Alcohol-Predictive Cues Enhance Tolerance to and Precipitate “Craving” for Alcohol in Social Drinkers

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ABSTRACT. This study attempts to show that tolerance to alcohol is in large part a “learned” response, precipitated by contextual cues predictive of the unconditional drug effect. It also aims to show that the contextual cues integral to such “environment-dependent” tolerance function to increase motivational desire to drink alcohol. Male students (N = 40), drinking on average 10–20 units of alcohol per week, were randomly assigned to one of four groups. Two groups ingested 1.2ml/kg alcohol: one (AL-EXPT) with exteroceptive contextual cues typically associated with alcohol use, and the other (AL-UNEXPT) in a context not normally associated with alcohol. A third group (placebo) believed that they were drinking alcohol but, in fact, consumed a nonalcoholic beverage in the alcohol-expected context. The fourth group drank juice in the alcohol-unexpected context. As predicted, tolerance to the deleterious effects of alcohol on cognition and motor-performance, and subjective desire to consume alcohol, were influenced by the alcohol-predictive contextual cues. A physiological index (pulse rate) also tended to confirm that these cues elicited a conditioned compensatory response to alcohol. The implications of these findings for tolerance to and motivation to drink alcohol in a nonpathological population are discussed. (J. Stud. Alcohol 51: 494–499, 1990)

WORK triggered by Siegel (1978) on classically conditioned drug-opposite responses and on the implications of this for tolerance has seriously questioned the view that drug tolerance is wholly determined by pharmacological mechanisms (Goldstein et al., 1974). Animal research (Le et al., 1979; Mansfield and Cunningham, 1980) has shown how tolerance to the hypothermic and hypnotic effects of alcohol is a function of contextual cues. These cues when reliably paired with alcohol come to “prepare” the organism for the unconditional drug effect in a compensatory and adaptive fashion. As the conditioned compensatory response grows stronger, via repeated pairings of the cues with alcohol, tolerance develops. Their studies show how tolerance is reduced if alcohol is administered in an environment associated with saline injection and an alcohol-opposite hyperthermic response occurs if saline is injected when the contextual cues normally associated with alcohol are present.

A number of human alcohol studies have lent support to this conditioning theory of tolerance. The tachycardic effect of alcohol (Dafters and Anderson, 1982) and its deleterious effects on cognition (Shapiro and Nathan, 1986; Williams et al., 1981) were greater when alcohol was administered in a nonassociated context, compared to its effects in the presence of contextual cues with which it had previously been paired. Newlin (1985, 1986) has reported drug-opposite physiological responses (decreased pulse transit time, finger pulse amplitude and skin temperature) in social drinkers given a tonic placebo in a distinctive alcohol-linked room.

These studies are similar in that the authors, through a number of “conditioning” trials, initially form in the subjects the associations between the unconditional alcohol effect and some distinctive experimental environment. The present study attempts to show that, in the “real” world, there are cues strongly associated with the presence of alcohol and that these cues are instrumental in mediating tolerance in social drinkers. Jones (1974), for example, found social drinkers to be more tolerant to alcohol impairment on cognition, if tested in the evening rather than the afternoon. Since there was no evidence of circadian variation in alcohol absorption and elimination, he suggested that those subjects drinking alcohol at a time of day normally associated with alcohol consumption (i.e., the evening) may have been more tolerant to the drug than those consuming it at an “unexpected” time. Other “naturally” predictive cues may be a social context, visual and auditory cues specific to a drinking environment and the sight, smell and taste of one’s preferred beverage. The significance of these “social” cues (rather than experimentally contrived cues) in mediating tolerance to the disruptive effects of alcohol on cognition and motor...
performance and to physiological effects of the drug are investigated.

Hinson and Siegel (1982) take the model further. They suggest that the precipitation of conditioned compensatory responses by drug predictive cues may be a major factor in the addictive cycle. Such conditioned drug-opposite states, presumably well developed in the addict, may be more or less uncomfortable, may be cognitively labeled as "craving" and may lead to appetitive drug behavior in attempts to relieve the symptoms. Ludwig and his colleagues (Ludwig and Stark, 1974; Ludwig et al., 1974) have shown that alcohol-typical cues precipitate "craving" and augment operant behavior for the drug in alcoholics. Thus, a second aim of the present study is to examine the effect that such alcohol-typical cues may have on reported desire to consume alcohol in social drinkers.

Method

Subjects and criteria

Male undergraduate students (N = 40) were used, the mean (± SD) age being 20.8 ± 2.3 years. Subjects were selected only if they were regular social drinkers consuming between 10 and 20 units of alcohol a week (1 unit = 1/2 pint). Subjects were asked not to volunteer if they had any alcohol-related problems and were randomly selected from the university psychology department. Except for the control group, the subjects were told that the study was looking at some effects of alcohol, and all subjects consented to take part in a study in which a degree of inebriation could be expected.

Independent variables

A 2 × 2 independent groups design was employed to assess the effects of two alcohol-expectancy contexts (expected versus unexpected) and the actual presence or not of the drug on various dependent measures. A 1.2ml/kg dose of alcohol was used.

Context 1 simulated typical interoceptive and exteroceptive alcohol-expectancy cues. A simulated lounge-bar room was used—soft chairs, soft lighting, cans and bottles of various drinks were clearly visible and a tape of pub noises was played throughout the drinking and absorption phases. The room was used in the evening (normal alcohol drinking time), and the alcohol-expected (AL-EXPT) and placebo groups drank socially in groups of 10. Subjects received the alcohol in the form of their preferred drink, thus visual and taste cues were provided.

Context 2 was a typical alcohol-unexpected environment. It was an office-type room, used during the day (a time when the subjects did not typically drink). Subjects were tested individually (unlike their usual social drinking context) and alcohol was given in pure form mixed with an artificial sweetener. No typical alcohol cues, visual or auditory, were present.

Dependent variables

Tolerance and placebo reactions to alcohol in the two contexts were assessed in the following ways:

Physiological effect. Percentage increase or decrease in finger pulse rate was measured from a pre-ingestion baseline, after alcohol, placebo or juice had been ingested. A San-El Pulsometer was used.

Cognitive effects. Tolerance to the deleterious effects of alcohol on cognitive functioning was assessed using the Advanced Raven Progressive Matrices Test (Raven et al., 1962). Set 1, a practice set, was administered before any alcohol was ingested to control for any predrug IQ deviance and there was no time limit. Set 2 was administered 1 hour after subjects had finished drinking, the approximate time at which peak blood alcohol concentration was expected for the dose given (Jones, 1974). Blood alcohol concentrations were not taken for reasons of time efficiency and since it would be unlikely that there would be any significant difference between groups (Shapiro and Nathan, 1986). Subjects were asked to complete all the odd numbers (18 problems) and were given a 20-minute time limit. The total number answered correctly in this set was recorded.

Motor performance effects. The perceptual motor skills exercise (Drexel University, 1986) was conducted using a Mackintosh Plus computer system. The task involved moving a pictorial "mouse" around the boundaries of a square displayed on the screen, using a flexible lever attached to the computer. The task was further complicated in that when the subject moved the lever up the mouse went down, and vice versa, and when the subject moved the lever to the left the mouse moved to the right, and vice versa. Feedback was both visual and auditory in that when the subject moved off target a tone sounded. There were three trials, each lasting 60 seconds, and the subjects were told to move around the square as quickly and accurately as possible. The mean time off target for every 100mm travelled was recorded across the three trials.

Subjective effects. The effect of the contexts and the drug dose on the desire to consume more alcohol was assessed by using a "craving" continuum. On finishing their drink subjects were asked to rate on a scale between 0 and 10 how much they would like another drink. The experimenter added that a 0 might indicate: "I definitely would not like another drink," and 10: "I am really craving another drink." It was hoped that this measure would assess the impact of the drinking cues, interacting with the presence or absence of the drug, on motivational desire to consume alcohol.
General procedure

The subjects were divided into four equal groups of 10 and underwent the following treatments:

Alcohol expected group (AL-EXPT). This group arrived together for the experiment at 7 PM, and had been told not to eat anything after lunch or consume any alcohol. Subjects sat down in a “neutral” room and completed the practice set 1 of the matrices and their pulse rates were recorded. They were then taken into the alcohol-expected context (Context 1) where they ingested 1.2 ml/kg of alcohol provided in two pints of lager (5% v/v alcohol), the subjects’ preferred drink, with 95% (v/v) alcohol added to make it up to the correct dose. They were given 15 minutes to consume their drink, after which time a second pulse-rate reading was taken. At this point they were asked to rate on the “craving” continuum how much they would like another drink. They were then told to relax, write a “drinking history” and talk together for 1 hour. The purpose of the “drinking history” was to verify that no subject drank in unusual contexts or had any alcohol-related problems. At the end of the hour the subjects completed the matrices task and the motor-performance exercise. On completion of these tasks the subjects were debriefed and escorted home.

Alcohol unexpected group (AL-UNEXPT). Subjects in this group arrived individually at 2 PM. They were asked not to eat anything after breakfast and have no alcohol that day. The same procedure was repeated as for the AL-EXPT group, except that the alcohol was given in pure form (95% v/v ethanol) mixed in an artificial carbonated sweetener to the same absolute liquid volume as the first group. Context 2 was used and the subjects were tested individually.

Placebo group. The procedure was the same as for the AL-EXPT group except that no real alcohol was consumed. A nonalcoholic lager with a thin film of ethanol floating on top was served. This placebo technique is probably the most successful and the floater film is pharmacologically insignificant (Keane et al., 1980). The purpose of this group was to investigate compensatory physiological responses in the presence of alcohol-expected cues but in the absence of alcohol and to see the effects of these cues alone on alcohol “craving.”

Control group. Individuals were tested in the afternoon and in the office-type room. They did not expect to drink alcohol and were given a similar volume of the alcohol mixer to drink in 15 minutes. As in the other groups, pulse-rate readings were taken before and after drinking, their “craving” rating was taken to counter any suggestion factors in the question itself, and they completed the matrices tests and the motor-performance task.

The cognitive and motor-performance variables were analyzed using a 2 x 2 between subjects analysis of variance (ANOVA), with follow-up post hoc analyses on the interactive and main effects. A multiple regression analysis was used on the postdrinking pulse-rate variable with the pulse rate before drinking as a covariate (Kerlinger and Pedhazur, 1973). Mann-Whitney U tests were applied to the “craving” measure since this had an ordinal scale.

Results

Cognitive and motor-performance effects

The pattern of results on both measures was similar. Figure 1 shows the mean scores for each group on set 2 of the matrices (there were no differences between groups on practice set 1 [F = 0.368, 1/36 df, p < .77] suggesting no pre-drug differences in cognitive functioning). Mean errors on motor performance as measured by time off target for every 100mm travelled on target are displayed in Figure 2. On both measures the control group performs the best and the AL-UNEXPT group the worst. Interestingly, as Williams et al. (1981) also found, the group consuming alcohol and expecting alcohol (the AL-EXPT group) performed better than the group expecting alcohol but given a placebo (the placebo group).

A 2 x 2 between subjects ANOVA showed that the interactive effect of the alcohol and the context was highly significant on both the matrices (F = 11.93, 1/36 df,
p < .002) and motor-performance task (F = 9.812, p < .004). Simple main effects post hoc analyses revealed similar trends on both tasks.

Tolerance to the disruptive effects of alcohol on cognitive and motor performance interacted with the drinking context. The AL-EXPT group scored significantly higher on the matrices test than the AL-UNEXPT group (F = 11.97, 1/18 df, p < .001) and showed less motor impairment to the same dose of alcohol (F = 7.75, 1/18 df, p < .008), suggesting situational specificity of tolerance to the drug. Interestingly, there were no significant differences between the AL-EXPT and placebo groups on either the matrices test (p = .61) or the motor-performance task (p = .44). When the context is predictive of alcohol the actual presence or absence of alcohol had no differential effect.

Pulse rate

Mean changes in pulse rate following the various treatments are summarized in Figure 3. The mean (± SD) increase in pulse rate of the AL-EXPT group (3.9 ± 5.4 beats/min.) was not quite as great as that of the AL-UNEXPT group (4.7 ± 5.1 beats/min.), suggestive perhaps of enhanced tolerance, whereas the placebo group’s pulse rate actually decreased (−5.7 ± 9.3 beats/min.), consistent with the conditioned compensatory response model.

The high standard deviations across groups on this measure, reflecting individual variation in autonomic lability, suggested that an ANOVA could be misleading here. Consequently, a multiple regression analysis was conducted on the data, with alcohol and context as predictor variables, the predrinking pulse rates as a covariate and postdrinking pulse rates as the criterion variable (Kerlinger and Pedhazur, 1973). Table 1 summarizes the results of this analysis.

The results show that both the alcohol and the context variables made significant contributions to postdrinking pulse rates when an adjustment was made for the predrinking pulse rate. This suggests that not only did alcohol have the unconditional effect of producing a

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Note: The table describes the increase in $R^2$ (i.e., the added variation accounted for by each variable) when an adjustment is made for the overall variation accounted for by the covariate ($R^2 = 0.388$).
subjective desire to consume alcohol

Mann-Whitney U-test analyses were carried out on all intergroup differences, since the "craving" rating was ordinal in nature.

The mean "craving" ratings across the four groups (Figure 4) would suggest that the context of drinking had the greatest influence on subjective desire to consume alcohol. Not only was the AL-EXPT group's mean rating of 7.8 ± 1.66 significantly greater (p = .01) than that of the AL-UNEXPT group (3.7 ± 2.33), but this latter group scored significantly lower (p = .05) than the placebo group (6.2 ± 1.93) who experienced the alcohol-predictive cues but consumed no alcohol. This suggestion is further supported by the fact that there were no differences between the placebo and the AL-EXPT groups or between the AL-UNEXPT and control groups.

Discussion

This study provides ecological validity to previous work that has suggested the importance of conditioning factors in alcohol tolerance (e.g., Dafters and Anderson, 1982; Shapiro and Nathan, 1986). These studies demonstrated enhanced tolerance to alcohol when subjects were tested in an alcohol-associated context, compared to an unassociated context. The present study has shown enhanced tolerance to the deleterious effects of alcohol on cognition and motor performance when social drinkers consume alcohol in conjunction with cues typically associated with drinking alcohol in the real world. The finding that, on both tasks, the AL-EXPT group showed significantly less impairment than the AL-UNEXPT group further questions theories of tolerance that rely solely on pharmacological factors and lends further support to the concept of "environment-dependent" tolerance.

It is true that many cues were manipulated (time of day, social context, etc.) in this study. However, Jones (1974) found no difference between his "evening" and "afternoon" drinking groups in absorption and elimination rates, suggesting no significant circadian variation in alcohol metabolism at these times. Furthermore, the fact that the placebo group performed worse on both tasks compared to the control group, whereas the AL-EXPT group (exposed to the same context cues as the placebo group) performed better than the AL-UNEXPT group would suggest no significant main effect of these cues on performance. Their effects lay, rather, in how they interacted with alcohol.

This interaction is consistent with an explanation in terms of a classical conditioning process on a number of counts. Unlike the Shapiro and Nathan (1986) study, subjects did not have the opportunity to "practice" the tests in the drugged state, making an explanation of tolerance in terms of instrumental conditioning theory, as proposed by Wenger et al. (1981), unlikely. Furthermore, the effects on pulse rate are consistent with a conditioned drug-opposite response theory. Although the interaction was not significant, the context exerted a significant main effect on pulse rate, seen most clearly by a drop in pulse rate (opposite to alcohol's unconditional effect) in the placebo group.

The results, however, pose an apparent contradiction for a conditioned compensatory response model of environment—dependent tolerance. If an alcohol compensatory mechanism is involved the placebo group would have been expected to perform better than the control group (Beirness and Vogel-Sprott, 1984). However, Williams et al. (1981) also found that subjects expecting alcohol and given a tonic placebo scored significantly lower on the Raven matrices than subjects expecting tonic and given tonic. They suggest that "such inconsistency between expectations and interoceptive cues for alcohol may be con-
fusing to subjects, and thereby produce novel effects'" (p. 270). It is difficult, though, to reconcile these findings with those of Beirness and Vogel-Sprott (1984). A conditioned compensatory response may have positive and negative effects on performance, depending on the particular demands of the task. Hinson and Siegel's (1980) model does suggest that the arousal of this state may be "uncomfortable" (p. 189) for the organism, and thus it is not inconsistent with this theory to suppose that this may have a deleterious effect on performance.

The second aim of this study was supported. The context cues predictive of alcohol contributed most to the motivational desire to consume alcohol. The AL-EXPT and placebo groups (both in an "alcohol-expected" environment) had the highest "craving" ratings. The fact that the placebo group scored higher than the AL-UNEXPT group but lower than the AL-EXPT group would suggest that, if anything, it was the alcohol that was having a secondary additive effect to the context on precipitating "craving".

In summary, the results support an "environment-dependent" tolerance model and provide ecological validity for it. These results, together with the main effect of the context cues on pulse rate and subjective desire to consume alcohol, are consistent with a conditioning theory of tolerance, with implications for our understanding of "craving" and dependency.

References


