RESEARCH REPORT

Selective attentional bias to alcohol related stimuli in problem drinkers and non-problem drinkers

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Abstract

Aims. The issues explored in this study were whether a patient group of problem drinkers selectively attend to alcohol-related stimuli and the time course of any interference from alcohol-related stimuli in comparison with two control groups of non-problem drinkers. Design. A 3 × 2 × 2 × 5 factorial design was used. Drinking group (low, high and problem) and word order (alcohol-neutral, neutral-alcohol) were between-participant factors, and word type (alcohol, neutral) and presentation block (1–5) were within participant factors. Participants. Three groups were used, 20 participants from a local community alcohol Service (CAS) and 40 participants (student volunteers) in two control groups. The two control groups were differentiated as scoring high or low on the Alcohol Use Disorders Identification Test (AUDIT). Measurements. A modified computerized Stroop colour naming test was used to measure response latencies. Anxiety was measured using the State–Trait Anxiety Inventory. Findings. The CAS group showed significantly longer reaction times to respond to the colour of alcohol-related words than to neutral category words. Although the interference was smaller for the high AUDIT group it was significant. No significant interference was found in the low AUDIT group. There was no statistical evidence that the interference habituated in the three groups. Conclusions. The present study showed it is possible to use a modified Stroop task as a measure of implicit processing of alcohol stimuli. Despite the fact that all participants were asked to ignore the words, they were unable to do so. Alcohol-related words produced more interference than neutral category words in a group of problem drinkers and a control group of high alcohol drinkers.

Introduction

The role of cognition in the maintenance or deterrence of health-compromising behaviours is well documented. For example, theories of decision-making and health behaviour emphasize the cognitive interpretation of an expectancy–outcome associated with a potential behaviour to aid the understanding of intention to act (e.g. Ajzen & Madden, 1986; Weinstein, 1988; Tiffany, 1990; Ronis, 1992). Other approaches suggest the role of both cognitive and affective factors specifically with regard to substance use.
and addiction-related learnt cues (e.g. Niaura et al., 1988). For instance, Marlatt (1985) suggests the development of behaviour-specific outcome expectancies from the learnt association between cues to action (stimuli) and reinforcers of the behaviour. These expectancies or anticipatory cognitions have motivational properties. The presentation of alcohol may generate the expectation of various learnt affective states associated with drinking behaviour, such as pleasure or happiness, and as such the desire for the experience of these emotions.

Much of the research on expectancy outcome has been characterized as emphasizing the role of explicit cognition. More recently the role of implicit cognition has also been emphasized (Tiffany, 1990; Greenwald & Banaji, 1995). In particular it has been argued that explicit cognition (i.e. outcome expectancies) and implicit cognition (memory associations) may reflect independent aspects of cognition. For example, Stacy (1995; Stacy, Leigh & Weingardt, 1994) has suggested that memory activation (an implicit memory component) represents the effects of associative memory that is activated automatically by motivational and situational factors. Importantly, Stacy (1997) showed that implicit cognition (as measured by free associations to drug-related cues) could predict drug use prospectively. Assuming that problem drinkers have an activated memory structure for alcohol-related concepts, two predictions can be made. First, problem drinkers will demonstrate greater priming or free association for alcohol-related stimuli compared to neutral stimuli (Stacy, 1995). Secondly, problem drinkers will demonstrate greater interference from alcohol-related stimuli than neutral stimuli, when the stimuli are irrelevant to the current task. The present paper focuses on the second of these predictions.

In line with the research on implicit cognition this paper investigates the usefulness of considering problem drinkers having memory structures (or processes) that are biased towards the processing of alcohol-related material. In particular we investigate an alternative implicit correlate of alcohol-related problems, utilizing the Stroop task (Stroop, 1935). This task involves naming the ink colour of colour-related words (e.g. the response to the word ‘green’ written in red ink is ‘red’). The typical finding is that participants are slower at colour naming incongruent stimuli. This task has traditionally been used to demonstrate the attention-seizing power of different types of stimuli on ongoing information processing (Klein, 1964).

In recent years the Stroop task has been modified to investigate information processing in a number of psychopathologies. The general strategy has been to investigate the processing of concern related stimuli. Typically, greater interference has been found from concern-related stimuli in panic disorder (Ehlers et al., 1988; McNally, Rieman & Kim, 1990), depression (Gotlib & Cane, 1987; Segal & Vella, 1990), anorexia nervosa (Channon, Hemsley & de Silva, 1988), bulimia nervosa (Fairburn et al., 1991), post-traumatic stress disorder (McNally et al., 1990; Foa et al., 1991) and generalized anxiety disorder (Martin, Williams & Clark, 1991; Mathews & Klug, 1993). In one study spider phobics showed greater disruption from phobia-related words than a group of non-spider phobics (Watts et al., 1986). This research highlights that concern-related stimuli show greater disruption on task-relevant processing than non-concern-related stimuli (MacLeod & Mathews, 1991). Although the modified Stroop task has been used predominantly with clinical groups, greater disruption can also be found from general emotional stimuli in non-clinical groups (McKenna, 1986; Williams & Nulty, 1986; Ehlers et al., 1988, experiment 2; McKenna & Sharma, 1995).

In this paper we investigate the potential of using the modified Stroop paradigm (alcohol Stroop) in understanding the cognitive mechanisms involved in problem drinking. To date, four studies have used versions of an alcohol Stroop paradigm (Johnsen et al., 1994; Stetter et al., 1994, 1995; Bauer & Cox, 1998). All four of these studies used vocal response latencies to compare colour naming to alcohol-related and neutral control words. Two of these studies (Johnsen et al., 1994; Bauer & Cox, 1998) measured response latencies to individual stimuli, whereas the other two measured the total time to respond to a particular class of stimulus. In addition one of these studies (Bauer & Cox, 1998) presented the word stimuli in a randomized order. The other three studies presented the alcohol and neutral word sets in a counterbalanced order.

To compare these studies an interference score was calculated by subtracting mean reaction times to colour name neutral stimuli from
mean reaction times to colour name alcohol stimuli. Johnsen et al. (1994) reported larger interference scores for a group of problem drinkers (220 ms) than for a group of control participants (i.e. social drinkers, 40 ms). Stetter et al. (1995) also reported larger interference scores for problem drinkers (60 ms) than for a control group (20 ms). Although Stetter et al. (1994) reported a similar result in terms of the size of the interference, the interaction was not statistically significant—the problem drinkers’ interference score was 77 ms, the control group was 23 ms. The Bauer & Cox (1998) study also failed to find a larger interference score in a group of problem drinkers (problem drinkers’ interference score 22 ms, control group 13 ms).

Although two of the four studies indicate larger interference scores for a group of problem drinkers, a number of fundamental methodological problems with each of these studies make the interpretation of results difficult. In the two Stetter et al. studies word stimuli were presented simultaneously on a card and response latency was the total time to name the stimuli on any one card. Two problems arise from this method. First, it is not possible to measure response latencies to individual stimuli and therefore is a less sensitive measure of performance. One reason for this is that the total time includes both correct and incorrect responses. Secondly, it is not possible to determine the time-course of the effects. This is important because it is possible that alcohol-related stimuli capture the attention of both problem drinkers and non-problem drinkers, but the difference between them lies in the rate at which they habituate to the alcohol-related stimuli.

In the Johnsen et al. (1994) experiment stimuli were presented individually, but interpretation is hindered because word frequencies between the alcohol and neutral words were not matched. Although word sets were matched for number of letters, longer response latencies for alcohol stimuli could be interpreted as indicating merely that participants take longer when two words (e.g. liquor-store, red wine) are presented on the screen than when one word is presented. A second, more important, inadequacy surrounds the simultaneous use of a vocal and manual response (participants were asked to say the colour of the Stroop word as well as press a key relating to the colour), although only vocal responses were recorded and reported. This allows for an alternative interpretation that participants may have used different response strategies. For example, the observed larger alcohol Stroop effect in problem drinkers may be accounted for by the fact that these participants tended to make a vocal response before the manual response, whereas control group participants made a manual response before the vocal response. It is possible that the interference effect was diminished by the time the second response was made.

The small interference scores reported in the Bauer & Cox (1998) study can be accounted for by the presence of carry-over effects. It is well known in the emotional Stroop literature that emotional stimuli produce potent carry-over effects, particularly with vocal responses (McKenna, 1986). McKenna (1986) measured response latencies to colour name emotional and neutral words. Half the participants responded to the neutral words before the emotional words and half responded to the emotional words before the neutral words. McKenna (1986) showed that the response latencies to neutral stimuli were increased by the prior presentation of emotional stimuli. In the Bauer & Cox study all stimuli were presented randomly. If alcohol stimuli produce carry-over effects similar to emotional stimuli, this implies that with random presentations the interference scores will be small, as some of the effects of alcohol stimuli will carry over onto neutral stimuli. Therefore, the present research focused on presenting all stimuli in a blocked format. Half the participants were presented with alcohol-related stimuli before the neutral stimuli and half neutral stimuli before alcohol-related stimuli.

As the four studies reviewed earlier all use vocal responses, the present research concentrates on manual responding to generalize the findings from using a vocal response. The Stroop literature highlights that the type of response is an important factor in the magnitude of interference observed (Redding & Gerjets, 1977; Sharma & McKenna, 1998) and it would therefore be important to demonstrate any interference from alcohol-related stimuli using manual responding.

In addition to these problems, the above studies reported no significant interference from alcohol stimuli in the control group of social drinkers. Does this lack of interference reflect a null effect or the insensitivity of the measures used? In the present study this issue was ad-
Table 1. Mean, (standard deviation) and [min-max] for the three groups on each of the three questionnaires

<table>
<thead>
<tr>
<th>Group</th>
<th>Audit</th>
<th>State</th>
<th>Trait</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>3.65 (2.39) [0–7]</td>
<td>42.45 (10.39) [23–65]</td>
<td>45.10 (9.05) [32–62]</td>
</tr>
<tr>
<td>High</td>
<td>11.30 (3.21) [8–22]</td>
<td>41.40 (7.49) [30–57]</td>
<td>42.25 (8.26) [30–59]</td>
</tr>
<tr>
<td>CAS</td>
<td>24.75 (9.98) [12–36]</td>
<td>43.50 (12.69) [23–64]</td>
<td>53.25 (11.02) [30–69]</td>
</tr>
</tbody>
</table>

dressed in two ways. First, one problem with using a single control group is that the range within such a group can be extensive (e.g. from those who do not drink to those who drink as much as the group of problem drinkers). It is possible that the interference from alcohol stimuli is not present in a group of low drinkers but is present in a group of high drinkers. In the present study two control groups defined as low and high social drinkers are included as well as a third group of problem drinkers. Secondly, any difference between a group of social and problem drinkers could be accounted for in two ways. (1) The magnitude of the interference from alcohol stimuli is larger in a group of problem drinkers than a group of social drinkers. This supports the view that for a group of problem drinkers, alcohol-related stimuli capture greater attentional resources than neutral stimuli. (2) The magnitude of interference is the same in the two groups but the rate of habituation to the alcohol stimuli is more rapid in a group of social drinkers than a group of problem drinkers. This would support the view that the main difference between the two groups is not the extent to which alcohol-related stimuli capture attentional resources, but the speed with which the two groups disengage attentional resources to alcohol-related stimuli. This possibility was not investigated in previous studies. The time-course of the interference from alcohol stimuli will be investigated by observing the interference across five blocks.

Method

Participants

Sixty participants took part in the study, 20 in each of three groups. Forty psychology undergraduates were divided into high or low alcohol groups based on scores derived from the Alcohol Use Disorders Identification Test (AUDIT), which has been shown to be a reliable and valid measure of harmful drinking in the general population (Saunders et al., 1993; Conigrave, Saunders & Reznik, 1995). The AUDIT questionnaire contains eight questions on a five-point scale (scored 0–4, e.g. 'How often do you have a drink containing alcohol?') and two questions on a three-point scale (scored 0, 2 and 4, e.g. ‘Have you or someone else been injured as a result of your drinking?’). The total score ranges from 0 to 40. Scores below 8 represent non-harmful drinking behaviour and scores of 8 or above represent harmful drinking (non-dependent) behaviour (Conigrave, Hall & Saunders, 1995).

Twenty participants (20 females) with scores less than 8 formed the low drinking group (scores varied from 0 to 7) while 20 participants (three males, 17 females) with scores greater than or equal to 8 formed the high drinking group (scores varied from 8 to 22). The AUDIT questionnaire was administered after the Stroop study to avoid any problems with priming the participants with alcohol-related stimuli. This meant that a total of 71 participants were tested in the high and low groups. The first 20 to meet the above criteria for the high and the low groups were included in the analysis. All participants in these two groups received research participation credit.

A third group of 20 (15 males, five females) in-treatment abstinence problem drinkers were recruited from a local community alcohol service (CAS). Their AUDIT scores varied from 12 to 36 (see Table 1 for further details). The abstinent problem drinkers were asked to respond to the AUDIT questionnaire based on a typical heavy session of drinking. An estimate of actual alcohol consumption is provided for the three groups using one of the items in the AUDIT questionnaire: ‘How many drinks containing alcohol do you have in a typical day when you are drinking?’ Mean, standard deviation and modal responses are as follows: low group (mean = 0.50, SD = 0.76, mode = 0: ‘1 or 2’), high group (mean = 1.25, SD = 0.85, mode = 1: ‘3 or 4’).
and CAS group (mean = 3.10, SD = 1.21, mode = 4: ‘10 or more’).

The type and length of treatment varied within the CAS group. The mean length of treatment prior to participation was 9.8 months (scores varying from 1 to 50 months). During treatment participants attended a mixture of group and individual counselling. The local community alcohol service uses medical, counselling and psychotherapeutic methods.

**Design**

The design formed a $3 \times 2 \times 2 \times 5$ factorial model with group (low, high, CAS) and order (alcohol-neutral, neutral-alcohol) as between participant factors, word type (alcohol, neutral) and block (1–5) as within-participant factors.

The first five neutral words were presented as part of one block, the second five as part of another block and so on for a total of five blocks (see Materials section for the words used). In each of the five blocks a different set of five words were used. The words across the five blocks were counterbalanced using a Latin square design. Each of the words was presented in each of four ink colours, red, green, blue and brown, giving 20 stimuli per block. These 20 stimuli were randomized with the restriction that an identical word or colour could not repeat itself on consecutive trials. This formed one block in the stimulus array. Five such blocks were formed to produce 100 neutral category stimuli. The same design was used for the alcohol-related words producing 100 alcohol-related stimuli. For half the participants the alcohol stimuli were presented before the neutral stimuli and for the other half the neutral stimuli were presented before the alcohol stimuli. There was a short break of about 1 minute at the end of one stimulus set and the beginning of the second stimulus set.

**Materials**

The words used in the experiment were all presented in capital letters and were as follows.

*Neutral category (environmental features)* words: bog, ravine, valley, bridges, pebble, cove, crags, leaves, plain, geyser, trench, canal, inlet, harbour, tree, swamp, moss, hill, tunnel, cliff, hollow, meadow, winds, fog, ocean.

*Alcohol words:* pub, liqueur, wine, cocktail, brewery, brew, cider, spirits, liquor, tavern, mead, stout, booze, drunk, bitter, scotch, sherry, bar, bourbon, saloon, alcohol, whiskey, port, gin, beer.

Each alcohol word was matched with a corresponding neutral word for word length and word frequency using Kucera & Francis (1967). Mean word frequency did not differ significantly between alcohol (mean = 20.6, SD = 23.10) and neutral (mean = 21.04, SD = 23.01) words, $t(48) = 0.067$, $p > 0.9$. Word length also did not differ significantly between alcohol (mean = 5.36, SD = 1.44) and neutral (mean = 5.16, SD = 1.03) words, $t(48) = 0.565$, $p > 0.5$. In addition, word frequency and word length were matched between the five blocks. The neutral words selected were from the category of environmental features, some of which had been used previously by McKenna & Sharma (1995). The words used for the environmental features and alcohol categories were selected in the following way. First, a number of words that the authors thought might belong to this category were selected. These words were then administered to four judges who rated them on a five-point (0–4, bad–good) scale as to category membership. Using a criterion of at least three out of four judges giving a rating of 2 or more, the selected words were then matched for word frequency and word length. If an insufficient number of words were found, the same process was repeated with another set of words and a different set of judges.

All stimuli were presented using a Viglen 386 PC computer. A computer program written in TURBO BASIC controlled stimulus presentation and collected response latencies with an accuracy of 1ms. Participants sat approximately 60 cm from the computer screen with each word of the dimensions 0.6 cm high (0.6 degrees of visual angle) and approximately 2 cm wide (2 degrees of visual angle).

**Procedure**

The task involved presenting a single colour-word at the centre of a white-coloured video screen. Each stimulus remained on the screen until a response was made. Following the participants’ response the next stimulus was presented immediately.
Participants were introduced to the task as a colour perception task in which they would be presented a word in one of four ink colours. They were instructed to ignore the words and make a key-press response to the colour of the ink as quickly and as accurately as possible. If any errors were made they were asked not to correct themselves.

Before conducting the experiment all participants were given extensive practice. There were two practice sessions. Each practice session involved presenting 100 repeated letter strings (e.g. XXXX, MMM). The number of letters in the letter strings was matched with the number of letters in the neutral and alcohol words. During the first practice session participants were asked to learn the position of the response buttons such that they would not have to look at the response buttons every time they made a response. This was performed without any time pressure. During the second practice session participants were told not to look at the buttons while making a response, unless it was absolutely necessary, and to make their response as quickly and as accurately as possible. A short break was given between each of the two practice sessions and the beginning of the experimental session.

Prior to the experimental session participants were informed that real words were going to be presented but were not informed of the nature of these words. All participants were instructed to ignore the word stimuli and report only the ink colours as quickly and accurately as possible. All responses were made using one of four buttons by positioning the index and middle fingers from each hand on top of each of the buttons. Each button was labelled with one of four words written, in black ink, BLUE, BROWN, RED and GREEN. Half the participants received the red and green labels on the left hand and the blue and brown labels on the right hand and the other half in reverse order.

After completing the Alcohol Stroop task participants were asked to complete two questionnaires: AUDIT (Saunders et al., 1993) and State–Trait Anxiety Inventory (Spielberger et al., 1983). Half the participants completed the AUDIT before the anxiety questionnaire and the other half in reverse order.

Results

Analysis of AUDIT, state anxiety and trait anxiety

The scores on the three questionnaires were analysed using a one-way analysis of variance (ANOVA) with group as a between-participants factor. For scores on the AUDIT there was a significant main effect of group, $F(2,57) = 99.11$, $MSE = 23.03$, $p < 0.001$ (see Table 1). Tukey multiple comparison tests showed that all three groups were significantly different from each other. As would be expected, groups differed in terms of their past drinking behaviour.

For state anxiety scores there was no significant main effect of group, $F(2,57) = 0.20$, $MSE = 108.36$, $p > 0.8$ (see Table 1). Groups did not differ in their anxiety levels at the time of testing. For scores on trait anxiety there was a significant main effect of group, $F(2,57) = 7.20$, $MSE = 90.48$, $p < 0.003$ (see Table 1). Tukey multiple comparison tests showed that the low and high groups were not significantly different from each other but both were significantly different from the CAS group, with the CAS group generally more trait anxious than the other two groups.

Analysis of error

The number of errors made in this study were analysed in a three-way ANOVA, with group and order as between-participant variables and word type as a within-participant variable. The factor for block was not included in this analysis, as very few errors were made overall. The analysis revealed a main effect of word type, $F(1,54) = 5.41$, $MSE = 2.11$, $p < 0.03$. More errors were made for alcohol words (2.58%) than neutral words (1.97%). No word type $\times$ group interaction, $F(2, 54) = 1.59$, $MSE = 2.11$, $p = 0.35$, nor main or interaction effects of order or group (all $F < 1.7$, $p > 0.2$) were shown.

Analysis of response latencies

The mean correct reaction times (RT) were analysed using a four-way ANOVA, with group and order as between-participant variables, and word type and block as within-participant variables. Initial analysis indicated some departure from the sphericity assumption. The Huynh–Feldt epsilon correction degrees of freedom have been reported. We note that the interpretation of our results was unaffected whether the epsilon correction was or was not used.

Analyses revealed that the colour identification
of alcohol words (1054 ms) took longer than neutral words (991 ms), $F(1,54) = 32.60$, MSE $= 18417.70$, $p < 0.001$. Of more importance was a significant interaction between word type and group, $F(2,54) = 19.40$, MSE $= 18417.70$, $p < 0.001$ (see Fig. 1). Simple main effects analysis revealed that reaction times were significantly longer for alcohol than neutral words for the CAS group (1268 and 1108 ms, respectively), $F(1,18) = 31.67$, $p < 0.001$, for the high group (918 and 896 ms, respectively), $F(1,18) = 4.50$, $p < 0.05$, but not the low group (976 and 968 ms, respectively), $F(1,18) = 0.36$, $p > 0.5$. However, when the analysis was restricted to the high and low participants the interaction between word type and group was not significant, $F(1,36) = 0.65$, $p = 0.42$.

A main effect of group $F(2, 54) = 19.00$, MSE $= 227917$, $p < 0.001$, indicating a longer RT for the CAS group than the two control groups (low, high) was shown. There was also a main effect of block, $F(3,745, 216) = 2.49$, MSE $= 15608.67$, $p < 0.05$, which indicated an increase in RT from blocks 1–5, and an interaction of block with group, $F(7.49, 216) = 3.20$, MSE $= 15608.67$, $p < 0.003$. Simple main effect analysis revealed a significant simple main effect of block for the low $F(4,72) = 5.05$, $p < 0.002$ and high $F(4,72) = 6.58$, $p < 0.001$ groups but not the CAS group, $F(3.414,72) = 1.603$, $p > 0.1$. No other main or interaction effects were significant (all $Fs < 1.0$, $p > 0.4$). That there was no significant three-way interaction between group, word type and block indicates that the rate of habituation to alcohol words was not significantly different between the three groups (see Fig. 2).

Can these findings be explained by the uneven distribution of gender within the three groups? In particular, as the CAS group contained mainly males, could the interference for alcohol-related words be larger for males than females? We do not believe this to be the case for three reasons. First, an analysis of variance including only the female data produced a significant group × word type interaction, $F(2,36) = 17.906$, $p < 0.001$. Secondly, an analysis of variance including the factor for gender did not affect the interpretation of the results. The group × word type interaction was still significant $[F(2,50) = 12.359$, $p < 0.001]$ and the gender × group × word type interaction was not significant $[F(1,50) = 2.385$, $p > 0.1]$. Thirdly, the magnitude of the interference (Alcohol RT minus Neutral RT) for CAS females (215 ms) was higher than that for CAS males (142 ms), although this was not significant ($t(18) = 1.14$, $p = 0.27$).

Another variable that could potentially explain the larger interference scores found in the CAS group is trait anxiety. Table 1 shows that the CAS group not only had higher AUDIT scores but also higher trait anxiety scores. An analysis of covariance with trait anxiety as the covariate did not eliminate the two-way interaction between word type and group: $F(2,56) = 17.14$, MSE $= 17775.92$, $p < 0.001$.

**Correlation analysis**

An interference score (Alcohol RT minus Neutral RT) was calculated for each participant and correlated with the scores on the AUDIT. Overall there was a significant correlation between AUDIT and interference scores: $r(58) = 0.50$, $p < 0.001$ (see Fig. 3).

Because the control and problem drinking groups are heterogeneous subgroups further analysis was performed on each of the three groups. Within each of the three groups AUDIT...
scores did not significantly predict interference scores: low $r(18) = -0.046, p = 0.85$; high $r(18) = -0.156, p = 0.51$; CAS $r(18) = -0.138, p = 0.563$.

**Discussion**

The present study sought to address a number of issues that were either not addressed or uncontrolled for in previous research using the alcohol Stroop task. Three main findings were apparent from this experiment. First, the CAS group showed longer latencies to respond to the colour of alcohol-related stimuli than matched neutral stimuli. This finding therefore demonstrates that it is possible to find larger interference from alcohol-related stimuli than neutral stimuli in a group of problem drinkers. It also demonstrates
that it is possible to generalize any interference found using vocal responses to a manual version of the Stroop task. Of course, it is possible that there are differences between vocal and manual responding. One possible difference is that vocal responding generally produces carry-over effects (McKenna, 1986). However in our study, using manual responses, there was no evidence of carry-over effects (no interaction effects with order were significant). It is possible that there are other differences and these await further investigation.

Although there are group differences the correlation analysis within each group demonstrated that the AUDIT scores did not significantly correlate with interference scores. This indicates that there is another, as yet unidentified, variable other than AUDIT scores that could better explain the variability in the interference scores.

Our explanation for the main finding is that problem drinkers (or at least those with a past history of problem drinking) have a highly activated memory structure related to alcohol concepts. It is possible that when asked to ignore the words these subjects are unable to because their attention is involuntarily diverted to the word, which in turn slows them down in responding to the colour. In addition, Stacy (1995) has suggested that the memory activation of concepts relating to alcohol is an implicit memory component and can be activated automatically.

Secondly, a control group of high drinkers also show larger interference from alcohol stimuli than neutral stimuli. However, a control group of low drinkers do not show larger interference from alcohol stimuli than neutral stimuli. Although the interference was apparent within the high drinkers control group it was much reduced compared to the CAS group. This may also be accounted for by the development of a memory structure that is related to alcohol concepts. In particular it highlights the development of an alcohol-related implicit memory from low to high to problem drinkers. Although this is our preferred explanation this conclusion is tempered by the fact that, within the control groups, the interaction between word type and group was not significant. In addition, as with any between-subject design, the differences between groups may be due to other confounding variables. Some of these are immediately apparent: gender, age, treatment, social economic status, level of education, etc. In other, similar, studies involving different psychopathologies, when some of these variables have been controlled the interference effects are still found (see Williams, Mathews & MacLeod, 1996). Such controlled studies with abstinent problem drinkers must await further investigation.

Thirdly, no substantive statistical evidence of habituation to alcohol-related stimuli was found in either the control or CAS groups. It is therefore concluded that the main factor explaining the difference in interference between the control and CAS groups is the degree to which alcohol-related stimuli capture attention. However, it is possible that increasing the number of blocks beyond five may have illustrated the effects of habituation more clearly. It can be noted that for both the high and CAS groups the tendency was for habituation across blocks. That is, there was a tendency for the difference in response latency between alcohol and neutral stimuli to decrease from block 1 to block 5. This is consistent with evidence from the emotional Stroop paradigm, which also indicates habituation to emotional stimuli (McNally et al., 1990; McKenna & Sharma, 1995), as well as other more general encounters with emotional stimuli where repeated exposure is an effective treatment (Foa & Kozak, 1986). Much of this evidence is consistent with the existence of an alcohol-related information processing bias in problem drinkers.
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