



Deleterious Effects of Alcohol Intoxication: Diminished Cognitive Control and Its Behavioral Consequences

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INTRODUCTION

Research indicates that alcohol-induced compromises in behavioral functioning tend to be relatively limited in contexts where stimuli are explicit or simple, competing demands are absent, and processing is automatic and linked to immediate responses. In contrast, significant deleterious behavioral effects of drinking are commonly associated with tasks involving abstract or complex contextual stimulus arrays, the competition of multiple demands, and deliberate processing that may be tied to delayed responding. These latter conditions are characterized by an elevated need for cognitive control, suggesting that when deleterious behavioral effects of alcohol occur, they may well be a reflection of a diminished cognitive processing capacity.

The notion that impairment of complex cognitive processes underlies alcohol-induced behavioral dysfunction has received considerable attention as an explanation for the connection between drinking and expression of sexual, aggressive, and other important behaviors that involve competing approach and avoidance inclinations. Once an individual under the influence of alcohol develops a prepotent response tendency -- for instance, approach in pursuit of immediate gratification -- it may persist even in the face of competing cues that suggest it should be curtailed. Such "perseveration" under cognitively demanding conditions is typically associated with errors of commission (continued active responding when cues should encourage restraint), but impaired cognitive control might also yield errors of omission (failure to execute responses when action is indicated). Commission errors represent behavioral excesses linked to drinking, whereas omission errors represent behavioral deficits that may enhance vulnerability to victimization or other loss in inebrates.

The present study sought to test the hypothesis that elevations in perseverative errors during intoxication are attributable to the deleterious impact of alcohol on cognitive control. Accordingly, we examined effects of alcohol on performance within the context of an "n-back" working memory task that included manipulations of task complexity (Memory Load) and the prepotency of inclinations to respond or to withhold responding based on patterns established through training. Prepotency effects were evaluated as a function of both "block response frequency" (the required frequency of responding within a training block) and "response frequency order" (the frequency of responding required in prior training blocks). Participants received either alcoholic or non-alcoholic beverages and then all completed the n-back procedure.

SPECIFIC AIMS

To determine the extent to which alcohol intoxication interacts with the cognitive demands or complexity of a task to increase:

- 1) Perseveration Due to Prepotent Response Tendencies Established by "Block Response Frequency" Within the Current Task Block
- 2) Perseveration Due to Prepotent Response Tendencies Established in Prior Training Blocks as a Function of the Required "Response Frequency Order"

We were interested in determining if alcohol would increase perseveration of both prepotent inclinations to respond and to withhold responding.

METHOD

SAMPLE

Participants were 32 undergraduate social drinkers (16 male), at least 21 years of age ($M = 22.9$, $SD = 2.3$), 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 minute period.

The 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 behavior under varying levels of cognitive complexity (i.e., Memory Load). Under heavy load instructions (i.e., determine if the current stimulus matches the stimulus two positions back and react according to instructions), the task is substantially more cognitively demanding than under light load instructions (i.e., determine if the current stimulus matches the stimulus one position back and react according to instructions).

Within the task, stimuli were organized so that participants were required to actively respond to 80% of stimuli in some trial blocks at each Memory Load, but only 20% of stimuli in other blocks. Half of participants completed 20% blocks first and 80% blocks second at each Memory Load, and half completed 80% blocks first and 20% blocks second. Two independent factors within the paradigm, (a) Block Response Frequency and (b) Response Frequency Order, were manipulated to permit testing of the hypothesis that alcohol would produce perseverative effects of prepotent response inclinations at varying working memory loads.

Block Response Frequency (i.e., 80% vs. 20%) within the current task block was designed to establish a prepotent inclination to either respond (in 80% response blocks) or withhold a response (in 20% response blocks). **Response Frequency Order** was designed to establish a prepotent response inclinations through "prior" training at a specific response frequency. For example, initial exposure to a series of 80% response blocks was expected to establish a prepotent inclination to respond that would bias task performance in subsequent 20% response frequency blocks in contrast to performance in comparable 20% response frequency blocks that occurred first (without pre-exposure to 80% blocks). There were 32 one-minute trial 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 Memory Load instruction criteria and 80% of stimuli did not. Instructions regarding Memory Load and Block Response Frequency were varied at different points within the task so that participants completed eight blocks of four different block types:

MEMORY LOAD

	Light Load	Heavy Load
20% BLOCK RESPONSE FREQUENCY	Respond <u>only</u> if the stimulus matches the stimulus <u>two</u> positions back	Respond <u>only</u> if the stimulus matches the stimulus <u>two</u> positions back
80% BLOCK RESPONSE FREQUENCY	Respond to <u>every</u> stimulus <u>unless</u> it matches the stimulus <u>one</u> position back	Respond to <u>every</u> stimulus <u>unless</u> it matches the stimulus <u>two</u> positions back

The following variables were derived:

- **Between-Subjects Factor**
Beverage (Alcohol vs. No Alcohol)
Response Frequency Order (20% first vs. 20% after 80% or 80% first vs. 80% after 20%)
- **Within-Subjects Factors**
Memory Load (Light vs. Heavy)
Block Response Frequency (20% response vs. 80% response)
- **Dependent Variables**
Commission Error (CE) Rates
Omission Error (OE) Rates

RESULTS

Specific Aim #1 - Perseveration Due to Prepotent Response Tendencies Established by "Block Response Frequency" Within the Current Task Block

Use of a doubly multivariate repeated measures MANOVA revealed a significant multivariate Beverage X Memory Load X Block Response Frequency interaction, $F(2,29) = 4.61$, $p = .018$. Simple effects tests of Beverage across the four combinations of Memory Load and Block Response Frequency (i.e., light load/20%, light load/80%, heavy load/20%, and heavy load/80%) revealed that:

- Intoxicated participants made more commission errors than non-intoxicated participants only during heavy load/80% response trials, $t(30) = 3.25$, $p = .003$, (see figure 1, top panel). This suggests an alcohol-induced increase in perseveration on a prepotent inclination to respond only under cognitively complex current contexts.
- Intoxicated participants also made more omission errors than non-intoxicated participants only during heavy load/20% response trials, $t(30) = 2.85$, $p = .008$, (see figure 1, bottom panel). This suggests an alcohol-induced increase in perseveration on a prepotent inclination to withhold a response only under cognitively complex current contexts.

Specific Aim #2 - Perseveration Due to Prepotent Response Tendencies Established in Prior Training Blocks as a Function of the Required "Response Frequency Order"

Four separate Beverage X Response Frequency Order X Memory Load ANOVAs were conducted. Results from the four analyses were used to examine perseveration due to prior training as listed below. The between-subjects Response Frequency Order contrasts and dependent variables for each analysis are as follows:

- Response Frequency Order (20%-first vs. 20% after 80%)
Dependent Variable: Commission Errors in 20% Blocks
- Response Frequency Order (80%-first vs. 80% after 20%)
Dependent Variable: Commission Errors in 80% Blocks
- Response Frequency Order (20%-first vs. 20% after 80%)
Dependent Variable: Omission Errors in 20% Blocks
- Response Frequency Order (80%-first vs. 80% after 20%)
Dependent Variable: Omission Errors in 80% Blocks

All significant 3-way interactions were followed up by simple effects tests of Beverage across the four combinations of Memory Load and Response Frequency Order.

- Commission errors during 20% response frequency blocks:

Result of Interest: A significant Beverage X 20% Response Frequency Order X Memory Load interaction, $F(1,28) = 7.97$, $p = .009$.

Simple effects tests revealed that intoxicated participants made more commission errors than non-intoxicated participants only during heavy load, 20% after 80% blocks, $t(14) = 3.27$, $p = .006$, (see Figure 2, top panel). This suggests an alcohol-induced perseveration of a previously trained prepotent tendency to respond.

- Commission errors during 80% response frequency blocks:

Result of Interest: A significant Beverage X 80% Response Frequency Order X Memory Load interaction, $F(1,28) = 6.33$, $p = .018$.

Simple effects tests revealed that intoxicated participants made more commission errors than non-intoxicated participants only during heavy load, 80% first blocks, $t(14) = 3.31$, $p = .005$, (see Figure 2, bottom panel). This finding, in combination with the lack of a Beverage group difference in the heavy load, 80% after 20% blocks suggests that perseveration of the prepotent tendency to withhold response due to prior training in 20% blocks interfered with development of a tendency to respond in 80% blocks that followed 20%.

- Omission errors during 20% response frequency blocks:

Results of Interest: The ANOVA analyzing omission error rates in 20% response blocks failed to reveal a significant three-way interaction. Thus, evidence of alcohol-induced perseveration due to prior training was not observed in this analysis. However, a significant Beverage X Memory Load interaction was observed, $F(1,28) = 7.31$, $p = .01$.

The simple effect follow-up test for Beverage within levels of Memory Load in this interaction revealed that intoxicated participants made more omission errors than non-intoxicated participants during heavy, 100% = 2.85, $p = .008$, but not light load blocks, (see figure 3, top panel).

- Omission errors during 80% response frequency blocks:

Results of Interest: The ANOVA analyzing omission error rates in 80% response blocks failed to reveal a significant 3-way interaction. Thus, evidence of alcohol-induced perseveration due to prior training was not observed in this analysis. A main effect of Memory Load, $F(1,28) = 4.36$, $p = .046$, was the only significant effect observed.

FIGURE 1

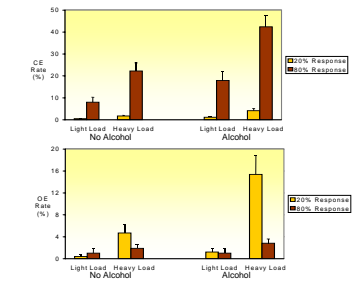


FIGURE 2

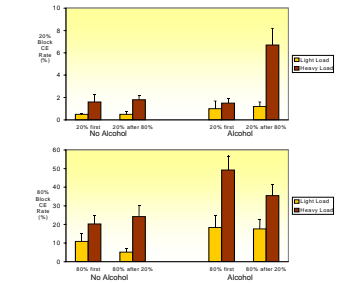
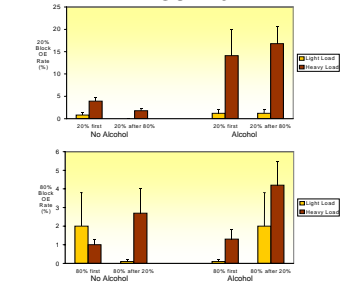


FIGURE 3



CONCLUSIONS

Specific Aim #1 - Current Context Perseveration

Results provided strong evidence for alcohol-induced perseveration within one's current instructional context. Such effects were apparent only in conditions characterized by both high cognitive complexity and prepotent, but task-inappropriate response inclinations. Under heavy load conditions, alcohol increased commission errors when the prepotent response inclination was to respond, and omission errors when the prepotent inclination was to withhold a response.

Specific Aim #2 - Perseveration Due to Prior Training

Results provided mixed evidence for alcohol-induced increases in perseveration due to prior training. Such effects were found only for commission errors and were weaker than those for current context.

Overall, results support the notion that alcohol-induced perseveration results from alcohol-induced impairment in cognitive control. Notably such perseveration can take the form of either behavioral excesses (i.e., commission errors) or behavioral deficits (i.e., omission errors) with the form depending on which type of response inclination is prepotent.