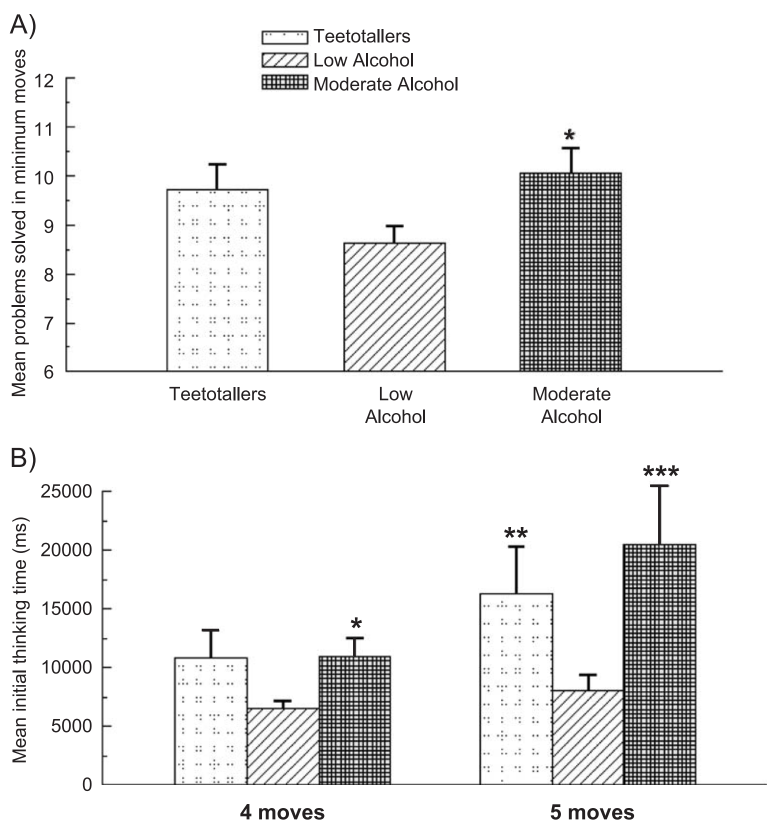

Fig. 5. Mean (± S.E.M.) problems solved in the minimum moves (A) and initial thinking time for four and five moves (B) in the planning task for teetotallers, low- and moderate-alcohol groups. * $P < .05$, ** $P < .01$, *** $P < .001$ compared with low-alcohol group.

Table 2
Performance in cognitive tests

	Teetotallers	Low alcohol		High alcohol	
	($n=11$)	Male ($n=9$)	Female ($n=13$)	Male ($n=12$)	Female ($n=5$)
IDED					
Stages completed	9.0 ± 0.0	9.0 ± 0.0	8.9 ± 0.2	9.0 ± 0.0	8.2 ± 0.5
Total errors	14.6 ± 2.1	13.3 ± 2.5	13.5 ± 2.0	12.9 ± 1.8	19.4 ± 7.2
EDS errors	5.0 ± 1.8	2.8 ± 0.6	6.7 ± 2.1	4.8 ± 1.4	12.6 ± 6.3
Pre-ED errors	7.8 ± 1.1	6.4 ± 0.8	5.4 ± 0.5	7.0 ± 0.8	6.2 ± 1.2
Logical memory					
No. of units—immediate recall	15.5 ± 1.3	13.9 ± 1.7	16.4 ± 1.0	15.8 ± 1.0	17.0 ± 1.5
No. of units—delayed recall	13.6 ± 1.7	12.7 ± 1.5	15.4 ± 1.2	14.3 ± 1.1	16.6 ± 1.3
Stroop					
Time to complete (s)					
Dots	12.0 ± 1.0	10.9 ± 0.6	12.7 ± 0.9	11.7 ± 0.8	11.0 ± 1.1
Words	13.1 ± 0.5	13.3 ± 0.9	13.8 ± 0.7	13.1 ± 1.0	16.2 ± 2.0
Colours	20.8 ± 1.0	20.6 ± 1.7	20.8 ± 1.4	20.3 ± 1.5	24.6 ± 2.8
Total errors					
Dots	0	0	0	0.08 ± 0.08	0
Words	0.09 ± 0.09	0.1 ± 0.1	0.08 ± 0.08	0	0
Colours	0.3 ± 0.1	0.8 ± 0.3	0.2 ± 0.2	0.4 ± 0.2	0
Interference$^{S \times A}$	1.8 ± 0.1	1.9 ± 0.1	1.7 ± 0.1	1.8 ± 0.1	2.3 ± 0.2**
Trail-making test					
Time to complete part A (s)	28.1 ± 3.3	28.8 ± 5.7	24.9 ± 1.8	20.7 ± 1.8	28.6 ± 1.9
Time to complete part B (s)	60.3 ± 6.8	59.7 ± 7.9	51.3 ± 2.8	51.9 ± 5.2	52.6 ± 7.3
COWAT					
No. of words—letter fluency	42.2 ± 3.4	52.0 ± 3.7	48.2 ± 3.6	46.3 ± 2.7	46.6 ± 4.0
No. of words—category fluency	22.0 ± 1.1	23.8 ± 1.4	23.3 ± 0.9	22.9 ± 0.9	23.0 ± 0
Clock drawing					
Drawing score	9.1 ± 0.3	8.8 ± 0.5	9.3 ± 0.3	9.3 ± 0.5	8.2 ± 1.1
Time to complete (s)	26.8 ± 3.0	26.0 ± 3.2	23.5 ± 1.7	25.2 ± 2.5	29.0 ± 2.9

Values shown are means ± S.E.M.
** Significant Sex × Alcohol interaction, $P<.005$, see text for details.

3.3.4. Pencil-and-paper tests

In the Stroop test, there was a significant Sex × Alcohol interaction on the interference measure [$F(1,35)=11.3$, $P<.005$], which was due to the women in the moderate-alcohol group, but not the men, showing an increased interference effect (see Table 2). There were no other significant differences between the three groups in the performance of the Stroop test [alcohol $F(2,47)<1.0$, NS; $\chi^2(2)<2.0$, NS; see Table 2].

There were no significant differences between the three groups in the performance of the logical memory, Trails, COWAT or clock-drawing tests [in all cases, $F(2,47)<2.0$, NS; $\chi^2(2)<1.0$, NS] and no significant effects of sex [in all cases, sex $F(1,35)\leq 3.0$, NS] or Sex × Alcohol interactions in these tasks [in all cases, $F(1,35)<3.0$, NS; see Table 2].

4. Discussion

Our study found no evidence for cognitive differences between the teetotal group and the light and moderate drinkers. This is in contrast to results from middle-aged drinkers, where abstainers/teetotallers have generally been found to perform worse than light and/or moderate drinkers (Tivis et al., 2003; Hendrie et al., 1996; Dufouil et al., 1997; Elias et al., 1999). There could be two possible explanations for this. One is that there are personality differences between teetotallers and drinkers and that these contribute to their different attitudes to, and consumption of, alcohol and to their performance in cognitive tasks. If this were the case, then we would expect to see differences in our study. We did find greater increases in the teetotallers in ratings of aggressive mood and somatic anxiety in response to cognitive testing, suggesting a greater vulnerability to this kind of stress. However, there were no other mood or cognitive differences. Almost all the students in this study were British Asians, and therefore, the reason for being teetotal was religious. It is possible that greater mood or personality differences would be found in a group that was teetotal for other reasons. The second explanation for worse cognitive performance in middle-aged teetotallers is that, over a period of time, low to moderate levels of habitual alcohol consumption have protective effects. Our finding of no differences is likely to be because of the relative short period for which our subjects had been drinking, because they were only in their early 20s.

Our finding that the teetotallers responded to the stress of cognitive testing with a more adverse mood than either the low- or moderate-alcohol-consumption groups, is in agreement with Baum-Baicker's (1985) conclusion that moderate alcohol consumption was effective in reducing stress, which was evident in both physiological and self-report measures. In addition, Peele and Brodsky (2000) identified 15 studies that investigated mental health in relation to alcohol consumption, and found that 11 of those indicated that moderate drinkers had superior mental health scores compared with abstainers. In addition, Hartley et al. (2004) found higher total scores on the HAD in their teetotal students compared with binge drinkers.

We also found little evidence for cognitive impairment from drinking within the upper limits of the recommended UK government guidelines (currently 28 units/week for men and 21 units/week for women). This may well be because only three of the students in the present study could be classified as binge drinkers. Weissenborn and Duka (2003) found greater impairments in spatial working memory and planning in binge drinkers compared with nonbinge drinkers. Hartley et al. (2004) found impaired performance in binge drinkers compared with teetotallers in long-term recall of line drawings, a test of sustained attention (PASAT), which has a strong working memory component, and in planning. Thus, it seems that binge drinking may impair working memory and planning. We did not study working memory in this experiment, but the performance of our moderate drinking group was actually superior in the planning task. This is further evidence that the effect of the pattern of drinking (i.e., bingeing) has different consequences from that of the alcohol intake per se. The better cognitive performance in our moderate drinking group would agree with the conclusions of Peele and Brodsky (2000) that drinking in moderation may be beneficial to cognitive functioning. Our results certainly provide no evidence for cognitive impairment, which is in line with the overall pattern of results in the literature (Eckardt et al., 1998). However, it is possible that a lifetime of alcohol consumption may have different consequences at least in certain populations with perhaps genetic or environmental vulnerability factors. For example, elderly black Americans consuming >10 drinks/week had poorer cognitive performance than those drinking < 4 drinks/week (Hendrie et al., 1996).

There were significant sex differences in the test of sustained attention (RVIP) and in the planning task, with men performing better than women. Sex differences in sustained attention tasks appear to be task specific (Dittmar et al., 1993), as some tests seem to be affected by sex (e.g., Continuous Performance Test, Symbol Digit Modalities Test) whilst others (e.g., PASAT) do not (Spreen and Strauss, 1998). Hartley et al. (2004) did not find any sex differences in PASAT. In the present study, the male superiority in the planning task was limited to the initial thinking time (i.e., the time taken to initiate the first move in solving a problem). Klintegerg et al. (1987) also noted that high-school boys (17–19 years) were quicker than girls at solving problems on a computerised Perceptual Maze Task, a test that can also be used as a measure of executive function, although the level of correctness was similar. According to the authors, the boys applied a more "impulsive–global cognitive style" (i.e., tendency to start tracking almost instantly, without planning) whereas the girls adopted a more "reflective–sequential cognitive style" (i.e., tendency to allow longer inspection time before starting to track). Similarly, significant sex differences were reported by Reavis and Overman (2001) on the Iowa Card Task, with young and middle-aged adult men performing better as a group than women, although Boone et al. (1993) found that older women outperformed older men on six measures from the WCST. Boone et al. suggested the possibility that the superiority of women on this frontal task emerged only in older age.

The only Sex × Alcohol interaction that we found was in the Stroop test. This was due to the women, but not the men, in the moderate-alcohol group showing more interference (i.e., worse performance) in the incongruent condition of the test. Our results provided no evidence that moderate drinking in female students had greater cognitive benefits than in male students.

In summary, the main effects on mood were that the teetotallers showed greater increases after cognitive testing in self-ratings of somatic anxiety and aggressive mood than either of the other groups. Thus, there is little evidence for adverse mood in groups of students drinking within the limits suggested by the UK government and no evidence for any adverse effects on cognitive function.

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