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# The Effects of Alcohol on Visual Attention

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# Abstract

Alcohol has been shown to have a variety of effects on cognitive performance in humans; the present study tested the effects of alcohol on visual selective attention using three different paradigms. The effects of alcohol intoxication over a broad range of blood alcohol concentrations (average between 0.01 and 0.08) were evaluated for change blindness, inattentional blindness, and multiple object tracking. Alcohol was found to impair inattentional blindness performance, negatively affecting participants' ability to notice the unexpected changes presented. This result is interpreted as support for the alcohol myopia theory. No significant effects of alcohol were found for change blindness or multiple object tracking.

## Keywords

Visual Attention, Alcohol, Change Blindness, Inattentional Blindness, Multiple Object Tracking, Attention, Alcohol Myopia.

Acknowledgments

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# Table of Contents

# List of Tables

# List of Figures

# List of Appendices

# Chapter 1

## 1 Introduction

Attention is a concept that is often discussed in scientific literature. In more common terms, attention can be considered the mental effort we use during cognitive processing to select which stimuli to focus this processing on. This view of attention stems from the belief that our cognitive processing abilities are limited, and require a mechanism to be able to control what inputs are processed. Attention is such a vast topic that most studies choose to focus on a specific subcategory of attention (Johnston & Dark, 1986). The present study focuses on the subcategory of selective attention, specifically visual selective attention. Selective attention is the process of dedicating cognitive resources to attend to specific stimuli in the presence of competing stimuli, and visual attention is when attention is distributed over a visual scene and then concentrated onto a specific aspect of the visual scene.

Alcohol has been shown to have a variety of effects on cognitive performance in humans; most people have experienced this at some point in their lives. From a practical perspective, one of alcohol's more important effects on cognition is its impact on visual attentional processes. A better understanding of the effect that alcohol has on visual attention could be useful for several everyday situations. An example of one such common situation is driving a vehicle. The ability to notice unexpected stimuli, such as a pedestrian stepping onto the road, and our ability to detect changes between glances at a visual scene, such as when glancing back and forth between a map and the road, can have significant consequences for driving safety. We are also required to attend to multiple stimuli simultaneously while driving. The effect that alcohol has on attention has largely been studied in the context of the alcohol myopia theory. The alcohol myopia theory posits that alcohol intoxication causes a short-sightedness in our information processing abilities (Steele & Josephs, 1990). By this theory, the more alcohol that is consumed, the less able we are to distribute attentional resources to cognitive tasks (Clifasefi, Takarangi, & Bergman, 2006). The present study examines the effects of alcohol on three different laboratory-based tasks, selected to attempt to represent the complex demands on our attention we face on a daily basis. The three tasks chosen were change blindness (CB), inattentional blindness (IB), and multiple object tracking (MOT). Change and inattentional blindness tasks probe visual attention, and multiple object tracking is a task that probes selective attention. Change blindness and inattentional blindness have been used to investigate the concept of alcohol myopia, but reached opposing conclusions (Clifasefi, Takarangi, & Bergman, 2006; Colflesh & Wiley, 2013). The use of the change blindness paradigm in alcohol and attention literature has largely been to study attentional biases towards alcohol related stimuli, leaving the effect that alcohol has on attentional processing abilities relatively unexplored (Jones, Jones, Smith, & Copley, 2003). To date, there has been little research on the effects of alcohol on change and inattentional blindness with a focus on the effect that alcohol has on attentional processing, and the results thus far have been conflicting.

## 1.1 Change Blindness

Change blindness is the difficulty in detecting changes between scenes that occurs reliably in normal individuals. Change blindness was first described empirically in scientific literature in 1968 by Hochberg, who noted that participants often have a great deal of difficulty noticing changes that occur during a brief flash on a computer display (Hochberg, 1968). Although first described empirically in 1968, inferences consistent with the phenomenon of change blindness appear as early as the 1950s. The change blindness phenomenon has received more attention in recent years (Simons & Levin, 2003).

Alcohol has been reported to improve performance in male participants on change blindness tasks at a blood alcohol concentration (BAC) average of 0.077, using complex images of everyday scenes. Intoxicated participants had faster response times for correct change detections than sober participants, with no significant difference in change detection accuracy (Colflesh & Wiley, 2013). However, in another study, alcohol has also been shown to have no significant effects on change blindness performance (Colflesh, 2010).

## 1.2 Inattentional Blindness

Inattentional blindness is the surprising failure to notice unexpected salient stimuli when attention is engaged elsewhere that occurs in normal individuals. The term inattentional blindness was first coined in the 1990s by Mack and Rock, who noted that observers often do not perceive an unexpected shape presented during a judgement task about a different stimulus, even though the unexpected shape was perceptible (Mack & Rock, 1998). Although first named in the 1990s, early demonstrations of the phenomenon of inattentional blindness include a visual analogue of the dichotic listening task, where observers viewing two superimposed videos often fail to notice unexpected events in one video while attending the other video (Neisser & Becklen, 1975). It has also been shown that inattentional blindness still occurs within one non-superimposed video even when the unexpected object is fully visible (Simons & Chabris, 1999). In their task, participants viewed a video, wherein participants were instructed to count the number of passes one team made in a basketball game. During the game, a person in a gorilla suit walks on screen, beats their chest, and walks off screen. Only 44% of participants noticed the gorilla (Simons & Chabris, 1999).

One study found that intoxicated participants at a moderate BAC of 0.04 were less likely to notice the gorilla than sober participants, with only 18% of the intoxicated participants noticing the gorilla while 46% of the sober participants noticed the gorilla (Clifasefi, Takarangi, & Bergman, 2006). Another study found that alcohol negatively affected inattentional blindness task performance at a higher BAC of 0.08, using a video of a driving scene where participants were asked to count the number of times the car in front of them braked and instructed to attend to pedestrians and road signs (Pavuna & Ivanec, 2012). However, it has also been reported that alcohol has no significant effect on inattentional blindness task performance (Colflesh, 2010).

## 1.3 Multiple Object Tracking

Multiple object tracking involves attending to multiple moving stimuli while ignoring identical distractors. The multiple object tracking paradigm was developed in the 1980s by Pylyshyn and Storm (1988) who showed that, while certain aspects of visual attention can only scan visual locations in series, with attention acting as a single concentrated locus that can be moved independently of eye movements, identifying and tracking objects can be carried out in parallel across several independent locations in the visual field. They showed that participants were able to track up to five objects in a field of ten identical objects moving randomly with about 87% accuracy (Pylyshyn & Storm, 1988). Normal individuals are able to perform this task reasonably well, with performance beginning to decline after the age of 60. While multiple object tracking is a fairly common paradigm, it does not appear to have been used in studies of the effects of alcohol on visual attention (Meyerhoff, Papenmeier, & Huff, 2017).

The current body of research on the effects of alcohol on change blindness and inattentional blindness is conflicted and was performed over a limited range of BACs. Two studies show decreased performance on an inattentional blindness task, one at a BAC of 0.04 using the gorilla video and one at a BAC of 0.08 using an inattentional blindness video depicting a driving scene (Clifasefi, Takarangi, & Bergman, 2006; Pavuna & Ivanec, 2012). One paper shows improved performance on a change blindness task at a higher blood alcohol level of 0.077 using images of complex everyday scenes, and another paper shows no significant effect of alcohol on performance for either change or inattentional blindness tasks (Colflesh, 2010; Colflesh & Wiley, 2013). As far as I am aware, the effect of alcohol on multiple object tracking has yet to be explored. A summary of the previous research on the effects of alcohol on these three tasks is presented below in Table 1. This study seeks to resolve the apparent discrepancies in the current literature with a carefully designed study of the effects of alcohol on these visual attention tasks, across a broad range of BACs.

**Table 1: Summary of the Previous Research on the Effects of Alcohol on Change Blindness, Inattentional Blindness, and Multiple Object Tracking**

<table>
<tr><th>CB and Alcohol</th><th>IB and Alcohol</th><th>MOT and Alcohol</th></tr>
<tr><td rowspan="2">Improved performance at 0.077BAC (Colflesh & Wiley, 2013)</td><td>Decreased performance at 0.04BAC (Clifasefi, Takarangi, & Bergman, 2006)</td><td rowspan="3">No previous studies with alcohol</td></tr>
<tr><td>Decreased performance at 0.08BAC (Pavuna & Ivanec, 2012)</td></tr>
<tr><td colspan="2">No significant effect of alcohol (Colflesh, 2010)</td></tr>
</table>

# Chapter 2

## 2 Methods

The three tasks used in this experiment were change blindness (CB), inattentional blindness (IB), and multiple object tracking (MOT). The standard inattentional blindness paradigm was modified to allow for a within-subjects design to be used throughout the study. This experiment was divided into two parts; during Part 1 participants performed the change blindness and multiple object tracking tasks, alternating between each task every five minutes and completing six five-minute blocks of change blindness and six five-minute blocks of multiple object tracking per session. In Part 2 participants performed the inattentional blindness and multiple object tracking tasks, alternating between each task every five minutes and completing six five-minute blocks of inattentional blindness and six five-minute blocks of multiple object tracking per session, for a testing time length of approximately one hour per session. Multiple object tracking was used in both Part 1 and Part 2 for two primary reasons: first, this task had not yet been studied with alcohol and it was important to gather as much data as possible; second, because the task difficulty manipulations were less subjective than for the other two tasks, it had the potential to provide a more direct index of alcohol-induced impairment. 16 individuals participated in each part, with 12 individuals participating in both Part 1 and Part 2. Each participant attended two sessions on separate days at the lab, one sober session and one alcohol session, for a testing time of approximately one hour per session. Within each part, participants were divided into four groups; Groups 1 and 4 had their first session as the sober condition with their second session being the alcohol condition, and Groups 2 and 3 had their first session as the alcohol condition with their second session being the sober condition. The change blindness images and inattentional blindness videos were counterbalanced between groups, such that each individual image or video was viewed by an equal number of participants during their first or second session, and while sober or intoxicated, as indicated in Table 2.

**Table 2: Participant Counterbalancing**

| | | | |
|---|---|---|---|
| Part 1: CB and MOT | | | |
| Group 1: | Group 2: | Group 3: | Group 4: |
| Session 1 Sober, CB Image Set A and MOT | Session 1 Alcohol, CB Image Set A and MOT | Session 1 Alcohol, CB Image Set B and MOT | Session 1 Sober, CB Image Set B and MOT |
| Session 2 Alcohol, CB Image Set B and MOT | Session 2 Sober, CB Image Set B and MOT | Session 2 Sober, CB Image Set A and MOT | Session 2 Alcohol, CB Image Set A and MOT |
| Part 2: IB and MOT | | | |
| Group 1: | Group 2: | Group 3: | Group 4: |
| Session 1 Sober, IB Video Set A and MOT | Session 1 Alcohol, IB Video Set A and MOT | Session 1 Alcohol, IB Video Set B and MOT | Session 1 Sober, IB Video Set B and MOT |
| Session 2 Alcohol, IB Video Set B and MOT | Session 2 Sober, IB Video Set B and MOT | Session 2 Sober, IB Video Set A and MOT | Session 2 Alcohol, IB Video Set A and MOT |

## 2.1 Ethics Statement

The methods used in the present study were approved by the University of Western Ontario Research Ethics Board for Non-Medical Research Involving Human Subjects (see Appendix A).

## 2.2 Participants

21 individuals, 9 males and 12 females, aged 19 years (the legal drinking age in Ontario) to 38 years, with an average age of 23.9 years, participated in this study. As age has only been shown to affect performance on these attention tasks when comparing participants who are over 60 years of age to participants in their 20s and 30s, and the previous studies did not report any sex differences, age and sex differences are not presented here (Clifasefi, Takarangi, & Bergman, 2006; Meyerhoff, Papenmeier, & Huff, 2017). One participant's Part 1 data was excluded due to a fire alarm during testing. Participants were randomly assigned to each of the counterbalanced groups. Written informed consent and proof of legal drinking age was obtained from all participants prior to their participation in the study. Participants were screened for a variety of exclusion criteria, including; a history of receiving medical treatment for alcohol related problems, diabetes, pregnancy or breastfeeding, and medication contraindications. Participants also completed a questionnaire to ensure they were moderate social drinkers (Addiction Research Foundation, 1992) (see Appendix B).

## 2.3 Alcohol Administration and Blood Alcohol Measurement

A Computerized Blood Alcohol Calculator (CBAC, Addiction Research Foundation, 1992; version 1.2) was used to determine an estimate of the number of alcoholic beverages (1.5oz alcohol/beverage), mixed at a 1:4 vodka to orange juice ratio, required to raise a participant's blood alcohol concentration to 0.08, the legal driving limit in Ontario. This calculator considers a participant's age, weight, height, and sex in its estimation. A Draeger Inc. Alcotest 6510 breath measuring device was used to monitor and infer a participant's blood alcohol concentration at various intervals throughout the experiment.

## 2.4 Stimulus Display

All stimuli were displayed on a SONY Trinitron computer screen from a viewing distance of 100cm, maintained and centered by a fixed chin-rest. Change blindness stimuli were presented using custom software from VPixx Technologies Inc. (version 3.4), and a VPixx RESPONSEPixx button box. Change blindness images were presented in the center of the display. The images were of varying sizes for each trial, and subtended an average of 5.2° by 7.2° of visual angle on the screen. Inattentional blindness stimuli were presented using Quick Time Player (version 10.2) software and Maxell AMPlified over-ear headphones. The inattentional blindness videos subtended 5.7° by 10.5° of visual angle. Multiple object tracking stimuli were presented using Java Terminal (version 2.3) software and a Black Box Toolkit Response Pad button box, with stimuli subtending a visual angle of 8.0° by 10.5°. The stimuli are described in greater detail below.

## 2.5 Stimuli

Change Blindness:

The change blindness task stimuli photographs, obtained from the George Eastman House collection (George Eastman House, 2008), consisted of a combination of colour and greyscale images of everyday scenes, such as a baseball player catching a ball, or a view of a busy street. They were presented using a flicker paradigm that has been shown to be effective in inducing change blindness in normal individuals (Jones, Jones, Smith, & Copley, 2003). In the flicker paradigm, a source image, and that source image with target visual changes, are presented in alternation with a visual mask. In this case the visual mask was a neutral grey square that matched the grey border on which the images were presented. The timing sequence used was 400ms source image presentation, 200ms visual mask, 400ms target image with change presentation, 200ms visual mask, looped continuously. While participants were led to believe that each image had one change for them to detect, each image was edited to include two changes. The locations of the changes were randomized across all four quadrants of the image. The changes in the images were edited to be of varying difficulties to detect (easy, medium, hard), with images of each difficulty level randomized throughout the testing session. As an example of some of the changes, for the baseball player picture the baseball disappears and reappears, and the grandstand buildings in the background disappear and reappear. Genres of changes also included objects getting larger and smaller, changing locations, changing orientation, or being exchanged for other objects.

Inattentional Blindness:

Customised videos were filmed specifically for the purposes of this study. The custom made inattentional blindness videos were filmed by Hodgson and colleagues (Hodgson, 2017), and were presented in full colour on the computer monitor with sound provided through over-ear headphones. The videos were of everyday scenes, such as getting coffee in a coffee shop, and a group of friends over at someone's house. The videos ranged in length from 44 seconds to 3 minutes and 4 seconds. At the beginning of each video participants were given a counting task based on the video content, in keeping with the traditional paradigm. They were then asked to state their answer from the counting task at the end of each video. The counting tasks in the videos were of varying difficulty level (easy, medium, hard), with videos of each difficulty level randomized throughout the testing session. Difficulty was manipulated by the total number of events to count in counting task, and the subtleness of the unexpected change. Traditionally, studies of inattentional blindness and alcohol use a between-subjects design (Clifasefi, Takarangi, & Bergman, 2006). In this study the inattentional blindness paradigm was modified to allow within-subject comparisons.

Multiple Object Tracking:

The multiple object tracking task was presented using Java Terminal (version 2.3) software and a Black Box Toolkit Response Pad button box. Participants were presented with a number of small red squares (8mm × 8mm) on the monitor screen as the stimuli to be tracked or ignored. Every trial had ten red squares in total. To match the easy, medium, and hard difficulty levels of the change blindness and inattentional blindness tasks, participants were asked to track three, four, or five of the ten red squares. At the start of each trial all ten red squares were presented stationary, and three to five of the red squares would flash, indicating that those were the red squares to be tracked, while the other red squares were to be ignored. After four seconds the flashing ended so that all ten of the red squares were identical. All of the squares then began to move randomly across the screen for six seconds, with the caveat that none of the squares would cross over each other. Participants were instructed to maintain fixation on a central crosshair while tracking the indicated stimuli. At the end of each trial, all of the red squares stopped moving, and one of the red squares was shown slightly larger (15mm × 15mm). Participants were asked to indicate whether that square was one of those they had been asked to track, indicating whether they had been able to track the stimuli throughout the task to their end location.

## 2.6 Procedure

Alcohol Administration and Breath Alcohol Measurements:

Participants were given approximately 15 minutes to consume their beverage (Polar Ice Vodka (40% ABV) mixed with orange juice for the alcohol session, or orange juice without vodka, with alcohol swabbed around the rim of the cup, for the sober session). Where the volume of alcohol was too large to be mixed at a 1:4 ratio with the orange juice in one cup, the beverage was divided equally between two cups. Participants were asked to rinse their mouth with water once they finished their beverage. All participants had their breath alcohol measured at the start of testing during alcohol sessions to verify their BAC, and at the start of sober sessions to ensure participants were in fact sober. Then, after the tasks had been explained, their breath alcohol was measured immediately prior to beginning the testing phase of the session. This usually occurred approximately 30 minutes from when participants were first given their beverage to consume, and approximately 15 minutes after they finished drinking their beverage. Measurements were taken approximately every five minutes during alcohol sessions to allow BAC to be monitored throughout testing.

Change Blindness:

The change blindness photographs were presented using the flicker paradigm described above. Each image was presented until participants indicated via a button press that they had detected a change, or 60 seconds had elapsed without the participant detecting a change. Detection latency was recorded into the VPixx data output file at this button press, and participants were asked to state what change they saw. Participants were then asked to indicate by button press which quadrant of the image they had detected the change in. Participants were asked to make their responses as quickly and as accurately as possible. Participants were led to believe that each image had one change for them to detect, and told that the changes in the images were of varying difficulties to detect (easy, medium, hard), with images of each difficulty level randomized throughout the testing session. Participants completed six blocks of change blindness per session, with five images per block, such that each block was approximately five minutes in length, allowing a breath alcohol measurement to be taken approximately every five minutes at the start and end of each block during the alcohol sessions. Previous studies have shown that the only case where alcohol shows a significant effect on eye movements is during the first saccade towards an alcohol related change when participants have a high craving for alcohol, regardless of their BAC (Hobson, Bruce, & Butler, 2013). As all of the changes in the images used in this study are considered neutral, eye tracking measurements were deemed unnecessary. From the perspective of the participants, the task was to spot a change between the images as quickly and accurately as possible, identify it, and indicate where on the screen they spotted the change. They were told that the changes would be of different difficulties randomized throughout testing, and that the images would time out after 60 seconds.

In the change blindness task the measures taken were detection latency, change accuracy, and quadrant accuracy. Detection latency was defined as the time in seconds from the beginning of an image stimulus presentation, to the button press participants gave to indicate they had detected a change. If participants did not detect a change before the trial timed out at 60 seconds, the detection latency was recorded as 60s. Change accuracy was defined as whether the change between the source and target images was correctly identified. If participants correctly identified the change they received a score of 1.0 for that trial. If participants perceived the change but gave a slightly inaccurate description of the change (for example, some participants identified a dog appearing in the street as a donkey) they received a score of 0.5 for that trial. Scores of 0.0 were given when participants described a change that did not exist within that image, and scores were excluded from the analysis on trials where participants were unable to detect a change. Change accuracy scores were then computed as a percentage. Quadrant accuracy was defined as whether participants indicated correctly the quadrant in which the change they identified occurred. Participants were given a score of 1.0 for correct matches, a score of 0.0 for incorrect matches, and scores for trials where participants were unable to detect a change were excluded from analysis. These scores were then computed as a percentage.

Inattentional Blindness:

The inattentional blindness videos described above were presented to participants. Participants were given a counting task based on the content of each video, and asked to state their answer from the counting task at the end of each video as accurately as possible. Participants were told that the counting tasks in the videos were of varying difficulty level (easy, medium, hard), with videos of each difficulty level randomized throughout the testing session. Participants viewed two inattentional blindness videos per block, such that each block was approximately 5 minutes in length, allowing a breath alcohol measurement to be taken approximately every five minutes at the start and end of each block during the alcohol sessions. Participants completed six blocks per session. Participants viewed a total of 24 inattentional blindness videos, 20 of which had an unexpected event, and four of which did not have an unexpected event. Participants viewed half of the videos while sober and half while intoxicated, instead of each participant viewing only one video and performing between-subjects comparisons as has been traditionally done in inattentional blindness studies (Clifasefi, Takarangi, & Bergman, 2006). At the end of their second session, participants were presented with freeze frame images from each of the 24 videos, and asked if they could recall what they were supposed to count for that video, and if they remembered anything strange that happened. If participants could not remember what they were supposed to count for a video, that video was excluded from their noticing accuracy score. This was done to ensure that videos where participants had poor memory for the video overall would not be included as videos where they did not notice the change. From the perspective of the participants, the task was to perform the counting task for each video as accurately as possible. They were unaware that they would be asked any further questions about the videos until after they had seen all 24 videos, when they were shown the freeze frame images.

In the inattentional blindness task, the measures that were taken were counting accuracy and noticing accuracy. Counting accuracy was defined as whether participants reported an accurate counting total for the counting task at the end of each video. Scores were computed such that counts higher or lower than the correct number were both presented as a score of less than 100%, and only exactly correct counts were presented as 100%. Noticing accuracy was defined as whether participants noticed and correctly described the unexpected change that occurred in a video at the end of their second testing session when presented with freeze frame images of each video. Participants were given a score of 1.0 for correct identifications, a score of 0.05 if only part of the unexpected event was detected (for example in one video several actors walk through a door repeatedly, and some participants only noticed one actor duplicate). A score of 0.0 was given when participants did not notice an unexpected event, and scores for trials where participants were unable to remember the counting task for that video were excluded from the analysis. These scores were then computed as a percentage.

Multiple Object Tracking:

The multiple object tracking task was presented as described above. Participants were asked to attend to multiple the moving stimuli and provide a response at the end of each trial that would indicate whether they had been able to track the stimuli throughout the task to their final location. Participants were told that they would be tracking three to five stimuli that would flash at the beginning of the trial, after four seconds the flashing indication would end so that all ten of the red squares would be identical, and all of the squares would then begin to move randomly across the screen for six seconds. Participants were instructed to maintain fixation on a central crosshair while tracking the indicated stimuli. Maintaining fixation and using attention independent of eye movements to track the multiple moving objects ensures that any effects seen would be due to impaired attentional abilities and not due to impaired eye movement ability. While eye tracking measurements were not taken, the experimenter was situated such that they could observe that participants were able to maintain fixation for both sober and alcohol sessions. At the end of each trial participants were instructed to respond by button press as quickly and accurately as possible whether the indicated square was one of those that was to be tracked, or that the indicated square was not one to be tracked. The time it took participants to respond by button press was measured as response latency by the button box and recorded in the Java data output file. Participants completed approximately 20 trials per block, for a block length of approximately five minutes, allowing a breath alcohol measurement to be taken approximately every five minutes at the start and end of each block during the alcohol sessions. Participants completed six blocks per session. From the perspective of the participants, the task was to track three to five moving objects among identical distractors while maintaining fixation, and respond via button press whether an indicated object was one that they had been asked to track.

In the multiple object tracking task, the measures that were taken were response latency and tracking accuracy. Response latency was defined as the time in milliseconds from the end of the trial when one stimulus square was presented larger, indicating a response is required, to the button press participants gave to indicate their answer. Tracking accuracy was defined as whether participants correctly identified the stimulus as an object that was or was not to be tracked for that trial. If participants correctly identified the tracked stimulus they received a score of 1.0 for that trial. Scores of 0.0 were given for incorrect responses. Tracking accuracy scores were then computed as a percentage.

## 2.7 Data Analysis

All analysis of variance (ANOVA) calculations were performed using Prism 5 software (GraphPad version 5.03). While all participants served as their own controls in this study, it was not always possible to obtain performance measurements for each of the BAC ranges selected for analysis (<0.05BAC and ≥0.05BAC). This meant that there were a number of missing values that would have had to be excluded from a repeated measures ANOVA. Therefore, independent samples ANOVAs were performed on these data, while acknowledging that this would result in a loss of statistical power.

# Chapter 3

# 3 Results

Analyses of performance differences due to BAC were performed to see if BAC had an effect on these three attention tasks. Measures of the effects of alcohol and noticing accuracy on counting accuracy for the inattentional blindness paradigm were done to see if this aspect of the task was affected by alcohol, and to see if the results of the inattentional blindness task could provide support for the idea that attention is a limited resource. Analyses of performance differences due to difficulty levels were done post hoc to ensure that the manipulation of the difficulty levels was effective for all three tasks, and that the difficulty levels were significantly different enough to produce changes in performance. Measures of performance differences due to day order were done to ensure participant counterbalancing for which session participants received alcohol was effective.

## 3.1 Blood Alcohol Concentration

Participants had their breath alcohol measured and began testing approximately 15 minutes after they had finished consuming their beverage. Participants consumed an average of 3.9oz of 40% alcohol in the alcohol condition, with a range of 3.0 to 5.4oz of alcohol. BACs during testing ranged from 0.0230 to 0.0795 for change blindness, 0.0075 to 0.0785 for inattentional blindness, and 0.0070 to 0.0860 for multiple object tracking. Figure 1 below shows the BACs obtained during testing for each paradigm, with BAC in percentage on the Y axis and paradigm on the X axis. To ensure that there were no significant differences between BACs obtained in each of the three paradigms, a one-way ANOVA was performed. The analysis revealed no significant differences between the BACs obtained in the three paradigms ($p = 0.9518$). For further analyses the results were divided into BACs $<0.05$ and $\geq 0.05$, near the mean, to allow comparisons to current driving regulations in Ontario.

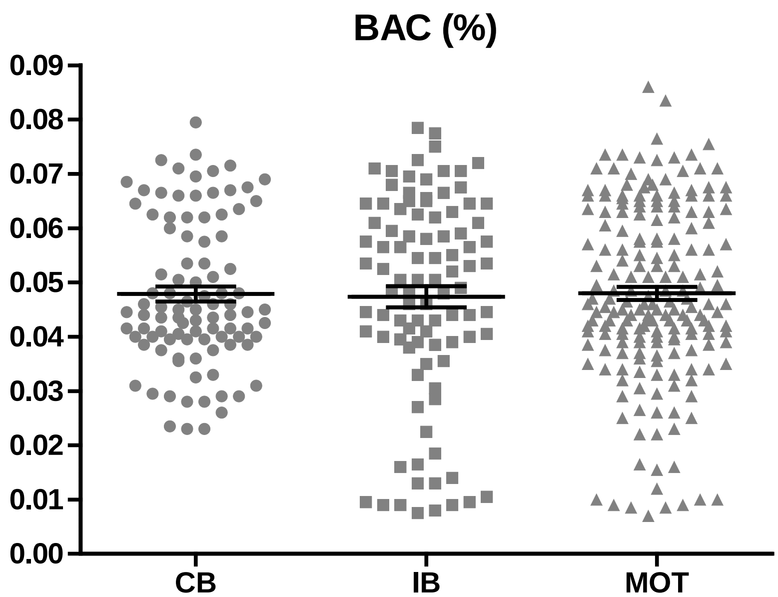


**Figure 1: BACs Obtained During Testing.** Blood alcohol concentrations measured during change blindness (grey circles), inattentional blindness (grey squares), and multiple object tracking (grey triangles). The black line indicates the mean, with error bars denoting ± 1 SEM.

## 3.2 Performance Differences Due to Blood Alcohol Concentration

The primary purpose of this study was to see if alcohol has an effect on the performance of change blindness, inattentional blindness, and multiple object tracking tasks. Performance differences due to blood alcohol concentration were analyzed.

Change Blindness:

Detection latency in seconds, change accuracy in percentage, and quadrant accuracy in percentage are plotted on the Y axes of the graphs in Figure 2, against the alcohol conditions of sober control, <0.05BAC, and ≥0.05BAC on the X axes. Figure 2 shows a slight trend towards increased detection latency, decreased change accuracy, and decreased quadrant accuracy for BACs greater than 0.05 as compared to sober trials. To test for the significance of these data a one-way ANOVA was carried out. Due to the fact that not all participants were tested with BACs that fell into both the <0.05 and ≥0.05 categories, independent samples ANOVA instead of repeated measures ANOVA are reported here. The analysis revealed no significant effects of blood alcohol concentration (BAC) on detection latency, change accuracy, or quadrant accuracy. No significant differences were observed between the sober control condition, trials performed at a BAC of less than 0.05, or trials performed at a BAC greater than or equal to 0.05 for detection latency ($p = 0.7426$), change accuracy ($p = 0.111$), or for quadrant accuracy ($p = 0.4554$). These data are presented below in Figure 2A-C.

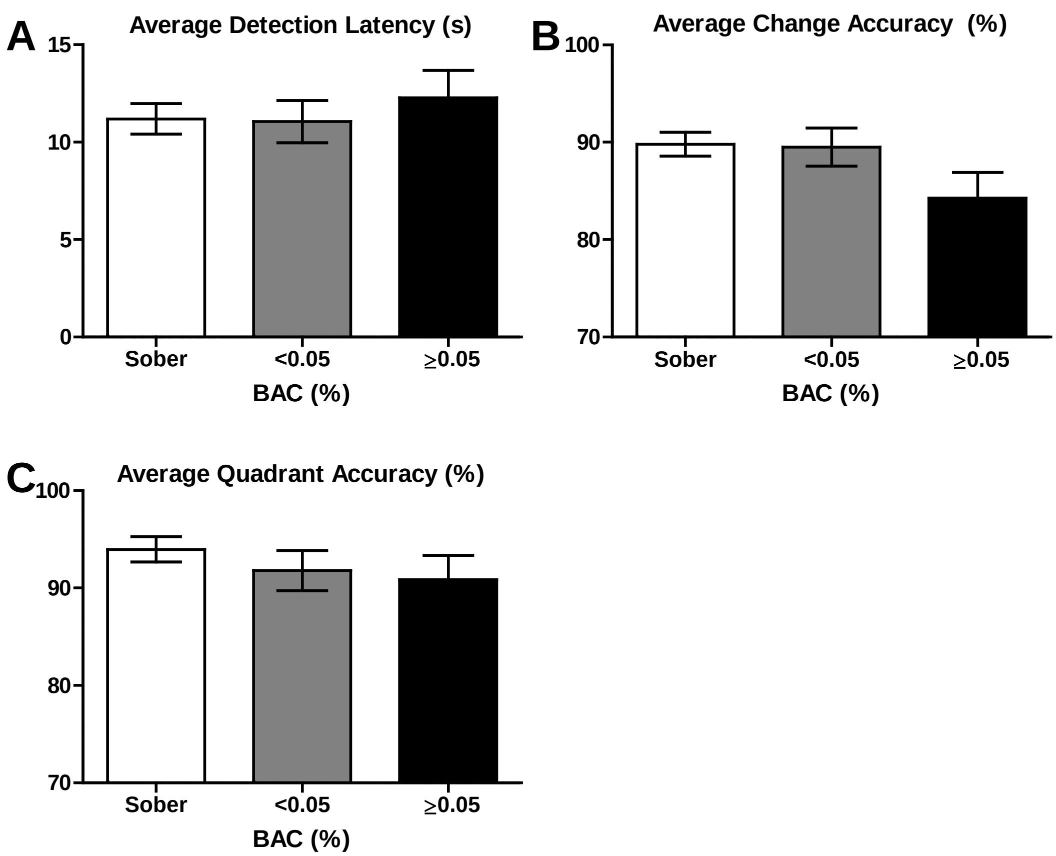


**Figure 2: Change Blindness Performance Differences Due to BAC.** A: Average detection latency (s) during the sober control condition (white), at BACs below 0.05 (grey), and BACs equal to or greater than 0.05 (black). B: Average change accuracy (%) sober, at <0.05BAC, and at ≥0.05BAC. C: Average quadrant accuracy (%) sober, at <0.05BAC, and at ≥0.05BAC. Error bars denote ± 1 SEM.

Inattentional Blindness:

Counting accuracy in percentage and noticing accuracy in percentage are plotted on the Y axes of the graphs in Figure 3, against the alcohol conditions of sober control, <0.05BAC, and ≥0.05BAC on the X axes. Figure 3 shows a slight trend towards decreased counting accuracy for BACs greater than 0.05 as compared to sober trials, and a trend toward decreased noticing accuracy as BAC increases. Due to the fact that not all participants were tested with BACs that fell into both the <0.05 and ≥0.05 categories, independent samples ANOVA instead of repeated measures ANOVA are reported here. One-way ANOVA revealed no significant effects of BAC on counting accuracy ($p = 0.5048$). However, the analysis did reveal a significant effect of BAC on noticing accuracy. Significant differences were found between both the sober condition and ≥0.05BAC, and <0.05BAC and ≥0.05BAC ($F(2,183) = 6.757$, $p = 0.0015$). These data are presented in Figure 3A-B.

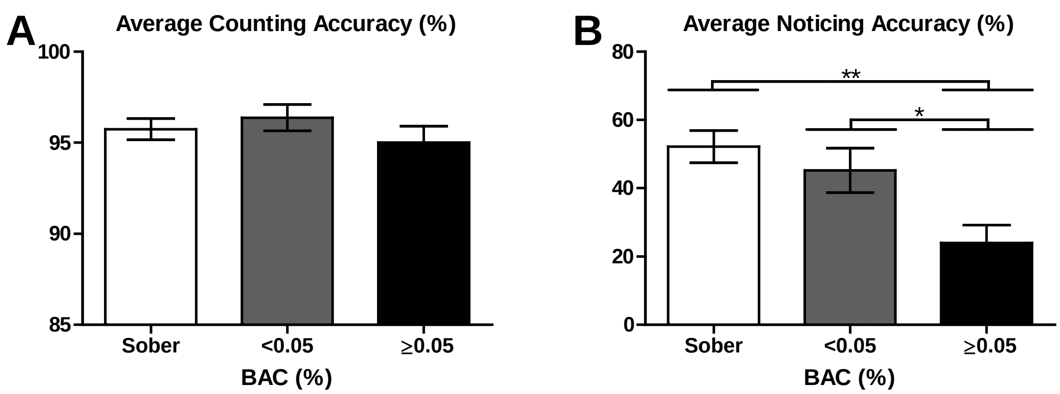


**Figure 3: Inattentional Blindness Performance Differences Due to BAC.** A: Average counting accuracy (%) during the sober control condition (white), at BACs below 0.05 (grey), and BACs equal to or greater than 0.05 (black). B: Average noticing accuracy (%) sober, at <0.05BAC, and at ≥0.05BAC. Error bars denote ± 1 SEM, and significance bars indicate the results of the Tukey's Multiple Comparison post tests.

Another aspect of the inattentional blindness paradigm that can be analyzed is whether noticing accuracy has an effect on counting accuracy. Since the previous analysis revealed that alcohol had a significant effect on noticing accuracy but not counting accuracy, a two-way ANOVA was performed on counting accuracy for both BAC and noticing accuracy. Due to the fact that not all participants were tested with BACs that fell into both the <0.05 and ≥0.05 categories, independent samples ANOVA instead of repeated measures ANOVA are reported here. Counting accuracy in percentage is plotted in Figure 4 on the Y axis, against noticing accuracy on the X axis grouped by BAC. Figure 4 shows a trend for counting accuracy being decreased on trials where the unexpected stimulus is not noticed as compared to trials where the unexpected stimulus is noticed. Figure 4 also shows a trend for counting accuracy increasing as BAC increases for trials where the unexpected stimulus is noticed. Two-way ANOVA revealed a significant effect of noticing accuracy on counting accuracy at ≥0.05 BAC (F (1,283) = 12.06, p = 0.0006) and no significant effect of BAC on counting accuracy (p = 0.7080). These data are presented in Figure 4.

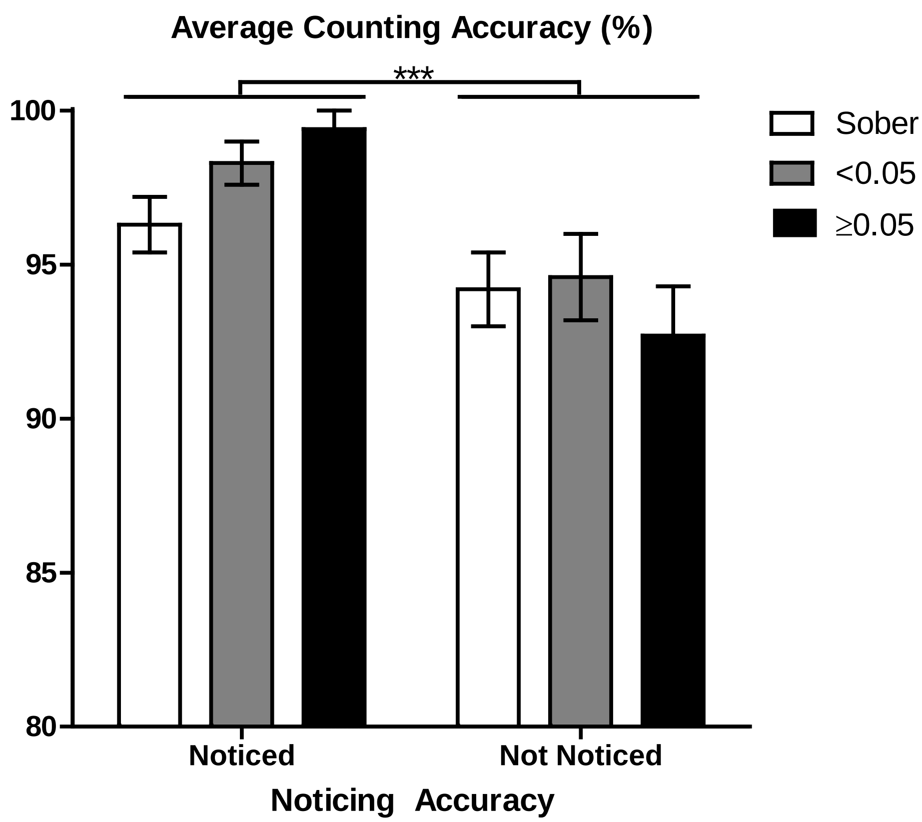


**Figure 4: Inattentional Blindness Noticing Accuracy and BAC Effect on Counting Accuracy.** Average counting accuracy (%) during the sober control condition (white), at BACs below 0.05 (grey), and BACs equal to or greater than 0.05 (black), for trials where the unexpected change was noticed or not noticed. Error bars denote ± 1 SEM.

Multiple Object Tracking:

Response latency in milliseconds and tracking accuracy in percentage are plotted on the

Y axes of the graphs in Figure 5, against the alcohol conditions of sober control, <0.05BAC, and ≥0.05BAC on the X axes. Figure 5 shows a slight trend towards decreased response latency and decreased tracking accuracy for BACs greater than 0.05 as compared to sober trials. Due to the fact that not all participants were tested with BACs that fell into both the <0.05 and ≥0.05 categories, independent samples ANOVA instead of repeated measures ANOVA are reported here. One-way ANOVA revealed no significant effects of blood alcohol concentration on response latency or tracking accuracy. No significant differences were observed between the sober control condition, <0.05BAC, or ≥0.05BAC for response latency ($p = 0.2399$) or for tracking accuracy ($p = 0.3159$). These data are presented below in Figure 5A-B.

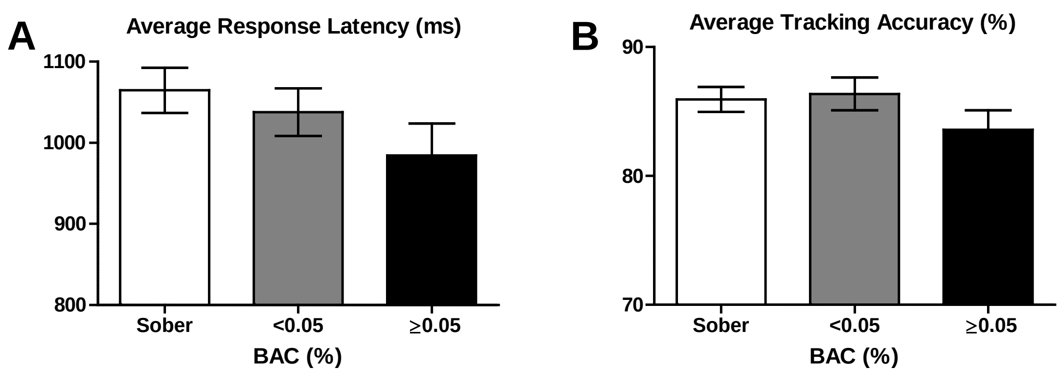


**Figure 5: Multiple Object Tracking Performance Differences Due to BAC.** A: Average response latency (ms) during the sober control condition (white), at BACs below 0.05 (grey), and BACs equal to or greater than 0.05 (black). B: Average tracking accuracy (%) sober, at <0.05BAC, and at ≥0.05BAC. Error bars denote ± 1 SEM.

## 3.3 Performance Differences Due to Difficulty Levels

To verify that the division of the stimuli into easy, medium, and hard difficulty levels was effective, performance differences due to difficulty levels were analyzed.

Change Blindness:

Detection latency in seconds, change accuracy in percentage, and quadrant accuracy in percentage (as defined above) are plotted on the Y axes of the graphs in Figure 6, against the difficulty levels of easy, medium, and hard on the X axes, grouped by BAC. Figure 6 shows a trend towards increased detection latency, decreased change accuracy, and decreased quadrant accuracy for the hard difficulty level as compared to the easy difficulty level. To test for the significance of these data a two-way ANOVA was carried out. Due to the fact that not all participants were tested with BACs that fell into both the $<0.05$ and $\geq 0.05$ categories, independent samples ANOVA instead of repeated measures ANOVA are reported here. The analysis revealed a significant effect of difficulty ($F(2,3689) = 55.74$, $p = <0.0001$) but not BAC ($p = 0.9759$) for detection latency, a significant effect of difficulty ($F(2,15853) = 10.12$, $p = <0.0001$) but not BAC ($p = 0.7402$) for change accuracy, and a significant effect of difficulty ($F(2,12073) = 11.40$, $p = <0.0001$) but not BAC ($p = 0.2473$) for quadrant accuracy. These data are presented in Figure 6A-C.

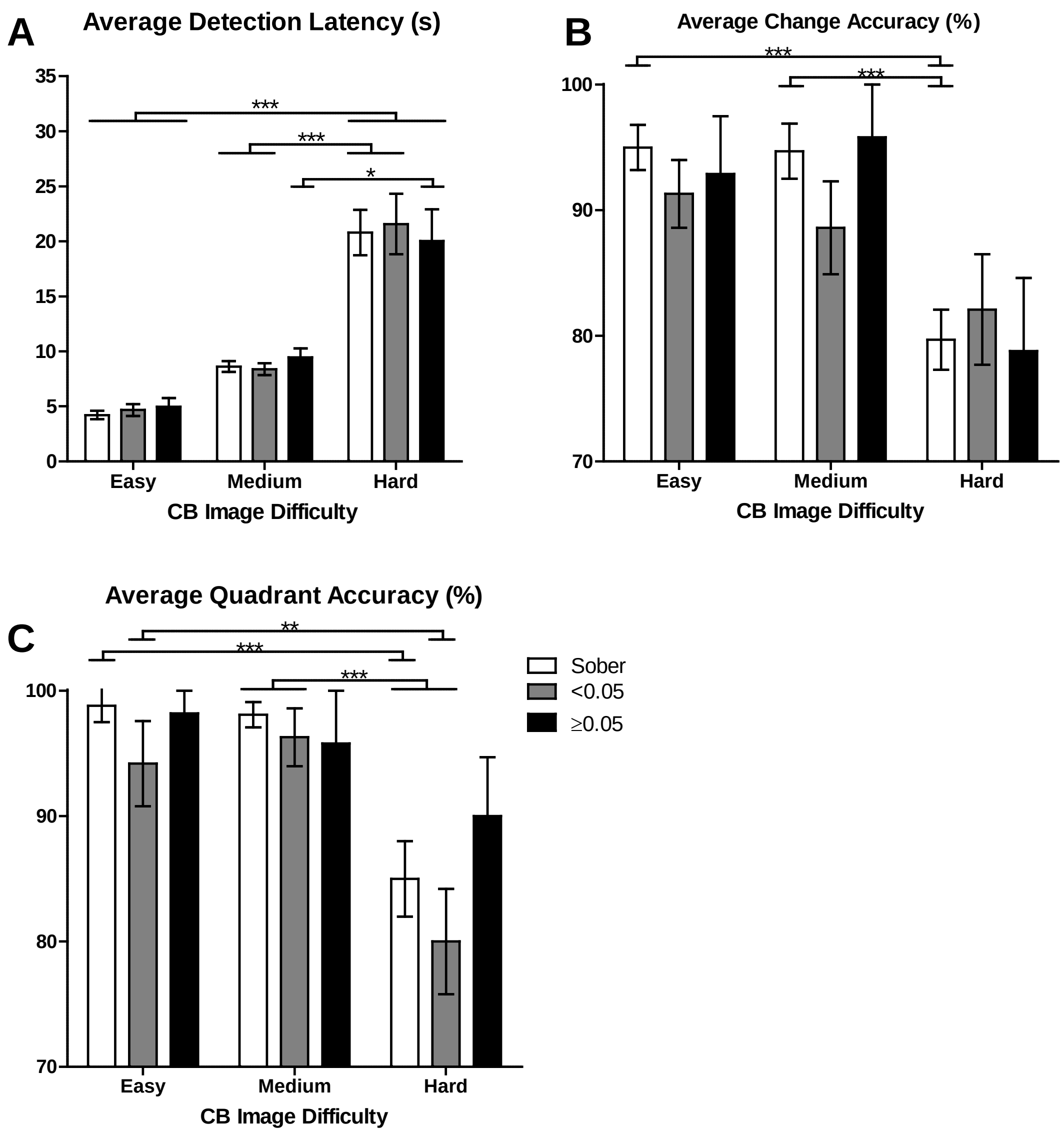


**Figure 6: Change Blindness Performance Differences Due to Difficulty Level.** A: Average detection latency (s) during the sober control condition (white), at BACs below 0.05 (grey), and BACs equal to or greater than 0.05 (black) for easy, medium, and hard difficulty levels. B: Average change accuracy (%) sober, at <0.05BAC, and at ≥0.05BAC for easy, medium, and hard difficulty levels. C: Average quadrant accuracy (%) sober, at <0.05BAC, and at ≥0.05BAC for easy, medium, and hard difficulty levels. Error bars denote ± 1 SEM, and significance bars indicate the results of the Bonferroni post tests.

Inattentional Blindness:

Counting accuracy in percentage, and noticing accuracy in percentage (as defined above) are plotted on the Y axes of the graphs in Figure 7, against the difficulty conditions of easy, medium, and hard on the X axes, grouped by BAC. Figure 7 shows a trend towards decreased counting accuracy and decreased noticing accuracy as difficulty increases. Due to the fact that not all participants were tested with BACs that fell into both the <0.05 and ≥0.05 categories, independent samples ANOVA instead of repeated measures ANOVA are reported here. Two-way ANOVA revealed no significant effects of difficulty on noticing accuracy ($p = 0.1434$). The data for noticing accuracy was quite variable, which may have contributed to this lack of significance. However, the analysis did reveal a significant effect of difficulty on counting accuracy ($F (2,39) = 24.23$, $p = <0.0001$). No significant effect of BAC was found for counting accuracy ($p = 0.3336$). These data are presented in Figure 7A-B.

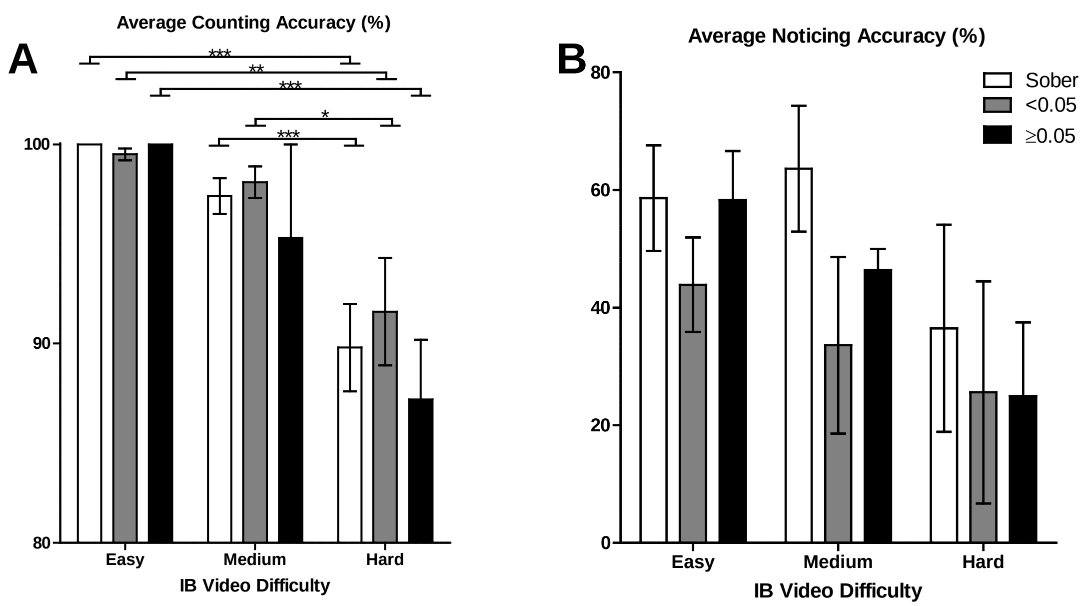


**Figure 7: Inattentional Blindness Performance Differences Due to Difficulty Level.** A: Average counting accuracy (%) during the sober control condition (white), at BACs below 0.05 (grey), and BACs equal to or greater than 0.05 (black) for easy, medium, and hard difficulty levels. B: Average noticing accuracy (%) sober, at <0.05BAC, and at ≥0.05BAC for easy, medium, and hard difficulty levels. Error bars denote ± 1 SEM, and significance bars indicate the results of the Bonferroni post tests.

Multiple Object Tracking:

Response latency in milliseconds and tracking accuracy in percentage (as defined above) are plotted on the Y axes of the graphs in Figure 8, against the difficulty conditions of easy (three objects tracked), medium (four objects tracked), and hard (five objects tracked) on the X axes, grouped by BAC. Figure 8 shows a slight trend towards increased response time as difficulty increases, and a trend towards decreased tracking accuracy as difficulty increases. Due to the fact that not all participants were tested with BACs that fell into both the <0.05 and ≥0.05 categories, independent samples ANOVA instead of repeated measures ANOVA are reported here. Two-way ANOVA revealed significant effects of difficulty on response latency (F (2,7086) = 27.81, p = <0.0001), as well as a significant effect of BAC on response latency (F (2,7086) = 10.50, p = <0.0001). The analysis also revealed a significant effect of difficulty on tracking accuracy (F (2,7086) = 60.31, p = <0.0001) and a significant effect of BAC on tracking accuracy (F (2,7086) = 3.724, p = 0.0242). These data are presented in Figure 8A-B.

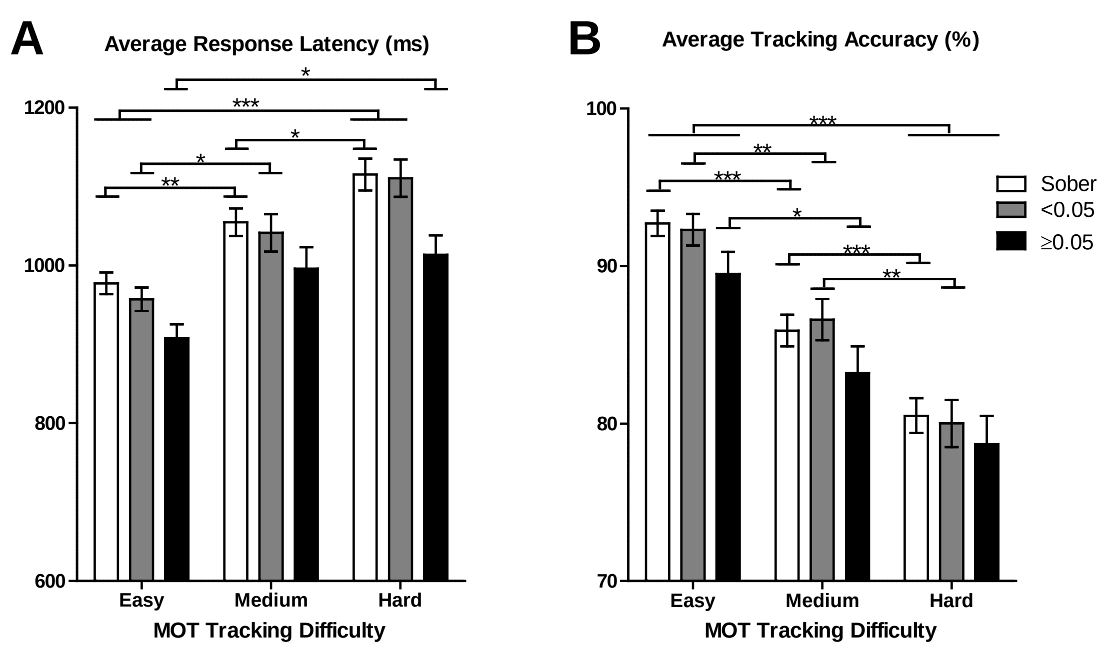


**Figure 8: Multiple Object Tracking Performance Differences Due to Difficulty Level.** A: Average response latency (ms) during the sober control condition (white), at BACs below 0.05 (grey), and BACs equal to or greater than 0.05 (black) for easy, medium, and hard difficulty levels. B: Average tracking accuracy (%) sober, at

<0.05BAC, and at ≥0.05BAC for easy, medium, and hard difficulty levels. Error bars denote ± 1 SEM, and significance bars indicate the results of the Bonferroni post tests.

## 3.4 Performance Differences Due to Day Order

To confirm that the counterbalancing of participants was effective, an analysis of whether the sober versus alcohol day order randomly assigned to participants affected performance for each task. Participants either had their sober session on day one and their alcohol session on day two, or their alcohol session on day one and their sober session on day two. This was done to ensure that practice effects would not obscure the effects of BAC on performance.

Change Blindness:

Detection latency in seconds, change accuracy in percentage, and quadrant accuracy in percentage (defined above) are plotted on the Y axes of the graphs in Figure 9, against the day order on the X axes, grouped by BAC. Visually, Figure 9 shows no clear trend towards differential detection latency, change accuracy, or quadrant accuracy for the sober day one as compared to the alcohol day one condition, except for perhaps the ≥0.05BAC day one alcohol trials for detection latency and change accuracy. To test for the significance of these data a two-way ANOVA was carried out. Due to the fact that not all participants were tested with BACs that fell into both the <0.05 and ≥0.05 categories, independent samples ANOVA instead of repeated measures ANOVA are reported here. The analysis revealed a significant effect of day order ($F\ (1,186) = 3.963$, $p = 0.0480$) for detection latency. However, no significant effect of day order was found for change accuracy ($p = 0.5545$) or quadrant accuracy ($p = 0.7401$). These data are presented below in Figure 9A-C.

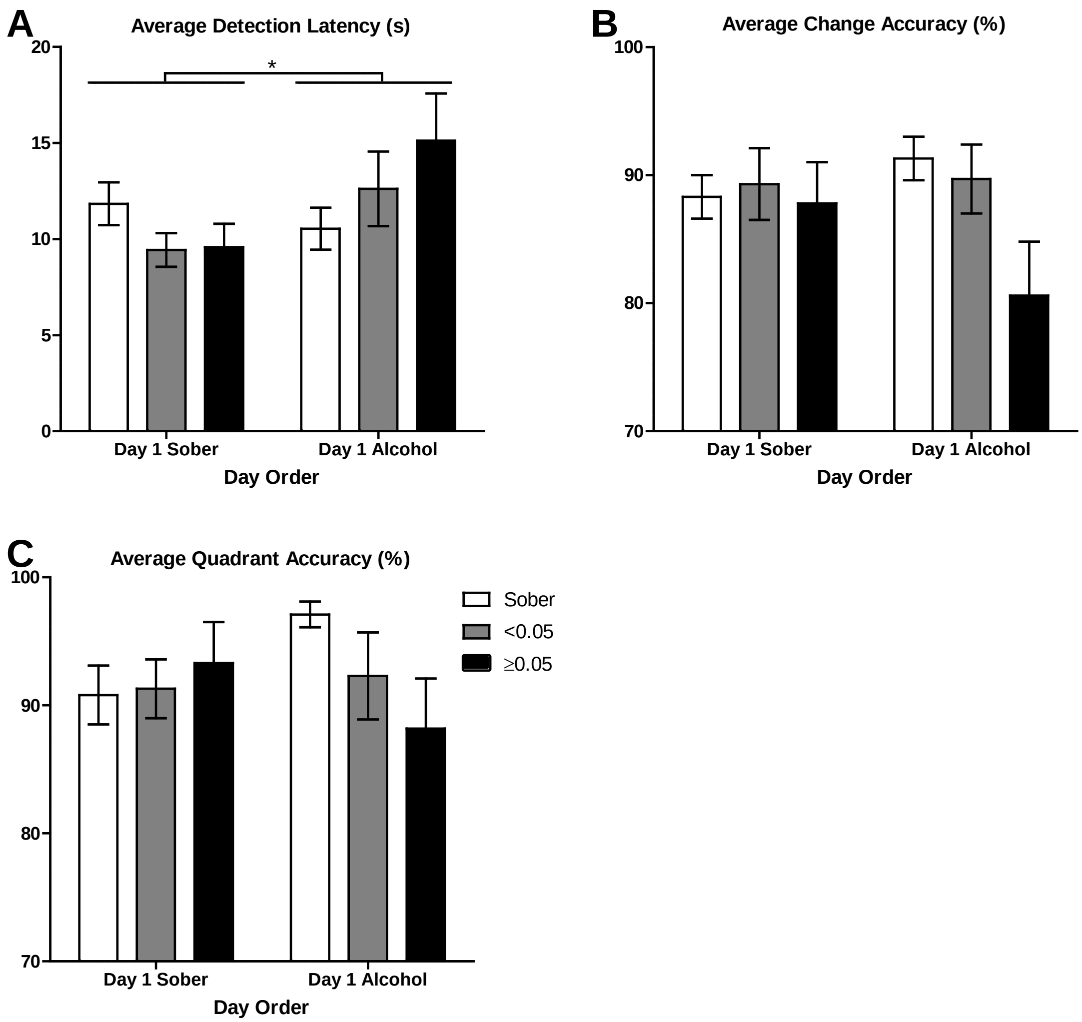


**Figure 9: Change Blindness Performance Differences Due to Day Order.** A: Average detection latency (s) during the sober control condition (white), at BACs below 0.05 (grey), and BACs equal to or greater than 0.05 (black) for day one sober or day one alcohol groups. B: Average change accuracy (%) sober, at <0.05BAC, and at ≥0.05BAC for day one sober or day one alcohol. C: Average quadrant accuracy (%) sober, at <0.05BAC, and at ≥0.05BAC for day one sober or day one alcohol. Error bars denote ± 1 SEM.

Inattentional Blindness:

Counting accuracy in percentage and noticing accuracy in percentage (defined above) are plotted on the Y axes of the graphs in Figure 10, against day order on the X axes, grouped by BAC. Figure 10 shows no trend for counting accuracy, and a trend towards decreased noticing accuracy in the day one alcohol condition. Due to the fact that not all participants were tested with BACs that fell into both the <0.05 and ≥0.05 categories, independent samples ANOVA instead of repeated measures ANOVA are reported here. Two-way ANOVA revealed no significant effects of day order ($p = 0.5334$) or BAC ($p = 0.4612$) on counting accuracy. However, the analysis did reveal a significant effect of day order on noticing accuracy ($F (1,179) = 10.80$, $p = 0.0012$), as well as a significant effect of BAC on noticing accuracy ($F (2,179) = 7.171$, $p = 0.0010$). These data are presented in Figure 10A-B.

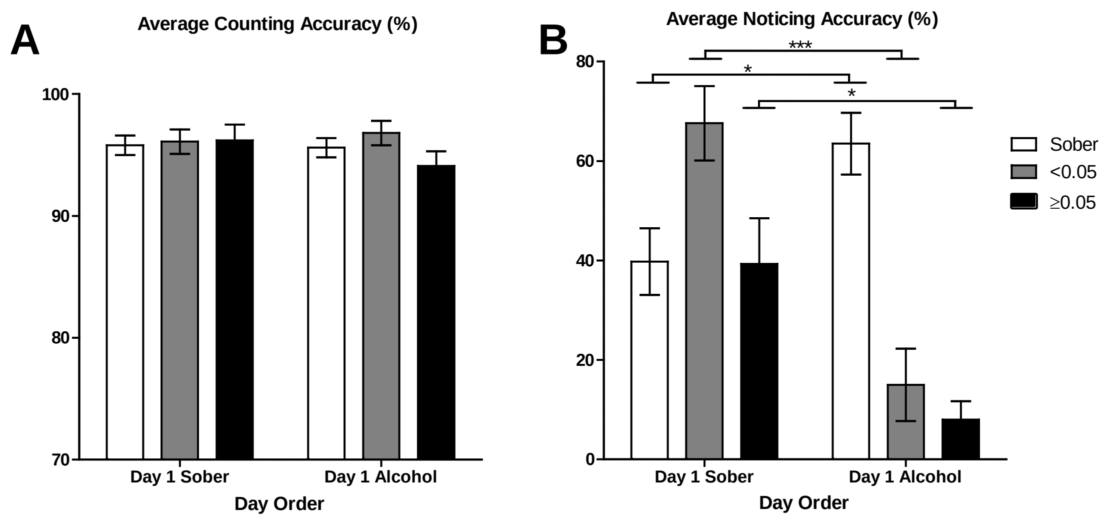


**Figure 10: Inattentional Blindness Performance Differences Due to Day Order.** A: Average counting accuracy (%) during the sober control condition (white), at BACs below 0.05 (grey), and BACs equal to or greater than 0.05 (black) for day one sober or day one alcohol. B: Average noticing accuracy (%) sober, at <0.05BAC, and at ≥0.05BAC for day one sober or day one alcohol. Error bars denote ± 1 SEM, and significance bars indicate the results of the Bonferroni post tests.

Multiple Object Tracking:

Response latency in milliseconds, and tracking accuracy in percentage (defined above) are plotted on the Y axes of the graphs in Figure 11, against the day order on the X axes, grouped by BAC. Figure 11 shows a slight trend towards a differential response time in sober trials for the day one sober condition as compared to the day one alcohol condition, and a trend towards differential tracking accuracy for ≥0.05BAC trials between the sober day one and alcohol day one groups. Due to the fact that not all participants were tested with BACs that fell into both the <0.05 and ≥0.05 categories, independent samples ANOVA instead of repeated measures ANOVA are reported here. Two-way ANOVA revealed overall no significant effects of day order on response latency ($p = 0.6297$), or tracking accuracy ($p = 0.1026$). These data are presented in Figure 11A-B.

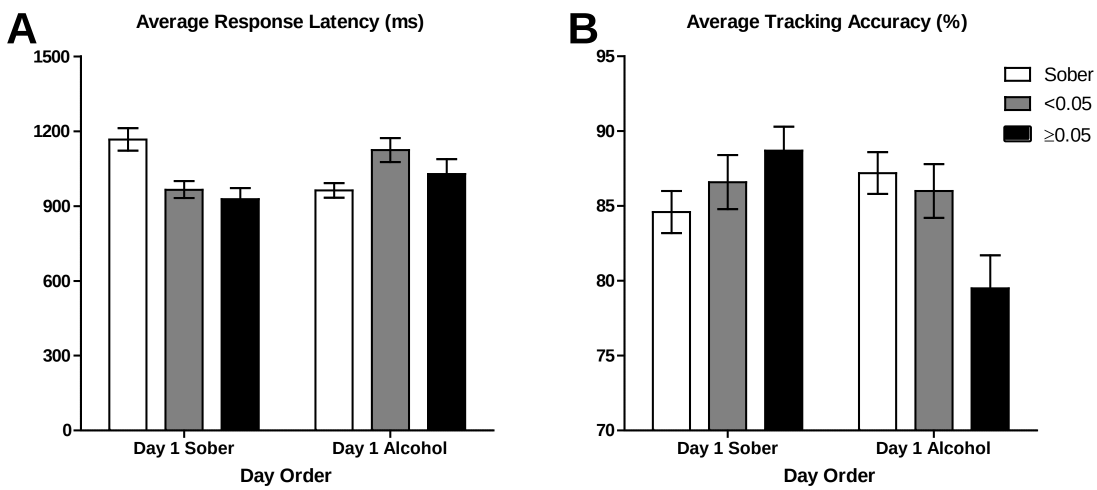


**Figure 11: Multiple Object Tracking Performance Differences Due to Day Order.** A: Average response latency (ms) during the sober control condition (white), at BACs below 0.05 (grey), and BACs equal to or greater than 0.05 (black) for day one sober or day one alcohol. B: Average tracking accuracy (%) sober, at <0.05BAC, and at ≥0.05BAC for day one sober or day one alcohol. Error bars denote ± 1 SEM.

# Chapter 4

# 4 Discussion

The purpose of the present study was to examine whether alcohol has an effect on visual selective attention, using three different paradigms. These three paradigms were change blindness, inattentional blindness, and multiple object tracking. Change blindness is a difficulty in detecting changes between scenes, and inattentional blindness is a surprising failure to notice unexpected salient stimuli when attention is engaged elsewhere. Both of these phenomena occur in normal individuals. Multiple object tracking is a task that requires attending to multiple moving stimuli simultaneously while ignoring identical distractors, and can be performed reliably by normal individuals. Overall it was found that alcohol has an effect on inattentional blindness task performance, but not on change blindness or multiple object tracking task performance. The results are discussed below in order of their appearance in Chapter 3.

## 4.1 Performance Differences Due to Blood Alcohol Concentration

Change Blindness:

While there appears to be a slight trend towards increased detection latency and decreased change accuracy for BACs over 0.05, overall it appears that alcohol has no significant effects on the three measures of change blindness considered here; detection latency, change accuracy, and quadrant accuracy. Since the previous study that found a significant effect of alcohol on change blindness detection latency was performed at an average BAC of 0.077 (Colflesh & Wiley, 2013), and the average BAC for the ≥0.05BAC condition in the present study was 0.063, it is possible that these trends fell short of significance due to the lower blood alcohol concentration obtained in the present study. Another difference between this previous study and the present study is that the changes in the images presented within this study were located randomly throughout each quadrant of the images, including centrally, while the changes in the images presented by Colflesh and Wiley were located exclusively in the periphery of the images (Colflesh & Wiley, 2013). Previous studies of the effects of alcohol on attention have found that alcohol alters peripheral attention performance while leaving central attention performance intact (Bayless & Harvey, 2017). Given these differences, it is possible that alcohol does in fact have no significant effect on these measures of change blindness, as would be consistent with other previous findings (Colflesh, 2010).

Inattentional Blindness:

Counting accuracy performance in the inattentional blindness task appears to be unaffected by BAC, while noticing accuracy is significantly affected. These results lend support to the argument that attention is a limited resource. It can be said – since counting performance remained relatively unchanged by alcohol but noticing accuracy decreased significantly as BAC increased – that as blood alcohol increased the total attentional resources available were diminished, leaving only enough to attend to the counting task, and not enough remaining attentional resources to pick up on the unexpected changes occurring in the videos. This interpretation would also support the alcohol myopia theory, which postulates that the more alcohol is consumed, the less we are able to allocate attentional resources to cognitive tasks (Steele & Josephs, 1990; Clifasefi, Takarangi, & Bergman, 2006).

Whether or not noticing the unexpected change in the inattentional blindness videos had an effect on participants' ability to accurately perform the counting task for that video was also analyzed, and it was found that noticing the unexpected change only affected counting accuracy at BACs greater than or equal to 0.05. This could provide further support for the alcohol myopia theory; as BAC increased, if participants noticed the unexpected change, their counting performance was altered, which could be an indication that they were less able to split attentional resources between noticing and counting. Importantly, there was no significant effect of noticing accuracy on counting accuracy in the sober condition, which would indicate that it is not the case that distraction from the counting task caused performance differences. The noticing accuracy results found here are comparable to the results found in one of the original inattentional blindness studies that was performed without alcohol; they found that 44% of participants noticed the unexpected stimulus (Simons & Chabris, 1999). The results found here are also comparable to a previous inattentional blindness study that had a between-subjects comparison of the effect of alcohol on inattentional blindness performance. They found that 46% of participants noticed the unexpected stimulus while sober, while only 18% of participants noticed the unexpected change while intoxicated (Clifasefi, Takarangi, & Bergman, 2006). In the present study we found that participants noticed 52% of the unexpected stimuli while sober, 45% while at <0.05BAC, and only 24% at ≥0.05BAC. This indicates that our modification of the paradigm to a within-subjects design was effective, and that the inattentional blindness phenomenon may be more robust than it was originally thought to be.

Another factor of the inattentional blindness paradigm that has been commonly debated is whether the deficit in noticing is due to attention or due to memory. Previous studies have found strong evidence against the idea that noticing accuracy results are actually due to inattentional amnesia rather than inattenional blindness (Simons & Chabris, 1999). They showed that inattentional blindness performance is the same when the inattentional blindness video is played in full, with 35% of participants noticing the unexpected event, or when the video is stopped immediately after the unexpected event, where 33% of participants notice it. Furthermore, if the video is stopped while the unexpected event is half way through, only 7% of participants notice the unexpected change even though it was the last image they saw and they were asked immediately if they saw anything (Simons & Chabris, 1999). Combined with the fact that the analyses in this study excluded any videos where participants had poor memory for the video overall, the results found here are attributed to alcohol affecting attention.

Multiple Object Tracking:

Overall there were no significant effects of BAC on multiple object tracking performance. As it appears that the effect of alcohol on multiple object tracking performance had not been previously studied, there is no existing literature to compare this result to. However, the seminal paper that developed the multiple object tracking paradigm reported that participants could track up to five of ten objects with an accuracy of around 87% (Pylyshyn & Storm, 1988), which is comparable to the results found here of 86% tracking accuracy sober and <0.05BAC, and 84% tracking accuracy for BACs ≥0.05. This would indicate that our ability to attend to and track stimuli at multiple different locations in the visual field in parallel is not impaired by alcohol, and may be separate from the type of attention required to perform the inattentional blindness task. It is possible that the subset of attention that is affected by alcohol is involved in the detection of new and previously unattended stimuli, while tracking of previously detected stimuli is unaffected by alcohol. This would be consistent with the finding here that noticing accuracy in inattentional blindness is affected by alcohol, while counting accuracy was not affected by alcohol; participants are able to detect repetitions of the same stimulus through time, but failed to notice novel stimuli. By the same logic, participants were able to track multiple stimuli across changing locations due to the fact that they were not required to attend any new previously unattended stimuli within a trial.

## 4.2 Performance Differences Due to Difficulty Levels

Change Blindness:

For all three measures recorded during the change blindness task (detection latency, change accuracy, and quadrant accuracy) it was found that there was a significant effect of difficulty level but not BAC on performance. This indicates that the attempt to create change blindness images of varying difficulty levels was effective. The manipulation of difficulty of this task also shows that the change blindness paradigm itself was effective. As participants were able to perform the change blindness task at all three difficulty levels regardless of alcohol, it shows that alcohol does not have an effect on change blindness, and that it was not the case that the task was not difficult enough to see a difference in performance. This result lends support to the finding that alcohol does not affect these measures of change blindness performance.

Inattentional Blindness:

For the inattentional blindness task, the manipulation of difficulty was centered on both the counting task and the subtleness of the unexpected event during the video. As the analyses revealed a significant effect of difficulty level for counting accuracy but not for noticing accuracy, it appears that the subtleness of the unexpected changes does not have an impact on whether they might be noticed. An example of an unexpected change that always or almost always went unnoticed by participants includes a lamp disappearing from a bedside table as the bed was being made, which could be considered a subtle change. However, an example of an unexpected change that could be considered more obvious that also always or almost always went unnoticed includes the board game that a group of people are playing changing, which was a large and colourful difference that occurred in the centre of the screen and remained in view for a large portion of the video. It is also possible that the variability in noticing accuracy or the effect that alcohol has on noticing accuracy obscured any effect that difficulty may have had on noticing accuracy.

Multiple Object Tracking:

The analyses of the difficulty levels for this task revealed significant differences between the easy, medium, and hard conditions. The difficulty levels here corresponded to the number of objects participants were required to track simultaneously. This result indicates that the attempt to mimic the difficulty levels of the change and inattentional blindness tasks by manipulating the number of objects tracked in this task was effective.

## 4.3 Performance Differences Due to Day Order

An analysis of whether the order in which participants had their sober and alcohol days was performed to ensure that the day order did not obscure the analysis of the effects of alcohol on these attention tasks.

Change Blindness:

No significant effect of day order was found for change accuracy or quadrant accuracy, however, a significant effect of day order was found for detection latency. Participants who had their first session as an alcohol session had longer detection latencies than those who had their first session as a sober session. This could be due to alcohol slowing their acclimatization to performing the task, as detection latencies were most increased for ≥0.05BAC. A closer inspection of the data revealed that it was only the first few trials in the first change blindness block that seemed to have longer detection latencies, so it is likely that the unfamiliarity of the flicker paradigm took a little longer for participants to adjust to if they first witnessed it at a higher BAC. Thereafter participants were able to perform the task equally well between alcohol and sober sessions and on par with participants in the day one sober group, indicating that while alcohol may have affected their adjustment to viewing a flicker paradigm, which can be slightly intimidating visually, alcohol had no significant effect on their change blindness performance.

Inattentional Blindness:

No significant effect of day order was found for counting accuracy, however, a significant effect of day order was found for noticing accuracy. Participants who had their first session as an alcohol session had lower noticing accuracies than those who had their first session as a sober session. This could be due to alcohol slowing their acclimatization to performing the task as noticing accuracies were most decreased for $<0.05$BAC and $\geq 0.05$BAC as compared to sober. This result is also logical given that alcohol was shown to have an effect on noticing accuracy.

Multiple Object Tracking:

Overall there was no significant effect of day order on multiple object tracking response latency or tracking accuracy performance. This is likely due to the fact that the multiple object tracking paradigm used simplistic stimuli in comparison to the change and inattentional blindness paradigms.

A summary of the previous body of research on the effects of alcohol on change blindness, inattentional blindness, and multiple object tracking, along with the results of the present study, is shown below in Table 3. Overall this study found that alcohol has an effect on inattentional blindness task performance, but not on change blindness or multiple object tracking task performance. As change blindness and inattentional blindness could be considered somewhat conceptually similar, it is interesting that one appears to be affected by alcohol while the other is not. Change blindness requires that participants detect changes within a stimulus, while inattentional blindness asks participants to focus on a counting task and asks if they were still able to detect unexpected changes. As participants were able to perform the change blindness task without any significant effect of alcohol, it can be said that participants were still able to detect changes while intoxicated. This is consistent with the finding by Timney and colleagues (2016) that signal detection sensitivity is unaffected by alcohol, even though response thresholds change with alcohol. Their result was interpreted as participants expending the effort to concentrate on the task given to them and being more conservative in their responses while intoxicated because they are in a laboratory setting, resulting in threshold responses but not signal detection sensitivity itself being altered by alcohol (Timney, Ferreira, & Matson, 2016).

If participants' ability to detect changes during the change blindness task was intact with alcohol, then why did they fail to notice unexpected changes during the inattentional blindness task? It is possible that the reason alcohol was found to significantly affect only inattentional blindness noticing accuracy and not inattentional blindness counting accuracy or change blindness and multiple object tracking performance, was due to the implicit nature of the noticing accuracy performance measure in comparison to the other measures of performance which were all explicit. For change blindness, participants were explicitly told to search the images for changes and provide a response based on that task as quickly and as accurately as possible. For multiple object tracking participants were explicitly told to attend to specific stimuli and ignore the others, and provide tracking responses as quickly and as accurately as possible. However, during the inattentional blindness task, participants were explicitly instructed to perform the counting task as accurately as possible, but no mention of the noticing aspect of the task was made until participants were asked if they had noticed anything unexpected in the videos at the end of their second session. It is possible that alcohol was shown to have no significant effects on the explicit portions of each task, but did have an effect on the implicit measure of inattentional blindness noticing accuracy, because participants expended all of their attentional resources on being able to perform the explicit task requirements, leaving no additional attentional resources remaining for the implicit aspect of the inattentional blindness task. This interpretation of the results would lend support to the notion that attention is a limited resource, and that alcohol impedes our ability to allocate our attentional resources, as is posited by the alcohol myopia theory.

**Table 3: Summary of the Previous Research and the Present Results on the Effects of Alcohol on Change Blindness, Inattentional Blindness, and Multiple Object Tracking**

<table>
<tr><th>CB and Alcohol</th><th>IB and Alcohol</th><th>MOT and Alcohol</th></tr>
<tr><td rowspan="2">Improved performance at 0.077BAC (Colflesh & Wiley, 2013)</td><td>Decreased performance at 0.04BAC (Clifasefi, Takarangi, & Bergman, 2006)</td><td rowspan="4">No significant effect of alcohol over a broad range of BACs, 0.01BAC-0.08BAC</td></tr>
<tr><td>Decreased performance at 0.08BAC (Pavuna & Ivanec, 2012)</td></tr>
<tr><td colspan="2">No significant effect of alcohol (Colflesh, 2010)</td></tr>
<tr><td>No significant effect of alcohol over a broad range of BACs, 0.01BAC-0.08BAC</td><td>Decreased performance over a broad range of BACs, 0.01BAC-0.08BAC</td></tr>
</table>

# Chapter 5

## 5 Conclusion

The effects of alcohol intoxication over a broad range of blood alcohol concentrations (average BAC between 0.01 and 0.08) were evaluated for change blindness, inattentional blindness, and multiple object tracking. Overall this study found that alcohol has an effect on inattentional blindness task performance, but not on change blindness or multiple object tracking task performance. It is possible that the reason alcohol was found to significantly affect only inattentional blindness noticing accuracy and not inattentional blindness counting accuracy or change blindness and multiple object tracking performance, was due to the implicit nature of the noticing accuracy performance measure in comparison to the other measures of performance which were all explicit. It is possible that alcohol was shown to have no significant effects on the explicit portions of each task, but did have an effect on the implicit measure of inattentional blindness noticing accuracy, because participants expended all of their attentional resources on being able to perform the explicit task requirements, leaving no additional attentional resources remaining for the implicit aspect of the inattentional blindness task. This interpretation of the results would lend support to the notion that attention is a limited resource, and that alcohol impedes our ability to allocate our attentional resources, as is posited by the alcohol myopia theory.

Advancing our understanding of how alcohol affects cognitive processes such as attention could have important applications, especially in the case of common situations like driving vehicles. Future studies on the effects of alcohol on visual attention could further explore whether implicit versus explicit task demands are differentially affected by alcohol intoxication. A better understanding of the effects of alcohol on attention could allow informed changes to current driving regulations to increase driving safety. Attention as a whole is too vast a topic to be analyzed using any one paradigm, so studies in which multiple paradigms are utilized could have an important role to play in elucidating the effects of alcohol on attention, and establishing support for theoretical frameworks such as the alcohol myopia theory, as was done here.

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# Appendices

Western Research

Research Ethics

**Western University Health Science Research Ethics Board**
**HSREB Full Board Initial Approval Notice**

**Principal Investigator**: Prof. Brian Timney
**Department & Institution**: Social Science,Western University

**Review Type**: Full Board
**HSREB File Number**: 108173
**Study Title**: The Effects of Alcohol on Visual Attention
**Sponsor**:

**HSREB Initial Approval Date**: August 18, 2016
**HSREB Expiry Date**: August 18, 2017

**Documents Approved and/or Received for Information**:

| Document Name | Comments | Version Date |
|---|---|---|
| Other | Sobriety Sign-off Sheet | 2016/06/09 |
| Other | Debriefing Form | 2016/06/09 |
| Other | Alcohol Use and Frequency Questionnaire | 2016/06/09 |
| Western University Protocol | Received Aug 3, 2016 | |
| Advertisement | | 2016/08/02 |
| Letter of Information & Consent | | 2016/08/02 |
| Recruitment Items | Email Script | 2016/08/02 |
| Data Collection Form/Case Report Form | | 2016/08/02 |

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the above named study, as of the HSREB Initial Approval Date noted above.

HSREB approval for this study remains valid until the HSREB Expiry Date noted above, conditional to timely submission and acceptance of HSREB Continuing Ethics Review.

The Western University HSREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use Guideline for Good Clinical Practice Practices (ICH E6 R1), the Ontario Personal Health Information Protection Act (PHIPA, 2004), Part 4 of the Natural Health Product Regulations, Health Canada Medical Device Regulations and Part C, Division 5, of the Food and Drug Regulations of Health Canada.

Members of the HSREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

Ethics Officer, on behalf of Dr. Joseph Gilbert, HSREB Chair

Ethics Officer: Erika Basile ✓ Katelyn Harris__ Nicole Kaniki__ Grace Kelly __ Vikki Tran __ Karen Gopaul __

**Western University, Research,** Support Services Bldg., Rm. 5150
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**Appendix A: HSREB Approval**

## Alcohol Use and Frequency Questionnaire*

This questionnaire asks questions about your alcohol use patterns. All information given on this questionnaire will be kept in confidence. Results will not be released in any manner in which you, or any other individual, can be identified. Please read each question carefully and indicate your answer below each question.

**First, we would like to ask you about drinking beer. How often, on average, do you usually have a beer? Please circle the appropriate number.**

1. never
2. every day
3. at least once a week, but not every day
4. at least once a month, but less than once a week
5. more than once a year, but less than once a month
6. once a year

**When you drink beer, how many 12 oz. beers (or equivalent), on average do you usually drink?**

I usually drink ______ beers.

**How often do you usually drink wine?**

1. never
2. every day
3. at least once a week, but not every day
4. at least once a month, but less than once a week
5. more than once a year, but less than once a month
6. once a year

**When you drink wine, how many 5 oz. glasses (or equivalent), on average do you drink?**

I usually drink ______ glasses of wine

**How often do you usually drink spirits (whiskey, gin, vodka, mixed drinks, etc)?**

1. never
2. every day
3. at least once a week, but not every day
4. at least once a month, but less than once a week
5. more than once a year, but less than once a month
6. once a year

**When you drink spirits, how many 1 ½ oz. shots (or equivalent), on average do you drink?**

I usually drink ______ 1 ½ oz shots of liquor.

**In the last twelve months how often, on average, did you drink alcoholic beverages?**

1. every day
2. 4-6 times a week
3. 2-3 times a week
4. once a week
5. 1-3 times a month
6. less than once a month
7. never

**On the days when you drank, how many drinks did you usually have?**

_________ number of drinks

**During the last 12 months, did you ever have 5 or more drinks of any kind of alcoholic beverage in a single day, that is, any combination of bottles of beer, glasses of wine, or drinks containing liquor of any kind?**

1. yes
2. no

**During the past week, not counting today, did you have any alcoholic drinks?**

1. yes
2. no

**If your answer to the above question was yes, please estimate the number and type of alcohol drinks that you had for each of the days during the past week. Do not count today.**

Amount and Type of Beverage

| Day | # of bottles of beer | # of 1 ½ oz. shots of spirits or mixed drinks | # of 5 oz. glasses of table wine |
|---|---|---|---|
| Sun | | | |
| Mon | | | |
| Tues | | | |
| Wed | | | |
| Thu | | | |
| Fri | | | |
| Sat | | | |

* These questions are taken from the "University Student Lifestyle Survey" created by The Addiction Research Foundation, 1992.

Page **2** of **2** Version Date: 14/06/2016

**Appendix B: Alcohol Use an Frequency Questionnaire**

# Curriculum Vitae

| | |
|---|---|
| **Name:** | Amber Robinson |
| **Post-secondary Education and Degrees:** | University of Toronto<br>Toronto, Ontario, Canada<br>2011-2015, HBSc |
| **Honours and Awards:** | University of Western Ontario Graduate Research Assistantship<br>2017 |
| | University of Western Ontario Graduate Research Scholarship<br>2015-2017 |
| **Related Work Experience** | Psychology Graduate Teaching Assistant<br>University of Western Ontario<br>2015-2017 |