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Interference in the alcohol Stroop task with college student binge drinkers

Kevin A. Hallgren, Barbara S. McCrady

University of New Mexico

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Corresponding Author:
Kevin A Hallgren,
University of New Mexico
khallg@unm.edu

Key words: Alcohol Stroop test, attention, binge drinking, college students, information processing

Abstract

Heavy drinking among college students is associated with social, health, and legal problems. One factor that may contribute to heavy drinking is an attentional bias for alcohol-related cues, which can influence drinking automatically and without an individual's awareness. Using tests of alcohol-related attentional bias, such as the alcohol Stroop task, previous research has shown that alcohol dependent drinkers have greater attentional biases than non-dependent drinkers, but results for college student drinkers have been mixed. The present study examined alcohol Stroop task performance and its relationship to drinking levels and drinking-related problems among 84 college students during the 2009-2010 academic year with at least one binge drinking episode in the previous month. As hypothesized, results indicated that participants had greater attentional interference when alcohol words were presented compared to when neutral words were presented during the Stroop task, suggesting that the students in the sample displayed greater attentional biases for alcohol words compared to neutral words. Results showed that Stroop task responding did not vary by drinking frequency or drinking-related problems, but did vary by drinking intensity. Presentation of alcohol-related cues may cause heavier drinking college students to attend to these stimuli, which may increase the saliency of these cues and influence their likelihood of drinking. Implications for prevention and treatment efforts are discussed.

INTRODUCTION

Heavy drinking among college students is associated with social, health, and legal problems. One factor that may contribute to heavy drinking is an attentional bias for alcohol-related cues, which can influence drinking automatically and without an individual's awareness. Using tests of alcohol-related attentional bias, such as the alcohol Stroop task, previous research has shown that alcohol dependent drinkers have greater attentional biases than non-dependent drinkers, but results for college student drinkers have been mixed. The present study examined alcohol Stroop task performance and its relationship to drinking levels and drinking-related problems among 84 college students during the 2009-2010 academic year with at least one binge drinking episode in the previous month. As hypothesized, results indicated that participants had greater attentional interference when alcohol words were presented compared to when neutral words were presented during the Stroop task, suggesting that the students in the sample displayed greater attentional biases for alcohol words compared to neutral words. Results showed that Stroop task responding did not vary by drinking frequency or drinking-related problems, but did vary by drinking intensity. Presentation of alcohol-related cues may cause heavier drinking college students to attend to these stimuli, which may increase the saliency of these cues and influence their likelihood of drinking. Implications for prevention and treatment efforts are discussed.

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Interference in the Alcohol Stroop Task with College Student Binge Drinkers

Heavy drinking in college is associated with many threats to health and safety, including driving while intoxicated, physical and sexual assault, and risky sexual behavior. In addition, heavy drinking in college often precedes long-term health consequences including the development of alcohol dependence [1,2].

Information processing models of alcohol use posit that drinking behavior is in part guided by automatic or implicit processes [3]. Such processes are said to be fast acting, automatic, and outside of executive control [4]. Among these processes, attentional bias for alcohol-related stimuli has been studied in an effort to understand how implicit cognition is involved in the maintenance and change of drinking-related behaviors.

In alcohol users, it is thought that memory structures of alcohol-related cognitions are formulated at the implicit level, and that when an alcohol cue is presented the activation of salient memory structures occurs automatically. This activation causes alcohol cues to occupy attention [4] and leads to biases where alcohol-related stimuli are attended to more immediately than other non-alcohol-related tasks, and the processing of non-alcohol-related tasks is delayed. Implicit cognitive processes, such as attentional bias, have been hypothesized to contribute actively to the development and maintenance of addictive behaviors [5,6] and are hypothesized to be mediating factors between the presentation of alcohol-related stimuli and subsequent behavioral responses [7]. The automatic attentional bias toward alcohol-related cues may guide behavior even when it is inconsistent with an individual's conscious goals [5], and may create increased potential for heavy drinking. For example, a heavy drinker may wish to abstain from drinking, yet have difficulty controlling his or her attention toward alcohol-related stimuli, increasing the likelihood that he or she will drink. In this manner, it is hypothesized that attentional bias toward alcohol cues increases motivational incentives to consume alcohol and influences drinking behavior.

Measures of implicit cognition contribute unique information that cannot be provided by self-report. Assessments of implicit cognition have been shown to account for variance in substance use beyond what is accounted for by explicit measures [8-10], and several studies have demonstrated that attentional bias toward alcohol-related stimuli is associated with greater drinking quantities [11,12] and a diagnosis of alcohol dependence [13-15].

The alcohol Stroop task [13] is one of the most common methods for assessing alcohol-related attentional bias. During the alcohol Stroop task, alcohol-related and neutral words are presented on a computer screen and participants are asked to name the color of each word presented while ignoring the meaning of the word itself. Slower color-naming responses for alcohol words compared to neutral words are thought to indicate that the semantic meaning of the alcohol words occupies attention more than neutral word meanings, which causes a delay in attending to the task of naming the word color.

Studies using the alcohol Stroop task with college students have had mixed results in detecting a relationship between alcohol Stroop interference and participants' typical drinking levels. For example, Sharma et al. [15] found that alcohol Stroop task responding failed to differentiate college students with higher levels of hazardous drinking from students with lower levels, yet others have found a significant association between drinking quantity and alcohol interference using text-based [12] and picture-based alcohol Stroop tasks [11]. Other studies have shown that heavier drinkers respond more slowly to alcohol words than neutral words in an alcohol Stroop task only after exposure to alcohol-related priming conditions, whereas lighter drinkers had no difference in responding regardless of priming condition [16,17].

Two notable theories provide different accounts for why individuals with high alcohol involvement display attentional biases for alcohol words [18]. Early work in this area espoused explanations driven by primarily cognitive factors, where the processing of alcohol-related stimuli takes immediate priority over other information processing tasks, such as the naming of the word color. The presence of this type of automaticity-based interference should typically result in a delay in the color-naming component in the alcohol Stroop task *during* trials in which alcohol words are presented. In contrast, more recent theoretical work has emphasized the importance of emotional factors, where alcohol stimuli may elicit conditioned emotional responses that slow other information processing tasks. This type of emotion-based interference should typically result in a delay in the color-naming component in the alcohol Stroop task *after* trials in which alcohol words are presented. Phaf and Kan [19] reported a meta-analysis of studies using anxiety- and depression-related Stroop tasks and found stronger support for the emotional-based interference, measured by delayed responding when anxiety- and depression-related stimuli were presented in the previous trial, and found less support for automaticity-based interference, measured by delayed responding when anxiety- and depression-related stimuli were presented in the current trial.

The goal of the present study was to assess the relationship between alcohol-related attentional bias and alcohol involvement among a sample of college

students with recent binge drinking. Specifically, the present study aimed to test whether participants who drank more frequently, more heavily, or had more negative consequences from drinking would be more distracted by alcohol-related stimuli compared to neutral stimuli, and to test how well both immediate interference (i.e., current-trial responding) and delayed interference (i.e., subsequent-trial responding) corresponded with alcohol involvement.

It was hypothesized that individuals with greater alcohol involvement would have greater current- and subsequent-trial response latencies for alcohol words relative to neutral words, while individuals with less alcohol involvement would have no difference in response latencies based on word type. Alcohol involvement was assessed based on measures of drinking frequency, drinking intensity, and drinking-related problems, as these constructs represent different dimensions of alcohol involvement, are likely to have considerable variability within a university sample, and have been commonly used in previous studies of alcohol-related attentional interference [12,16,17,20].

Support for these hypotheses would suggest that college students with higher alcohol involvement have attentional biases for alcohol cues that make it more difficult for them to disengage from alcohol-related stimuli, which may play a causal factor in their drinking. In addition to having implications for theories of treatment and prevention, these results would suggest that prevention and treatment providers may wish to incorporate issues of attentional bias into their programs, for example, by helping clients become aware of attentional biases that may appear when alcohol cues are presented and helping them find alternative ways of handling such situations without drinking.

METHOD

Participants

Participants were undergraduate university students receiving course credit for their participation in the study and were recruited during the 2009-2010 academic year through a university website listing available research credit opportunities. Recruitment advertisements described the study as an investigation of social networks and individual attitudes and did not explicitly advertise the study as being related to alcohol in order to avoid potential priming effects that might affect the alcohol Stroop task. Eligibility criteria included being at least 18 years old and having at least one binge-drinking episode within the previous 30 days, defined by the consumption of at least four alcoholic beverages in a single drinking episode for women or five alcoholic beverages for men. Only participants with a recent binge drinking episode were recruited because these individuals are considered to be at a higher risk for alcohol- and health-related problems, and we expected that participants meeting this criterion would still have a substantial amount of variance in their level of alcohol involvement. The recent binge drinking episode was assessed before participants signed up for the study by asking a small battery of questions on a variety of topics related to social networks and individual attitudes to maintain ambiguity about the nature of the study, and the battery included one item to assess the maximum number of drinks they had consumed in the last 30 days. This report was subsequently confirmed by the self-report questionnaires of alcohol consumption that were completed after during participation in the main study.

Of the 405 students who completed the eligibility pre-screen, 140 met eligibility criteria for enrollment into the study, and 84 students scheduled appointments and completed the study. Fifty-nine participants (70%) were female; 30 (36%) were Hispanic, 45 (53%) were White, and 9 (11%) reported other ethnicities. Participants had a mean age of 21.1 years (*SD* = 4.4) and on average had completed 2.1 years of college (*SD* = 1.5).

Measures

Alcohol-related attentional bias. An alcohol Stroop task [13] was used to measure attentional bias for alcohol-related words. Stroop tasks incorporating self-relevant words have demonstrated good test-retest reliability [21] and good convergent, discriminant, and predictive validity, particularly for individuals with high levels of alcohol involvement [18]. During the test, 80 trials of 20 alcohol words (e.g., “cocktail”) and 20 neutral words (e.g., “sweater”) matched for length and frequency of usage [22,23] were presented sequentially in a non-blocked, randomized order on a computer screen with red, yellow, blue, or green font color on a white background following the guidelines outlined by Cox et al. [18]. Participants were instructed to respond by identifying the font color of each word as quickly and as accurately as possible using the keyboard while ignoring specific word meanings, with response latencies and errors recorded for each trial. Keyboards were marked with colored stickers that matched the corresponding colors for responses, and participants were given 40 neutral practice trials consisting of household words (e.g., “attic”) to learn the locations for each response color. Stimuli were presented with an interval of 200 ms between trials. The alcohol Stroop task was programmed using DMDX software [24], which has a reported display accuracy within 4 ms and can accurately record response latencies within 2 ms. Participants completed the study in an area that

provided adequate privacy and viewed the stimuli at a distance that was comfortable for them.

Previous drinking behavior. Drinking quantity and frequency were assessed using a computerized Alcohol Timeline Followback questionnaire [25] to calculate the percentage of drinking days (drinking frequency) and the mean number of drinks per drinking day (drinking intensity) over the previous 90 days. Participants were given calendars marked with important holidays and academic dates to provide estimates of the number of drinks they consumed for each drinking day over the 90-day period. The Timeline Followback yielded separate variables for drinking frequency (percentage of drinking days) and drinking intensity (mean number of drinks per drinking day). For ANOVA tests, drinking frequency was dichotomized based on a median split, and drinking intensity was dichotomized such that "heavier drinkers" had a mean number of drinks per drinking day that was greater than or equal to the number of drinks constituting a binge episode (i.e., 4 drinks for women, 5 drinks for men), and "lighter drinkers" had a mean number of drinks per drinking day that did not exceed a binge episode. Approximately half of the participants were in each drinking intensity category (n = 41 higher-intensity drinkers, n = 43 lower-intensity drinkers).

Drinking-related problems. The Rutgers Alcohol Problem Index (RAPI) [26] is a unidimensional questionnaire that assessed the frequency of negative alcohol-related consequences participants had experienced within the previous three years. The RAPI contains 23 items designed specifically to detect negative alcohol-related consequences commonly experienced by college students (e.g., "How often have you not been able to do your homework or study for a test because of your alcohol use?"). The measure is well validated and has demonstrated good test-retest reliability when administered to college students in paper-and-pencil- and computer-based formats (r = .88) [27].

Procedure

Participants were not informed about the alcohol-related nature of the study during the enrollment or consent processes. To reduce the possible effects of assessment reactivity on the alcohol Stroop task, participants completed the alcohol Stroop task prior to completing the remaining questionnaires. All assessments were administered by computer. Institutional Review Board approval was obtained for all procedures in this study and informed consent was obtained from all participants.

Data Analysis

Data processing. Internal reliability for response latencies for each word type in the alcohol Stroop task was assessed using Cronbach's alpha, and response latencies were aggregated following methods consistent with previous research [12] by averaging within each trial type. Specifically, response latencies for each trial were divided into one of four trial types based on the type of word that appeared in the previous trial (alcohol or neutral) and the type of word that appeared in the current trial (alcohol or neutral) in order to disaggregate delayed and immediate interference effects. This resulted in four possible categories for each response: alcohol-alcohol, alcohol-neutral, neutral-alcohol, and neutral-neutral, based on the type of word presented in the previous trial and current trial, respectively. Consistent with the previous literature, trials with unrealistically fast or slow reaction times (i.e., less than 250 ms or greater than 1250 ms) were excluded, as were trials with incorrect color-naming responses.

Hypothesis testing. A one-way within-subjects ANOVA was used to test whether students in the present study had different response latencies for the different trial types. Response latency was used as the dependent variable, and trial type was used as an independent within-subjects variable. Three two-way mixed ANOVAs were used to test whether patterns of responding to the different trial types varied across the three measures of alcohol involvement, with one of these three measures included as a between-subjects independent variable in each of the models. Significant omnibus tests were probed using pairwise follow-up contrasts to determine whether significant differences were present between the four trial types within each group. Alpha was set at .05 (two-tailed) for determining statistical significance for omnibus tests and was reduced to .01 (two-tailed) for follow-up contrast tests to reduce Type-I error rates due to multiple contrast tests.

RESULTS

Descriptive Statistics

Participants consumed alcohol on 26% of the last 90 days (SD = 18%), reported heavy drinking (i.e., $\geq$ 4 drinks per drinking day) on 14% of days (SD = 13%), and had slightly higher scores on the Rutgers Alcohol Problem Index than non-clinical young-adult samples (M = 13.1, SD = 9.7). On days that drinking occurred, participants reported a mean of 4.47 drinks per drinking day (SD = 1.87).

Disaggregated Stroop task response latencies were distributed with a mean of 709 ms (SD = 259, *skew* = 1.85, *kurtosis* = 7.86). Cutoff points for acceptable scores were set at 250 and 1250 ms, approximately 2 standard deviations above and below the mean with some adjustment for positive skew, to remove

unrealistically fast or slow responses. Overall, 93.4% of response latencies were retained after removing incorrect items (3.3% of responses) and items with response latencies less than 250 ms or greater than 1250 ms (3.3% of responses). Cronbach's alpha was high for response latencies of alcohol words (0.90) and neutral words (0.89), and the responses latencies for each trial were aggregated to compute mean response latencies for alcohol words and neutral words for each participant.

Attentional Bias Hypothesis Tests

Full sample. A one-way within-subjects ANOVA tested whether participants responded differently to alcohol and neutral words. Results from the omnibus ANOVA indicated that participants responded differently based on the trial type, $F(3,249) = 3.148$, $p = 0.026$. Follow-up pairwise contrasts indicated that only alcohol-alcohol and neutral-neutral trials significantly differed at the $\alpha = 0.01$ level, $F(1,83) = 7.589$, $p = .007$, indicating that participants responded more slowly when two alcohol words were presented sequentially than when two neutral words were presented sequentially (see Figure 1).

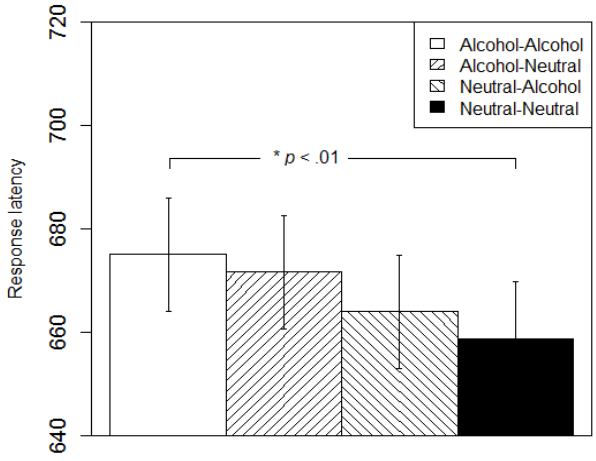

Figure 1. Stroop task responding by word type for the previous trial and current trial (e.g., "Alcohol-Neutral" indicates response latencies for trials in which an alcohol word was presented followed by a neutral word).

Figure 1 Note: ** $p < .01$. Vertical bars represent 99% confidence intervals.

Correspondence with alcohol involvement. A series of two-way mixed ANOVAs tested whether the significant differences in responding to Stroop test items differed between individuals with higher or lower levels of the three indices of alcohol involvement. The omnibus test for the drinking frequency × trial category effect was non-significant, $F(3,246) = 1.58$, $p = 0.195$, indicating that participants with higher and lower drinking frequencies did not differ in response latencies to different trial types in the Stroop task. This analysis also produced a non-significant main effect for drinking frequency on response latency, $F(1,82) = 0.06$, $p = 0.81$, indicating that overall mean response latencies collapsed across trial type did not differ based on drinking frequency.

The omnibus test for the drinking intensity × trial category interaction was significant, $F(3,246) = 4.407$, $p = 0.005$, indicating that participants responded differently to the Stroop task trial types depending on their level of drinking intensity. Mean response latencies with 99% confidence intervals for each trial type at each level of drinking intensity are presented in Figure 2. Follow-up contrasts tested for different levels of responding to each trial type within each drinking intensity group, and indicated that higher-intensity drinkers responded more slowly on alcohol-neutral trials compared to neutral-alcohol trials, $F(1,41) = 13.20$, $p < .001$, and higher-intensity drinkers also responded more slowly on alcohol-neutral trials compared to neutral-neutral trials, $F(1,41) = 9.00$, $p = .005$. Lower-intensity drinkers had no differences in responding to each of the four trial types. These findings indicate that higher-intensity participants, but not lower-intensity participants, responded significantly more slowly in trials where alcohol words preceded a neutral word relative to trials where neutral words preceded either word type, indicating partial support for a delayed interference effect of alcohol words. The results of this ANOVA also produced a non-significant main effect for drinking intensity, $F(1,82) = 0.75$, $p = 0.39$, indicating that overall mean response latencies collapsed across trial type did not differ based on drinking intensity.

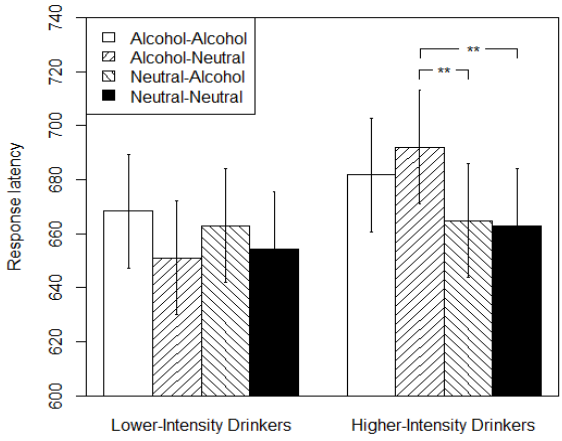

Figure 2. Stroop task responding by drinking intensity and word type for the previous trial and current trial (e.g., "Alcohol-Neutral" indicates response latencies for trials in which an alcohol word was presented followed by a neutral word).

Figure 2 Note: ** $p < .01$. Vertical bars represent 99% confidence intervals based on the word type × subject error component.

The omnibus test for the drinking-related problems × trial category effect was non-significant, $F(3,246) = 0.795$, $p = 0.498$, indicating that participants with higher and lower levels of alcohol-related problems did not respond differently to the Stroop task. This analysis also produced a non-significant main effect for drinking-related problems on response latency, $F(1,82) = 0.22$, $p = 0.64$, indicating that overall mean response latencies collapsed across trial type did not differ based on drinking-related problems.

DISCUSSION

When operationalizing attentional bias by performance on an alcohol Stroop task, the results from the present study showed that college students with a recent binge drinking episode tended to exhibit significant alcohol-related interference in the expected direction by responding more slowly to sequences of alcohol words compared to sequences of neutral words. The results failed to find that this pattern of interference differed based on drinking frequency or drinking-related problems, but the pattern of interference was significantly moderated by heaviness of drinking. Specifically, participants who drank more heavily tended to have longer delays in responding to trials in which an alcohol word was presented then followed by a neutral word compared to trials in which a neutral word was presented then followed with either an alcohol word or a neutral word. Participants who drank less heavily did not have any differences in responding to the different trial types, suggesting that the significant interference was specific to the heavier drinkers in the sample.

Competing theories have provided different hypotheses regarding the underlying processes that account for the alcohol-word interference effects in alcohol Stroop tasks [18]. For example, emotion-based theories posit that presentation of alcohol cues may cause affective responses that lead to generalized disengagement from the color-naming task, whereas automaticity theories posit that the salience of the meanings for alcohol words causes a bias in favor of processing the semantic meanings of those words before processing other relevant information, thus delaying attention toward the color-naming task. Support for emotion-based theories comes from longer delays caused by previous-trial alcohol words, while support for automaticity-based theories comes from longer delays caused by current-trial alcohol words [19].

For the full sample of the current study, follow-up contrasts revealed that the only significant difference in responding based on trial type was found between alcohol-alcohol trials and neutral-neutral trials, which does not clearly favor either automaticity or emotion-based theories. However, when the results were analyzed separately for heavier and lighter drinkers, heavier drinkers exhibited longer delays in alcohol-neutral trials compared to neutral-alcohol or neutral-neutral trials, lending more support for emotion-based theories of attentional interference. However, the strongest support for this would have been established if alcohol-alcohol trials similarly caused longer delays compared to neutral-alcohol and neutral-neutral trials, which was not found in the current study. Thus, the results of the present study do not strongly favor either emotion- or automaticity-based theories; however, the pattern of findings provided partial support for emotion-based theories of attentional bias and lent no direct support for automaticity theories. Slow-acting effects in various emotional Stroop tasks have also tended to provide stronger support for emotion-based theories of attentional biases related to other behavioral health problems, including anxiety and depression [19,28,29], marijuana and cocaine use [30], tobacco use [31], and heroin use [32].

The results of the present study suggest that attentional biases for alcohol-related cues may play important roles in the context of prevention and treatment programs for college students. The significant interference effects in the present study suggest that college students with recent binge episodes, particularly those who tend drink more heavily, appear to have attentional biases toward alcohol cues that make it difficult to cognitively disengage from alcohol-related stimuli. This difficulty with disengaging from alcohol-related stimuli may play a causal factor in students' drinking, even if they have explicit goals of avoiding drinking. The evidence for delayed effects suggests that alcohol cues may cause emotion-based interference such as emotional rumination [19], which could be distressing to clients and lead to unwanted behavior, which could be addressed with clients in prevention and treatment programs. For example, service providers could help their clients identify and understand their cognitive and emotional responses to alcohol-related cues, which clients may not be aware of, and help them plan for ways to notice these responses, understand how such cues can affect cognition and subsequently lead to drinking, and plan for alternative ways of handling such situations without ruminating or drinking. Cue exposure therapy, which aims to reduce conditioned responses to alcohol cues and help clients enact adaptive coping skills through repeated exposure to alcohol cues without drinking, may also be an effective method for service providers [33].

There are several limitations of this study. Other constructs that could affect responding on the alcohol Stroop task were not measured, such as participants'

emotional state during the experiment and comorbid substance use, which could have added additional noise variance and reduced power in the present study. The word list used in the alcohol Stroop task contains beverages with different levels of alcohol by volume and was normed on a British-English speaking sample [22] but used in an American-English speaking sample in the current study, which could have caused differential functioning of each stimulus used in the Stroop task; nonetheless, internal reliability analyses indicated good internal consistency of responses. Additionally, drinking was not assessed longitudinally, preventing us from testing whether alcohol Stroop responses predicted future drinking behavior.

CONCLUSION

The link between alcohol-related attentional bias and drinking has been less established for college students than for clinical populations [11,12,15-17], and the results of the present study suggest that alcohol-related interference may differentiate participants with heavier and lighter binge-drinking intensities. Future work may aim to incorporate aspects of alcohol-related implicit cognition into treatment and prevention programs.

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