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The effects of alcohol on different classes of motion perception

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A thesis submitted in partial fulfillment of the requirements for the Master of Science degree in Psychology

THE EFFECTS OF ALCOHOL ON DIFFERENT CLASSES OF MOTION PERCEPTION

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by

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Abstract

We used a psychophysical approach to investigate how alcohol affected visual sensitivity to perceive different classes of motion. Visual sensitivities were measured in both a non-alcohol and an alcohol condition for three classes of motion: Minimum Motion, Simple Motion, and Complex Motion. Perceptual thresholds, taken as the degree of motion at which an observer responded correctly with an accuracy of 75%, or Weber fractions were compared between the non-alcohol and the alcohol conditions. For Simple and Complex motion, similar comparisons were made as a function of speed (e.g., $2°s^{-1}$, $6°s^{-1}$, and $12°s^{-1}$). Perceptual thresholds were significantly greater in the alcohol condition for the Minimum Motion, and were significantly greater in the alcohol condition for Complex Motion at the fast speed only. We concluded that deficits in motion perception were more from interruptions in cognitive elements brought about by the nature of the visual task, rather than impairments in sensory processing.

Keywords

alcohol, motion, vision perception, random-dot-kinematogram, visual psychophysics, motion processing

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Chapter 1

1 Introduction

1.1 Alcohol, Vision, and Motion

Ethyl alcohol, a psychoactive substance widely consumed for its well-known cognitive and social effects, exhibits biphasic dose-dependent influences on the central nervous system (CNS). At the neurochemical level, it interacts primarily with the $GABA_A$ receptor-complex, NMDA-glutamate receptors, 5-HT_3-serotonin receptors, as well as with serotonergic and dopaminergic transmission (see Eckardt et al., 1998, for review). As a result, lower Blood Alcohol Concentration (BAC) levels during early stages of intoxication produce a temporary excitation of CNS activity; however, progressive consumption of alcohol and progressive absorption into the blood stream, and subsequently higher BAC levels, lead to a generalized suppression of CNS and cortical activity (Lewis et al., 1970; Berry & Pentreath, 1980; Levin et al., 1998; Calhoun et al., 2004; Khan & Timney, 2007; Chen et al., 2010; Esposito et al., 2010). The altered experiences that follow alcohol consumption are products of atypical neural activity in sensory and cognitive systems caused by these neurochemical influences. Unfortunately we know relatively little about how these known neurophysiological influences of alcohol manifest in sensation and perception compared to physiology and behaviour.

Vision, a primary sensory modality, evolved to assist animals with acting and responding in the physical world (Milner & Goodale, 2006). It accomplishes this in part by providing an internal pictorial representation of the physical world. Select perceptual abilities of vision have been shown to be modestly impaired by alcohol consumption

(Hill & Toffolon, 1990; Watten & Lie, 1996; Pearson & Timney, 1998; Wegner & Fahle, 1999; Pearson & Timney, 1999a; Pearson & Timney, 1999b; Fernando et al., 2010; Weschke & Niedeggen, 2012) despite common reports of large deficits in vision perception while inebriated. To date, the majority of this research has focused on low-level visual processing using mostly static visual stimuli.

Daily activities like walking and driving, however, depend largely on high-level visual-motion and visuo-motor processing of dynamic visual stimuli. Destructive alcohol-related outcomes such as fatal impaired driving accidents, which occur more frequently under moderate-high BACs (Perreault, 2013), may partly result from disrupted high-level visual processing in visual motion perception, specifically. The lack of research examining the effects of alcohol on high-level visual processing warrants further investigation. Therefore, we assessed how alcohol influenced the perception of visual stimuli that involved high-level visual processing, in this case motion.

1.2 Perceiving Motion

Motion, a feature of objects in the physical world, involves continuous or discontinuous change(s) in position over a period of time in a given direction. For example, an individual perceives continuous motion when observing a passing motor-vehicle and discontinuous motion when observing a person dance at a nightclub when a stroboscope activates. Changes in position over time (i.e., speed), and direction are fundamental physical properties of motion. The retina captures these spatiotemporal changes and transmits the information to the distinct areas of the cortex via various interconnected sub-cortical and cortical structures (Yukie & Iwai, 1981; Livingstone &

Hubel, 1988). The conscious perception of motion results from (a) the activation of motion sensitive neurons in the occipital cortex that recognize these spatiotemporal changes, and (b) their rate of activation. Excitatory and inhibitory transmission between inter-connected motion-sensitive neurons mediates this physiological ensemble of activation. This activity allows an individual to both detect and discriminate visual motion stimuli.

Motion sensitive neurons that vary in sensitivity and selectivity to the motion properties of a stimulus have been identified in distinct striate and extrastriate regions along the dorsal visual pathway in primates (Hubel & Wiesel, 1968; Wurtz, 1969; Dubner & Zeki, 1971; Zeki, 1974; Van Essen et al., 1981; Ungerleider & Mishkin, 1982; Van Essen & Maunsell, 1983; Maunsell & Van Essen, 1983a; Maunsell & Van Essen, 1983b; Albright, 1984; Ungerleider & Desimone, 1986; Desimone & Ungerleider, 1986; Tanaka et al., 1986; Tanaka & Saito, 1989; Celebrini & Newsome, 1994). Hubel and Wiesel (1968) first discovered complex-type neurons that showed activation to the movement of a visual stimulus in a particular direction in the striate cortex of primates. Some classes of these motion sensitive striate neurons responded equally to diametric opposite directions while others responded optimally to a preferred direction (Dow, 1974). These motion sensitive striate neurons also demonstrated a sensitivity to slow and fast stimulus speeds (Wurtz, 1969; Schiller et al., 1976).

Motion sensitive striate neurons were found to generally possess a greater preference for a stimulus' size, shape, position, contrast or orientation than direction or speed of motion (Wurtz, 1969; Dubner & Zeki, 1971; Albright, 1984; Albright et al., 1984). Such a preference for stimulus form properties over stimulus motion properties

suggested that striate cortex only partially contributed to the processing required to perceive motion. Moreover, disruptions to striate cortex processing from lesions and Transcranial Magnetic Stimulation (TMS) have been shown to only minimally increase psychophysical thresholds to visual displays of wide-field dot patterns (Rodman et al., 1989; Beckers & Zeki, 1995), supporting the idea that striate cortex only partially processes visual information for the perception of motion.

Findings of central visual field information being represented in the Superior Temporal Sulcus (STS), presumed to be from direct neural projections from striate cortex (Zeki, 1969; Zeki, 1971), motivated investigators to examine the response-properties of neurons in these extrastriate areas to visual motion stimuli. Recording from a number of single-cells within the STS, Dubner and Zeki (1971) found two general characteristics of motion sensitive neurons. The most predominant type of motion sensitive neurons responded best to a particular direction of stimulus movement despite changes in stimulus size, shape, or contrast. These cells responded optimally to preferred stimulus speeds of $1°s^{-1}$ - $5°s^{-1}$. A more rare type of cell with larger receptive fields responded to motion for all directions of a stimulus' movement. Optimal responses for these rarer neurons were found for extremely fast stimulus speeds of $100°s^{-1}$ - $200°s^{-1}$.

By recording from single neurons in the STS, Zeki (1974) later identified a subdivision of Dubner and Zeki's (1971) directionally sensitive cells wherein some cells responded to a preferred direction regardless of stimulus form properties while others responded only to the preferred direction for specific form properties. His recordings, however, determined most STS neurons responded preferentially to stimulus speeds that ranged between $5°s^{-1}$ to $50°s^{-1}$. The specialized response-properties of these neurons for

properties of motion suggested that this extrastriate region was crucially important for perceiving motion.

This notion was later confirmed when lesions to extrastriate visual areas along the dorsal visual pathway (Ungerleider & Mishkin, 1982) within the posterior bank of the STS were found to severely impair perceptions of motion but not perceptions of objects, shapes, contrast, or orientations in both monkeys and humans (Zhil et al., 1983; Newsome & Pare, 1988; Plant et al., 1993). Van Essen et al., (1981) identified two distinct areas along the posterior bank of the STS whose clusters of neurons demonstrated similar response-properties that had been found previously (Dubner & Zeki, 1971; Zeki, 1974) for stimulus movement and stimulus form. They also found that the differences in response-properties they had observed in neurons of the Middle Temporal (MT) area resembled the two subtypes of directionally sensitive neurons previously identified by Zeki, one sensitive to stimulus form and the other insensitive to stimulus form.

Of these motion sensitive MT neurons that possessed a directional preference, optimal responses for preferred stimulus speeds were found between $2°s^{-1}$ to $256°s^{-1}$ where the highest concentrations of neurons exhibited a speed preference around $32°s^{-1}$ (Maunsell & Van Essen, 1983a). Unlike in striate neurons, the majority of neurons in area MT demonstrated a greater preferential response for direction and speed of motion than for stimulus form properties (Wurtz, 1969; Maunsell & Van Essen, 1983a; Albright, 1984; Albright et al., 1984).

Albright's (1984) single-cell recordings of neurons specifically within area MT to various stimulus directions and orientations identified a further subdivision within the subtype of MT neurons that showed direction- and form-sensitivity (Zeki, 1974). Some

direction-form-sensitive MT neurons, classified as Type I neurons, responded optimally to a preferred direction of movement when the long-axis of a rectangular light stimulus was oriented perpendicular to the preferred direction of motion. In contrast, Type II neurons responded optimally to a preferred direction of motion when the long-axis of a rectangular light stimulus was oriented parallel to the preferred direction of motion. A group of MT neurons, believed to resemble Type II neurons, were later found to respond to whole patterns of motion despite the local component-movement(s) of the contour(s) within a stimulus pattern (Movshon et al., 1985; Rodman & Albright, 1989). The activity of these whole-pattern motion sensitive neurons found largely in area MT was presumed to depend on the convergence from other component motion sensitive MT neurons and striate neurons that possessed a similar sensitivity to the component motion properties (i.e., contours) within a moving stimulus pattern (Movshon et al., 1985; Stoner & Albright, 1992a).

Although substantially smaller than striate cortex, area of MT exhibited retintopic-organization like that in striate cortex (Hubel & Wiesel, 1968; Gattass & Gross, 1981), the processing of motion in area MT has been considered to involve greater degrees of processing than of that in striate cortex as MT neurons integrated substantially larger amounts of visual information across their substantially larger receptive fields (Zeki, 1974; Van Essen et al., 1981; Gattass & Gross, 1981). This MT processing has been shown to be directly related to vision-based perceptions of motion patterns and vision-based responses to perceived motion patterns (Newsome & Pare, 1988; Newsome et al., 1989; Salzman et al., 1990; Salzman et al., 1992; Britten et al., 1992a)

However, another distinct region medial to area MT within the STS appeared especially important for processing and perceiving motion, particularly large complex patterns of motion (Van Essen et al., 1981; Maunsell & Van Essen, 1983b; Tanaka et al., 1986; Celebrini & Newsome, 1994; Morrone et al., 2000). This visual region, named the Medial Superior Temporal (MST) area (Maunsell & Van Essen, 1983b), has been shown to receive direct reciprocal connections with area MT but not with striate cortex while area MT has been shown to receive direct reciprocal connections with both area MST and striate cortex (Maunsell & Van Essen, 1983b; Ungerleider & Desimone, 1986; Desimone & Ungerleider, 1986).

To distinguish the differences in motion processing that occur in area MT and area MST, Tanaka et al. (1986) compared the responses of single-cell recordings from directionally sensitive neurons in area MT and area MST to either a single moving bar or a wide-field of moving dots. Where the majority of MT neurons responded to both stimuli moving in their preferred direction, select groups of MST neurons responded optimally to: the bar moving in a preferred direction only; the wide-field of dots moving in a preferred direction only; or both the bar and the wide-field of dots as long as they moved in their preferred direction. These subdivisions in response-properties of MST neurons to specific motion stimuli demonstrated a more specialized processing of motion relative to area MT.

Tanaka and Saito (1989) later found that the MST neurons sensitive to wide-fields of motion patterns appeared to generalize the local movements within a stimulus pattern into a common global motion signal. For example, they identified three subgroupings of MST neurons sensitive to specific forms of wide-field motion patterns. One group

responded particularly to wide-fields of dots that translated in a unidirectional frontoparallel pattern where the other groups responded to either a wide-field of dots that translated in a radial pattern or a wide-field of dots that translated in a contracting/expanding pattern. Further, their recordings from these MST neurons responded optimally to a broader range of preferred speeds than that seen in MT neurons (Maunsell & Van Essen, 1983a; Tanaka & Saito, 1989).

Although the retinotopic organization evident in area MT had not been found in area MST, the neurons in area MST possessed substantially larger receptive fields that were found to integrate motion information from MT over respectively larger portions of the visual field (Gattass & Gross, 1981; Tanaka et al., 1986; Ungerleider & Desimone, 1986). The activation of some of these wide-field MST neurons to a wide-field pattern of moving dots has also been positively correlated with psychophysical thresholds for perceiving particular wide-field patterns of moving dots, suggesting that the motion processing in area MST, like in area MT, is directly linked to the perception of moving stimuli (Celebrini & Newsome, 1994).

Another distinct motion-sensitive extrastriate visual area, V3 in primates and V3A in humans (Van Essen & Zeki, 1978; Tootell et al., 1997), has been shown to receive representations of the peripheral visual field directly from V1 and V2 while indirectly interacting with MT and MST via the parieto-occipital area (PO) (Ungerleider & Desimone, 1986; Colby et al., 1988). The specialized nature of this visual area has yet to be fully understood but its affinity for motion signals, particularly speed, in both primates and humans suggests a higher-level supporting but non-essential role in motion

processing (Felleman & Van Essen, 1987; Gaska et al., 1988; Galletti et al., 1990; McKeefry et al., 2008).

Although many of these findings have been derived from physiological studies based on primate models of the visual system, anatomical and neuroimaging evidence exists to suggest that the human visual system not only contains these motion sensitive visual areas but that they are functional homologues of the primate visual system (Zeki et al., 1991; Tootell & Taylor, 1995; Tootell et al., 1995; Heeger et al., 1999; Dukelow et al., 2001; Huk et al., 2002). The medial temporal/medial superior temporal (MT/MST) area for primates (Zeki, 1974; Van Essen et al., 1981; Maunsell & Van Essen, 1983a; Desimone & Ungerleider, 1986), and the functionally homologous MT+ Complex (MT+) for humans (Zeki et al., 1991; Watson et al., 1993; Zeki, 1993; Tootell et al., 1995; Tootell & Taylor, 1995; Dukelow et al., 2001; Huk et al., 2002) have become known as the central processing units involved in visually perceiving motion (Albright, 1993). The activity in both of these functionally specialized visual areas (Zeki et al., 1991) has not only been shown to be critically involved in motion perception (Newsome et al., 1989; Salzman et al., 1990; Britten et al., 1992a) but has also been directly linked to vision-based actions in response to perceived motion (Salzman et al., 1992; Britten & van Wezel, 1998). These neurophysiological findings have helped to develop processing models for perceiving motion that serve as a framework for investigating the effects of alcohol on motion perception.

1.3 Classes of Motion Perception

Studies investigating motion perception and motion processing have presented motion stimuli in a variety of forms. These motion stimuli have included: a single spot of light or a single oriented bar translating in a unidirectional frontoparallel fashion (Hubel & Wiesel, 1968; Zeki, 1974; Tanaka et al., 1986; Desimone & Ungerleider, 1986); wide-field patterns of dots translating in a unidirectional frontoparallel, radial, or a contraction/expansion fashion (Tanaka & Saito, 1989; Snowden et al., 1991; Morrone et al., 2000; Huk et al., 2002; Schlack et al., 2007; Fernando et al., 2010), and wide-field patterns of stroboscopic dots moving coherently in a unidirectional fashion along a frontoparallel plane (Morgan & Ward, 1980; Newsome & Pare, 1988; Newsome et al., 1989; Britten et al., 1992a; Braddick et al., 2001; Weschke & Niedeggen, 2012). The processing involved in the perception of these motion forms has been shown to depend primarily on: (a) the area of the retina stimulated by motion in a visual display, and (b) the degree of motion complexity in the visual display (Desimone & Ungerleider, 1986; Ungerleider & Desimone, 1986; Tanaka & Saito, 1989; Morrone et al., 2000). Thus, there are different classes of motion perception that differ in their processing load.

The psychophysical approach to studying motion perception focuses on examining the nature of the visual system's sensitivity to motion stimuli; specifically, determining how visual sensitivity for perceiving motion changes for varying physical properties of motion (e.g., speed). In other words, it attempts to relate different forms of visual motion stimuli and their physical properties with people's ability to consciously sense and perceive them.

These psychophysical relationships are expressed as perceptual thresholds, the magnitude of a motion property that is critical for its perception. Perceptual thresholds are established through motion detection and motion discrimination paradigms. Motion detection paradigms involve measuring motion detection thresholds, the smallest magnitude of a physical property of motion (e.g., speed) in a visual stimulus that is required for a person to consciously recognize its presence. Motion discrimination paradigms involve measuring motion difference thresholds, the smallest change in magnitude of a physical property of motion between two visual stimuli that is required for a person to consciously recognize the change. These thresholds serve to explain the perceptual relationship.

In many cases perceptual thresholds are evaluated as a function of some motion property (i.e., speed) to help further explain the perceptual relationship. It is well established that difference thresholds will vary as a function of the magnitude of this motion property (Weber, 1834; Fechner, 1860; Hecht, 1924; Engen, 1972; Gescheider, 1976), but according to Weber's Law the difference threshold is normally a constant fraction of the magnitude of the motion property. Therefore, in order to compare the results for varying magnitudes of a motion property, data are normalized by calculating the Weber fractions.

Minimum motion, simple motion, and complex motion are three different classes of motion that have been commonly studied in visual psychophysics research (Aubert, 1886; Morgan & Ward, 1980; Newsome & Pare, 1988; Newsome et al., 1989; Watamaniuk & Heinen, 2003; Snowden & Kavanagh, 2006; Schlack et al., 2008). Perceptual thresholds for minimum motion are determined from motion detection

paradigms that measure the slowest speed of motion in a visual stimulus required to consciously recognize the stimulus' movement (Aubert, 1886; Snowden & Kavanagh, 2006). Perceptual thresholds for simple motion can be determined by detection and/or discrimination paradigms. Where simple motion detection paradigms measure the smallest magnitude of a property of simple motion (e.g., speed/acceleration) in a visual stimulus that is required to recognize its presence, simple motion discrimination experiments measure the smallest change in a property of simple motion between two visual stimuli that is required to consciously recognize the change (Watamaniuk & Heinen, 2003; Schlack et al., 2008). Perceptual thresholds for complex motion are also determined by detection and or discrimination paradigms. They measure the smallest magnitude of a complex motion property (e.g., coherence) or the smallest difference in the magnitude of a complex motion property that is required for its perception (Morgan & Ward, 1980; Newsome & Pare, 1988; Newsome et al., 1989; Britten et al., 1992a; Weschke & Niedeggen, 2012).

1.4 The Current Study

Alcohol-related impairments are evident in low-level visual sensory processes related to contrast sensitivity (Nicholson et al., 1995; Pearson & Timney, 1998; Pearson & Timney, 1999b; Weschke & Niedeggen, 2012). Some of these alcohol-induced sensory impairments have been specifically associated with deficits in neural inhibitory mechanisms and temporal processing that are also involved in motion processing (Adelson & Bergen, 1985; van Santen & Sperling, 1985; Khan & Timney, 2007; Johnston & Timney, 2008; Johnston & Timney, 2013). It is possible that these modest

impairments become exacerbated in the higher-level visual processes that impose greater processing loads when perceiving motion.

To explore the effects of alcohol on vision perception in high-level visual processing, the current study conducted four separate psychophysical experiments that examined whether a moderate-high intoxication level affected different classes of motion perception. Two-interval alternative forced choice (2IFC) visual tasks under a method of constant stimuli were used to measure perceptual ability in a non-alcohol and an alcohol condition for: (I) minimum motion; (II) simple motion as speed; (III) simple motion as acceleration; and (IV) complex motion. A motion detection experiment was used to measure perception of minimum motion, simple motion as speed, and complex motion, whereas a motion discrimination paradigm was used to measure perception of simple motion as acceleration. Observers' sensitivities to perceive these different classes of motion were compared between the non-alcohol and alcohol condition.

To explore these perceptual relationships in more depth, the current study examined the effects of alcohol on simple motion perception, and complex motion perception as a function of speed. Past research has found that alcohol mildly impaired a generic measure of perceptual ability for simple motion discrimination represented as speed for slow standard speeds but not fast standard speeds (Fernando et al., 2010). Moreover, no such distinction for speed has yet been made for complex motion perception As an extension of Fernando et al., (2010) we investigated whether alcohol affected Weber fractions as a function of speed in simple motion discrimination.

Chapter 2

2 General Methods

2.1 Methods

Materials

A letter of information (see Appendix A) outlined the purpose and details of the study. This letter informed participants that they may or may not receive alcohol in any of the testing sessions. It also provided an opportunity for participants to withdraw from the study without revealing any confidential information about themselves. An informed consent form (see Appendix B) followed the letter of information to acknowledge that participants understood the study's procedures and inclusion/exclusion criteria.

The Alcohol Use and Frequency Questionnaire (AUFQ; see Appendix C), a modified version of the National University Student Health Behaviour Survey (Addiction Research Foundation Division, 1998), assessed participants' demographic information and drinking patterns. A 'Moderate Drinker' was defined as an individual who self-reported to consume 17.5 standard drinks or less per week (Johnson et al., 1977; US Department of Health and Human Services & US Department of Agriculture, 1995; Eckardt et al., 1998).

Visual displays. A Cambridge Research Systems VSG2/5 graphics card generated visual motion displays onto a 120Hz 21" Sony Trinitron GDM-F520 CRT monitor. Based on a viewing distance of 140cm, the motion stimuli in all experiments consisted of white dots subtending 0.1° x 0.1° at a luminance of 100cdm^{-2} that were moving according to their respective form of motion on a dark background of 0cdm^{-2}.

Participants

Thirteen healthy young adults, including the experimenter, with normal or corrected to normal vision completed all four experiments tasks in both the non-alcohol and alcohol condition. Of 7 females and 6 males, ages ranged from 20 to 31 years (M = 24.92, SD = 3.57). Only participants who scored as being a 'Moderate Drinker' on the AUFQ, and who satisfied the legal drinking age requirement in Ontario received invitations to proceed with the study.

Individuals were recruited through direct solicitation through acquaintances of the experimenter. Out of the 16 individuals asked to participate, three people withdrew from the study. Individually, participants reported to a designated room for testing at a secured university testing facility. They were provided $20 in compensation for each testing session attended, for up to four sessions that lasted 3-5 hours per session. Testing typically required four sessions scheduled on different days, two sessions to complete the visual tasks in the sober condition and two sessions to the complete the visual tasks for the alcohol condition. Participants performed the visual tasks for two different forms of motion in each testing session. For each additional testing session attended after the fourth session, $10 was provided as compensation. If needed, pre-paid taxi services transported participants from the testing facility to their home after completing the session and after the participant reached a Breathalyzed Alcohol Concentration (BrAC) of 0.03 or less while showing no obvious signs of impairment.

2.2 Beverage Administration

Each participant was asked to consume a light, low-fat meal approximately 2 hours before arriving at the testing facility on testing days to avoid any adverse effects from consuming alcohol on an empty stomach. A Computerized Blood Alcohol Calculator (Kapur, 1989) determined the theoretical number of alcoholic beverages (45ml of liquor per beverage), mixed at a 1:4 vodka to citrus-juice ratio, to be initially consumed to raise the participant's BAC to .08%. In the non-alcohol conditions the participant imbibed the same volume of liquid, mixed at a 1:4 water to citrus-juice ratio, and followed the same protocols as in the alcohol condition. The beverage cups were always rimmed with alcohol to help mask which sessions contained alcohol. The experimenter prepared all of the beverages in a separate room that could not be seen by the participant. Note that the study was not concerned with the effects of a belief of being intoxicated on visual perception, and participants were informed of the possibility of consuming alcohol in any of the testing sessions. Thus, the non-alcohol condition was not regarded as a placebo condition.

Every participant received an initial 30 minute consumption period to drink the beverages. To monitor intoxication levels throughout the session, the experimenter recorded BrAC, used to infer a participant's BAC, every 10 minutes with a Draeger Inc. Alcotest 6510 breathalyzer device. These recordings began 20 minutes after the consumption period ended to allow for the alcohol to permeate into the bloodstream and for the alcohol residue to clear from the mouth. In the alcohol condition, a participant began the visual tasks when their recorded BrAC measures reached a minimum of 0.06%. Participants' average maximum BrAC levels for each experiment are shown in Table 1.

Table 1. ***Average Maximum Breathalyzed Alcohol Concentrations (%)***

Experiment	n	Mean *(SD)*
1	13	0.0893 *(0.010)*
2	13	0.0863 *(0.008)*
3	13	0.0848 *(0.007)*
4	13	0.0856 *(0.008)*

An additional alcoholic beverage was administered to the participant if they failed to reach a BrAC of 0.06% at the end of the 20 minute absorption period. This cycle ensued until the participant reached the appropriate intoxication levels. In the non-alcohol conditions, a participant began the visual tasks immediately after the initial 20 minute absorption period. Experimental testing was halted if a participant's BrAC dropped below .06% before completing all visual tasks. The experimenter scheduled an additional testing session on a later date for the participant to complete any unfinished visual tasks.

2.3 Procedure

At the beginning of the first testing session, each participant read the letter of information before providing written informed consent. While he or she completed the AUFQ, the experimenter verified the date of birth on a government-issued piece of identification to ensure the participant was at least 19 years of age. If they qualified as moderate drinkers they proceeded with the study, otherwise they were excused from the study, and compensated for a full testing session. Seated with their head rested in a chin

holster, the participant first received training and practice in each testing session on the visual tasks being performed that day.

In a dark room, the visual motion displays were presented in a series of 2IFC trials. A single 2IFC trial comprised of a pair of visual displays that contained either a standard motion stimulus or a comparison motion stimulus. In sequence, both stimulus displays appeared for 750ms with an inter-stimulus interval of 500ms. The standard stimulus always presented the same magnitude of a motion parameter whereas the magnitude of that motion parameter in the comparison stimulus varied from trial to trial. The motion parameter was different for each experiment. The tasks in every trial required participants to identify which display of the pair contained the comparison stimulus using a button box attached to the computer. Participants indicated whether the motion form being tested had been perceived in the first display by depressing the 'left-button' on the response box, or in the subsequent display by depressing the 'right-button' on the button box. Separated by inter-trial intervals of 500ms, trials were repeated multiple times with the presentation order of the standard stimulus and the comparison stimulus randomized in every trial. A series of repeated trials constituted an experimental run. The computer recorded the overall proportion for correctly identifying the comparison stimulus in the experimental runs for each participant.

The experiments were all conducted using a method of constant stimuli. The method of constant stimuli involved the presentation of 7 to 9 different comparison stimuli whose motion parameter magnitude varied in equal increments. The ranges of magnitudes for the different motion stimuli parameters in the comparison stimuli were selected such that performance for the lowest magnitude was close to chance levels, and

the highest magnitude could almost always be identified. In an experimental run each comparison stimulus was presented 10 times in random order. Participants completed at least four experimental runs per condition in each experiment.

Upon completion of the visual tasks and/or upon reaching a BrAC of 0.06% or less, participants were compensated for their time, and escorted to a waiting room where they remained under the supervision of the researcher until their BrAC reach 0.03% or lower and showed no obvious signs of impairment. Both the participant and experimenter signed a sobriety sign-off form (see Appendix D) to acknowledge that the participant reached an appropriate state to be discharged from the testing facility. A pre-paid taxi service then transported the participant from the testing facility to their place of residence. The experimenter provided a Debriefing Form (see Appendix E) and an opportunity to ask any questions about the study at the end of the final testing session.

Chapter 3

3 Minimum Motion Perception

3.1 Motion Detection

The first experiment measured sober and intoxicated observers' sensitivity to detect motion with minimum motion detection thresholds, the slowest speed required to recognize the presence of motion in the stimulus. These detection thresholds were then compared between the non-alcohol and alcohol condition.

Procedure

As described in the general methods procedure, minimum motion detection thresholds were obtained using 2IFC tasks with a method of constant stimuli.The standard stimulus was a single stationary dot centered on the screen within a 10° x 10° aperture for the duration of the presentation time. The comparison stimuli, however, presented a single dot centered on the screen that translated horizontally at one of eight speeds in the frontoparallel plane. The speeds presented by the different comparison stimuli within a single experimental run varied from $0.01°s^{-1}$ to $0.08°s^{-1}$, in equal increments of $0.01°s^{-1}$ (see Figure 1). The dot's horizontal direction of movement diametrically alternated on each successive trial. Each observer completed four experimental runs in the non-alcohol and alcohol condition. The task required observers to identify the comparison stimulus that contained a moving dot.

3.2 Results

For each participant, the total number of correct comparison stimulus identifications from all experimental runs were recorded and divided by the total number

of repetitions for each of the different comparison stimulus speeds. These proportions of correct responses were plotted against their respective comparison stimulus speed (see Figure 1).

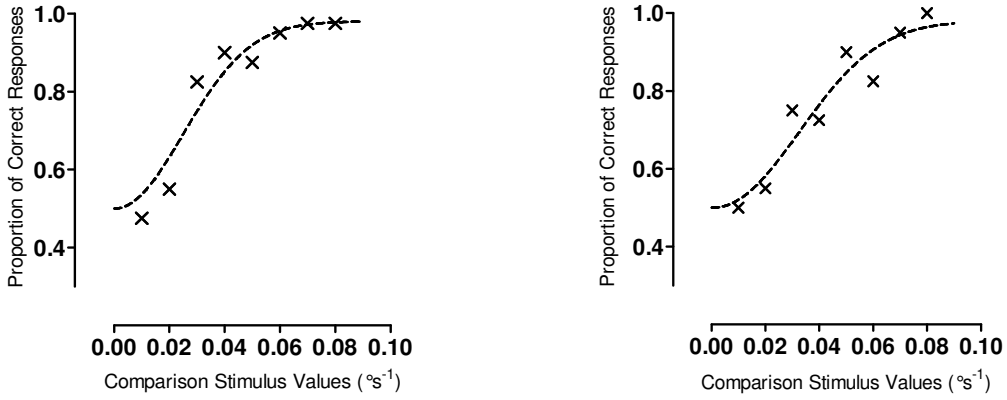

Figure 1. Sample data from a single observer in the non-alcohol condition (left) and the alcohol condition (right). The data were fitted by a Weibull function shown as a dashed line. The total proportions of correct responses, averaged across all runs, are plotted as a function of comparison stimulus speed.

A maximum-likelihood estimation fitted a Weibull psychometric function to the distribution of observations along the varying comparison stimulus speeds (Wichmann & Hill, 2001). For each participant, a minimum motion detection threshold was computed from the fitted psychometric at the speed at which an observer could correctly identify the presence of motion 75% of the time. In accordance with Wichmann and Hill, a bootstrap method (n = 10000) based on the deviance statistic (D) verified a significant goodness-of-fit for every fitted psychometric functions ($p > 0.05$). The minimum motion detection thresholds from all participants were averaged across subjects for the non-alcohol condition and the alcohol condition.

A two-sample dependent measures t-test determined whether the minimum motion detection thresholds in the non-alcohol condition ($M = 0.056$, $SD = 0.022$) differed significantly from the minimum detection thresholds in the alcohol condition ($M = 0.043$, $SD = 0.016$). As seen in Figure 2, the minimum motion detection thresholds in the alcohol condition were found to be significantly greater than those in the non-alcohol condition, $t(12) = 5.05$, $p < 0.001$, $r^2 = 0.68$. Thus, intoxicated individuals required the visual stimulus to be moving at a faster speed in order to detect the stimulus's motion compared to sober individuals.

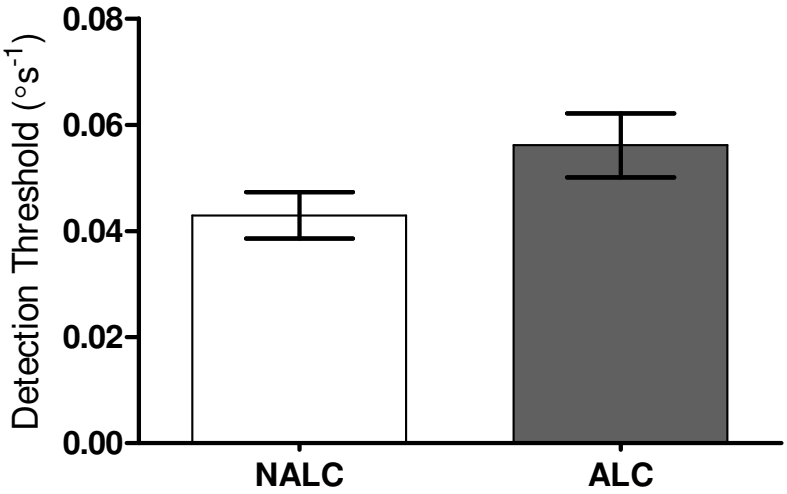

Figure 2. Mean minimum motion detection thresholds in the non-alcohol and alcohol condition. Error bars represent 1 SEM.

3.3 Discussion

This experiment examined whether a moderate-high intoxication level affected minimum motion detection thresholds. Our results indicated that minimum motion detection thresholds increased following moderate-high doses of alcohol compared to

sober observers. In other words, intoxicated observers were less sensitive in detecting the movement of a stimulus than sober observers. Past research found these minimum motion detection thresholds to measure 0.16 $°s^{-1}$ in sober observers (Aubert, 1886). More recent investigations using more sophisticated technology to generate visual motion stimuli have found motion detection thresholds of moving gratings to occur below $0.1°s^{-1}$ in healthy young observers (Snowden & Kavanagh, 2006). They found that these thresholds tended to persist for spatial frequencies between 0-5 cycles per degree of visual angle. Our minimum motion detection thresholds were found to be even lower than those of Snowden and Kavanagh in both the sober and intoxicated observers. This difference could have been an artifact of the different types of visual stimuli used. It is possible that the visual system is generally more sensitive to dot stimuli than to gratings as dots are visual stimuli that are more naturally represented in the environment than arbitrary gratings. As such, observers may be more sensitive to moving dots than to moving gratings because they likely interact with dot-like stimuli more than grating-like stimuli throughout their daily events.

It is possible that alcohol in moderate-high doses suppressed the sensory processing for detecting the slightest degree of motion in a seemingly stationary stimulus. Leibowitz et al. (1972) examined motion detection in the central and peripheral field of vision for various viewing conditions using a single-line motion stimulus. They found that an observer's sensitivity to detect the stimulus' motion decreased when the stimulus form features, including its edges, were blurred. Moreover, Pearson and Timney (1998) investigated the effects of alcohol on spatial and temporal contrast sensitivity. They found that alcohol impaired sensitivity to high spatial and high temporal frequencies

when perceiving contrast gratings. The experience of a loss in contrast sensitivity at high spatial frequencies can be described as a defocusing or blurring of fine visual details. An alcohol-induced impairment in contrast sensitivity at high spatial frequencies could have led to a blurring of the edges in the motion stimulus in our experiment. Such a blurring of the stimulus' edges could have in turn caused observer's to misperceive motion, causing a greater number of incorrect responses that would have ultimately increased detection thresholds in the alcohol condition. In this case, we would see an augmentation of alcohol's influences on low-level sensory processes in higher-level visual processing.

Alcohol has also been shown to impair temporal processing and lateral inhibition in vision, important functions for perceiving motion (Khan & Timney, 2007; Johnston & Timney, 2008; Johnston & Timney, 2013). For example, Khan and Timney used the Poffenberger paradigm, the flash-lag effect, and backwards masking to measure temporal processing in a sober condition and in a moderate intoxication condition. They found that all three indices of temporal processing became impaired at moderate intoxication levels. Some impairments in temporal processing have been selectively demonstrated in the temporal processing of cone photo-receptors in the central visual field (Pearson & Timney, 1999a), the location where the visual stimulus in our experiment had been presented. Thus, it is possible that alcohol's influences on these sensory mechanisms may have also resonated in this high-level visual function.

On the other hand, alcohol may have influenced cognitive components that led to the differences in minimum motion detection between sober and intoxicated individuals. Although the visual task in this experiment was fairly simple, the motion presented in the comparison stimulus was extremely subtle. In many cases observers reported hysteresis

in the standard stimulus. In order to distinguish the moving dot in the comparison stimulus from the stationary dot or from the the apparent hysteresis in the standard stimulus, an observer had to consciously evaluate both stimuli before reaching a perceptual decision. This evaluation introduces cognitive elements such as attention and memory into the perceptual process. Although, alcohol has not been found to influence visual attention at low doses (MacArthur & Sekuler, 1982), it has been found to impair attentional capacity and visual short-term memory in moderate-high doses (Wegner & Fahle, 1999; Wester et al., 2010). It is possible that disruptions in these cognitive elements may have led to a greater degree of second guessing and, consequently, to a greater number incorrect responses that would have inflated detection thresholds rather than impairments in sensory processing.

Given the pervasion of cognitive elements in the visual task here, we interpreted these results in favor of non-sensory factors mostly contributing to the found perceptual deficit in motion detection. One avenue for future research would be to test which aspect of perception for detecting motion was specifically affected by alcohol. By comparing the results from two different analytical techniques performed on the same set of perceptual observations, Ferreira and Timney (2004) demonstrate one possible approach. Using signal detection theory and ideal observer analysis, they obtained estimates of *d*' and of perceptual thresholds for contrast sensitivity. Although they found that alcohol impaired contrast thresholds, *d*' remained relatively unchanged. Because signal detection theory considers perception to involve a combination of top-down processes as well as bottom-up processes, its methodology accounts for cognitive elements in perception. When cognitive influences were taken into consideration, the effects of alcohol that were

evident from an ideal observer analysis seemed to disappear. This suggested that the deficits in contrast sensitivity results, at least in part, from non-sensory factors. Future research may consider such an approach to further examine whether alcohol interrupted sensory factors or non-sensory factors in motion detection.

Chapter 4

4 Simple Motion Perception

Simple motion can be expressed in a visual stimulus as a constant or a changing rate of continuous motion (i.e., constant speed, or acceleration). These two different motion properties have been found to be processed similarly by the visual system (Lisberger & Movshon, 1999; Price et al., 2005; Schlack et al., 2007; Schlack et al., 2008). The perception of acceleration, however, is believed to be indirect and processed via similar visual mechanisms responsible for processing the direct perception of speed (Gottsdanker et al., 1961; Price et al., 2005; Schlack et al., 2007; Schlack et al., 2008). It has been found to involve a multi-stage process involving an integration of initial speed and final speed over some period of time (Gottsdanker et al., 1961; Snowden & Braddick, 1991; Werkhoven et al., 1992). Its speed-dependent processing makes it a similar yet distinct representation of simple moti on. Therefore, we divided this chapter into two experiments to determine whether alcohol affected simple motion perception as a function of speed for two distinct simple motion properties, speed and acceleration.

4.1 Speed Discrimination

Using speed as the simple motion property, our second experiment measured observers' sensitivity to changes in speed from a speed discrimination tasks in a non-alcohol and an alcohol condition at three standard speeds. Weber fractions as a function of speed were computed and compared between the non-alcohol and alcohol conditions.

Procedure

As described in the general methods procedure, speed discrimination thresholds

were obtained using 2IFC tasks with a method of constant stimuli. The standard stimulus in our speed discrimination task contained 100 dots that were randomly generated within a 10° x 10° aperture. These dots translated horizontally in the frontoparallel plane at a slow ($2°s^{-1}$), a medium ($6°s^{-1}$) or a fast ($12°s^{-1}$) standard speed. The comparison stimulus contained a similar array of randomly generated dots; however, its dots translated horizontally in the frontoparallel plane at one of seven different speeds that varied from 101% to 122% of the speed presented in the paired standard stimulus. This range of comparison stimulus speeds varied in increments of 2%. To maintain a consistent motion signal throughout all of the stimulus presentations, the dots wrapped around the aperture during the presentations and they randomly regenerated at the aperture's beginning to continue the same pattern of motion (Williams & Sekuler, 1984). To prevent visual adaptation to the moving dots the direction of horizontal motion alternated in opposite directions on subsequent trials. The experimental runs were blocked in terms of slow, medium, and fast speed whereas observers completed four experimental runs for each speed in the non-alcohol and alcohol condition. The task required an observer to identify the stimulus that moved at a faster speed.

4.1.1 Results

As in the first experiment, the percentage of correct responses was calculated for each comparison speed and a Weibull psychometric function was fitted to the distribution of data for every participant in the non-alcohol and alcohol condition at each standard speed. We computed the speed at which an observer could correctly identify a change in speed between the standard stimulus and comparison stimulus 75% of the time from the

psychometric function. To obtain a difference threshold, the speed of the respective standard stimulus was subtracted from the speed that was computed from the fitted psychometric function. It is known that speed difference thresholds vary with standard speed so to normalize the data we computed Weber fractions as a function of speed. Weber fractions were determined by dividing each difference threshold by the standard speed from which it was obtained. A Weber fraction was computed for every participant in the non-alcohol and alcohol condition at each of the different standard speeds. These fractions were then averaged across participants in the non-alcohol and alcohol conditions for each standard speed of motion (see Figure 3).

A 2 x 3 repeated-measures ANOVA tested whether the Weber fractions in the non-alcohol condition differed from the Weber fractions in the alcohol condition at any of the different standard speeds. The analysis indicated that no significant differences existed between the non-alcohol and alcohol conditions for any of the standard speeds. Thus, an intoxicated observer's ability to discriminate simple motion represented in speed was no different than that of a sober observer regardless of the speed of motion.

4.1.2 Discussion

The second experiment examined whether alcohol affected speed discrimination as a function of speed. In the sober condition, the Weber fractions from speed discrimination experiments tended decrease as speed increased, suggesting that an observer's ability to discriminate rate of motion increased as the standard speed of motion increased. In other words, people can distinguish a difference in the relative speed between two moving objects more easily when the objects are moving at faster speeds.

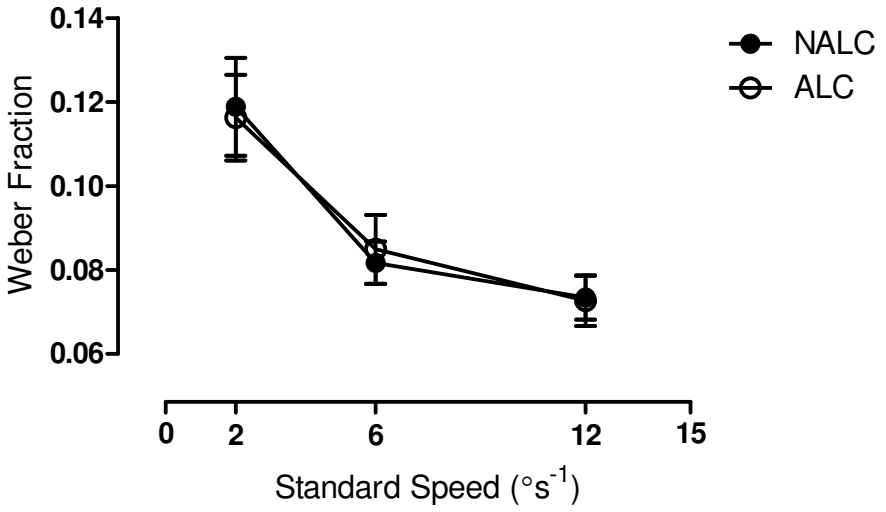

Figure 3. Mean Weber fractions for speed discrimination in the non-alcohol and alcohol conditions. Error bars represent 1 SEM.

These findings are consistent with previous research examining the perceptual ability to discriminate speed in sober observers (Orban et al., 1984; De Bruyn & Orban, 1988; Snowden & Kavanagh, 2006). Using a similar speed discrimination experiment, Orban et al. found Weber fractions to decrease as the standard speed of motion increased between a range of $1°s^{-1}$ to $32°s^{-1}$. De Bruyn and Orban also found that Weber fractions decreased as standard speed of motion increased between standard speeds of $1°s^{-1}$ to $64°s^{-1}$. More recently, Snowden and Kavanagh found Weber fraction for speed discrimination to decrease as standard speed increased from $0.1°s^{-1}$ to $8°^{-1}$. Thus, it appears that sensitivity to changes in relative speed increases for a wide range of standard stimulus speeds.

The Weber fractions in the alcohol condition were found to be virtually identical to those in the non-alcohol condition at all standard speeds. In other words, intoxicated observers were just as sensitive to differences in relative speed between two moving

stimuli as sober observers. Their capability to detect the difference in speed between two moving stimuli equally improved for faster moving stimuli. These findings are similar to other studies that examined the effects of alcohol on speed perception. Kearney and Guppy (1988) found that alcohol intoxication at high BAC levels did not influence an observer's ability to estimate speed in a driving simulation. Thus, alcohol did not appear to interfere with the sensory processing involved in speed discrimination. The multiple input pathways from the retina that reach the primary motion processing areas, and the large number of reciprocal connections found between the primary motion processing areas (Maunsell & Van Essen, 1983b; Ungerleider & Desimone, 1986; Rodman et al., 1989; Rodman et al., 1990) may buffer against any alcohol-induced attenuation of motion signals being transmitted through the visual system.

Contrary to our results, some past research found that alcohol impaired visual speed discrimination in a similar task. Fernando et al. (2010) found that measures of an observer's perceptual ability to identify a faster moving visual stimulus from a pair of moving stimuli was impaired for fast ($12°s^{-1}$) speeds of motion. The reason for this discrepancy in results is not entirely clear. It is possible that these differences resulted from subtle differences in the methodology and analyses employed. Our analyses computed discrimination thresholds from a fitted Weibull psychometric function to compare Weber fractions as a function of speed rather than comparing the slopes from a linear regression on observer performance. These different analytical approaches could produce rather different estimations of perceptual ability depending on the distribution of an observer's performance over the different comparison stimulus values, especially if the range of comparison stimulus values is overly large or skewed. In any case, the

impairments found by Fernando et al. were modest at fast speeds of motion. Our findings and those of Fernando et al. taken together suggest that alcohol had little, if any, influence on the high-level visual processing involved in speed discrimination.

It is possible that the high-level visual processes involved in speed discrimination are capable of mitigating alcohol's influences on underlying visual processing mechanisms. For example, Gegenfurtner et al., (2003) found the speed of smooth pursuit eye movements to be highly correlated with the perceptual judgments for discriminating speed, suggesting the process for perceiving speed differences largely involves smooth pursuit eye movements. Further, Harrmeier and Thier (2006) found pursuit eye movements to facilitate the perception of speed differences. Alcohol has been shown to impair several facets of eye movements in response to visual motion stimuli (Collins et al., 1971; Stapleton et al., 1986). Although smooth pursuit eye movements are seemingly necessary for perceiving speed differences, our results indicate that alcohol does not alter the smooth pursuit mechanisms pertinent for evaluating the differences in perceived speed or it does not affect the information extracted from smooth pursuit eye movements when discriminating speed of motion.

4.2 Acceleration Detection

Our third experiment measured observers' sensitivity to changing rates of speed with acceleration detection thresholds in a non-alcohol and an alcohol condition at a slow, a medium, and a fast standard speed. Weber fractions were compared between the alcohol and non-alcohol conditions for the varying levels of standard speed.

Procedure

As described in the general methods procedure, an observer's ability to perceive acceleration was obtained using 2IFC tasks with a method of constant stimuli. The standard stimulus in our acceleration detection task contained 100 dots randomly generated within a 10° x 10° aperture that translated horizontally in the frontoparallel plane at a slow ($2°s^{-1}$), medium ($6°s^{-1}$) or fast ($12°s^{-1}$) standard stimulus speed. The comparison stimulus contained a similar array of randomly generated dots; however, its dots translated horizontally in the frontoparallel plane given one of eight different acceleration rates whose starting speed matched that of the speed in the paired standard stimulus.

The range of acceleration rates presented in the comparison stimuli differed for each of the different standard stimulus speeds. These ranges of acceleration rates all began at $0.1°s^{-2}$ and increased in equal increments of $0.2°s^{-2}$, $0.4°s^{-2}$, or $0.9°/s^{-2}$ for the slow, medium, and fast standard speeds, respectively. The dots wrapped around the aperture in the visual displays as in the speed discrimination task to ensure a continuous motion signal throughout the stimulus presentations. Experimental runs were blocked in terms of standard stimulus speed and observers completed four experimental runs for each speed in both the non-alcohol and alcohol conditions. As in the speed discrimination tasks, the direction of horizontal motion alternated on subsequent trials to avoid motion adaptation. This visual task required an observer to identify the stimulus containing the accelerating dots.

4.2.1 Results

As in the first two experiments, a Weibull psychometric function was fitted to the participants' performance distributions along the varying comparison stimulus values in the non-alcohol and alcohol condition for each standard speed. As in speed discrimination, it is known that acceleration detection thresholds vary with standard speed so similarly we normalized the data for the different speeds using Weber fractions. However, it is not possible to calculate a Weber fraction for acceleration rates because the standard stimulus had zero acceleration. Instead, we converted the acceleration rates in the comparison stimuli into an estimate of final speed by calculating the speed of the comparison stimulus' dots at the end of the presentation. This is a simple linear transformation that does not affect the distribution of the observed performance data along the varying comparison stimulus values, and it is also consistent with other findings that suggest acceleration is detected indirectly by comparing the initial and final speeds of a moving stimulus (Gottsdanker et al., 1961; Snowden & Braddick, 1991; Schlack et al., 2008). The final speed of a comparison stimulus was computed by adding the standard stimulus' speed to the product of the comparison stimulus' acceleration and presentation time. After this transformation, the psychometric function was fitted to an observer's performance data based on the final speeds of the varying comparison stimulus values rather than acceleration rates.

We computed the speed at which an observer could correctly identify the accelerating stimulus 75% of the time from the psychometric function. To obtain a difference threshold, the speed of the respective standard stimulus was subtracted from the speed that was computed from the fitted psychometric function. Weber fractions were

determined by dividing a difference threshold by the standard speed. These Weber fractions were averaged across participants for the non-alcohol and alcohol conditions at each standard speed (see Figure 4) and were compared.

A 2 x 3 repeated-measures ANOVA tested whether the Weber fractions in the non-alcohol condition differed from the Weber fractions in the alcohol condition for the varying standard speeds. The analysis indicated that no significant differences existed for any level of standard speed. Thus, an observer's ability to detect acceleration was not affected by alcohol at any level of the standard speed of motion.

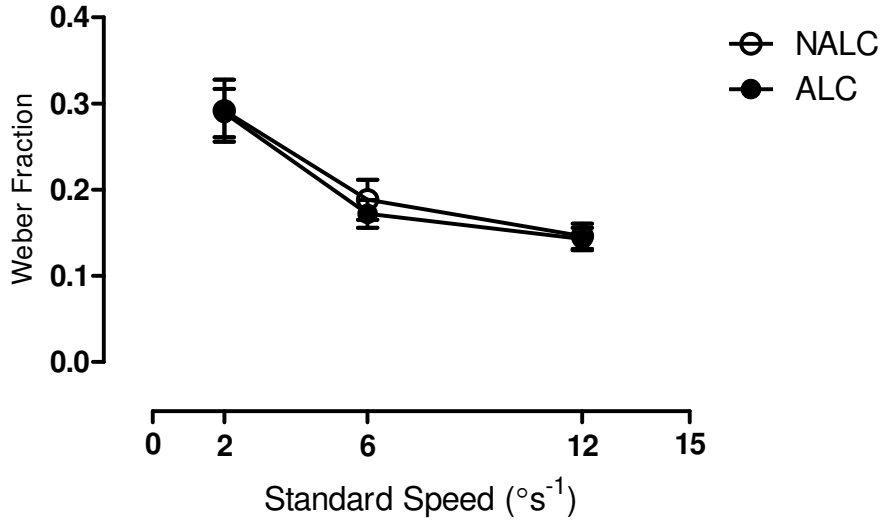

Figure 4. Mean Weber fractions for acceleration detection in the non-alcohol and the alcohol condition. Error bars represent 1 SEM.

4.2.2 Discussion

In this experiment, we determined whether alcohol affected acceleration detection at several different standard speeds. As we found from the Weber fractions for speed discrimination in sober observers, the Weber fractions for acceleration detection tended

to decrease as the standard speed increased. In other words, acceleration becomes easier to perceive for a sober observer when objects are moving at faster relative speeds.

The Weber fractions for acceleration detection in sober participants were found to be much larger than what we found in speed discrimination, suggesting sensitivity to acceleration is much lower than sensitivity to speed. This finding has been well supported by previous studies on speed and acceleration perception (Gottsdanker, 1956; Gottsdanker et al., 1961; Snowden & Braddick, 1991; Werkhoven et al., 1992). A lesser sensitivity to detect acceleration compared to speed has been said to partially result from acceleration processing being dependent on speed processing and its underlying mechanisms (Gottsdanker et al., 1961; Werkhoven et al., 1992; Lisberger & Movshon, 1999; Watamaniuk & Heinen, 2003; Schlack et al., 2008).

In the alcohol condition, Weber fractions, like in speed discrimination, were nearly identical to those obtained in sober observers. An intoxicated observer could identify changes in rate of motion just as accurately as a sober observer. As such, the increase in sensitivity to detect acceleration for faster moving objects seen in sober observers was also evident in intoxicated observers. Thus, it does not appear that alcohol influences the sensory processing involved in acceleration detection.

We know speed is directly perceived by many speed-tuned neurons in the motion processing areas of the brain (Dubner & Zeki, 1971; Zeki, 1974; Maunsell & Van Essen, 1983a; Liu & Newsome, 2005; Schlack et al., 2007). Although no motion sensitive neurons have been found to date that show direct tuning for acceleration rates specifically, patterns of activity in area MT have been associated with acceleration perception (Lisberger & Movshon, 1999; Price et al., 2005; Schlack et al., 2007).

Acceleration has, thus, been generally considered an indirect form of perception that depends on mechanisms for visual processing of speed (Watamaniuk & Heinen, 2003; Schlack et al., 2008).

For example, Lisber and Movshon (1999) proposed that patterns of MT neuron activation were responsible for perceptions of accelerating stimuli as opposed to a relatively small number of MT neurons for constant speed of motion (Newsome et al., 1989). It was later demonstrated that observations of accelerating stimuli led to an adaptation of preferred speeds and speed-tuning curves in motion sensitive MT neurons (Krekelberg et al., 2006; Schlack et al., 2007). Specifically, they found that individual responses of MT neurons were attenuated and that their tuning-curves narrowed following observations of constant speed. Schlack et al. (2007) determined that these changes in response properties can explain changes in perceived speed (i.e., acceleration). Schlack et al. (2008) later combined physiological evidence from macaque MT with findings from human observers to show that their interpretation of these changes in response-properties generalized to the human perception. The lack of an effect from alcohol on acceleration detection suggests that it bears no influence on the motion processing mechanisms involved in generating the differences in speed-tuning and responding of MT neurons required to perceived and detect acceleration.

This lack of an effect from alcohol on acceleration detection is not overly surprising. We found that alcohol exhibited no influence on speed discrimination, suggesting that the integrity of the underlying processing for discriminating speed remained fairly intact. And as we have previously mentioned, the ability to detect acceleration has been shown to depend on the visual processing involved in speed

discrimination. By extension, alcohol should similarly exhibit little, if any, influence on the processing for acceleration detection. It does not seem that acceleration detection involves a visual processing mechanism that is both selectively affected by alcohol and not involved in speed discrimination.

Chapter 5

5 Complex Motion Perception

5.1 Coherence Detection

Our fourth experiment examined whether alcohol affected observers' sensitivity to detect complex motion as a function of stimulus speed. Complex motion can be represented in a variety of forms. Some of these forms have included translational, radial, or expanding/contracting representations of optic flow or motion coherence. We chose discontinuous motion coherence to represent complex motion in this experiment. Here the motion path of any individual dot could not be tracked across the visual field (Williams & Sekuler, 1984; Britten et al., 1992a). An observer viewing motion coherence would perceive a global pattern of unidirectional motion that seemed to emerge within stochastic visual noise. Coherence detection thresholds were measured in a non-alcohol and an alcohol condition for slow, medium, and fast standard speeds. These thresholds were then compared to examine possible differences in sensitivity between intoxicated and sober observers.

Procedure

Coherence detection thresholds were measured using 2IFC tasks and a method of constant stimuli, as described in the general methods procedure. Random-Dot-Kinematograms (RDK) were used to generate the coherent motion stimuli, as had been done in previous examinations of complex motion processing (Morgan & Ward, 1980; Newsome & Pare, 1988; Britten et al., 1992a). The standard stimulus in our coherence detection task was a RDK containing a set of 100 dots with a limited lifetime that

stroboscopically translated in random directions within an aperture of 6° in radius. For example, the dots would randomly appear for the duration of the first frame (8.3ms) in the visual presentation and then reappear for a single frame after a 25ms delay-interval. The dot's position following the 25ms delay-interval would be displaced according the standard speed in a random direction. After this single 'jump' cycle, each dot would be randomly repositioned within the aperture and complete another 'jump' cycle. This ensued for the duration of the presentation. The lifetime of each dot lasted a single frame. This standard stimulus appeared as a pattern of random stroboscopic noise with no presence of a coherent global motion pattern.

The comparison stimulus comprised of a RDK that contained 100 dots that were presented in the same stroboscopic fashion as in the standard stimulus. The direction of displacement for one set of these dots was randomized as in the standard stimulus. The direction of displacement for the remaining proportion of dots was fixed in the horizontal rightward direction. This comparison stimulus appeared as a pattern of stroboscopic visual noise with a presence of coherent horizontal global motion embedded within the noise. The presence of coherent global motion in the comparison stimulus was indirectly generated by the dots that 'jumped' coherently in the same horizontal direction. The salience of this presence of global motion could be varied by adjusting the proportion of dots that moved coherently in the horizontal direction; the greater the proportion of coherently moving dots the more salient the appearance of global motion in the display.

Within an experimental run, our coherence detection task presented seven different comparison stimuli that varied in the proportion of dots that moved coherently in the horizontal rightward direction. In equal increments of 9%, the proportions of

coherent dots in the comparison stimuli ranged from 8% to 62%. The experimental runs were blocked in terms of a slow ($2°s^{-1}$), a medium ($6°s^{-1}$), and a fast ($12°s^{-1}$) standard speed. The task required observers to identify the stimulus with the dots that appeared to move horizontally in the rightward direction.

5.2 Results

As in the first three experiments, a Weibull psychometric function was fitted to the distribution of the proportions of correct responses along the varying degrees of coherence for each participant in the non-alcohol and alcohol condition for each standard speed. Participants' coherence detection thresholds, the proportion of coherently moving dots that corresponds to the point at which an observer could identify the presence of global motion 75% of the time, were computed from the psychometric functions in all conditions. These coherence detection thresholds were averaged across participants for the non-alcohol and alcohol conditions at each standard speed, and were compared (see Figure 5).

We first performed Mauchly's test of sphericity to test for a homogeneity of variance in the differences between the intoxication and speed conditions. Mauchly's test of sphericity was not significant, $\chi^2(2) = 4.07$, $p = 0.13$, indicating that the data did not violate the assumption of sphericity. A 2 x 3 repeated measures ANOVA then determined whether coherence detection thresholds differed between the non-alcohol and alcohol conditions across the varying standard speeds. Our analysis found that coherence detection thresholds significantly differed between the non-alcohol and alcohol condition across the varying levels of standard speed, $F(2, 24) = 4.46$, $p = 0.02$, $\eta^2 = 0.27$. Thus, an

interaction existed with respect to one's sensitivity to detect coherent motion at different speeds.

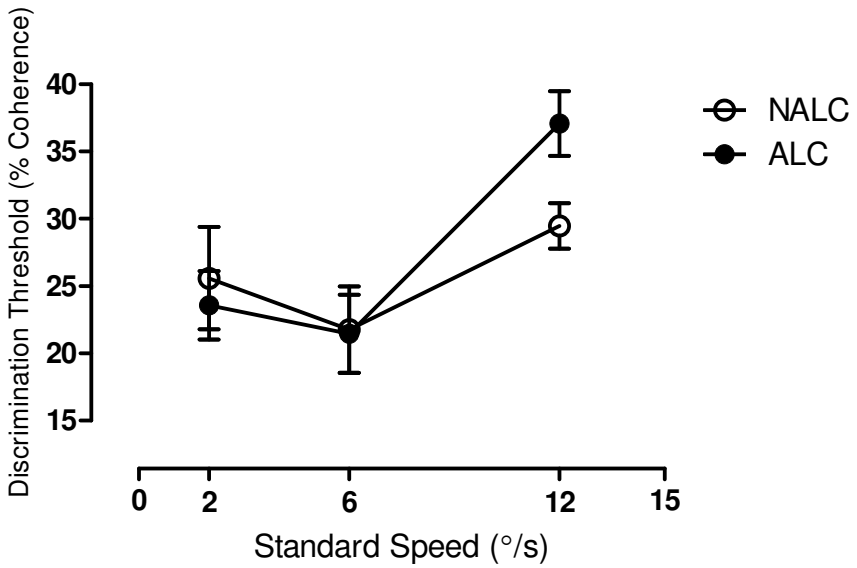

Figure 5. Mean coherence detection thresholds in the non-alcohol and alcohol condition. Error bars represent 1 SEM.

A series of planned comparisons tested for differences between the coherence detection thresholds in the non-alcohol and alcohol conditions for alike standard speeds. A dependent samples t-test indicated that coherence detection thresholds in the alcohol condition (M = 37.08, SD = 8.67) were significantly greater than the coherence detection thresholds in the non-alcohol condition (M = 29.47, SD = 6.10) for the fastest standard speed only, $t(12) = 3.13$, $p = 0.005$, $r^2 = 0.43$. Intoxicated observers could not detect coherent motion as well as sober observers. Thus, alcohol did not exert any influence on ability to detect coherent motion until the standard speed of motion reached relatively fasts levels.

5.3 Discussion

Discontinuous coherence detection has been commonly used to study high-level visual processing (Morgan & Ward, 1980; Newsome & Pare, 1988; Britten et al., 1992a; Burr et al., 1998; Santoro & Burr, 1999; Braddick et al., 2001; Burr & Thompson, 2011). Our last experiment examined whether sensitivity to coherent motion changed following alcohol consumption for varying standard speeds. We found that alcohol impaired coherence detection thresholds for fast speeds only. In both intoxication conditions, coherence thresholds tended to remain fairly low at slower standard speeds, but increased markedly when the standard speed increased to $12°s^{-1}$. In other words, sober and intoxicated observers could equally recognize differences in coherent motion until the speed of motion increased to a level where both groups of observers could no longer perceive the differences as proficiently. However, the observed decrement in sensitivity to differences in coherent motion at fast speeds was much greater for intoxicated observers. This suggests that alcohol exacerbates a general loss in the sensitivity to perceive coherent motion as relative speed increases.

Our findings from the performance of sober observers have been fairly consistent with past research investigating the sensory parameters to perceive coherent motion as a function of speed (Hiris & Blake, 1995; Snowden & Kavanagh, 2006). Using similar RDK displays for presenting coherent motion as in our experiment, Snowden and Kavanagh examined how motion coherence thresholds changed as a function of speed in young and older adults. They found that young healthy observers could detect motion coherence fairly consistently at slower speeds but that their ability began to degrade as relative speed increased. The difference in their mean coherence thresholds between $2°s^{-1}$

and $4°s^{-1}$ of 7% was nearly the same as the difference in the mean coherence thresholds that we found between $2°s^{-1}$ and $6°s^{-1}$, suggesting that Snowden and Kanavagh's young healthy observers could perceive differences in coherence as consistently as our sober observers for slower speeds, and similarly appeared to become less sensitive to the differences in coherence as relative speed increased.

With respect to alcohol, our findings were also consistent with those from a study similarly investigating the effects of alcohol on coherent motion detection. Weschke and Niedeggen (2012) measured coherence detection thresholds using similar RDK stimuli as in our experiment. The coherence detection task in their experiment, however, simultaneously presented both the standard stimulus and the comparison stimulus side-by-side for each trial. They reported no differences in the coherence threshold between sober observers and moderately intoxicated observers. Although their experiment only compared coherence detection thresholds for a single displacement rate, 0.03°/10ms (i.e., $3°s^{-1}$), this rate of motion was within the range of speeds examined in our study. Thus, we can be confident that alcohol has no distinguishable effect on an observer's sensitivity to coherent motion at slower speeds.

Psychophysical, physiological, and neuroimaging evidence has suggested that stroboscopic coherent motion perception results from a multi-stage processing of visual motion information (Ullman, 1979; Braddick, 1980; Williams & Sekuler, 1984; van den Berg & van de Grind, 1991; Stoner & Albright, 1992b; Qian & Andersen, 1994; Qian et al., 1994; Morrone et al., 1995; Burr & Santoro, 2001; Braddick et al., 2001; Suchow & Alvarez, 2011; Burr & Thompson, 2011). This multi-stage process involves the integration of many discontinuous local motion signals into a global motion signal that

produces the percept of coherent global motion. Whereas local motion signals are generated by the movements of the individual dots in a RDK, the global motion signal is generated from a correlational type of analysis that integrates all of the coherent local motion inputs (Lappin & Bell, 1976; van den Berg & van de Grind, 1991). Specific types of neurons in striate cortex and area MT have been associated with the processing that recognizes these local movements (i.e., local-motion detectors). Other types of neurons in area MT and area MST, commonly referred to as global-motion detectors or pattern-motion detectors, have been linked with the processing that achieves the global motion percept (Adelson & Bergen, 1985; Stoner & Albright, 1992b; Braddick et al., 2001). Our findings indicate that alcohol only interferes with this multi-stage processing when motion exceeds some critical speed. It is possible that alcohol selectively affects the different stages of coherent motion processing for different speeds.

Snowden (1990) first proposed the possible existence of two independent speed-tuned global-motion processors; one tuned to integrate local motion signals at slow speeds, and another tuned to integrate local motion signals at fast speeds. Edwards et al. (1998) have since supported such a notion. Through a series of motion coherence experiments, they measured coherence detection thresholds using a motion coherence detection task similar to our experiment. By introducing additional non-coherent noise dots that moved at a different speed than the standard into the RDKs, they were able to examine how coherent motion thresholds changed when non-coherent noise dots moving at relatively different speeds interfered with the extraction of global motion.

For slow standard speeds, Edwards et al. (1998) found that non-coherent noise dots only interfered with coherent motion detection when the speed of the non-coherent

noise dots were relatively close to the standard speed. For fast standard speeds, they found that the non-coherent dots interfered with coherent motion detection regardless of their speed. However, the interference was much more pronounced when their speeds were closer to the standard speed. The decrement in coherent motion detection thresholds had been said to occur because the non-coherent noise dots moving at speeds similar to the standard were drawing from the processing capacity of a similar processing system. The lack of a decrement in coherence detection thresholds when non-coherent noise dots moved at rather different speeds resulted from the non-coherent noise dots drawing from a separate processing system with a separate processing capacity. These results were taken as evidence of independent speed-tuned global-motion extraction processors. With respect to our findings, alcohol may selectively impair the global-motion extraction for higher speeds by reducing the limitations of spatiotemporal integration in the system.

Alternatively, alcohol may be affecting cognitive factors that contribute to perceiving motion coherence. The ability to perceive motion coherence and, subsequently, the ability to perceive changes in motion coherence have been shown to largely depend on attentional control (Burr et al., 2009). In a series of experiments Burr et al. presented eight separate patches of RDKs on a computer screen. In one experiment, some of the RDK patches contained coherent motion while the others contained non-coherent motion in randomized directions. Another experiment presented these RDK patches within a larger aperture that was filled with non-coherent motion in randomized directions. The direction of motion in the coherent patch(es) randomly alternated in the leftward or rightward direction on different trials. In both of these experiments, observers attempted to identify the direction of the coherent motion generated by the RDK

patch(es) in a cued condition and a non-cued condition. The cued condition prompted an observer to attend to the region(s) of the aperture that were to contain the patch(es) with the coherent motion. In the non-cued condition, observers attempted to identify the direction of coherent motion within patch(es) without any prompts. They found that sensitivity to coherent motion increased in all of the cued conditions. Because the cues directed attention to the appropriate regions on the screen that would contain coherent motion, they interpreted these results as coherent motion perception being largely mediated by attention.

We have previously mentioned that alcohol has been shown to impair attentional capacity in moderate-high doses (Wester et al., 2010). In Wester et al., participants performed a single- or a divided-attention task while in a driving simulation. They completed both of these tasks in a sober and in an intoxicated condition. Shifts in event-related potentials (ERPs) were recorded and interpreted as shifts in attention. Their results found that participants exhibited slower ERP-shifts when intoxicated for both the single- and divided-attention tasks; however, the deficits were more pronounced in the divided-attention task. The alcohol-induced delays in ERP-shifts indicated that participants could not allocate their attention as effectively as sober participants. The alcohol-induced deficits that we found in coherent motion detection for fast speeds may have resulted from such attentional impairments. Alcohol-induced reductions in attentional capacity may interfere with one's ability to control attention, leading to higher detection thresholds. Perhaps, the fast global-motion system relies more on attentional capacity than the slow global-motion processing system to perceive coherent motion.

As mentioned, discontinuous coherent motion is just one form of complex motion. Radial motion, expanding/contracting motion, and even illusory motion are other distinct forms of complex motion. It would be of interest to determine whether alcohol similarly demonstrated selective impairments in one's sensitivity to perceive these other forms of complex motion at fast speeds only.

Chapter 6

6 General Discussion

Alcohol consumption in Canada has continued to rise (Statistics Canada, 2014) over the past 10 years. We know much about how alcohol affects physiology and behavior. We know far less, however, about how it affects our sensitivity to perceive physical stimuli in the external world. I conducted a series of experiments to study the perceptual effects of alcohol on the visual system. Specifically, I focused on how one's sensitivity to perceive visual motion stimuli changed following alcohol consumption.

Motion is a multidimensional visual stimulus that can occur in a variety of forms. The perception of these different forms draws upon specialized high-level visual processing. I compared sober and intoxicated observers' visual sensitivity to several classes of motion. These included: minimum motion, simple motion, and complex motion. First, it was found that alcohol impaired the measures of sensitivity for detecting minimum motion; however, these differences may be attributed largely to alcohol's interference with top-down cognitive factors involved in detecting minimum motion rather than bottom-up sensory factors. Second, sensitivity to discriminate and detect different forms of simple motion (e.g., speed/acceleration), was not altered by alcohol intoxication. The primary motion processing areas appeared to be capable of compensating for alcohol's generalized suppression of neural activity to allow the accurate perception of speed and acceleration. Finally, alcohol was found to impair sensitivity for coherent motion detection for fast speeds only. These increased thresholds could have resulted from a loss in sensitivity from a selective influence of alcohol on a

speed-tuned global-motion extraction system for fast motion, and/or a loss in attentional control from a reduction in attentional capacity. It would be of interest to see whether alcohol influences the perception of other forms of complex motion as a function of speed, such as radial motion or expansion/contraction motion.

Comparing the results from all experiments, it appears that alcohol does not alter the visual perception of all kinds of motion stimuli. The effects observed in our experiments seemed to result from the nature of the tasks' difficulty. In order to make accurate judgments of the visual stimuli, the minimum motion detection task and the complex motion detection task required observers to make a conscious decision about the visual stimuli when completing the tasks. On the other hand, the simple motion detection tasks could be accurately performed from rather simple judgments of the stimuli. Thus, it was concluded that the observed deficits in perceptual thresholds were not from alcohol-induced impairments in sensory processing but more from an interruption in the cognitive elements that were required to complete the minimum motion detection and complex motion detection tasks.

To perceive continuous or discontinuous forms of motion the visual system must resolve at least one of two issues in motion processing, the aperture problem (Marr & Ullman, 1981) and the correspondence problem (Julesz, 1971; Ullman, 1979). When perceiving continuous motion forms, an issue arises with evaluating the direction of a stimulus when the stimulus' size exceeds the size of a motion-sensitive neuron's receptive field, the aperture problem. In such instances, motion processes must determine the direction of motion without cues from a stimulus' form features such as its edges. When perceiving discontinuous forms of motion, the problem arises when a spatial gap

exists between stimulus' initial position and its subsequently displaced position, the correspondence problem. Here motion processes must correlate each dot's initial position with its displaced position. The complications in this issue become rather apparent when observing multiple dots moving in this discontinuous form, as in the RDKs of coherent motion in the current study.

Several lines of evidence exist to indicate that the aperture problem and the correspondence problem are resolved in the primary motion processing areas (Britten et al., 1992b; Celebrini & Newsome, 1994; Pack & Born, 2001). Perceptual sensitivity to minimum motion detection and simple motion detection relies on an effective resolution of the aperture problem whereas sensitivity to coherent motion detection relies on an effective resolution of the correspondence problem. Our results suggest that alcohol for the most part does not impede the motion processing system's ability to resolve either of these issues locally or globally.

The select and modest influences of alcohol on vision perception that have been observed for low-level visual processes did not appear to become exacerbated in the high-level visual processing required to perceive different forms of motion. As in low-level visual sensory processing, the effects of alcohol on the high-level visual processing in motion perception were found to be selective and mild. These results are consistent with the findings that alcohol only has relatively small effects on basic visual processes. Given the widely acknowledged impairments in visual perception following the consumption of moderate-high doses of alcohol, further investigation is warranted. In light of our findings, a number of alternative possibilities may help to explain such reports of impaired vision.

First, an exacerbation of the mild effects of alcohol in vision perception may not become apparent until even higher-levels of visual processing that occur further along the dorsal visual pathway become engaged. Processing that occurs further along the dorsal visual pathway, beyond MST, begins to integrate information across multiple sensory systems, particularly visuomotor processing (Milner & Goodale, 2006). This higher-ordered multisensory processing requires an even greater reliance on top-down cognitive elements for perception than does motion perception. Thus, we may find that alcohol imposes much of its influence on perception in such higher-ordered multisensory processing.

Alternatively, the reported deficits in vision perception following moderate-high doses of alcohol may results from a selective impairment in the processing of one visual pathway over another. It is well known that the visual system is divided into two distinct functional pathways, one that extends ventrally from the striate cortex and another that extends dorsally from the striate cortex (Ungerleider & Mishkin, 1982; Milner & Goodale, 2006). Originally proposed as the 'what' pathway (i.e., the ventral stream) and the 'where' pathway (i.e., the dorsal stream), these two streams have become known as the 'what' and 'how' pathways, respectively. The 'how' visual pathway largely processes visual information for motion and visuomotor perception whereas the 'what' pathway processes visual information for form perception. Alcohol may have different effects on vision perception that occurs in the 'how' pathway versus the 'what' pathway.

We have previously mentioned that the primary motion processing areas responsible for motion perception are located within the dorsal visual pathway. So far, alcohol has yet to been shown to substantially disrupt perception that results from

processing in the ‘how’ dorsal stream. However, Goodale (2011) discusses a number of experiments that would allow for a future studies to determine whether alcohol differentially affects the perception that results from the processing in the different pathways. For example, the Ebbinghaus size-contrast illusion (Haffenden & Goodale, 1998), the rod and frame illusion (Dyde & Milner, 2002), and the horizontal-vertical illusion (Servos et al., 2000) have been used as a means of differentially engaging the different pathways. These illusions offer models for examining possible differential effects of alcohol on the perceptions that result from the processing in the different visual pathways. Such future investigations could perhaps help to explain the selective nature of alcohol’s influences on vision perception.

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Appendices

Appendix A: Letter of Information

Department of Psychology

Effects of Alcohol on Human Motion Perception

Letter of Information

Research Investigators:

Steven Matson Department of Psychology, UWO

Dr. Brian Timney Department of Psychology, UWO

I. Invitation to Participate

You are invited to participate in a study conducting a series of experiments on the way in which raised Blood Alcohol Concentration (BAC) can influence performance on a variety of visual tasks. Although there is a great deal known about the physiological effects of alcohol and the way it affects motor and cognitive skills, there is much less information about how it affects the more basic aspects of sensory function, including visual sensitivity.

II. Purpose of Letter

If you qualify and are willing to participate in this study we will ask you to consume beverages containing a quantity of alcohol sufficient to raise your BAC to approximately 80 mg/ 100 ml, the former maximum legal driving limit in Ontario. You will then be asked to detect and respond to visual patterns presented on a computer screen. At the end of each testing session you will be asked to take breathalyzer tests until you are no longer considered alcohol impaired. The breathalyzer test will require you to continually blow into a plastic tube for a short period of time.

III. Possible Risks and Harm

The beverages may cause intoxication, drunkenness, dizziness, stomach upset, tiredness and/or headaches. You may also experience physical and/or mental impairments for up to 4 to 5 hours after you have consumed the alcohol beverages. In order to protect you, a trained professional will be in attendance at all times and you will not be allowed to leave the study site until you have a breathalyzer reading of less than 30 mg/100 ml **AND** show no obvious signs of impairment. The attendant, experienced in the objective assessment of impairment states, will be required to document that you are not impaired before you will be permitted to depart from the study area. If necessary, you will be physically restrained to prevent your leaving prior to meeting the above

conditions. IT IS STRONGLY RECOMMENDED THAT YOU NOT DRIVE A VEHICLE OR OPERATE HEAVY OR DANGEROUS MACHINERY FOR A PERIOD OF 12 HOURS AFTER YOU HAVE BEEN RELEASED FROM THE STUDY SITE. At the end of the study you will be provided with taxi fare for transportation home, if necessary.

IV. Exclusion Criteria

Please Read the Following Statements:

1. I often have difficulty controlling the amount I drink at one time.

2. I have received medical treatment for alcohol related problems.

3. There is a history of alcoholism within my family.

4. I suffer from diabetes.

5. I have not been in good health for the past several months.

6. I am pregnant, or there is a possibility that I might be pregnant.

7. I am currently consuming prescription or other medications.

If you feel that any of these statements could apply to you or if you do not wish to consume alcohol in a laboratory setting you should refuse to participate in this study at this point in time.

V. Purpose & Procedure

The purpose of this experiment is to explore the effects of increased blood alcohol level on a person's visual sensitivity. If you agree to participate you will be asked to attend four testing sessions. The study involves the following:

1. Before the first session we will ask you to fill out a short questionnaire about your alcohol drinking habits in order to determine if you are eligible to participate. This should take five to ten minutes to complete. At this time, arrangements for your transportation home on the day of testing will be made. We would like to test individuals who are in good health, who consider themselves to be "moderate drinkers", have no history of alcohol abuse, and have no condition that may be adversely affected by alcohol.

2. The testing sessions will be identical except that in half of the sessions the beverages you will be asked to consume before taking the tests will contain a quantity of alcohol. The amount of alcohol will be sufficient to raise your BAC to approximately 80 mg/100 ml (the former maximum legal driving limit). This volume will be calculated on the basis of your age, gender, height and weight. We will measure your Breathalyzed Alcohol Concentration (BrAC) several times throughout the course of the experiment using a standard breathalyzer device to

infer your BAC. You should refrain from consuming alcohol in the 12-hour period prior to attending a testing session, and should consume a low-fat meal two hours before the session. If you feel sick or excessively drunk in one session you will not be permitted to participate in any remaining sessions involving the consumption of alcohol. The Student Emergency Response Team (SERT) will be contacted in the event that a participant becomes unwell during the sessions.

3. We will be measuring your ability to detect visual patterns. Each session will be run under computer control and should take about 2-3 hours to complete.

4. After you have completed all of the testing we will ask you to remain in the laboratory under the supervision of the experimenter until your BrAC has fallen below 30 mg/100 ml. This may take approximately two hours. You will be provided with compensation for transportation to and/or from the testing facility, if necessary.

5. At the end of the experiment you will receive a written feedback sheet, and have a chance to ask questions.

6. All the information collected in this experiment will be kept confidential and will be identified by assigning participants a coded ID. Personal identifiers of participants will NEVER be held with the corresponding data at any point. If the results of this study are published, your name will not be used and information disclosing your identity will not be released or published without your specific consent.

7. You will be provided with a copy of this letter once it has been signed. **Participation in this study is voluntary and you may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect on your employment status, academic status, or personal status. However, if you have consumed any of the alcohol YOU WILL NOT BE ALLOWED TO LEAVE THE STUDY SITE UNTIL YOU HAVE A BREATHALYZER READING OF LESS THAN 30 MG/100 ML AND SHOW NO OBVIOUS SIGNS OF IMPAIRMENT. IF NECESSARY, YOU WILL BE PHYSICALLY RESTRAINED TO PREVENT YOU FROM LEAVING PRIOR TO MEETING THE ABOVE CONDITIONS. IN THE EVENT YOU BECOME PHYSICALLY OR VERBALLY ABUSIVE, CAMPUS POLICE OR THE LONDON POLICE MAY BE CALLED TO INTERVENE.**

VI. Conditions of Participation

To participate in this study you must acknowledge and agree to the following conditions:

- YOU MAY NOT LEAVE THE TEST FACILITY UNTIL YOU HAVE A BREATHALYZER READING OF LESS THAN 30MG/100ML AND SHOW NO OBVIOUS SIGNS OF IMPAIRMENT.

- YOU COULD BE PHYSICALLY RESTRAINED TO PREVENT YOUR LEAVING PRIOR TO MEETING THE ABOVE CONDITIONS.

- YOU WILL NOT WITHDRAW YOUR CONSENT TO THE STUDY CONDITIONS FOR A PERIOD OF AT LEAST 24 HOURS AFTER STARTING THE STUDY PROCEDURES (IE. CONSUME ALCOHOL).

- YOUR ATTENDANCE ON CAMPUS FOR THE PURPOSE OF PARTICIPATING IN THIS STUDY IS CONDITIONAL UPON YOU AGREEING TO ALL THE CONDITIONS EXPLAINED IN THIS LETTER AND IF YOU IGNORE THESE CONDITIONS YOU WOULD BE CONSIDERED A TRESPASSER AND CAMPUS POLICE AND/OR LONDON POLICE MAY BE CALLED TO INTERVENE.

- YOU ARE UNDER NO IMPAIRMENT IN MAKING THESE ACKNOWLEDGEMENTS.

VII. Compensation

For your participation in this study you will be compensated $20.00 for each completed testing session. If you do not complete the entire study you will be able to keep the compensation that you received from previous sessions. You will also be provided with taxi fare for transportation to and/or from the testing facility for each session, if necessary.

VIII. Contacts for Further Information

Additional information regarding these studies may be obtained from the experimenters, Steven Matson or Dr. Brian Timney.

If you have any questions about the conduct of this study or your rights as a research subject you may contact the Office of Research Ethics, The University of Western Ontario.

Participant Initials: _____

Appendix B: Informed Consent Form

Department of Psychology

Effects of Alcohol on Human Motion Perception

Informed Consent Form/Declaration

Research Investigators:

Steven Matson Department of Psychology, UWO

Dr. Brian Timney Department of Psychology, UWO

I have read the letter of information and have had the nature of the study explained to me. I meet all inclusion and exclusion criteria. I acknowledge and agree to adhere to the Conditions of Participation outlined in the letter of information (see Section VI.) All my questions have been answered to my satisfaction. I agree to participate and am under no impairment in making this informed consent.

_____ _____

Signature of Research Participant Print Name

_____

Date

_____ _____

Signature of Person Obtaining Consent Print Name

_____

Date

Appendix C: Alcohol Use and Frequency Questionnaire w/ Scoring Key

Alcohol Use and Frequency Questionnaire

ID: _____

Normal or Corrected to Normal Vision (circle one): YES NO

Year of Birth: _____ Height: _____ Weight: _____

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.

1. 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

1b. When you drink beer, how many 12 oz. beers (or equivalent), on average do you usually drink?

I usually drink _____ beers.

2. 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

2b. When you drink wine, how many 5 oz. glasses (or equivalent), on average do you drink?

I usually drink _____ glasses of wine

3. 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

3b. 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.

4. 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

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

_____ number of drinks

6. 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

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

1. yes
2. no

8. 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.

Alcohol Use and Frequency Questionnaire Scoring Key

Each participant's response to Item 4, the average of the selected numerical range, was multiplied by the numerical response to Item 5. A participant was discharged from the study if the product value of their responses to Item 4 and Item 5 was greater than 17.5.

Appendix D: Sobriety Sign-off Sheet

Effect of Alcohol on Human Motion Perception

Sobriety Sign-off Sheet

I _____, hereby certify that experimental participant _____ obtained a BrAC reading of less than 30 mg/100 ml AND demonstrated no obvious signs of impairment prior to their release from the laboratory.

_____ _____

Signature of Experimenter Print Name

_____

Date

I hereby acknowledge that I have obtained a BrAC reading of less than 30 mg/100 ml AND showed no obvious signs of impairment prior to being released from the laboratory.

I am under no impairment in making this statement.

_____ _____

Signature of Research Participant Print Name

_____

Date

Appendix E: Debriefing Form

Western SocialScience

Department of Psychology

Effects of Alcohol on Human Motion Perception
Debriefing Form

Research Investigators:
Steven Matson Department of Psychology, UWO

Dr. Brian Timney Department of Psychology, UWO

The purpose of the current study is to determine how alcohol affects the neural mechanisms involved in the ability to perceive various types of motion. In this study, you were asked to detect minimum motion, acceleration, and coherence at various starting velocities by indicating which of two presentations contained the specific motion type in simple visual detection tasks. Performance was measured in two conditions, one with alcohol and one with no alcohol.

The effects of alcohol on visual performance have produced mixed results in the past, but it has been shown that alcohol can have a large effect on vision, causing reliable deficits in visual processing (Pearson & Timney, 1998). Previous research has demonstrated that alcohol in low doses significantly lengthens reaction time to the perception of visual movement (MacArthur & Sekuler, 1982). Research has also demonstrated that impairment by alcohol-induced consumption is greater for dynamic, moving tasks compared to static, stationary tasks (Andre et al., 1994). Many vehicle accidents (road and water) are a result of alcohol consumption, but we do not have a full understanding of all the ways in which alcohol-induced impairments can affect the perception of the array of motion that is involved in visual-motor activities such as driving.

Given this information, we predict that alcohol will reduce the ability to accurately detect motion that requires neural inhibitory mechanisms, such as suppression. We also predict that alcohol will show significantly greater impairments in the perception of global and complex forms of motion (e.g. coherent motion) than in simple forms of motion (e.g. minimum motion) because of a larger recruitment of neural-inhibitory mechanisms involved in the processing of global and complex forms of motion.

Due to the high number of driving accidents and deaths caused by alcohol consumption, a detailed knowledge of how alcohol affects motion perception is crucial. The current study attempts to further this knowledge by describing the effects of alcohol

on the perception of the different forms of motion, and by providing a comprehensive understanding how alcohol affects perception across various motion types of differing processing complexities.

Thank you for your time as your responses and participation are much appreciated. Without your involvement, it would not be possible to conduct this research. All the information collected in this experiment will be kept private and confidential, and will be identified by coded participant IDs only.

If you have any further questions regarding this study, please contact Steven Matson, or Dr. Brian Timney.

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Curriculum Vitae

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