Alcohol-Induced Commission Errors: Premature Responding or Interference in Context Processing?

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INTRODUCTION

In recent years alcohol researchers have increasingly sought to investigate the impact of acute alcohol intoxication on behavioral dysregulation, which can be defined as a failure (a) to implement appropriate behaviors based on current contextual demands or (b) to appropriately adjust one's behavioral patterns in response to changing contextual demands. In this connection, results from laboratory analogue experiments utilizing alcohol challenge methodology in conjunction with cognitive response tasks, have demonstrated alcohol-induced increases in behavioral dysregulation in the form of increased commission errors (i.e., engaging in a specific response option when contextual demands call for its inhibition). This effect of alcohol appears to be particularly likely under cognitively complex conditions requiring infrequent inhibition of a frequently executed prepotent (i.e., strong or automatic) response to visual stimuli. Thus, the commission errors in these studies appear to reflect "perseveration," defined as the general continuance of a behavior pattern when other signals call for its alteration.

Despite the consistent finding that alcohol increases the likelihood of perseverative commission errors, understanding of the mechanism(s) underlying this effect is limited. This could stem, in part, from a failure to distinguish between different types of commission error and from a failure to consider how alcohol might influence them differentially as a function of varied environmental demands.

Commission errors can occur for different reasons or through interference in different cognitive processes (e.g. Cohen, Barch, Carter, Servan-Schreiber, 1999; Scheffers and Coles, 2000). Specifically, when determining the appropriate course of action in a particular situation, a cognitive control mechanism involving at least two distinct processes may be needed to effectively guide contextually appropriate behavior. First, an inhibitory process must be brought on-line to prevent premature selection of any response option. This initial inhibitory process allows time for the occurrence of the second critical step -- processing of contextual information (e.g., contextual stimuli, task goals, or instructions held in working memory) necessary to determine the most appropriate response option. Interference or failure within either of these processes can result in commission errors, and certain contextual characteristics determine the extent to which effortful, controlled cognition is necessary to effectively carry out each process to prevent such errors. For example, the effort needed to inhibit premature selection of a response option is likely to vary as a function of the strength of competing response options. Thus, in the presence of a competing response option that is prepotent, substantially more cognitive effort is needed to inhibit premature response selection than in the absence of a competing prepotent response option. Similarly, in implementing the second process, substantially more cognitive effort is needed to process contextual information when stimulus-response relations are complex than when they are simple.

Thus, two distinct types of commission errors can occur when there is some type of interference, breakdown, or failure within the cognitive control mechanism: (a) premature response errors and (b) context processing errors. The former reflects a failure of the initial inhibitory processes. This results in impulsive enactment of an incorrect response before the stimuli and/or task instructions can be fully processed. Following commission of a premature response error, the individual typically experiences almost immediate recognition of the error. Reaction times (RTs) on such errors have been shown to be significantly shorter than RTs on correct response trials (Scheffers & Coles, 2000). In contrast, context processing errors reflect enactment of an incorrect response due to interference in the processing of task stimuli and/or instructions. This interference prevents the individual from determining the appropriate response, thereby forcing him/her to guess, leaving uncertainty about whether an error was made. Reaction times on these errors are typically longer than those on correct response trials (Scheffers & Coles, 2000) (see Table 1 for a summary of these two error types).

Table 1

Error Type	Aspect of Cognitive Control That Failed	Conditions Increasing Likelihood of Occurrence	Determination of Appropriate Response	Subjective Certainty of Error Occurrence	RT (Relative to Correct Response Trials)
Premature Response Error	Inhibitory control over premature response selection	Presence of prepotent competing response option(s)	Occurs, but only after selection of the inappropriate response	Certain	Shorter (Faster)
Context Processing Error	Control over maintenance, manipulation, updating, and retrieval of task stimuli, goals, instructions	High complexity in stimulus-response relations	Does not occur – important information is unavailable	Uncertain	Longer (Slower)

The present study sought to investigate the interactive effects of alcohol and working memory load on the two types of commission errors described here. Accordingly, participants received nonalcoholic or alcoholic beverages prior to an "n-back" working memory task, requiring execution or inhibition of behavioral responses during processing of information that placed either a light or heavy load on working memory. The task was structured to elicit active responding on 80% of trials at each memory load level in order to establish a prepotent inclination to respond, thus increasing the likelihood of perseverative commission errors.

SPECIFIC AIM

To determine the extent to which alcohol intoxication interacts with the cognitive demands or complexity of a task to differentially influence the likelihood of two types of commission errors. These error types are believed to reflect interference in effortful control over different cognitive processes. We predicted that alcohol would increase both types of errors, but would do so differentially, depending on working memory load.

Hypothesis 1 – Premature Response Errors

As noted above, task stimuli were arranged in configurations that elicited active responses on 80% of trials, thereby creating a prepotent inclination to respond in both light and heavy load conditions. Thus, in both of these conditions, significant cognitive effort was needed to effectively support the inhibitory process that is needed to prevent premature response selection and allow time for sufficient contextual processing. Because alcohol was expected to interfere with this aspect of cognitive control, a main effect of Beverage group on premature response errors was predicted. Specifically, alcohol was expected to increase these errors (relative to sober) at both the light and heavy working memory loads.

Hypothesis 2 - Context Processing Errors

Because contextual processing required substantially more cognitive effort/control at the heavy load level than at the light load level, and because alcohol was expected to interfere with this aspect of cognitive control, a Beverage group X Memory load interaction was predicted with regard to context processing errors. In particular, the increase in this type of error from light to heavy load conditions was expected to be greater among intoxicated participants than among their sober counterparts.

METHOD

SAMPLE

Participants were 16 undergraduate social drinkers (8 male), at least 21 years of age (M = 22.9, SD = 2.6), with recent and exclusively non-problematic experience at or above the doses administered and no conditions contraindicating alcohol consumption.

PROCEDURES

Beverage Manipulation

After completion of preliminary screening measures, we randomly assigned equal numbers of participants of each sex to a beverage condition. In the Alcohol condition, they consumed a 95% ethyl alcohol + juice mixture calculated to yield an approximate mean peak BAL of .075. In the No Alcohol condition, a juice-only beverage of comparable volume was administered. Beverage consumption was paced evenly over a 20-min period.

N-back Task

Participants were given specific instructions about when to respond (with a button press) to a "target" alphabetic character and when to withhold responses to it, and then viewed a series of target and non-target alphabetic characters presented in succession on a computer screen. Variations in these instructions allowed for examination of alcohol's effects on perseverative commission errors under varying levels of cognitive complexity (i.e., Memory load). Under heavy load instructions (i.e., respond to every stimulus unless the current stimulus matches the stimulus two positions back), the task is substantially more cognitively demanding than under light load instructions (i.e., respond to every stimulus unless the current stimulus matches the stimulus one position back). Within the task, stimuli were organized so that participants were required to actively respond to 80% of stimuli in each trial block within each Memory load. This was done to increase the likelihood of perseverative commission errors. There were 16 one-minute trial blocks (8 light load blocks and 8 heavy load blocks) consisting of 20 letters (trials) each. Each letter stimulus was presented for 500 ms with a 2500 ms intertrial interval. In each block, 20% of stimuli matched according to Memory load instruction criteria and 80% of stimuli did not. Half of participants completed all of the light load blocks followed by all of the heavy load blocks, and half of participants completed heavy load blocks first and light load blocks second.

Classification of Error Types

Within the current study, commission errors were classified as either premature response errors or context processing errors for each individual participant by comparing his/her RT on each individual commission error trial with his/her average correct response RT. Commission errors with shorter RTs than the average correct response RT for a given participant were classified as premature response errors, whereas those with longer RTs than the average correct response RT were classified as context processing errors (see Figure 1 for a graphical depiction of average RTs for all 3 trial types as a function of Beverage group and Memory load). For both error types, error rates were calculated by dividing the number of errors of a given type by the number of trials on which subjects were required to inhibit a response.

RESULTS

To examine predictions about the combined effects of alcohol and task complexity (i.e., working memory load) on the two types of errors, a doubly multivariate repeated measures Beverage group X Memory load MANOVA was conducted using error rates for the two error types as variates. This analysis revealed significant multivariate main effects of Beverage group, F(2,13) = 5.93, p = .015, and Memory load, F(2,13) = 15.91, p < .001, as well as a significant multivariate Beverage group X Memory load interaction, F(2,13) = 6.87, p = .009. Because the multivariate Beverage group main effect and Beverage group X Memory load interaction were germane to examination of hypotheses 1 and 2, respectively, these multivariate effects were followed up with separate Beverage group X Memory load ANOVAs for each of the two error types. Results from these follow-ups are summarized below:

Hypothesis 1 – Premature Response Errors

Univariate results failed to support our prediction that alcohol intoxication would lead to a significant increase in premature response errors in both light and heavy load conditions -- the main effect of Beverage group on premature response error rates was non-significant, F(1,14) = 1.25, p = .282. This is surprising given that a number of recent studies utilizing a "go-stop" paradigm have demonstrated significant alcohol-induced impairment in control over inhibitory processes (e.g., Fillmore & Vogel-Sprott, 1999, 2000; Mulvihill, Skilling, & Vogel-Sprott, 1997). Although not significantly different in the current study, group means on premature response error rates were higher for intoxicated participants than sober participants at both memory load levels (see left half of Figure 2). Given the relatively small sample size in the current study, it is possible that these differences may have failed to reach levels of statistical significance due to insufficient statistical power. Thus, at best, our group mean data provide only tentative support for our first hypothesis. Future studies using the n-back task with larger samples will be needed to provide more conclusive data.

Univariate results did reveal a significant main effect of Beverage group on context processing error rates, F(1,14) = 11.00, p = .005. However, this effect was moderated by the significant interaction described below.

Hypothesis 2 – Context Processing Errors

Univariate results provided strong support for our second hypothesis of a significant Beverage group x Memory load interaction for context processing error rates, F(1,14) = 14.25, p = .002. Inspection of the right half of Figure 2 suggests that alcohol substantially increased context processing errors (relative to sober) only at the heavy load level. This finding suggests that as intoxicated individuals find themselves in increasingly complex contexts, they are likely to experience significant difficulty maintaining, manipulating, updating, and/or retrieving all of the relevant contextual information needed to guide appropriate behavior. The result is confusion for the inebriate and increased likelihood that contextually inappropriate behavior will occur.

As expected, there was no indication of a Beverage group X Memory load interaction for premature response errors, F(1,14) = 0.04, p = .851.

FIGURE 1

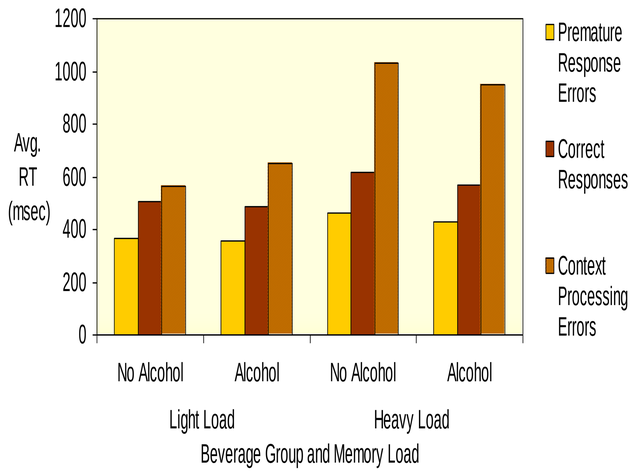
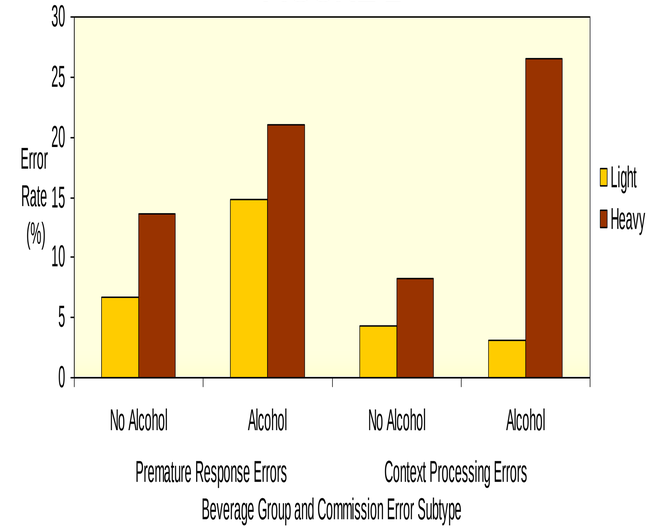


FIGURE 2



DISCUSSION

Overall, the current study provided preliminary support for the notion that alcohol-induced behavioral dysregulation may result, at least in part, from impairment in a two-stage cognitive control mechanism responsible for guiding contextually appropriate behavior. Evidence strongly indicated alcohol-induced impairment in contextual processing (i.e., the second stage of the mechanism). Evidence was only tentative for alcohol-induced impairment in inhibitory processes (i.e. the first stage) needed to effectively delay responding until the most appropriate response can be determined through contextual processing.

The study suffered from at least two potentially important limitations. First, the sample size was relatively small, yielding limited statistical power to detect significant effects. Second, premature response errors and context processing errors were distinguished strictly on the basis of RT data, limiting certainty that all commission errors were classified into the most appropriate error type category. Future research on this topic would benefit greatly from recruitment of larger samples and inclusion of psychophysiological measures of cognitive processing (e.g., EEG) that could be used to validate the distinction of error types by RT.