Drunk, but not blind: The effects of alcohol intoxication on change blindness

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A R T I C L E   I N F O

Article info
Article history:
Received 15 August 2012

Keywords:
Alcohol
Attentional control
Working memory
Change blindness

A B S T R A C T

Alcohol use has long been assumed to alter cognition via attentional processes. To better understand the cognitive consequences of intoxication, the present study tested the effects of moderate intoxication (average BAC between .071 and .082) on attentional processing using complex working memory capacity (WMC) span tasks and a change blindness task. Intoxicated and sober participants were matched on baseline WMC performance, and intoxication significantly decreased performance on the complex span tasks. Surprisingly, intoxication improved performance on the change blindness task. The results are interpreted as evidence that intoxication decreases attentional control, causing either a shift towards more passive processing and/or a more diffuse attentional state. This may result in decreased performance on tasks where attentional control or focus are required, but may actually facilitate performance in some contexts.

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1. Introduction

Alcohol use has long been assumed to alter cognition via attentional processes, and this hypothesis has been offered as a mechanism to explain other effects of intoxication including reduced anxiety and dampened stress responses in more applied literatures (Sayette, 1993; Sher, Bartholow, Peusser, Erickson, & Wood, 2007). However, it is not yet clear how alcohol affects the attentional system. One prevailing theory, the alcohol myopia theory (Josephs & Steele, 1990; Steele & Josephs, 1988), posits that the consumption of alcohol restricts attentional capacity, thus creating “myopia” or a narrowed scope of attention.

In one particularly striking finding consistent with the alcohol myopia theory, Clifasefi, Takarangi, and Bergman (2006) reported that intoxicated individuals were less likely to be distracted by an interloper during an inattentional blindness task. Using the classic gorilla video (Simons & Chabris, 1999), participants were tasked with counting the number of passes of a basketball among actors in the foreground. While the basketball was being passed, a gorilla crossed through the scene. Intoxicated participants were less likely to report noticing the gorilla than the sober controls. This was attributed to the intoxicated participants having a narrowed scope of attention, or a reduced attentional capacity, which was fully consumed by the “counting” task, thus preventing them from allocating any attention to the unheralded event.

Although there are some findings that seem consistent with the idea that intoxication may cause a narrowing in the focus of attention, there is little direct evidence for this proposition (Sher et al., 2007). For example, Saults, Cowan, Sher, and Moreno (2007) explored the effects of intoxication on a set of memory tasks. In some of the tasks stimuli were presented simultaneously in an array and in other tasks the stimuli were presented sequentially. Intoxication had a greater impact...
on memory for sequential items than for items presented simultaneously in an array. This led Sauls et al. to suggest that moderate doses of alcohol may affect performance by impairing mnemonic strategies and executive processes (i.e., processes related to attentional control), rather than by reducing attentional capacity. Hence, it may not be attentional capacity that is affected by intoxication, but rather attentional control processes.

What is needed is more research using cognitive tasks that may isolate and test for specific effects of intoxication on attentional processing. To this end, the present study sought to directly test how alcohol may affect performance on tasks that require more or less attentional control, to see whether a narrowed focus metaphor, or a reduced control metaphor, provides a better fit for the data.

The tasks that were chosen to test this question included a set of complex span tasks, which are typically used to measure working memory capacity (WMC), and a visual change detection task, which is typically used to demonstrate change blindness. Complex span tasks consist of two components: a processing component such as verifying a sentence or equation; and a storage component such as remembering lists of words or letters. Previous research has suggested that performance on complex span tasks generally represents the ability to control one's attention (Engle, 2002). In order to successfully perform these tasks, the participant must maintain and update their memory for the to-be-remembered items while resisting interference from the processing task. The ability to maintain task goals and overcome interference is thought to be central to executive function and attentional control. Convergent evidence for this interpretation comes from a number of studies that have contrasted the performance of high WMC spans (people who do well on complex span tasks) and the performance of low WMC spans (people who generally score lower on complex span tasks) on other measures. For example, high spans are better at the anti-saccade task, which requires participants to inhibit looking towards a visual cue that occurs in the opposite direction of the target stimulus (Kane, Bleckley, Conway, & Engle, 2001). They are better able to maintain the goal of reporting ink color in the face of interference during a Stroop task (i.e. when ink and color match on 75% of the trials, Kane & Engle, 2003). High spans are better able to filter out irrelevant information, which results in a reduced likelihood of experiencing cocktail party effects (hearing their name in an unattended channel) under selective attention instructions (Conway, Cowan, & Bunting, 2001). However, once participants are told to try to listen for their name, then high WMC individuals become more likely to hear their name than low WMC individuals (Colflesh & Conway, 2007). The results of these studies provide evidence that WMC measures are highly related to the ability to control one's attention. Thus, if intoxication affects executive functioning or the control of attention, then we would expect that performance on complex span tasks should suffer. However, reduced capacity or scope of attention could also be consistent with this prediction.

Thus, a second attention task was chosen that might help to test between these two accounts. A visual change detection task was selected to serve as a visual analog to the divided attention dichotic listening task that has been used in other studies on attentional control. Visual change detection tasks are generally used to demonstrate change blindness (CB) or difficulty in noticing small changes between visual scenes (Rensink, O’Regan, & Clark, 1997). These tasks typically employ a flicker paradigm where an initial image is separated from a secondary image by a brief visual mask. Detecting a change is thought to require the direction of one’s attention across the scene and also the maintenance of a representation of the initial image in visual working memory to compare to the secondary image. If intoxicated individuals experience either a narrowing of attentional capacity or scope, one might expect participants to perform more poorly on change detection tasks. However, if intoxication reduces attentional control which results in a broadening of attentional scope, then it might actually lead to better change detection performance.

2. Method

2.1. Participants

The overall sample was comprised of 48 healthy males under the age of 30, recruited by Craigslist, campus flyers and from the university community. Due to IRB concerns over unknown pregnancies and failures to detect pregnancy using standard tests, the sample was limited to male participants, as has been the case in other studies of acute intoxication (e.g., Kirchner & Sayette, 2003). Following established procedures (Kirchner & Sayette, 2003), potential participants completed a telephone screening to establish that they met age, health and drinking pattern criteria for the intoxicated condition. Individuals were excluded from participating if they showed signs of problem drinking behaviors and/or medical contraindications (e.g., heart or liver disease, psychiatric disorders). Based on the results of the telephone screening, those who qualified were invited to the lab for a follow-up session. Participants in the alcohol-administration and no-alcohol groups were matched based on WMC composite scores obtained in an initial pre-intoxication task set to ensure equivalence between the groups.

2.2. Measures

2.2.1. WMC

Three different measures of WMC were employed: operation span (OSpan), reading span (RSpan) and symmetry span (SSpan). The procedures used were adapted from the versions used by Kane et al. (2004). The experimenter controlled administration and exact order scoring guidelines recommended by Conway et al. (2005) were followed. Each span task
consisted of 12 items. The number of elements (sentences, equations or figures) per item varied from 2 to 5, with three items at each size. The order of the items was randomized such that the number of elements was unpredictable.

In the OSpan task, each element consisted of a mathematical operation and a word (e.g., IS \(7 \times 3 + 4 = 21\) ? SNOW). The participant’s task was to read the math problem aloud, say “yes” or “no” to indicate whether the given answer was correct or incorrect and then say the word. After all the elements in an item were presented the participant was required to recall the words in correct serial order. This task was administered both as part of the first pre-intoxication cognitive task set and also as part of the second cognitive task set to assess changes in WMC due to intoxication.

In the RSpan task, each element consisted of a sentence and a letter (e.g., Andy crossed the yellow heaven. ? S). The participant’s task was to read the sentence aloud, say “yes” or “no” to indicate whether it made sense and then say the letter. After all the elements in an item were presented the participant was required to recall the letters in correct serial order. This task was administered as part of the first pre-intoxication cognitive task set to obtain baseline measures of WMC.

In the SSpan task, each element consisted of a geometric figure. The participant’s task was to say “yes” or “no” to indicate whether it was symmetrical and then they were shown a grid with one box filled in. After all the elements in an item were presented the participant was required to recall the box locations in correct serial order. This task was administered only as part of the second cognitive task set (after the alcohol-administration group had received alcohol), to test for differences between groups with a span task was not subject to practice effects.

2.2.2. Change Blindness

Participants completed eight trials of a visual change blindness task that were presented using a flicker paradigm. The trials consisted of complex everyday scenes including both outdoor and indoor locations, such as a farmers market and an office. The location of the change occurred in the periphery of the image, and was balanced such that targets occurred in each one of the quadrants an equal number of times. Each trial consisted of a source scene that was presented for 250 ms, followed by a visual mask for 80 ms, followed by the target scene for 250 ms, which was followed by a visual mask for 80 ms. This loop continued until: (a) the participant noticed the item that changed between the source and target scenes, or (b) no response was given and the trial timed out at 2.5 min. If participants noticed the change, they were instructed to press the spacebar. Participants were then prompted to indicate the quadrant where the change occurred. Finally, the participant was prompted to briefly type what the changing item was. Each trial provided an accuracy measure (i.e., whether the correct quadrant was selected and the changed item was properly identified) and reaction time measure (i.e., the time required to notice the change). Two independent raters scored the responses for accuracy and were in complete agreement.

2.3. Procedure

2.3.1. Alcohol Administration Group

All participants completed the first cognitive task set, including both OSpan and RSpan tasks, while sober. After completing the first task set, participants in the alcohol administration group followed the established methods of Sayette et al. (1994). They received a drink containing 1 part 100-proof Smirnoff vodka and 2.5 parts cranberry juice. The dose of alcohol was calibrated by weight on a modified dose table to produce a moderate level of intoxication (.08 BAC), based on Sayette et al. (1994). The drink was administered in three equal doses over 10 min periods. Participants watched an animated feature film (Ratatouille) while they consumed the alcoholic beverages. Average BAC readings obtained immediately before the second task set was .071 (range = .048 – .109, SD = .016). Average maximum BAC readings obtained during the second task set was .082 (range = .056 – .109, SD = .012).

Participants then completed the second cognitive task set, including the change blindness task, the SSpan task, and a second OSpan task. Participants remained in the lab until their BAC dropped to a safe level.

2.3.2. No Alcohol Group

Participants in the no alcohol group engaged in the same cognitive tasks. They watched the animated film between the first set of cognitive tasks and the second set of cognitive tasks. Upon completing the cognitive tasks, participants were dismissed.

3. Results

3.1. Baseline working memory capacity

All participants completed both baseline WMC tasks (OSpan and RSpan) while sober. Performance between the tasks was significantly correlated \((r = .59\), which was in the normal range (Conway et al., 2005). Participants in the two groups did not differ in either sober Ospan (\(Ms = 26.58\) and 26.13, respectively) or sober RSpan performance (\(Ms = 28.54\) and 29.63, respectively; \(ts < 1\); see Fig. 1).
3.2. Intoxication and working memory capacity

Two complex span tasks were completed as part of the second set of cognitive tasks. As shown in Fig. 1, there was a significant difference between the alcohol and no-alcohol groups in performance on the SSpan task ($M_s = 14.83$ and $22.25$; $t(46) = -3.54, p < .05$, Cohen’s $d = -1.03$). Because the groups were matched in WMC while sober, this suggests a decrement to WMC due to intoxication. As shown in Fig. 1, there was also a significant difference between the groups on the second OSpan measure ($M_s = 23.83$ and $27.75$; $t(45) = -1.99, p = .05$, Cohen’s $d = -.58$; one participant’s data was missing for the second OSpan measure).

To more directly assess the change in WMC, performance on the two measures of OSpan (pre- and post-intoxication) were submitted to a repeated measures analysis of variance. Neither the main effect of group (alcohol, no alcohol) nor the effect of assessment time (pre-, post-intoxication) were significant (condition: $F(1,45) = 1.07, p > .05, \eta^2_p = .02$; assessment time: $F < 1, p > .05, \eta^2_p = .01$). However, the group $\times$ assessment time interaction was significant, $F(1,45) = 8.74, p < .05, \eta^2_p = .16$. Alcohol-administered participants were equivalent to the no-alcohol participants in their initial sober OSpan performance, but differences were observed on the second OSpan measure. Follow-up tests indicated that no-alcohol participants marginally improved their WMC performance from the first to the second OSpan assessment ($t(23) = -1.47, p = .15$, Cohen’s $d = -.31$), while alcohol-administered participants’ WMC performance showed significant decreases due to intoxication ($t(22) = 2.81, p < .05$, Cohen’s $d = .59$).

3.3. Change blindness and intoxication

The two groups did not differ in change detection accuracy ($M_s = 63\%$ and $67\%$, respectively, $t < 1$). However, as can be observed in Fig. 2, when response times for these correct detections were examined, intoxicated participants were significantly faster than sober participants ($M_s = 28,510$ ms and $38,094$ ms, respectively; $t(46) = -2.21, p < .05$, Cohen’s $d = -.64$).

Several different types of errors were possible. Participants could fail to detect a target in the time allotted, they could indicate that they found the change but then indicate an incorrect answer (quadrant or object), or they could fail to provide any answer once they said they found a change (suggesting they responded prematurely). Intoxicated and sober participants did not differ in rates for any of these error types (failure to respond, $24\%$ and $26\%, t < 1$; incorrect quadrant, $4\%$ and $1\%, t < 1.27$; incorrect object, $3\%$ and $2\%, t < 1$; premature response, $7\%$ and $5\%, t < 1$). Additionally, response times on incorrect trials also did not vary between intoxicated and sober participants ($M_s = 66,141$ ms and $67,897$ ms, $t < 1$), suggesting intoxicated participants faster times on correct trials was not due to an overall reduction in the threshold for making a response.

4. Discussion

Results of the current study indicated that intoxication to an average BAC between .071 and .082 decreased performance on both post-intoxication WMC measures. Intoxication had no effect on the likelihood of finding changes in a visual scene;
however, it improved accurate change detection times. The change detection results are inconsistent with the notion that intoxicated individuals are becoming overly focused, or narrow in their scope of attention, as intoxicated participants were able to detect small changes that occurred throughout large complex visual displays more quickly than sober participants.

These results are reminiscent of previous work by Smilek, Enns, Eastwood, and Merikle (2006) that showed that change blindness flicker tasks can actually be performed more efficiently when viewers adopt a more passive search process, where the changes may “pop out” as long as you don’t try to find them. Smilek demonstrated this by manipulating the instructions given to participants, prompting them to search for changes either actively or passively, and by manipulating processing load (no memory load or memory load) which encouraged a passive search. The present study extends these findings and suggests that intoxication may have changed the nature of the search strategies that were used. Intoxicated participants were more efficient at detecting changes which could be the result of intoxication causing participants to switch from attention-demanding controlled search processes, to a more passive search style.

The switch in search style may be representative of a switch in how the visual search is conducted during the change detection task. Watson, Brennan, Kingstone, and Enns (2010) conducted an eye-tracking follow up to the research conducted by Smilek et al. (2006) to see if passive and active searchers varied in their eye movements. Watson and colleagues found that passive searchers made fewer saccades and processed more from each fixation, whereas active searchers made more saccades. Passive searchers placed an emphasis on seeing the change, whereas active searchers placed an emphasis on looking for the change. These results suggest that intoxication may not affect the scope of the attentional spotlight, but instead may lead to a shift in search strategy where participants make fewer eye movements and process more from each of those. This is an interesting possible explanation, but testing of this will need to be addressed in a follow up eye-tracking study.

It can also be noted that the rate of noticing changes was lower in this study than in most studies in the literature. This may be due to the nature of the scenes that were used as stimuli in this study. The images represented complex scenes that presented a large number of potential distractors. In addition, because the changes were occurring away from the center of the image, the changes in this study may have been more difficult to detect than changes in other studies. The combination of these two aspects, complex, realistic scenes, and non-central interest, has yielded similar results, approximately 66% change detection within a 48 s time limit (O’Regan, Deubel, Clark, & Rensink, 2000). However, each of the eight change blindness trials had successful detections, suggesting that while these trials may have been difficult, they were not impossible.

Overall, the current results are inconsistent with a myopia theory of intoxication. The findings do not suggest that moderate intoxication leads to a narrowing or focusing of attention or a decreased ability to attend to peripheral information. If the myopia metaphor were correct then performance should have been worse on the change blindness task, as a narrowed scope of attention would mean that less of the visual scene could be processed at a time. However, we observed the opposite pattern of results: intoxication led to more efficient change detection. It also led to decreased performance on the complex span tasks. This pattern of results seems better explained by a reduction in attentional control or strategic processing as a result of moderate intoxication.

Further, these findings converge with other recent findings showing that moderately intoxicated participants are more likely to experience mind wandering, and are more likely to be unaware that mind-wandering is occurring (Sayette, Reichle, & Schooler, 2009). These effects are also consistent with the Sher et al. (2007) suggestion that intoxication is not limiting the scope of attention per se, but rather altering our ability to control our attention or engage in effective executive functioning. And, the results are consistent with increases in the ability to find remote associates in a creative problem solving task due to moderate intoxication (Jarosz, Colflesh, & Wiley, 2012). Taken together, the present results do suggest that our attentional processes are affected by intoxication. Yet, understanding why and when intoxication will result in more “blindness” as found by Clifasefi et al. (2006), or less “blindness” as found here, is still a very interesting open question. Further research

![Fig. 2. Average detection times for correctly detected changes for sober and intoxicated participants. Error bars represent standard errors.](image-url)
is needed using a broader range of cognitive tasks that target specific types of attention, and different levels of intoxication, so that we can better understand that the landscape of how alcohol consumption may affect basic information processing. These results also highlight that there may be some cognitive activities or contexts in which too much attentional control or focus may not be optimal for performance.

**Role of the funding source**

This research was supported by a UIC Provost’s Research Award and an APA Dissertation Research Award to Gregory Colflesh, and an Institute for Health Research & Policy Seed Grant Award to Jennifer Wiley and Jon Kassel. After agreeing to fund the research proposal, none of the funding sources played a role in study design, data collection, analysis, and interpretation, nor in the writing of the report and the decision to submit the research for publication.

**Acknowledgments**

This research was submitted to the University of Illinois at Chicago partial fulfillment of the requirements for a Ph.D. by Gregory Colflesh. The authors thank Daniel Aiello, Andrew Jarosz, Jessica Pinto, and Brittny Rayhorn for their help with this study. This research was supported by a UIC Provost’s Research Award and an APA Dissertation Research Award to Gregory Colflesh, and an Institute for Health Research & Policy Seed Grant Award to Jennifer Wiley and Jon Kassd.

**References**


