ALCOHOL EFFECTS ON VISUAL ATTENTION:

THE IMPACT OF INFORMATION PROCESSING

by

Judith Leslie Carscadden

A thesis
presented to the University of Waterloo
in fulfilment of the
thesis requirement for the degree of
Doctor of Philosophy
in
Psychology

Waterloo, Ontario, Canada, 2001

The University of Waterloo requires the signatures of all persons using or photocopying this thesis. Please sign below, and give address and date.

ABSTRACT

This research examined the effect of a moderate dose of alcohol on covert orienting of visual attention to test the prediction that greater information processing requirements of the orienting cue would result in greater impairment of the reaction time (RT) to a target stimulus under alcohol. Thirty-six male social drinkers who were randomly assigned to either an alcohol (0.62 g/kg) or placebo group performed three tasks: 1) exogenous orienting, where a peripheral spatial cue reflexively draws attention to a predicted target location; 2) endogenous orienting, with a central numerical cue; 3) endogenous orienting, with the central cue requiring arithmetic to predict the target location. Valid, and invalid (i.e., incorrect) cues, and trials where no cue was presented occurred on a test of each task. The different information processing demands of the tasks were reflected by shorter RT on the exogenous task and longest RT on the endogenous arithmetic task. The groups performed the three tasks once before, and twice after placebo or alcohol. In accordance with the hypothesis, alcohol impaired (lengthened) RT on the two endogenous tasks, and did not affect the reflexive exogenous task ($p>0.05$). Results showed alcohol selectively impaired RT to valid trials on the endogenous tasks ($p<0.001$) and the intensity of impairment on the two tasks did not differ ($p=0.917$). The findings suggested that the amount of information processing involved in the tasks may be less important in determining the intensity of alcohol impairment than the mode of processing (reflexive vs controlled), or other functions, such as spatial working memory. Potential practical implications of the findings for accident prevention were discussed.

ACKNOWLEDGMENTS

I would like to say a heartfelt thank you to my advisor, Dr. Muriel Vogel-Sprott. Her support and guidance throughout the various stages of this dissertation were greatly appreciated and were invaluable to the quality of this research. I feel privileged to have had the benefit of her considerable expertise in the area of alcohol research and have greatly appreciated her flexibility and willingness to be available for consultation during this dissertation, even when distance made communication a challenge. Her dedication to her research and her students is an inspiration.

I would also like to express my appreciation to my dissertation committee members Dr. Gary Griffin and Dr. Jennifer Stolz for their thoughtful scholarly advice during the preparation of this thesis, and to my external examiner Dr. Sara Jo Nixon, and my internal/external examiner Dr. Judy Wubnig for their valuable comments at the oral examination.

Drs. Barbara Bulman-Fleming, Mike Dixon and Mark Fillmore were very helpful during the early stages of this research and provided welcome expertise and constructive criticism.

My lab colleagues Karen Grattan, Jennifer Fogarty, and Lisa Mulvihill all provided advice and support over the years that was much appreciated.

I would also like to thank Dan Smilek and Bill Eickmeier for their computer assistance at various stages of the thesis, getting me "unstuck" when I ran into troubles.

Lastly, I would like to gratefully acknowledge my husband Curtiss, my two families, and my university and non-university friends for their enduring support, which gave me the confidence to undertake and complete this endeavour.

DEDICATION

To Curtiss, my soulmate,

Your endless love, patience, understanding and encouragement have made it possible for me to get to this point. This thesis is dedicated to you.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Alcohol is one of the most widely used drugs by humans. Its documented use dates back more than 10000 years when mead, a type of beer made from fermented honey, was a common social drink (Ray, 1983). Given its usage in virtually every human culture, it may seem strange that the consumption of alcohol is linked to numerous societal and personal problems ranging from alcohol dependence to serious accidents and injuries (e.g. Bushman & Cooper, 1990; NIAAA 1997). Alcohol use in the work environment creates problems affecting public safety, as well as productivity. In the United States, productivity losses due to alcohol were estimated to be $119 billion for 1995 (NIAAA, 1999) and alcohol was a factor in 40% of industrial accidents leading to death in the UK (Koelega, 1995). Recreational use of alcohol has been linked to injuries resulting in visits to a hospital emergency room (e.g. Cherpitel, 1999, 1994; Stephens, 1987). In addition, alcohol-related trauma is the fourth leading cause of death in developed countries (Cherpitel, 1992). Numerous studies have found a strong association between alcohol consumption and personal injury, drowning, falls, fires, burns, and pedestrian and motor vehicle accidents (e.g. Borges, Cherpitel & Rosovsky,1998; Cherpitel, 1992,1996).

While humans have been using various modes of transportation for millennia, it is unlikely that alcohol had the same impact on the chariot-driving of Rome and the camel-driving of Egypt as it has had on the task of driving the automobile. Forty percent of all traffic fatalities in the United States between 1979 and 1991 were alcohol-related (NIAAA, 1994) and it is known that the risk of a motor vehicle accident increases as blood alcohol concentration (BAC) increases (e.g. Donelson & Bierness, 1985). The risk of a single-vehicle

fatal crash for drivers is estimated to be 11.1 times higher for drivers with blood alcohol concentrations (BACs) between 50 and 90 mg/100ml, 48 times higher for drivers with BACs between 100 and 140 mg/100ml, and 380 times higher for those with BACs at or above 150 mg/100ml (Zador, 1991).

Failures of attention are one of the most frequently cited errors leading to driving accidents while sober (Hakkinen, 1976) and under alcohol (Moskowitz, 1984) and have been implicated as one of the primary reasons why alcohol consumption increases the probability of having a motor-vehicle accident (Moskowitz, 1984). Efforts to investigate this possibility have used driving simulators and other complex attention tasks, such as divided and sustained attention. However the findings on the effects of alcohol have not been consistent. This is possibly due to differences among the various tasks in their stimulus and response requirements as well as the cognitive processes involved. In order to gain a better understanding of the effects of alcohol on attention, this thesis used a task developed in cognitive science to assess one particular aspect of attention, covert visual orienting.

Background

Pharmacology of Alcohol

Alcohol (also known as ethanol) is classified as a sedative/hypnotic drug. It is a small molecule that dissolves in both fat and water and is widely distributed inside and outside cells throughout the body. It crosses the blood-brain barrier and the placental barrier without difficulty (McKim, 1996). Over 90 percent of alcohol consumed is metabolized in the liver and it is eliminated from the body at a constant rate (McKim, 1996). Unlike other depressant drugs, alcohol has no known receptor site (Hunt, 1993).

Neuropharmacological investigations have examined the action of alcohol on cell membranes. In vitro studies have shown that alcohol affects membranes surrounding cells. Membranes are composed mainly of lipids and proteins and the molecules within the cell membranes have some mobility. Alcohol has been found to disorder or "fluidize" membranes, which allows the molecules imbedded in them to be more mobile and the membranes to become more permeable (e.g. Feldman, Meyer, Quenzer, 1997; Hunt, 1993; Rall., 1991). However, lower doses, more akin to those consumed by humans, show little effect on the fluidity of membrane lipids (Dildy-Mayfield & Harris, 1995; Eckardt et al., 1998). Some authors now suggest that the primary effect of alcohol in the membranes is on membrane-bound protein complexes. Alcohol may disrupt the function of several voltage-gated ion channels, which respond to changes in electrical potential across the membrane, such as calcium, sodium and potassium (Dildy-Mayfield & Harris, 1995; Feldman, Meyer & Quenzer, 1997). Alcohol also may disrupt receptor-mediated ion channels, which allow a neurotransmitter to directly interact with its receptor (Hunt, 1993). In particular, alcohol appears to facilitate the binding of gamma aminobutyric acid (GABA), a major inhibitory transmitter in the brain, to its receptor site (Eckardt et al., 1998; Hunt, 1993; NIAAA, 1993), and inhibit the receptor function of glutamate (a major excitatory neurotransmitter) at several sites, including the N-methyl-D-aspartate acid (NMDA) receptor subtype (Dildy-Mayfield & Harris, 1995; Hunt, 1993; NIAAA, 1993).

Alcohol may also affect cellular functions indirectly, by increasing the production of the second messenger cyclic adenosine mono phosphate (cAMP) in brain tissue. Second messengers initiate a series of chemical reactions that ultimately alter the sensitivity of ion

channels (Hunt, 1993). Greater cAMP may increase the efficient translation of signals from neurotransmitters, such as dopamine, noradrenaline and adenosine, into a physiological response (Dildy-Mayfield & Harris, 1995; Feldman, Meyer & Quenzer, 1997; Hunt, 1993). The presence of alcohol also appears to interact with the endogenous opioid system to increase dopamine activity. In addition, alcohol is thought to stimulate the function of the 5-hydroxytryptamine-3 (5-HT3) serotonin receptor.

To date, only a few studies have used neuroimaging techniques to examine the effect of an acute dose of alcohol on brain activity in vivo, and the evidence is conflicting. For example, one study examined regional cerebral blood flow (rCBF) in social drinkers under a moderate dose of alcohol using positron emission tomography (PET), and found that rCBF decreased. Although these findings led to the conclusion that alcohol produces a general decrease in neuronal activity (de Wit, Metz, Wagner & Cooper, 1990), this was challenged by another study showing that rCBF increased in social drinkers under a moderate dose of alcohol (Schwartz et al., 1993).

In summary, research in neuropharmacology has greatly aided our understanding of changes in cellular functions in the presence of alcohol. These findings have also provided a basis for speculations about the behavioural effects of the drug. For example, alterations in the activity of GABA and glutamate may contribute to the sedative and stimulant effects of alcohol, respectively, and may alter memory formation and learning. Increases in dopamine and serotonin have been linked with the reinforcing effects of addictive drugs and the indirect link between alcohol and these transmitters suggests an explanation for the addictive use of alcohol (Eckardt et al., 1998; McKim, 1996; NIAAA, 1993). However, in spite of advances in

understanding the action of alcohol at the cellular level, reviews of this work show that these findings do not necessarily predict the effect of alcohol on intact functioning organisms. Convincing evidence for a specific causal relationship between these neurophysiological changes and particular behavioural responses to alcohol consumption is lacking (Hunt, 1993). As a result, a great deal of research has been conducted to directly examine the behavioural effect of alcohol.

Behavioural Effects

Concern over alcohol-related accidents has led to many experiments examining the effect of alcohol on tasks that resemble those that drinkers might perform under alcohol. Studies using driving simulators or examining actual driving ability on a closed course are examples. Some experiments indicate that impairment begins at 48mg/100ml BAC, and is shown by prolonged time needed to perform various manoeuvres and increased driving errors (e.g. Bjerver & Goldberg, 1950; Linnoila et al., 1986). However, impairment on driving simulation tasks is not consistently observed at these moderate BACs (e.g. Mitchell, 1985; Moskowitz & Burns, 1981).

The effects of alcohol on flying performance have also been widely investigated using flight simulators that involve all of the skills required in real flight (Asknes, 1954; Billings et al., 1991; Morrow et al., 1991, 1993). These studies have consistently found that performance was significantly impaired beginning at a BAC of 50 mg/100ml. Some experiments also have reported continued impairment on these complex flying tasks even after a peak blood alcohol concentration of 100 mg/100ml had returned to zero, up to 14 hours after drinking (e.g. Morrow et al., 1990; Yesavage & Leirer, 1986). However, this carry-over effect is not

consistently observed (e.g. Collins & Chiles, 1980).

Moskowitz & Burns (1981) have suggested that variability in the effects of alcohol on the performance of driving and flying simulation tasks may be due to differences in the particular combination of components in the tasks. Simulated driving and flying tasks are necessarily extremely complex because they model real life activity. Automobile driving involves many tasks and continually changing task demands. In order to safely drive a vehicle, one must be able to maintain an alert state, make decisions based on frequently changing environmental information, and execute manoeuvres based on these decisions (NIAAA, 1996) A similar complex combination of skills are also involved in flying. Unfortunately, the numerous motor and cognitive skills involved in driving and flying tasks make it very difficult to determine how alcohol affects the component motor and cognitive processes required to perform them well. For this reason, other researchers have examined the effect of alcohol on these components using laboratory tasks that may tap more specific abilities

Cognitive and Motor Skill Tasks

The effect of alcohol on the time to react to a stimulus (simple reaction time) has been measured in numerous studies. Some authors have found that impairment (slowing) of simple RT only appeared under a high dose of alcohol (e.g. 1.0 g/kg) (e.g. Lemon et al., 1993). However, others have found that only a few individuals are impaired on a simple RT task under an even higher dose (e.g. 1.2g/kg), and others maintain their sober level of RT (e.g. Linnoila et al., 1978).

In order to prevent anticipatory responses during reaction time tasks, many studies have used choice RT tasks. These tasks require a participant to press an assigned key only

when a particular target appears. At least two different targets are included with a corresponding response key assigned to each. Thus, participants must wait until they identify the target before making a response. Many studies show choice RT is impaired (lengthened) under alcohol when BAC reaches or exceeds 90 mg/100ml (e.g. Chiles & Jennings, 1970; Hindmarch et al., 1991). This has led some to conclude that choice RT is more sensitive to impairment than is simple RT (Mitchell, 1985). However, research on choice RT at lower moderate BACs yields inconsistent results. Some studies detect impairment and others do not (Kerr & Hindmarch, 1998; Mitchell, 1985).

Other researchers have opted to investigate the effect of alcohol on lab motor skill tasks, such as pursuit rotor and other motor tracking tasks. These tasks are simpler than simulated driving and flying tasks. While they depend on motor dexterity, they also are likely to require mental processes such as attention and information processing. Although the performance of such motor skill tasks are usually impaired (lengthened) by moderate doses of alcohol, these tasks likely involve both motor and cognitive components. Thus it is not clear what or which aspects are impaired. Reviews of this research have argued that cognitive processes are more impaired than motor processes (Mitchell, 1985). Thus, there has been considerable research on cognitive tasks. However, such cognitive tasks are also complex and may depend upon a number of cognitive processes, such as concentration, attention, and information processing. Thus, the particular different combinations of processes involved in these various tasks may account for the inconsistent results. Although sufficiently high doses of alcohol can impair the performance of any cognitive task, the question of what particular cognitive processes are affected at moderate BACs (less than 100 mg/100ml) remains

unanswered. Some research has attempted to address this question by investigating the effect of alcohol on one particular cognitive process, attention.

Attention

Although failures of attention are one of the most frequently cited errors implicated in accidents, findings from epidemiological studies showing that the probability of car accidents increased at low BACs were initially attributed to perceptual failure under alcohol. However, studies examining the effects of alcohol on simple sensory functions such as visual acuity, glare recovery, and peripheral vision showed no impairment except at very high blood alcohol concentrations (e.g. Moskowitz, 1984). Thus, it appeared that alcohol was likely impairing central information processing functions involved in attention rather than sensory functions (Moskowitz, 1984). Considerable research examining the effects of alcohol on attention has primarily used two types of tasks; sustained attention (vigilance) and divided attention.

Vigilance tasks are commonly defined as tasks requiring sustained detection of, and responding to specific changes in the stimulus situation that occur rarely and unpredictably (e.g. Koelega, 1995). These are usually tedious, repetitive tasks that require alertness and attention, which are essential components in industrial work, flying and driving (Moskowitz, 1984). The effect of alcohol on vigilance tasks seems partly related to the dose. Linnoila et al. (1978) found that the onset of impairment on a vigilance task was detected at BACs of approximately 70 mg/100ml, and thereafter increased as BAC increased. Others also have reported that impairment was detected only under a high dose of alcohol (e.g. Erwin et al., 1978; Gustafson, 1986; Rorbaugh et al., 1988). However, there are many exceptions to this finding. Some studies show impairment in vigilance tasks at lower BACs (e.g. Talland, 1966)

but other experiments detect no impairment at higher BACs (e.g. Foo & Lemon, 1997). Koelega (1995) has suggested that some of the inconsistent effects of alcohol here may be due to the wide variety of vigilance tasks used in experiments. Differences in the duration of the tasks, the complexity of the stimuli and/or response required may also affect performance under alcohol. In addition, given the large variability in task characteristics, it is possible that vigilance tasks are not even measuring the same aspects of attention. Overall, the many different types of vigilance tasks, and the inconsistency in the findings, make it difficult to reach any solid conclusions about the effects of a moderate dose of alcohol on sustained attention.

A divided-attention task requires the performance of two or more subtasks simultaneously, that are sufficiently demanding so that performance on either one or both of the subtasks is at a lower level than when the subtasks were performed by themselves (Moskowitz, 1984). It has been suggested that divided attention tasks overload the capacity of the person to decode and respond to all relevant information. This situation may also occur when the stimuli in a single task present more information than can be fully processed (Moskowitz, 1984).

In their landmark study, Moskowitz and Sharma (1974) examined the effects of a moderate dose of alcohol (peak BAC of 90mg/100ml) on a divided-attention task involving the detection of an unpredictable peripheral light (a vigilance task), and simultaneous counting of the blinking of a central stimulus. The authors found alcohol did not impair vigilance (peripheral light detection) in the absence of the second task (when the central light did not blink and there was no requirement for central visual information processing). However, under

the dual task (when participants were also required to process the information from the blinking light in central vision), detection of the peripheral light significantly decreased and errors in counting the blinking control light increased. The authors concluded that the performance deficit under moderate BACs only occurs under conditions involving the division of attention. Other authors have similarly found impairment on both tasks under alcohol during divided attention conditions, and no impairment on single task vigilance performance (e.g. Millar, Finnigan & Hammersley, 1999). Moskowitz (1984) theorized that the impairment under a particular dose of alcohol intensifies as the demand on central visual information processing is increased.

Divided attention paradigms sometimes show alcohol only impairs the performance of one of the tasks. Even though many studies have found impairment on one or both tasks in a divided attention paradigm, some studies have not found significant impairment under divided attention conditions even when fairly high doses of alcohol were used (e.g. Marks & MacAvoy, 1989). Thus, even these fairly consistent findings of impairment of divided attention under alcohol are questioned. Once again, the varied nature of the tasks appears to contribute to the inconsistency of the results (Koelega, 1995).

Several authors have proposed that many conclusions about the effect of alcohol seem to be based on interactions between alcohol and task complexity (e.g. Kerr & Hindmarch, 1998; Maylor et al., 1990; Maylor & Rabbitt, 1993). However, the term "complexity" has been used to refer to many different characteristics of a task, including response complexity, degree of reasoning or information processing required to perform a task, the discriminability of task stimuli, and the amount of memory required for task performance. Instead of

attempting to breakdown the complex characteristics of a task, Maylor and Rabbitt (1993) have argued for a global central interpretation and proposed that the impairing effect of alcohol on the performance of a particular task is determined by the amount of information processing required, as measured by the length of time it takes to make a response (e.g. RT).

While some inconsistencies in the effect of alcohol on sustained and divided attention may stem from the use of tasks that vary in complexity, some methodological difficulties and differences among alcohol studies also could contribute to the problem. For example, some studies using a placebo to control for the expectation of alcohol test the same person under both conditions. However this procedure may allow the drinker to distinguish between the alcohol and placebo treatments, and many studies do not report whether the placebo was a successful control for the expectation of receiving alcohol (e.g. Maylor et al., 1990; Newman et al., 1997). In addition, many investigations do not consider individual differences in drug-free levels of performance when analyzing the data obtained under alcohol (e.g. Lemon et al., 1993; Rorbaugh et al., 1988). Different doses of alcohol are administered in different studies (e.g. Lamb & Robertson, 1987; Chiles & Jennings, 1970) and some experiments do not report the BACs (e.g. Smith, Kendrick & Maben, 1992). Some researchers test performance while BAC is rising (e.g. Maylor et al., 1992), and others test when BAC is declining (e.g. Linnoila et al., 1978). This one procedural difference may lead to vastly different conclusions about the effect of alcohol because the impairment on motor skill tasks has been found to wax and wane as BAC from a dose rises and declines (e.g. Vogel-Sprott & Fillmore, 1993) whereas the intensity of impairment on cognitive tasks may be less affected by the limb of the BAC curve (e.g. Fillmore, Carscadden & Vogel-Sprott, 1998).

In summary, alcohol research on sustained and divided attention attests to the importance of understanding the effect of the drug on attention. However, the inconsistent effects of a moderate dose of alcohol obtained using paradigms to test these two types of attention make it difficult to reach a conclusion. While some of these problems may be due to methodological and procedural differences among experiments, the findings may also have been influenced by variations in the stimulus and response complexity of the tasks and the different types of cognitive processes or amount of information processing involved in performing the various tasks. In order to obtain a clearer answer to the question of whether alcohol impairs attention, it may be useful to design a task that can be modified to alter the information processing demands without changing the response requirements. One approach to this question that could provide clearer information would be to adopt tasks developed in Cognitive Science to assess specific cognitive components of attention. Basic research in cognition has used these tasks to test theories about specific attentive processes. One particularly well-researched task assesses the covert orienting of attention to a particular location (Posner, Snyder & Davidson, 1980). A covert orienting task is used in this thesis as a first step in unravelling the effect of moderate doses of alcohol on attentional processes.

Covert Orienting Paradigm

Orienting attention plays a very important function in the real world. If appropriate shifts of attention are not made when one is faced with environmental threats or opportunities, survival or physical integrity could be at risk. Conversely, if one is constantly shifting attention in response to every sensory event, it would be impossible to sustain purposeful action and behavioural chaos would result (Allport, 1989). Michael Posner, one of the pioneers in

research and theory on the orienting of attention, has defined orienting as "the aligning of attention with a source of sensory input or an internal semantic structure stored in memory." (Posner, 1980, p.4). With respect to visual stimuli, orienting refers to pointing attention in a particular direction, or selecting a position in space (Posner, Snyder & Davidson, 1980).

Posner and colleagues (e.g. Posner & Raichle, 1997) have proposed that the orienting of visual attention depends on a sequence of basic mental operations. First, attention is disengaged from the current focus of attention. Attention is then shifted and engaged at a new target location. Research with patients who have suffered brain injuries has shown that the "disengage" component of orienting is related to functioning in the posterior parietal lobe. Patients with injuries in this area have difficulty disengaging attention when it is focused on a target located in a direction opposite to a cue, when the cue occurs on the side of their brain lesion. In these patients, performance on trials that correctly cue the position of the target is usually intact. The "shift or move" component of orienting has been localized to the area of the superior colliculus. Patients with progressive deterioration in this and/or surrounding areas are much slower at shifting their attention to a new location after it has been engaged elsewhere. Lastly, "engaging" attention on a new target has been localized to the area of the lateral pulvinar of the thalamus. Patients with injuries to this area have difficulty engaging attention on targets that occur on the side opposite their lesion, even when a cue is presented at that location and they are given considerable time to move their attention. These patients are typically quite distracted by events at other locations (Posner & Petersen, 1990; Posner & Raichle, 1997). Research using brain cell recordings in animals and neuroimaging techniques in non-injured humans has supported these findings (e.g. Posner & Raichle, 1997).

Typically, when one notices an interesting object, the eyes are moved so that the image falls on the central portion of the retina (the fovea), where visual acuity is greatest (e.g. Folk, Remington, & Johnston, 1993; Posner & Raichle, 1997). This has been termed "overt orienting" and it can be observed in head and eye movements (Posner, 1980). Klein (1994) defines overt visual orienting as "when adjustments of gaze are made to control which regions of visual space are processed by the receptor-rich fovea and its associated neural machinery" (p.167). These eye movements may arise either as a result of stimulus input, such as the appearance of an object in the visual field, or due to an internal search plan that has been generated (Posner, 1980). However, it has been demonstrated that attention also can be shifted with the eyes fixed, and that attention and eye movements are not identical systems (e.g. Posner, 1980; Posner, Snyder & Davidson, 1980; Jonides, 1981; Muller & Rabbitt, 1989). Remington (1980) found that when a stimulus is present that elicits an eye movement, one's attention moves rapidly prior to one's eyes (see also Muller & Rabbitt, 1989). As the fovea settles on the stimulus, attention returns to the most probable location for the next stimulus (Posner, 1980). Posner (1980) likens the relationship between eye movements and attention to the relationship between eye and hand movements; they have a close, functional relationship, but their physical mechanisms are distinct. One can be moved without the other. Posner has termed orienting in the absence of eye movements "covert" (e.g. Posner, 1980).

Covert orienting refers to "the ability to direct processing resources in visual space without changes in gaze direction." (Klein & Hansen, 1990, p.790). The use of the covert orienting paradigm is particularly well-suited for investigating the effect of alcohol on the orienting of attention because performance of the task does not depend on movements of the

eyes. Thus, the specific effects of alcohol on the orienting of attention can be tested.

Covert shifts of attention are very rapid compared with eye movements. These shifts typically require less than 50 milliseconds (ms) after the onset of a target, whereas the eyes typically move to the same location about 200 ms after a covert attention shift (Posner & Raichle, 1997). Covert orienting has been found to facilitate behavioural responses to stimuli at the attended location (e.g. Posner, 1980; Posner, Nissen & Ogden, 1978). Posner and colleagues (e g. Posner, Snyder & Davidson, 1980) have devised a covert orienting task to examine the inner workings of the shifting of attention in the absence of eye movements.[1] In this covert orienting paradigm, participants are provided with cues signalling the location of a subsequent target so that they may orient attention to that location prior to the presentation of the target. In a typical paradigm, participants sit in front of a computer screen and are told to fixate on a stimulus at the center of the screen. After a short interval a cue appears. The cue may be presented centrally, at the location of the fixation point, or peripherally, at or near the target location. Central cues, such as an arrow, may point in the direction of the target location or may require further decoding in order to determine the target location. In contrast, peripheral cues indicate the location of the target by the cue position. After another short interval (referred to as "stimulus onset asynchrony", or SOA) the target appears and the participant must respond to the appearance of the target as quickly as possible.

Numerous studies using variations of this task have shown that prior knowledge of

---

[1] It should be noted that it is unclear whether attention can be "moved" from one location to another. Thus, the term "shifting" attention, as used in this thesis, merely refers to a redistribution of attentional resources in response to spatially informative cues (see Shepherd & Muller, 1989 for a more thorough discussion of this subject).

target position influences the speed and accuracy of detecting the target (e.g. Fernandez-Duque & Posner, 1997; Henderson & MacQuistan, 1993; Jonides, 1981; Posner & Cohen, 1984; Posner, Nissen & Ogden, 1978; Posner, Snyder & Davidson, 1980; Theeuwes, 1991). Some authors suggest that this response facilitation occurs because the spatial cue concentrates attentional resources on a specific portion of the visual field, allowing faster detection of objects at the attended location (e.g. Van Zomeren & Brouwer, 1994). Electrocortical activity is also enhanced when a signal occurs at a position for which the participant is prepared (Posner, Snyder & Davidson, 1980). In contrast, the efficiency of target detection, as measured by reaction time and response accuracy, is typically reduced when the cue misinforms a participant and the target occurs at an unexpected location (e.g. Jonides, 1981; Posner & Cohen, 1984; Posner, Nissen & Ogden, 1978; Posner, Snyder & Davidson,1980). Trials where a cue correctly predicts the target location are called "valid" trials (Posner, 1980). Performance on these trials primarily involves the "engage" component of attention. In these trials, the cue identifies the target location. Thus, once attention is oriented to the cue, attention only needs to be engaged upon the target when it arrives (Posner et al, 1984). Trials where a cue misinforms the participant about the location of the target are called "invalid" trials (Posner, 1980). In order to respond to the target on invalid trials, attention must first be disengaged from the cued location, moved to the target location, and then the target must be engaged. Thus, invalid trials are thought to also involve the disengage and move components of attention (Posner et al., 1984). In the covert orienting paradigm, the effects of cuing do not depend upon eye movements because they are evident even when stimulus presentations are too brief to permit saccades. Cuing effects continue to be observed when eye movements are

measured and only trials where the eyes remain fixed are included in analyses (e.g. Jonides, 1981; Muller & Rabbitt, 1989; Posner, Nissen & Ogden, 1978; Posner, Snyder & Davidson, 1980).

Covert attention shifts may occur exogenously, where attention is drawn or captured by external peripheral visual cues, or endogenously, through a conscious, voluntary effort (e.g. James, 1890, as cited in Johnston & Dark, 1986; Jonides, 1981; Posner, 1980; Rafal, Calabresi, Brennan & Sciolto, 1989; Tarnowski, 1996). Exogenous orienting to new sensory signals in the visual periphery is thought to serve an important defensive and social function (Rafal, Calabresi, Brannan & Sciolto, 1989). In the covert orienting paradigm, exogenous shifts of attention are typically generated by the appearance of a cue at or near the location that the target will appear (in the case of valid trials) (e.g. Posner, 1980). Exogenous orienting is thought to be quite passive and reflexive. Jonides (1981) has identified four characteristics of exogenous cues that distinguish them from endogenous cues: 1) Exogenous cues do not draw heavily on cognitive resources as compared with endogenous cues 2) A shift of attention induced by an exogenous cue is more difficult to voluntarily suppress than a shift induced by an endogenous cue 3) Exogenous cues capture attention even when their occurrence is unexpected, whereas the effectiveness of endogenous cues in causing attentional shifts is related to expectancies based on the probability that they will occur and 4) Responses to exogenous cues are more accurate than responses to endogenous cues.

Endogenous orienting, in contrast, is thought to be consciously controlled and prompted by a voluntary shift in attention to a particular area or object (e.g. Jonides, 1981; Klein, 1994; Posner, Nissen & Ogden, 1978; Tarnowski, 1996). These shifts in attention are

thought to be active and strategic in nature (Klein & Hansen, 1987). In the covert orienting paradigm, endogenous shifts of attention are typically generated by some centrally presented symbolic cue that indicates where attention should be shifted in order to locate an imminent target and respond optimally (Henderson & Macquistan, 1993). Endogenous cues must be decoded before the spatial location they designate can be determined (Muller & Rabbitt, 1989; Yantis & Johnston, 1990).

Considerable research and theory indicate that covert orienting to endogenous cues is more susceptible to cognitive interference and places greater demands on cognitive resources than orienting to exogenous cues (e.g. Jonides, 1981; Shepherd & Muller, 1989). In addition, orienting can occur to exogenous cues below the subjective threshold of awareness but endogenous orienting only occurs when an individual is aware of the cue (McCormick, 1997).

In summary, the important question about the effect of alcohol on attention has been approached using tasks that involve sustained or divided attention. But inconsistencies in the findings raise the suspicion that the tasks also involve other different factors, such as the type of response, or the degree of information processing required by stimuli, or the combination of attentional processes. An alternative approach that may aid an understanding of how alcohol affects attention is to use an experimental paradigm specifically developed to assess a particular attentional process. This thesis adopts that strategy by investigating the effect of alcohol on the process of visual-spatial attention using the covert orienting paradigm. The tasks used in this thesis research all measure the same response (RT to target) and only the nature of the stimulus cues are varied. Moreover, theory and research using exogenous and endogenous stimulus cues, makes a distinction between exogenous (sensory reflexive) and endogenous

(cognitive decoding) orienting of attention that appears somewhat analogous to the difference between simple RT and cognitive tasks. The greater sensitivity of cognitive tasks to alcohol, suggested by the research literature, raises the possibility that a moderate dose is more likely to affect orienting to endogenous rather than exogenous cues. The covert orienting paradigm provides an opportunity to test this hypothesis. In addition, endogenous covert orienting tasks that involve different amounts of information processing to decode the cue can test the hypothesis that greater impairment under alcohol is observed on tasks that require more information processing. Because a covert orienting paradigm had not previously been used to test these hypotheses some exploratory investigations and a preliminary experiment were conducted to assess the adequacy of the covert orienting tasks to be used in the major alcohol experiment of the thesis, and to determine the appropriate procedure.

Background Research

Two exploratory studies were conducted. The first study used an exogenous covert orienting task (Task O) modelled on the description by Fernandez-Duque and Posner (1997) to determine whether the measures confirmed their finding that RT to valid trials were shorter than RT to invalid trials, which were shorter than RT on trials where no cue was presented. This pattern of RTs was replicated in Task O, and also indicated that one practice block of trials was necessary before performance on the valid and invalid trials became stable. This suggested that the task involved some learning, a finding that had not previously been reported. The full method and results are presented in Appendix A.

The second study explored the effect of a moderate dose of alcohol on Task O performance. Given that this exogenous task is characterized as reflexive, and somewhat

analogous to RT tasks, it seemed likely that orienting to exogenous cues in the task may not be affected by a moderate (0.62g/kg) dose of alcohol. For this reason, tests on the task were scheduled to occur during rising, peak and declining BACs. The results indicated that alcohol did not affect RT to valid, invalid or no-cue trials at any point on the BAC curve. Appendix A contains the complete details of this investigation.

Preliminary Experiment Endogenous cues provide information that requires interpretation. Since alcohol research suggests greater impairment is induced when a task requires more information processing, the investigation of endogenous orienting provided an opportunity to test this possibility by using two tasks with endogenous cues that differed in the degree of information processing required. These tasks had to be developed, and data on their drug-free performance had to be obtained to verify that the RT to cues in the two endogenous tasks (N and A) differed; the endogenous Task A presented cues that were devised to require more information processing, and thus RT to valid and invalid trials on Task A should be longer than Task N. In addition, the RT to valid and invalid trials on both endogenous tasks should be longer than the exogenous orienting Task O.

Clearest evidence on the differential sensitivity of the tasks to alcohol should be obtained using a within-subjects design, where a given individual performs all three tasks in sequence at a similar BAC. Although alcohol research has seldom used this strategy, the tasks were brief enough to make this feasible. However, no drug-free research with covert orienting tasks appears to have used a within-subjects design. Thus, this experiment evaluated a within-subjects testing procedure to determine that: 1) The pattern of RTs to the three cue conditions on the exogenous Task O was replicated when a given individual performed all three tasks. 2)

The RTs to valid and invalid trials on the two endogenous tasks (N and A) were longer than the RTs to Task O. 3) The RTs to valid and invalid trials on Task A, whose endogenous cue should require more processing, were longer than the RTs on Task N.

The responses to targets were identical in all three tasks. The tasks differed only in the nature of the stimulus cues. Thus, differences between the tasks in RT to valid and invalid trials could be attributed to the different properties of the cues. In accord with the hypotheses, when a given individual performed all three tasks consecutively the pattern of RTs to the three cue conditions within Task O was replicated. The RTs to valid and invalid trials on the two endogenous tasks were longer than on the exogenous Task O, and the RTs to valid and invalid trials on Task A were longer than on Task N . In addition, the results for Tasks N and A revealed that RT to valid trials were shortest, and RTs to the invalid and no-cue trials did not differ. This experiment is fully reported in Appendix B.

In summary, the background research suggested that performance on the exogenous orienting Task O, was not impaired by alcohol. The two endogenous orienting tasks, N and A, were designed to differ in the degree of information processing required by the cues, and were tested in the drug-free Preliminary Experiment. This work showed that as the information processing requirements of the endogenous cues increased, RT to valid and invalid trials increased. These three tasks were then used in the Main Experiment to test the effect of a moderate dose of alcohol on covert orienting of attention.

Main Experiment

This experiment adopted a within-subjects design to examine the performance of the three covert orienting tasks under alcohol or placebo in order to test the following predictions:

Hypotheses

1. On valid trials, performance on the endogenous Tasks N and A should be impaired (i.e., lengthened) under alcohol compared to the exogenous Task O. Thus, RT to valid trials on Tasks N and A should be lengthened to a greater degree than on Task O. In addition, these RTs on Tasks N and A should be longer under alcohol than under placebo. In contrast, RT on Task O was not predicted to differ under alcohol, compared to placebo.

2. On valid trials, the endogenous task presenting cues requiring greater processing should be more impaired (i.e., lengthened). Thus RT to valid trials on Task A should be lengthened to a greater extent under alcohol as compared with Task N.

3. There are two possible outcomes of the effect of alcohol on invalid trials. RT on these trials are thought to contain an additional disengage/shift component of attention. The pilot study indicated that alcohol did not significantly affect RT to invalid trials on the exogenous task. This suggested that the disengage/shift component required by invalid trials was not impaired by alcohol. Because these same disengage/shift conditions occur with the target onset in endogenous tasks, the RT to invalid trials on these tasks also may not be affected by alcohol. On the other hand, drug-free RT to invalid trials showed that the response to the target was longer on the endogenous tasks than on the exogenous task. This is consistent with the assumption that endogenous tasks require more information processing. If tasks that require more information processing are more susceptible to disruption by alcohol, then RT to invalid trials on endogenous tasks might be impaired (lengthened) to a greater degree than on exogenous tasks.

4. No-cue trials are identical across tasks, and primarily involve a fairly reflexive capture of attention by the presentation of the target. As such, RT on these trials was not predicted to differ under alcohol for any of the tasks.

This experiment also provided an opportunity to explore another question not previously addressed: Do changes in subjective feelings of stimulation and sedation relate to performance under alcohol? It has long been speculated that the effect of alcohol on behaviour is related to arousal level (e.g. Erwin et al., 1978; Gustafson, 1986; Linnoila et al., 1978). Several studies have found increased self-reported sedation and reduced alertness after alcohol consumption (e.g. Foo & Lemon, 1997; Rammsayer, 1995). Interestingly, when research has examined the subjective effects of a moderate dose of alcohol at different points of the blood alcohol curve, a biphasic effect of alcohol on subjective feelings of alertness has been observed, with alcohol having a stimulating effect during rising blood alcohol levels and a sedating effect while BACs are declining (e.g. Jones & Jones, 1976; Morrow et al., 1991). However, the majority of the scales used in the past to assess the effect of alcohol on perceived stimulant and sedative effects have not been empirically derived or validated. One scale that has been recently developed to assess these characteristics is the Biphasic Alcohol Effects Scale (BAES) (Martin et al., 1993; Earleywine & Erblich, 1996). Research on the stimulation and sedation subscales of the BAES is supported by factor analysis.

The BAES has been used to show that drinkers under a moderate dose of alcohol report increased stimulation while BAC rises, and increased sedation while BAC declines (e.g. Martin et al., 1993). However, studies using this scale have not examined these ratings relative

to baseline ratings of stimulation and sedation, or in comparison to a credible placebo. Thus, it is unclear whether changes in feelings of sedation and stimulation are actually a result of alcohol consumption. This was explored in the present experiment. In addition, the possibility that this stimulation might accelerate reactions suggests that drinkers who report a greater increase in stimulation during rising BACs might also display shorter RT. On the covert orienting tasks used in this thesis, such an effect would result in less impairment (less slowing of RT). Alcohol-induced increase in sedation during declining BACs has often been thought to contribute to poorer performance under alcohol (e.g. Linoilla et al., 1978) and this suggests that those reporting a greater increase in sedation may perform more poorly (more slowing of RT) on the covert orienting tasks. The BAES was used to explore these possibilities.

METHOD

Participants

Thirty-six male volunteers between the ages of 19 and 22 (M = 19.583 years, SD = 0.874) were recruited from a "subject pool" of university students. Initial contact was made by telephone and volunteers were asked if they would agree to participate in a study involving the effect of alcohol on computerized tasks (Appendix C-1). Individuals with uncorrected vision problems or who were currently taking prescription medication were excluded from the study. Participants were paid $15.00 for their participation. Ethics approval was obtained for this study from the Office of Human Research of the University of Waterloo. All individuals were right-handed according to self-report. They were allowed to use whichever hand they preferred to perform the tasks and all used their right hand exclusively.

Apparatus and Measures

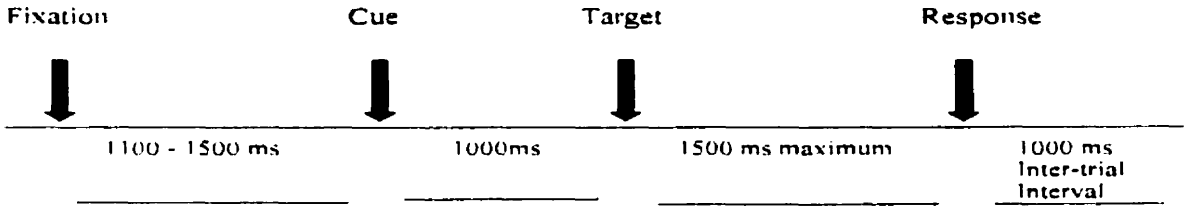
Three computerized covert orienting tasks were used, each of which measured reaction time to target stimuli after the presentation of visual-spatial warning cues, and when no warning cue was presented.

1. Original Exogenous Task (O) This task is based on the original paradigm developed by Fernandez-Duque & Posner (1997). Participants were seated directly in front of a computer screen and keyboard, at a distance of 85 cm from the screen. All stimuli were presented near the centre of the visual field to minimize eye movement. A pictorial representation of the timeline of events during a trial on this task and the others used in the experiment is presented in Figure 1.

A 0.1 cm dot subtending 0.07 degrees of visual angle served as a central fixation point

and was presented for random time periods of between 1100 and 1500 ms. On the cue trials, a cue (a 1.28 cm white circle) subtending 0.86 degrees of visual angle, with the centre at an eccentricity of 2.17 degrees of visual angle was presented for1000 ms immediately following the offset of the fixation point at one of four locations (upper, right, lower, left). The cue remained on the screen until the target was presented. The target, measuring 1.28 cm, subtending 0 86 degrees of visual angle, with its centre at an eccentricity of 1.31 degrees was either a plus sign (+) or a capital letter (X). The target was also presented in one of four locations on the screen (upper, right, lower, left), at the same eccentricity for each location. The target remained on the screen until a response key was pressed or 1500 ms had elapsed, at which point a blank screen appeared for 1000 ms and then a new trial began. Participants were instructed to press the "n" key on the keyboard if the target was a +, and the "m" key if the target was an "X." They were instructed to use two fingers of one hand, and all used their right hand. Reaction time to the target stimulus was measured in milliseconds (msec.). A test on the task consisted of 112 trials. Fifty-six cue trials were presented in a ratio of approximately 80% valid trials to 20% invalid trials. A valid trial occurred when the cue and the target were presented in the same location. An invalid trial presented the target in a different location than the cue. Forty-four valid trials were presented during a test with 11 trials occurring at each target location (upper, right, lower, left). Twelve invalid trials were presented during a test, with three trials occurring at each target location. No cues were presented on 56 trials. Each of the two target stimuli was presented on an equal number of trials in each cue condition.

Figure 1: Timeline for Presentation of Task Components for Three Tasks



2. Endogenous Numerical Identification Task (N) This task was identical to Task O in all respects except for the characteristic and location of the cues. In this task the valid and invalid cues were represented by the numbers one to four that appeared individually in the centre of the screen. The numbers were 0.5 cm in size and subtended 0.34 degrees of visual angle. Each number corresponded to a particular quadrant of the screen. (upper=1, right=2, lower=3, left=4). The quadrant numbers were clearly labeled on the front frame of the computer monitor in 3 centimeter high digits that were placed in the centre of the corresponding part of the monitor frame. On the 44 valid trials, the numerical cue identified the quadrant in which the target would subsequently appear. On the 12 invalid trials, the number incorrectly predicted the quadrant in which the target would appear. The proportion of valid to invalid trials remained the same as in the original task (80% to 20% respectively), and the remaining 56 trials presented no cues.

3. Endogenous Arithmetic Task (A) This task was designed to present cues that involved more information processing than Task N. It was identical to Task N except that the cue presented in the centre of the screen to indicate the location of the target was a basic mathematical equation. The equations consisted of two numbers between zero and six and were solved by addition or subtraction. The equations were 1.28 cm in size and subtended 0.86 degrees of visual angle. On valid trials, solving the equation predicted the location of the target. For example, the equation in the centre of the screen might read 1+3, indicating the target will appear in quadrant four. The equations were simple enough for university students to solve without difficulty. On invalid trials the solution to the equation did not identify the quadrant in which the target subsequently appeared. The remaining 56 trials presented no

cues.

Blood Alcohol Concentrations (BACs) Blood alcohol concentrations (BACs) were measured using a CMI Intoxilyzer, model S-D2.

Biphasic Alcohol Effects Scale (BAES) (Martin et al., 1993) This self-report adjective rating scale (Appendix C-5) provides a measure of the stimulant and sedative effects of alcohol. The instrument contains a seven-item stimulant subscale and a seven-item sedative subscale. Ratings are provided on a 10-point scale ranging from 0 "not at all" to 10 "extremely". Scores were calculated by summing the numerical responses for the seven adjectives on each scale, separately. The maximum score on each scale was 70. The BAES is very psychometrically sound. It has high internal consistency in both sober and intoxicated participants, and was developed using factor-analytic methods (Martin et al., 1993). A four factor structure was supported consisting of ratings on each subscale during rising and falling BACs. The factor structure has recently been confirmed (Earlywine & Erblich, 1996). The scale is typically completed after alcohol has been administered and the instructions ask respondents to indicate how alcohol is affecting them. In order to also obtain a drug-free baseline measure of stimulation and sedation, the instructions were modified for this experiment and asked for a report of feelings at the time of the administration of the scale.

Drinking Habit Questionnaire (Vogel-Sprott, 1992). This questionnaire (Appendix C-3) provided a measure of participants' current use of alcohol in terms of dose (ml absolute alcohol per kg body weight) per drinking occasion, and the weekly frequency of these occasions. Two additional questions asked if participants had ever been convicted for impaired driving, and if they had ever experienced problems due to their drinking. These two questions

were included in order to identify and exclude any individual who might have alcohol-related problems. However, no participants reported any such problems.

Drink Strength Questionnaire. All participants rated the alcohol content of their drinks by comparing it with bottles of beer containing 5% alcohol (Appendix C-6). The scale ranged from zero to 10 bottles of beer in 0.5 increments. Zero indicated that the beverage was equal to no beer (i.e. no alcohol). The scale ratings were used to determine whether participants reported that their beverage contained some alcohol. All participants in this study reported that they had consumed alcohol.

Procedure

Training Session This session allowed participants to become familiar with the three tasks and provided practice trials so that they acquired proficiency on the tasks prior to any treatment. Testing occurred on an individual basis. Upon arriving at the testing room, participants were given a general description of the study (Appendix C-7) and were asked to read and sign the study consent form (Appendix C-2). They were then seated in front of the computer screen and the instructions for Task O were read to them by the experimenter (Appendix C-8). Subsequently, participants performed a group of 20 familiarization trials on Task O. The experimenter observed their performance in order to ensure that the task instructions had been understood and the task was being performed correctly. After participants were familiarized with the task and testing procedure, the experimenter left the room and they practiced the task by performing a block of 112 trials. This procedure was repeated for Tasks N and A with a one and a half minute break in between each task, during which time the experimenter re-entered the room to start the next task. Participants performed

one practice block on each task.

At the completion of training, participants completed the Drinking Habit Questionnaire (Appendix C-3) and were weighed. Participants made appointments to return for the treatment session and it was explained that they would be required to abstain from alcohol and other drugs for 24 hours prior to the treatment session in order to prevent confounding effects of prior drugs in their bloodstream (Appendix C-9). In order to standardize the rate of absorption of alcohol, participants were also required to abstain from food and drink, apart from sips of water, for four hours prior to the experimental session and to avoid certain foods during the meal prior to fasting. To assist compliance with the eating and fasting requirements, a menu of permissible and nonpermissible foods prior to fasting (Appendix C-4) was given to all participants.

Treatment Session This session occurred within one week following the training session. Participants were randomly assigned to one of two groups: alcohol (A) or placebo (P). At the outset of this session, adherence to the fasting instructions was verbally confirmed (Appendix C-10) and a baseline breath sample was taken to ensure that the participant had not consumed any alcohol immediately prior to the session. Participants then completed the BAES. Subsequently, they were seated in front of the computer screen and the instructions for Task O were read to them by the experimenter (Appendix C-11). They then performed 10 reminder trials on this task. This procedure was repeated for each of the two remaining tasks. After completing the reminder trials on all three tasks, the experimenter left the room and the participant completed one pre-test block of 112 trials on each task. The task blocks were separated by a one and a half minute rest period during which the experimenter re-entered the

room and set the computer for the next task. The time to complete all three tasks was approximately 25 minutes. The order in which tasks were tested was counterbalanced among participants in each group and one of three possible task orders was administered to a given participant (O,N,A; N,A,O; or A,O,N). These pre-test blocks provided a pre-treatment baseline measure of participants' performance prior to receiving any treatment. The temporal schedule of events for the entire treatment session is shown in Appendix C-12.

Participants in Group A then received 0.62 g/kg of absolute alcohol divided equally into two drinks containing one part alcohol and two parts carbonated mix. Participants drank both beverages within six minutes, and then rested or read magazines for 17 minutes. Participants in Group P received a placebo consisting of carbonated mix with a few drops of alcohol on the top. It was served in two glasses that had been sprayed with an alcohol mist that appeared as condensation, but provided a strong alcoholic scent as the beverages were consumed. Previous research has shown that participants report that this beverage contains alcohol (e.g. Fillmore & Vogel-Sprott, 1995; Fillmore, Mulvihill, & Vogel-Sprott, 1994). Group P participants drank the beverage within six minutes and then rested or read magazines for 17 minutes.

After the rest, a breath sample was obtained from Group A to measure their BACs, and Group P also provided breath samples ostensibly to measure their BACs. All participants then performed one block of test trials on each task while alone in the room. The order in which a participant performed the three tasks was identical to the pre-test order of his tasks. Previous research has shown that the time period during which this three task block of trials (Test 1) was performed is when BACs are typically rising and peaking (e.g. Fillmore, Carscadden, &

Vogel-Sprott, 1998). Immediately following Test 1 participants again completed the BAES and then provided a breath sample.

Participants then rested or read magazines for 15 minutes before another breath sample was obtained. Eighteen minutes later participants completed a second block of trials on each of the three tasks (Test 2). This second test on the tasks was scheduled to encompass times when BACs were falling. At the conclusion of the test blocks all participants again completed the BAES and provided breath samples. They then completed the Drink Strength Questionnaire (Appendix C-6). After debriefing (Appendix C-13, C-14) and payment, participants remained in the lab for coffee and snacks and were provided with transportation home as needed.

Criterion Measures and Data Analyses

Task Performance A participant's mean RT for correct responses to valid, invalid, and no-cue trials respectively, were calculated for each of the three tasks, during the baseline and the two alcohol tests. Mean change in RT on a given task was calculated by subtracting each participant's RT for each cue condition on each test under alcohol from his baseline RT for that cue condition. This resulted in two measures of change in RT under alcohol for each task, for each of the three cue conditions within a task. A positive change score represented improvement (shorter RT) as compared with baseline performance, and a negative change score represented impaired performance (longer RT) under treatment.

Because the distribution of RT scores is often positively skewed, the change score results were confirmed with analyses using log transformations of the RT data.

Response accuracy scores for valid trials were computed for each participant by

determining the total number of accurate responses, out of a total of 44 possible responses, for each of the three tasks. Accuracy scores for invalid trials were computed for each participant by determining the total number of accurate responses, out of a total of 12 possible responses, for each task. Accuracy scores for no-cue trials were computed for each participant by determining the total number of accurate responses, out of a total of 56 possible responses, for each task.

BAES Ratings A participant's rating of stimulation and sedation were obtained for each of the three test periods during baseline and on each limb of the blood alcohol curve (while BACs were rising and falling). Change in stimulation and sedation were calculated by subtracting each participant's baseline rating on a subscale from the rating taken on each limb of the blood alcohol curve for that subscale. This resulted in two measures of change in subjective feelings for each subscale. A positive change score represented an increase in feelings of sedation or stimulation, as compared with baseline performance, and a negative change score represented decreased feelings of sedation or stimulation under treatment.

RESULTS

All raw data for each participant are presented in Appendix K.

Procedural Checks

Drinking Habits

Participants were between 19 and 22 years of age with a mean (SD) age of 19.58 (0.87) years. They reported that they had been drinking regularly for a mean (SD) of 47.56 (25.31) months. One-way ANOVAs performed on each of the three drinking habit measures revealed no significant group differences (ps$\geq$ 0.365)(Appendix D-1). The sample of participants (N=36) reported a mean (SD) drinking frequency of 1.58 (1.78) times per week, with a mean (SD) dose per drinking occasion of 1.22 (0.68) ml/kg. This dose is the equivalent of approximately five bottles of 5% alcohol beer for a 75 kg man. The mean (SD) duration of drinking occasions was 3.95 (1.91) hours. These findings are consistent with the norms reported by male university students on this questionnaire (Vogel-Sprott, 1992).

Beverage Ratings

All participants who received a placebo beverage (Group P) reported that their beverage contained alcohol. Their mean (SD) drink rating under placebo was 2.11 (0.83) beers. Thus, the placebo was a credible substitute for alcohol.

Pre-treatment Baseline Performance

A 2(group) x 3(task) ANOVA was performed on the RTs, separately for each of the three cue conditions. There were no significant group effects (ps$\geq$0.180) or task by group interactions (ps $\geq$0.076) for any of the cue conditions (Appendix D-2, Tables 1-3). Thus, the RT of the groups to cue conditions on the three tasks did not differ on the baseline test, prior

to treatment. In accord with the preliminary drug-free experiment, these ANOVAs also showed significant task effects for valid and invalid trials ($F(2,68)=10.854$, $p= \leq 0.001$ and $F(2,68)=5.472$, $p=0.006$ respectively) and no significant task effect for no-cue trials ($p=0.915$). ANOVAs of log transformed RT measures yielded the same conclusions (Appendix D-2, Tables 4-6).

The RT means and standard deviations for the sample ($N=36$) are presented in Table 1. The mean RT to valid trials in each task are in the order observed in the preliminary drug-free experiment with the shortest RTs occurring on Task O and the longest RTs occurring on Task A. The same pattern occurred with invalid trials, although there was little difference between the mean reaction times on Tasks N and A. The mean RTs on no-cue trials were almost identical for the three tasks. This was expected because these trials presented no cues for the targets and thus were the same in all tasks.

Table 1: Mean RT and SD (msec.) to Three Cue Conditions on each Task at Drug-Free Baseline

	Valid		Invalid		No Cue	
	Mean	SD	Mean	SD	Mean	SD
Task O	451	61.31	480	68.80	501	57.50
Task N	461	58.55	504	72.92	499	61.92
Task A	473	55.67	508	66.83	499	64.02

Table 1 also shows that the mean RTs to the three different cue conditions within Task O continued to show that RTs were shortest on valid trials and longest on no-cue trials, with RTs on invalid trials being intermediate. In the two endogenous tasks (N and A), RTs to valid

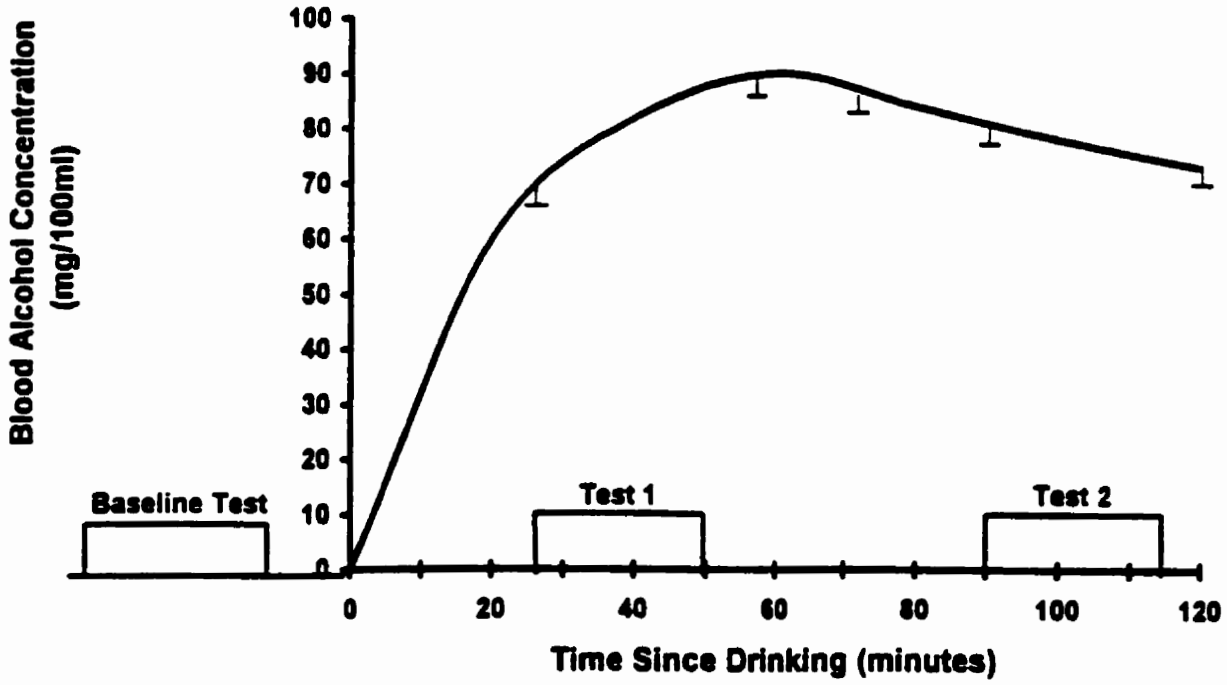
trials were shortest and RTs to invalid trials were slightly longer than RTs to no-cue trials.

Drug-free baseline accuracy of responses to the 44 valid trials on each task ranged from 42.91 to 42.44, representing 97.5% to 96.5% accuracy. Responses to Task O were most accurate and responses to Task A were least accurate. Responses to invalid and no-cue trials were similar with baseline accuracy of responses to the12 invalid trials on each task ranging from 11.89 to 11.67, representing 99.1% to 97.2% accuracy, and baseline accuracy to the 56 no cue trials on each task ranging from 54.75 to 54.50, representing 97.8% to 97.3% accuracy Response accuracy was exceptionally high, almost perfect, for all cues conditions on all three tasks. Appendix D-3, Tables 1-3 present the means and percent accuracy on the three tasks for valid, invalid and no-cue trials under drug-free and treatment conditions for both groups. Accuracy on the treatment tests for the alcohol group ranged from 98.1% to 93.1%. For the placebo group, accuracy ranged from 99.5% to 95.5%.

Treatment Effects

The mean BACs and Standard Error of Measurement (SEM) of participants in Group A during treatment are presented in Figure 2, together with the temporal schedule of tests on the set of tasks. The means show that BAC rose to a peak of 91mg/100ml at 55 minutes after drinking began, and subsequently declined. The first test under alcohol (from 25 to 50 minutes) occurred while BAC rose from 73 to 87 mg/100ml, for an average rising BAC of 80 mg/100ml. The second test (from 90 to 115 minutes) occurred during declining BACs of 80 to 74 mg/100ml, for an average of 77 mg/100ml. The means and standard deviations in BAC over time are presented in Appendix E.

Figure 2: Mean Blood Alcohol Concentration as a Function of Time Since Drinking



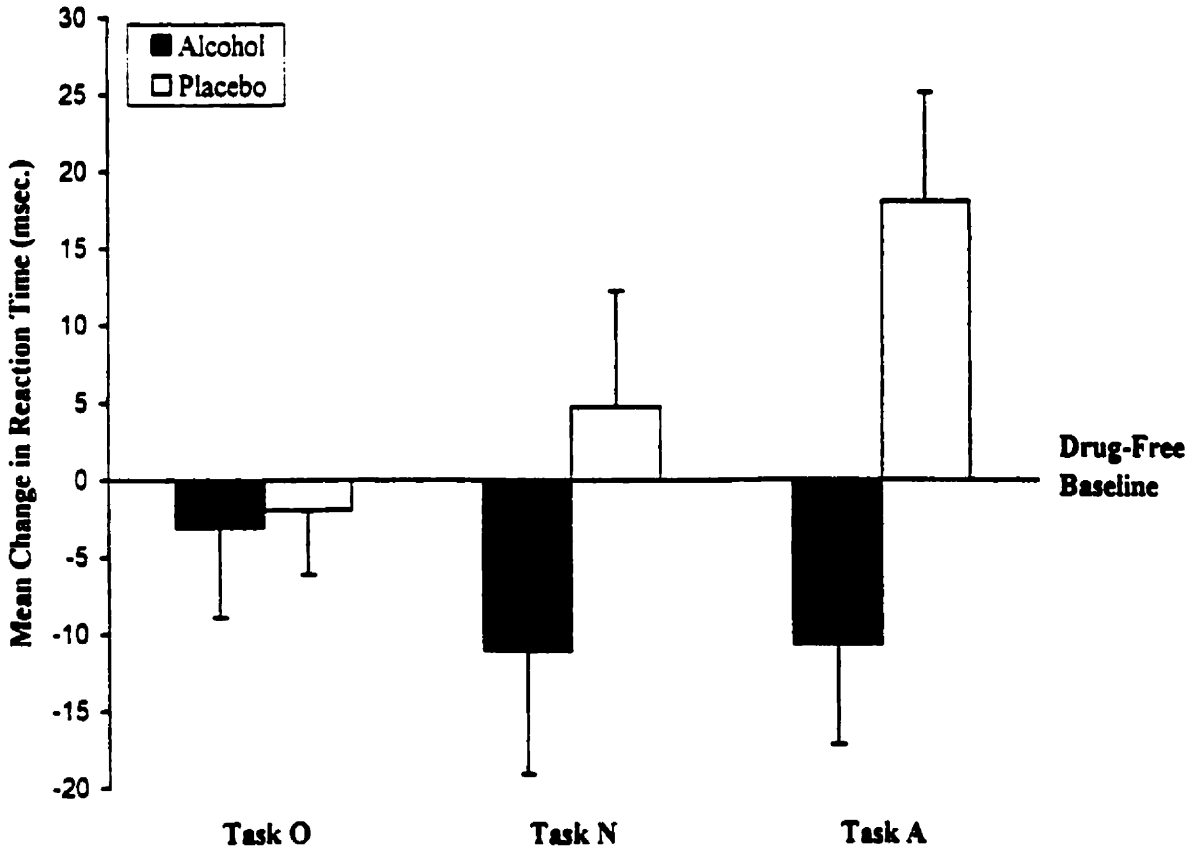
Valid Trials

A 2(group) x 3(task) x 2(test) ANOVA was performed on the changes in RT for the two groups on the three tasks during the two tests (Table 2). The results revealed a significant task x group interaction, $F(2,68)=3.450$, $p=0.037$, as well as a main effect of group, $F(1,34)=4.565$, $p=0.040$. No other main effects or interactions were significant ($ps \geq 0.360$). Figure 3 shows the mean change in RT from drug-free baseline for each task, averaged over the two tests. A positive change means improvement under treatment (RT became shorter) compared to baseline, whereas a negative change means impairment (RT became longer). The figure indicates that the interaction arose because the two groups did not differ in their performance on Task O.

Table 2: Analysis of Variance of Change in RT to Valid Trials For Two Groups on Three Tasks and Two Tests

Source	Df	MS	F	p
Between Subjects				
Group	1	12552.581	4.565	0.040
Error	34	2749.990		
Within Subjects				
Test	1	619.896	0.646	0.427
Test x Group	1	742.371	0.774	0.385
Error	34	959.394		
Task	2	1030.239	1.036	0.360
Task x Group	2	3431.502	3.450	0.037
Error	68	994.632		
Test x Task	2	119.911	0.358	0.701
Test x Task x Group	2	141.453	0.422	0.658
Error	68	335.387		

Figure 3: Mean Change in RT on Valid Trials for Two Groups on Three Tasks, Averaged Over Two Tests



On Tasks N and A, however, the RT of Group A was impaired (lengthened) whereas no such change was shown in Group P. The mean change in RT and standard deviations for the two groups, on each task averaged over the two tests, are presented in Appendix F-1, Table 1. The means and standard deviations for each group, on each task, are presented for each test in Appendix F-1, Table 2.

It was hypothesized that RTs on the two endogenous tasks, N and A would be significantly impaired by alcohol whereas no alcohol effect was predicted for the exogenous Task O. The simple effects of group for each task were tested using the within cell error term from the analysis in Table 2 as suggested by Howell (1992, p.450-452). The calculations for this analysis are presented in Appendix F-2 and the source table is presented in Table 3. As predicted, RTs of Group A were significantly longer than those of Group P on Tasks N and A (ps <0.012 and <0.001 respectively). In addition, alcohol did not significantly impair RT to valid trials on Task O relative to placebo (p>0.05).

Table 3: Comparison of Change in RT to Valid Trials for Groups A and P on Each Task

Source	df	MS	F	p
Group at Task O	1	46.950	0.030	>0.05
Group at Task N	1	9056.568	5.733	<0.012 (one-tailed)
Group at Task A	1	29727.277	18.818	<0.001 (one-tailed)
Error	80.039	1579.751		

It was also hypothesized that Task N should be more impaired by alcohol than Task O, and Task A should be more impaired than Task N. This was tested using the change in RT for Group A on the two tests of Tasks O, N and A (see Howell, 1992, p.449). The results of the

3(task) x 2(test) analysis of variance for Group A are presented in Table 4. The task error term from this ANOVA was used to test the prediction that the change in RT on Task A was greater than on Task N (Table 4). This hypothesis was not supported. The change in RT on the two endogenous tasks (N and A) did not differ, $F(1,34)=0.011$, $p=0.917$. However, a comparison between change in RT on Task O and the change in RT on Tasks N and A combined, confirmed that RT to valid trials in the two endogenous tasks was significantly more impaired than RT in the exogenous Task O, $F(1,34)=16.360$, $p<0.001$.

Table 4: Analysis of Variance of Change in RT for Group A on Valid Trials for Three Tasks on Two Tests

Within Subjects Source	DF	MS	F	p
Test	1	1359.508	1.481	0.240
Error	17	918.038		
Task	2	727.645	0.683	0.512
Error	34	1065.339		
Test x Task	2	20.435	0.055	0.947
Error	34	371.346		
Contrasts				
Tasks N vs A				
hypothesis	1	11.681	0.011	0.917
error	34	1065.339		
Task O vs N+A combined				
hypothesis	1	17428.445	16.360	<0.001
error	34	1065.339		

The conclusions based on the analyses of change in RT on valid trials were consistent with the groups' log-transformed RT measures on valid trials in each of the tasks. A 2(group) x 2(test) x 3(task) ANOVA of log RTs for valid trials at baseline and on the mean of the two treatment tests is presented in Appendix F-3, Table 1. The log means and the mean RTs converted from the log-transformations, are shown in Appendix F-3, Table 2. Figures 1a and b in Appendix F-3 show the group log means at baseline and under treatment on each task.

It is also of interest to note the performance of the placebo group on the tasks. The change in RT for Group P (Appendix F-1 Table 2) on the three tasks was negligible on Tasks O and N, but RT improved (shortened) from baseline on Task A. Further examination of Group P's performance on valid trials was conducted using an analysis of variance of the change in RT for Group P on the two tests of Tasks O, N and A. The results of the 3(task) x 2(test) analysis of variance are presented in Appendix F-4, Table 1. The task error term from this ANOVA was used to conduct a post-hoc comparison of the change in RT under placebo between Tasks O and N. These analyses revealed that change in RT on Tasks O and N did not significantly differ ($p=0.069$). A second post-hoc comparison revealed that RT on Task A improved (shortened) from baseline to a significantly greater degree than on Tasks O and N combined, $F(1,34)=86.382$, $p<0.001$. These analyses are presented in Appendix F-4, Table 1.

Invalid Trials

A 2(group) x 3(task) by 2(test) ANOVA was performed on the changes in RT to invalid trials for the two groups on the three tasks during the two treatment tests (Table 5). No main effects or interactions were significant ($ps \geq 0.116$). Means and standard deviations of change in RT on the three tasks for the two groups, on the two tests, are presented in

Appendix G-1. The mean change in RT from drug-free baseline for each task, averaged over the two tests is presented in Appendix G-1, Figure 1. Positive change means improvement under treatment (RT became shorter) compared to baseline, whereas a negative change means impairment (RT became longer) compared to baseline. The consistent positive change scores obtained by both groups on each of the tasks indicate that performance on invalid trials was not impaired. The mean change (SD) in RT to invalid trials for the entire sample was 12.94 (33.30) msec.

Table 5: Analysis of Variance of Change in RT to Invalid Trials for Two Groups on Three Tasks and Two Tests

Source	DF	MS	F	p
Between Subjects				
Group	1	71.392	0.010	0.919
Error	34	6847.672		
Within Subjects				
Test	1	3.697	0.006	0.939
Test x Group	1	535.815	0.855	0.362
Error	34	626.938		
Task	2	1179.017	0.307	0.737
Task x Group	2	636.484	0.165	0.848
Error	68	3946.559		
Test x Task	2	600.540	0.624	0.539
Test x Task x Group	2	2138.446	2.221	0.116
Error	68	962.854		

Although the analysis (Table 5) showed that alcohol did not impair (slow) RT to invalid trials on the endogenous tasks, the prediction that changes in RT under alcohol might relate to

tasks was tested using a 3(task) x 2(test) analysis of variance of changes in RT in Group A. The results of this analysis are presented in Table 6. No significant main effects or interactions were observed (ps≥0.515). Thus, the changes in RT on invalid trials under alcohol were not related to the tasks. The mean change in RT (SD) for Group A was 7.18 (41.99) msec. for Task O, 20.23 (36.84) msec. for Task N, and 13.13 (31.97) msec. for Task A.

Table 6: Analysis of Variance of Change in RT for Group A on Invalid Trials for Three Tasks on Two Tests

Within Subjects Source	DF	MS	F	p
Test	1	314.266	0.442	0.515
Error	17	711.255		
Task	2	1535.412	0.546	0.584
Error	34	2813.803		
Test x Task	2	407.196	0.448	0.643
Error	34	909.003		

The conclusions based on the analyses of change in RT on invalid trials (Table 5) were essentially confirmed by a 2(group) x 2(test) x 3(task) ANOVA of log RTs for invalid trials on the baseline and on the mean of the two treatment tests. This analysis (Appendix G-2, Table 1) also shows no significant effect of group, $F(1,34)=1.948$, $p=0.172$, or any interactions involving group (ps≥0.809). However, the analysis obtained significant main effects of test, $F(1,34)=7.742$, $p=0.009$ and task, $F(2,68)=10.781$, $p<0.001$. The log means and the mean RTs converted from the log-transformations for each task on the baseline and the mean of the two treatment tests are shown in Appendix G-2, Table 2. These means indicate that the RT of

both groups tend to be shorter (better performance) during treatment as compared to the baseline test. In addition, RTs continued to be shortest on Task O, and longest on Task A.

No-Cue Trials

A 2(group) x 3(task) x 2(test) ANOVA was performed on the change in RT for the two groups on the three tasks during the two treatment tests (Table 7). The results revealed no significant main effects or interactions ($ps \geq 0.408$). The means and standard deviations for change in RT on the three tasks for the two groups on each test separately are presented in Appendix H-1. As expected, alcohol did not impair reactions to no-cue trials on any task, and the alcohol and placebo groups performed similarly. The mean change in RT for the entire sample was 7 16 (20 17) msec.

Table 7: Analysis of Variance of Change in RT to No-Cue Trials for Two Groups on Three Tasks and Two Tests

Source	DF	MS	F	p
Between Subjects				
Group	1	542.102	0.217	0.644
Error	34	2497.094		
Within Subjects				
Test	1	38.330	0.047	0.829
Test x Group	1	3.398	0.004	0.949
Error	34	808.779		
Task	2	964.012	0.907	0.408
Task x Group	2	537.246	0.506	0.605
Error	68	1062.386		
Test x Task	2	259.028	0.746	0.478
Test x Task x Group	2	161.061	0.464	0.631
Error	68	347.100		

The conclusions based on the analyses of change in RT on no-cue trials were checked using the log RT measures. A 2(group) x 2(test) x 3(task) ANOVA of these log scores on the baseline and the mean of the two treatment tests is presented in Appendix H-2, Table 1. These results also show no significant effect of group, $F(1,34)=0.685$, $p=0.414$ or task, $F(2,68)=0.500$, $p=0.609$, and no significant interactions ($ps \geq 0.365$). However, the analysis obtained a significant main effect of test , $F(1,34)=4.211$, $p=0.048$. The log means and the mean RTs converted from the log-transformations, are shown in Appendix H-2, Table 2. These means indicate that the RT became shorter (better performance) during the treatment as compared to the baseline test.

In summary, the analyses of the RTs of alcohol and placebo groups to valid, invalid, and no-cue trials on the exogenous and endogenous tasks confirmed the hypothesis that alcohol impaired (lengthened) responses to valid trials only on the endogenous tasks. The change in RT shown by the groups to invalid and no-cue trials did not differ on any of the tasks, and these RTs tended to become shorter during the treatment tests, as compared to the baseline test.

The RT on valid trials was typically shorter than the RT on invalid trials within each task. However, because alcohol selectively lengthened the RT to valid trials in the endogenous tasks, the difference between the RT to valid and invalid trials tended to converge from baseline to treatment in the alcohol group but not in the placebo group. This suggests that an analysis of the RTs to these two types of cues on baseline and treatment tests might reveal a group x cue x test interaction for endogenous tasks. This would not be expected for the exogenous task because RTs were not significantly affected by alcohol. This thesis research

was not designed to test this possibility and the few tests on the tasks might limit the ability of an analysis to detect this three-way interaction. However, exploratory analyses of log RT scores on valid and invalid trials during baseline and the mean of the two treatment tests were performed for each task (Appendix I). The analysis of the exogenous Task O (Appendix I, Table 1) obtained no significant cue x test x group interaction effects, $F(2,68)=0.220$, $p=0.803$. Appendix I, Table 2 shows that the mean RT to valid and invalid trials was essentially similar across tests in alcohol and placebo groups.

Similar analyses of each endogenous task are shown in Appendix I, Tables 3 and 5 respectively. These analyses obtained three-way interaction effects that had lower probability, but did not reach $p=0.05$, [$F(2,68)=2.175$, $p=0.121$ and $F(2,68)=1.984$, $p=0.145$, respectively]. The mean RTs for valid and invalid trials on each endogenous task are shown for groups A and P in Appendix I, Tables 4 and 6. These means tend to suggest that the difference between the RTs to valid and invalid trials was beginning to converge (increasingly shorter RT to invalid trials and longer RT to valid trials from baseline to treatment) in group A. In contrast, the difference between these RTs in the placebo group remained substantial.

Subjective biphasic effects of alcohol The BAES was completed three times by all participants. Ratings were obtained during the pretreatment baseline and twice during treatment, at times when the BAC in Group A was rising and declining. The mean (SD) subscale ratings at each of these times are presented for Groups A and P in Appendix J-1, Table 1. Higher ratings represent greater feelings of stimulation or sedation. The table indicates that the ratings by Group A in this experiment are consistent with the findings of Martin et al. (1993). On the rising limb of the BAC curve, stimulation was rated higher than

sedation, whereas on the falling limb, sedation was rated higher than stimulation. The ratings also show that stimulation ratings increased from baseline when BAC was rising, and decreased when BAC was falling. In contrast, ratings of sedation continued to increase from baseline over the same time period.

Ratings by Group P showed a different pattern. They remained fairly stable on both scales during the two limbs of the BAC curve, with stimulation consistently rated higher than sedation.

A 2(group) x 2 (subscale) ANOVA was performed on the baseline ratings of the sedation and stimulation subscales for the two groups in order to verify that the group ratings did not significantly differ at drug-free baseline (Appendix J-1, Table 2). The main effect of group and the group x subscale interaction were not significant ($ps \geq 0.160$) indicating that the ratings of the two groups did not differ at baseline. The analysis also revealed a significant main effect of subscale, $F(1,34)=51.520$, $p<0.001$. Appendix J-1, Table 1 shows that both groups rated stimulation higher than sedation at baseline.

The difference between a participant's baseline rating on each subscale and each of his other two ratings were used to measure the change in stimulation and sedation during the rising and falling limbs of the BAC curve. A positive change represents an increase in intensity compared to baseline (e.g. increased stimulation or sedation) and a negative change represents a decrease in intensity (e.g. decreased stimulation or sedation). The mean (SD) changes in each subscale rating during rising and falling BACs are presented in Appendix J-2, Table 1.

Changes in ratings of stimulation or sedation under alcohol and placebo were measured in order to explore the possibility that they may relate to changes in task performance.

Because alcohol impaired RT on valid trials on the endogenous tasks, the change in RT on the valid trials of Task A was used to evaluate performance.

Correlations between these subjective and behavioural measures were calculated for each limb, separately for each group and subscale. The entire set of correlations are presented in Appendix J-2, Table 2. No significant correlations were obtained between changes in stimulation rating and RT on Task A for either group (p-values ranged from 0.283 to 0.822). Similarly, no correlations between changes in sedation and RT were significant (p-values ranged from 0.265 to 0.623).

The relation between changes in ratings of subjective effects and changes in RT to valid trials was also explored by hierarchical regression analyses. The possibility that an increase in stimulation during rising BACs might be associated with less impairment (i.e. less slowing in RT) was tested using participants' mean change in RT on Task A during the rising limb of the BAC curve as the dependent measure. Group (A and P) was treated as a categorical variable and was entered in the first step of the regression analysis to account for the amount of variance in RT that was due to the effect of alcohol versus placebo. Change in stimulation rating during rising BACs was entered next as a continuous variable in order to test whether this accounted for a significant amount of additional variance in participants' change in RT (Step 2). The group x rating interaction was entered last to determine its unique contribution to the variance in RT that was not accounted for by the main effects of group and change in stimulation rating (Step 3) (Cohen and Cohen, 1975, p.302). The results of the analysis are presented in Appendix J-2, Table, 3. Step 1 showed a significant main effect of Group (F=5.713, p=0.023). This finding is consistent with the increased RT under alcohol of Group

A compared with Group P. This group effect accounted for 14.4% of the variance in the change in RT. This result is consistent with other analyses in the thesis that show alcohol increased RT to valid trials on Task A as compared with a placebo. Step 2 revealed no significant effect of stimulation rating (p=0.666) and Step 3 revealed a nonsignificant group x rating interaction (p=0.643). Thus, neither the regression analysis, nor the separate correlations detected any significant relationship between change in ratings of stimulation and change in RT during rising BACs.

A similar hierarchical regression explored the possibility that an increase in ratings of sedation might be associated with greater impairment (i.e. longer RT) during declining BACs (Appendix J-2, Table 4). Step 1 showed a significant main effect of Group (F=7.388, p=0.010) that accounted for 17.9% of the variance in RT measures. This finding again confirmed that alcohol lengthened RT. Steps 2 and 3 revealed no significant effect of sedation rating (p=0.837) or group x rating interaction (p=0.378). Thus, the regression analyses and the separate correlations both showed no significant relationship between the changes in ratings of sedation, and change in RT during declining BACs.

DISCUSSION

This experiment was designed to test the effect of a moderate dose of alcohol on the performance of three covert orienting tasks of attention. A group of social drinkers performed a drug-free test on the set of three tasks. Two more tests were administered after alcohol was received. One occurred while BAC was rising, and the other occurred while BAC was declining. The order in which the tasks were performed during a test was counterbalanced within the group, so that each task was tested at the same average BAC. This procedure controlled for differences among individuals in the ability to perform the tasks, and sensitivity to alcohol. Another group that received a placebo was treated identically in order to control for the expectation of receiving alcohol.

The study tested four hypotheses regarding the effects of alcohol on covert orienting, using an exogenous task, and two endogenous tasks that differed in the amount of information processing required by the cues for the target. The first hypothesis focussed on the RT to valid trials and predicted that performance on the endogenous Number and Arithmetic tasks, which required cognitive decoding of the cues, would be impaired (lengthened) to a greater degree under alcohol than would be performance on the original exogenous task, which was more reflexive in nature. This hypothesis was supported. RT on the Number and Arithmetic tasks was lengthened by alcohol, whereas the RT on the exogenous task was not significantly changed. In addition, the change in RT under alcohol significantly differed from placebo on the endogenous tasks. RT became longer under alcohol and shorter under placebo. Thus, alcohol had no significant impact on reflexive exogenous orienting where attention was drawn to the target location by the cue. In contrast, orienting that required cognitive decoding of the

valid cues and a controlled shift of attention to the target location was impaired by alcohol.

The second hypothesis predicted that valid trials on endogenous tasks with cues that required greater cognitive processing should be more impaired by alcohol. Thus, RT to valid trials on the Arithmetic task was hypothesized to be more impaired, that is lengthened to a greater degree under alcohol, compared to the Number task. The results failed to support this hypothesis. The intensity of the alcohol impairment on valid trials did not differ between the two endogenous tasks, even though the Arithmetic task presented cues that required more information processing. This result might be considered to indicate that there was little difference in the amount of information processing required by the two endogenous tasks. However, this seems unlikely because the actual speed of RT on the tasks was consistent with the degree of information processing entailed in the tasks (i.e., RT on the Number task was shorter than on the Arithmetic task). This was demonstrated in the preliminary experiment and the present experiment, and suggests a robust and reliable difference in the processing requirements of the tasks. If alcohol were affecting the tasks as a function of the amount of information processing involved, there should at least have been a trend for greater impairment (a greater slowing in RT) on the Arithmetic task than on the Number task. However, no indication of any such trend was observed. Future research could examine whether tasks showing a greater difference in information processing demands drug-free, continue to show the same pattern of results found in the present research.

A number of possible explanations might be suggested to explain why the degree of impairment induced by alcohol on valid trials did not relate to the amount of information processing involved in the two endogenous tasks. It might be that the depressing effect of a

dose of alcohol exerts a fairly constant reduction in information processing, slowing it by the same amount regardless of how much processing the task cues require. The findings on the endogenous tasks show that some amount of information processing is required before alcohol will impair performance on the task. It is also possible that the degree of impairment might depend on the size of the dose, rather than the amount of information processing entailed in the task. This speculation could be evaluated by other research testing the effect of different doses of alcohol on endogenous orienting tasks that range widely in the degree of information processing required by the cues.

A third set of hypotheses concerned the effect of alcohol on RT to invalid trials. Invalid cues direct attention to an incorrect target location, and RT measures the time to disengage and shift attention from that location to the target when it is presented. Although cues in the exogenous task required no information processing and cues in the endogenous tasks presented information that had to be decoded, alcohol did not significantly affect RT to invalid trials on either type of task. No impairment was evident, and the RT of alcohol and placebo groups did not differ. Thus the results from invalid trials suggest that the disengage/shift component of attention is resistant to the effect of a moderate dose of alcohol, regardless of whether invalid cues require information processing.

The fourth hypothesis involved no-cue trials. Since these trials were identical across tasks and primarily involved a fairly reflexive capture of attention by the presentation of the target, alcohol was not expected to significantly affect RT to no-cue trials on any of the tasks. The results confirmed that performance on these trials was not impaired by alcohol for any task, and did not differ between alcohol and placebo.

In summary, the results showed that a moderate dose of alcohol had no significant effect on the exogenous task where the presentation of cues and targets fairly reflexively drew attention. In contrast, the performance of endogenous tasks was impaired by alcohol, and this effect was specific to valid trials, where cues convey correct information about the target location that must be decoded. Alcohol failed to affect RT to invalid trials on any task. These trials also presented informative cues about the target location, but the information was incorrect, and attention had to be shifted to the correct position when the target appeared.

Endogenous tasks, such as Tasks N and A, are thought to involve "controlled" processes where the information provided by the cue must be cognitively processed and decoded before it can be utilized. In contrast, exogenous tasks, such as Task O, have long been thought to involve more reflexive processes where attention is primarily drawn to the location of the cue once it appears. The fact that RTs on valid trials were only affected by alcohol on the endogenous tasks, suggests that only this controlled mode of processing information is affected by a moderate dose of alcohol. On valid trials in the endogenous tasks, attention is cued by information about the target location and is shifted to that position so that the target can simply be identified and responded to when it appears. Although invalid cues in these tasks are identical in nature to those presented on valid trials, the information provided by the cues is incorrect. Thus, attention is cued to the wrong location, and when the target suddenly appears in an unexpected place, attention must be shifted to that location before a response can be made. This additional disengage/shift component of invalid trials may be an important consideration in explaining why alcohol only impaired RT on valid trials on the endogenous tasks. It has been suggested that the abrupt onset of the target in an unexpected

location essentially interrupts the more controlled, voluntary shifting of attention to the cue, and elicits a reflexive orienting response which is more effective in drawing attention than is an incorrect cue (e.g. Muller & Rabbitt, 1989; Yantis & Johnston, 1990). This more reflexive mode of processing involved in invalid trials would also be expected to occur for no-cue trials, where attention is drawn by the sudden appearance of the target. The results of the experiment are in accord with this proposal because there was no significant effect of alcohol on RT to no-cue trials or invalid trials. The lack of impairment of RT to invalid and no-cue trials under alcohol is consistent with the notion that attention tasks that only involve a more controlled mode of processing are impaired by alcohol.

Although a controlled mode of processing might account for the different effect of alcohol on valid and invalid trials on endogenous tasks, it is also possible that the effect of the drug may be contributing to the selective disruption of performance on valid trials, and the resistance to impairment on invalid trials. Many drinkers mentioned that it was more difficult to concentrate on the task under alcohol. If alcohol reduced the ability to maintain concentration, drinkers may not have always attended to the cues or their information when endogenous tasks were being performed. It seems unlikely that drinkers were unable to use the endogenous cues at all, because the actual RT to valid trials under alcohol still appeared to be shorter than RT to invalid and no-cue trials. This suggests that at least some of the endogenous cues were utilized. It seems more likely that occasional lapses, rather than a consistent failure in the use of endogenous cues occurred. If occasional lapses in concentration occurred on a valid trial, RT to the target on endogenous tasks would be longer because participants would be responding to the target without having the benefit of the

correct information about the target location conveyed by the cue. However, a failure to maintain concentration on an invalid trial would be unlikely to affect RT because the cue only provided misleading and incorrect information about the position of the target. The RT to valid and invalid trials on the exogenous task would not likely be affected because the cue required no information processing, and operated similarly to the target in that attention was drawn to their sudden appearance.

The possibility that the slowing of RT on the covert orienting tasks under alcohol was related to subjective feelings of stimulation and sedation was explored through the use of the BAES. Previous research using this scale has shown that drinkers who have consumed a moderate dose of alcohol report greater feelings of stimulation than sedation when BAC is rising, and greater feelings of sedation than stimulation when BAC is declining (Martin et al., 1993). These stimulation and sedation ratings have been attributed to the effect of the drug. However, research had not compared these ratings to those of a placebo group who expected alcohol, nor had ratings under alcohol been adjusted for drinkers' drug-free baseline reports of stimulation or sedation. The present experiment addressed these concerns by administering the scale three times: prior to treatment, to obtain a baseline measure of stimulation and sedation; after the first test on the tasks under alcohol, when BAC was rising; and after the second test under alcohol, while BAC was declining. Ratings on the BAES under alcohol were consistent with those of Martin et al.(1993) such that participants who received alcohol rated stimulation higher than sedation on the rising limb of the BAC curve, whereas sedation was rated higher than stimulation on the falling limb of the BAC curve. These subjective experiences appear to reflect the drug effect because the ratings of stimulation and sedation in the group who

expected alcohol but received a placebo remained fairly stable.

Because the impairing effect of alcohol on RT was specific to valid trials on endogenous tasks, Task A was used to explore the possibility that the degree of impairment (slowing of RT) on these valid trials was related to changes in drinkers' subjective ratings of stimulation or sedation while BACs were rising (test 1) or declining (test 2). The change in each drinker's reported stimulation or sedation from his baseline rating was measured to examine the possibility that those who reported a greater increase in feelings of stimulation during rising BACs might have been more resistant to the slowing effect of alcohol, and thus show less slowing of RT under alcohol. Conversely, those who reported a greater increase in feelings of sedation during falling BACs may be more impaired and display a greater slowing of RT under alcohol. The results provided no evidence for any such relationships. Thus, this research suggests that subjective ratings of stimulation or sedation under alcohol are not related to impairment of drinkers' performance on this covert orienting task.

GENERAL DISCUSSION

Alcohol consumption has been associated with a significant increase in accident risk, and failures of attention have been implicated as one type of error that leads to driving accidents. Considerable research has attempted to clarify the effects of alcohol on attention by using vigilance and divided attention tasks. However, these tasks are often complex, involving a number of different cognitive processes. The review of the literature indicates that the results have been inconsistent, possibly because of methodological differences in the studies, variations in the complexity of the task stimuli or responses, the involvement of different types of cognitive processes or the amount of information processing required to perform the various tasks. Rather than testing the effect of alcohol on such tasks, research in this thesis used an experimental paradigm specifically designed to assess a particular attentional process (covert orienting). The influence of information processing on covert orienting was tested by the use of exogenous and endogenous cues. The utilization of endogenous and exogenous stimulus cues allowed a manipulation of the amount of information conveyed by the stimulus cues without changing the response requirements of the tasks. Each participant was tested on exogenous and endogenous covert orienting, and both types of tasks were performed at similar rising and declining BACs. This within-subjects design served to control for individual differences in covert orienting and BACs when the tests occurred.

The findings from the valid orienting cues showed that a reflexive exogenous orienting task was resistant to the effects of alcohol. However, when more conscious, controlled cognitive processes were required (i.e., the two endogenous tasks), impairment of orienting attention to a visual stimulus was observed. Interestingly, the hypothesis that greater

impairment would be observed for tasks that required greater information processing was not supported, and there was no trend in the data suggesting this was the case. The results suggest that impairment under alcohol is not simply a function of the amount of information processing required, as measured by reaction time.

The idea of using tasks developed in Cognitive Science to investigate the impairing effects of alcohol on particular cognitive processes is a fairly recent development in the alcohol research literature and the potential promise of using such tasks is starting to gain recognition. When the thesis research began there were no published studies examining the effects of alcohol on exogenous and endogenous covert orienting. Since then, two studies have been published that examined performance on covert orienting tasks under alcohol.

One study used an exogenous covert orienting task, similar to that used in the present research, to examine the effect of 0.78 g/kg of alcohol on performance at shorter SOAs (Post, Chaderjian & Maddock, 2000). A test on the task under alcohol occurred at an average BAC of 75 mg/100ml, on the falling limb of the curve. In accord with the results of the present thesis, these researchers found no significant impairing effect of alcohol on RT to valid trials on their exogenous task.

A second study examined the effect of alcohol on a divided attention task and an endogenous orienting task that used a central arrow cue to signal an impending target (Schulte et al., 2001). Participants performed both tasks under a dose of alcohol that achieved a peak BAC of 50 mg/100ml, which is considerably lower than in the present research. The task included only valid and invalid trials. The results were examined using a pre-post change in the difference between the RTs of valid and invalid trials, rather than change in actual RT to each

of the valid and invalid cues. These measures make it difficult to directly compare the results to those of the present thesis that measured the actual change in RT in each cue condition. Nevertheless, Schulte and colleagues (2001) also concluded that alcohol impaired performance on endogenous orienting compared to placebo.

These studies indicate the potential of covert orienting tasks for developing further understanding of the effects of alcohol on attention. The use of an exogenous and two endogenous covert orienting tasks in the present research further demonstrates how this paradigm may identify what aspects of visual attention are impaired by alcohol, and how other factors, such as information processing and subjective feelings of stimulation or sedation, may interact with the drug to affect the impairment of attention.

To date, there has been no research directly examining the role of mode of processing in the impairing effects of alcohol on the covert orienting of attention. The findings of the present research suggest that this may be a particularly important factor to investigate in future alcohol research in this area. Others have also speculated about the role of mode of processing in the effects of alcohol on various other tasks (e.g., Fisk & Schneider, 1982; Newman, Speak, Armstrong & Tiplady, 1997). These authors suggest that tasks which require the controlled processing of information are more readily disrupted by alcohol than are tasks in which performance is more reflexive. They note that "real world" skills that may be considered primarily reflexive, seem to be less likely to be affected by alcohol (Fisk & Schneider, 1982; Huntley, 1973). In his 1995 review on the effect of moderate doses of alcohol on various types of tasks, Holloway also suggested that tasks involving controlled performance might be more sensitive to the effects of alcohol than those involving automatic performance, such as

simple/choice RT. Holloway noted that these observations were trends only, that the studies he examined were not designed to test this theory, and that the use of different tasks and methodological problems prevented any conclusive statement. The present research allowed a direct comparison of the effect of alcohol on these two processing modes within one paradigm, and provides evidence that Holloway's speculations are consistent with the effects of alcohol on the covert orienting of attention.

The suggestion that endogenous orienting is a controlled and effortful process whereas exogenous orienting is more reflexive was empirically supported by a recent study that used functional Magnetic Resonance Imaging (fMRI) techniques to examine which areas of the brain are activated in endogenous compared to exogenous orienting (Rosen et al., 1999). The results showed that the total volume of activated brain tissue evoked by endogenous orienting was nearly double and triple that evoked by the exogenous and control conditions, respectively. In addition, the study showed that the right dorsolateral prefrontal area (or DLPF, BA 46) was selectively activated by the endogenous condition and not the exogenous condition. The authors note that this area is commonly associated with spatial working memory. The endogenous orienting condition in this study and the present thesis involved attending to and holding in memory the location of a target based on a predictive cue. The fMRI research and the results of this thesis raise the possibility that brain areas used for spatial working memory may be particularly impacted by alcohol. However, such a conclusion would require research that specifically examines brain functioning during orienting tasks both drug-free and under alcohol. The potential promise of such investigations is also suggested by an incidental observation by Schulte and colleagues (2001). Their comments suggested that

alcohol resulted in reduced leftward and improved rightward spatial orienting on their endogenous orienting task. This observation further highlights the usefulness of the covert orienting paradigm for understanding the effects of alcohol on attention and indicates the potential benefit of studies involving both imaging and behavioural methodologies.

Alcohol and Endogenous Covert Orienting

The idea that an impairment of spatial working memory may account for the reduced performance under alcohol observed on the valid trials of the endogenous tasks is intriguing and seems to fit with the pattern of results shown in the present research. The fMRI research did not find activation in spatial working memory areas of the brain for the exogenous task, suggesting that this may have been the case in the present study, as well. In contrast, spatial working memory areas were activated by the endogenous orienting task. While the two endogenous tasks in the present study differed from each other in the amount of information processing required to make use of the cue, the spatial working memory requirements (e.g., attending to and keeping a target location in memory based on a predictive cue) may have been identical for the two tasks. This might account for the similar degree of impairment on the valid trials of the two endogenous tasks. Thus, the difference in actual RT between the two tasks remained the same after treatment, continuing to reflect the time it takes to process different amounts of information, but the impairment of spatial working memory may account for the similar degree of impairment observed under alcohol. While the invalid trials also involved spatial working memory, the ability to attend to and keep the target location in memory was not relevant to overall task performance, because the predictive cue was false and provided no useful spatial information. Even though spatial working memory may have been

impaired, this would not have affected task performance on invalid trials. At present, this explanation has yet to be tested. However, some evidence suggests that working memory is impaired by alcohol in humans (e.g., Finn et al., 1999), and rats (e.g., Gibson, 1985). An interesting study for future research may be to examine performance, within a given participant, on the endogenous tasks in relation to performance on a task known to specifically tap spatial working memory, such as the spatial span subtest of the Wechsler Memory Scale (WMS-III). A relationship between the degree of alcohol impairment demonstrated on the covert orienting task and on the spatial span task would support a working memory interpretation of the drug effect.

The RT of the placebo group to the valid endogenous trials of the Arithmetic task raises some interesting questions. This task presented cues that required the most information processing, and the RT to these valid trials became shorter under placebo treatment tests. These observations raise the possibility that learning through practice facilitates endogenous covert orienting to cues that provide correct information requiring processing. This possibility has apparently never been investigated. However, it may be important because the amount of alcohol impairment might be determined by the extent to which an endogenous orienting task has been practised. This could be tested by comparing the degree of impairment shown by people with and without extensive prior practice on this task.

The expectation of receiving alcohol on the part of participants who received a placebo is another factor that might account for their shorter RT to valid trials on the Arithmetic task. Research using motor skill tasks has shown that people who expect to receive alcohol will perform better (faster) under placebo (e.g., Beirness & Vogel-Sprott, 1984). Other research

has shown that drinkers led to expect considerable impairment under alcohol show less impairment on a motor skill task than do others who expect little impairment (Fillmore & Vogel-Sprott, 1996). If participants receiving a placebo expected considerable impairment on this task under alcohol, they may have attempted to compensate by resisting this expected effect, thereby improving their performance over their drug-free baseline level. The effects of expecting to receive alcohol and the expected amount of impairment could be examined by measuring the degree of impairment drinkers expect, and comparing the covert orienting performance of those who neither expect nor receive alcohol to those who expect alcohol but receive a placebo.

The intensity of the effect of alcohol is usually assumed to depend on the blood alcohol concentration, and this is commonly observed in motor skill tasks Under moderate doses of alcohol, impairment of a motor skill task typically waxes and wanes in accord with rising and declining BACs, and the intensity of impairment at a given BAC is usually greater when BAC is rising than when it is declining (e.g., Vogel-Sprott and Fillmore, 1993). However, the degree of impairment in endogenous orienting of attention did not differ during an average rising BAC of 80 mg/100ml (Test 1) or an average declining BAC of 77 mg/100ml (Test 2). The lack of a reduction in impairment at a lower declining BAC seems unusual. It is possible that the difference between the BACs on the two tests was not great enough to generate different degrees in impairment on the endogenous orienting tasks. However, these tasks involve cognitive information processing, and some research testing the effect of alcohol on other cognitive tasks, such as rapid information processing and inhibitory control has also suggested that impairment during rising and declining BACs may not differ (e.g., Fillmore,

Carscadden & Vogel-Sprott, 1998; Fogarty, 2001; Mulvihill, Skilling & Vogel-Sprott, 1997). The design of the present study, with one test under alcohol on each limb of the BAC curve, afforded too few tests to justify concluding that endogenous tasks are insensitive to moderate rising and declining BACs. This possibility could be tested in future research by including tests on the tasks at other points on the curve (e.g., lower BACs) in addition to the tests taken closer to the peak BAC.

The findings of the present research generate a number of new potentially important questions that need to be clarified in order to better understand how other factors may mediate visual endogenous orienting under alcohol. Do lower or higher doses of alcohol yield different results? There is some evidence in research using rats that low doses of alcohol may increase alertness by stimulating extraneuronal noradrenaline (NA) output above the drug-free level, whereas higher doses inhibit NA output (e.g., Rosetti et al., 1992). It is possible that the level of alertness may be related to NA levels, and may play some role in mediating the effect of alcohol on visual orienting.

The possibility that lapses in concentration under alcohol are responsible for the impairment of performance on the endogenous tasks raises the question as to whether performance would improve if participants were given more time to process the endogenous cues. If the lapse in concentration occurs earlier (i.e. during the presentation of the cue) drinkers may be slow to start processing the information. In this case, increasing the SOA may reduce impairment under alcohol by allowing extra processing time. In contrast, if the lapse in concentration occurs later, after the information has been processed, increasing the SOA may further impair RT performance because there would be less likelihood that working memory

would endure long enough to maintain attention at the correct target location.

The main purpose of this thesis was to determine whether and what type of effect a moderate dose of alcohol had on covert orienting of attention when information processing demands were manipulated. For this reason, the sample of participants was chosen to be as homogeneous as possible in age, drinking habits, and gender. Given the interesting findings of this research, it will be important to determine whether they also apply to females and social drinkers older than 22 years of age.

There is also evidence that experienced drinkers (e.g. those who have been drinking regularly for a long time) typically show fewer behavioural effects to a dose of alcohol than do novice drinkers (e.g. Fillmore & Vogel-Sprott, 1996). The present research used relatively young social drinkers from a university population. As such, these participants may tend to have less drinking experience than older drinkers. It would be important to know whether age-matched social drinkers who differ in the length of time they have been drinking differ in their susceptibility to the impairing effects of alcohol on endogenous orienting tasks, or whether the degree of impairment is consistent regardless of the degree to which social drinkers are accustomed to alcohol. Identifying such potential individual differences in vulnerability to the impairment of visual orienting by alcohol could be particularly important in helping to understand who may be at greater risk for alcohol-related accidents when tasks involving the orienting of attention are performed.

The effect of other factors, such as environmental reinforcement and motivation on covert orienting under alcohol has not been investigated. This is an important gap in knowledge because research using a motor task that involves driving skills has found that

environmental reward for a sober standard of behaviour lessens the impairing effects of a moderate dose of alcohol (e.g. Vogel-Sprott, 1992; Vogel-Sprott & Fillmore, 1993). In addition, the reinforcement of a sober standard of performance has also been demonstrated more recently using tests of inhibitory control and information processing (e.g. Fogarty, 2001; Mulvihill, 1999). The present paradigm could serve as a useful tool for manipulating such environmental variables. This type of investigation could help to determine whether reinforcement might protect covert visual orienting from the impairing effects of alcohol

Practical Implications

Informative cues that predict upcoming events are a common occurrence in daily life and are necessary to function well in a variety of situations. For example, negotiating unfamiliar areas or responding to potential driving hazzards using traffic signs requires one to quickly process the information provided in the sign and then shift attention to the appropriate location. Air traffic controllers frequently use central computer information to help guide planes into and away from busy airports. Factory workers may also be required to accurately process visual information from machines and respond appropriately to another visual area. The results of this study indicate that while people may be able to adequately perform more reflexive tasks under a moderate dose of alcohol without impairment, performance on tasks involving visual cues that must be processed and interpreted before one is able to attend to the appropriate location, may be impaired.

This research showed that the impairment on the two endogenous orienting tasks persisted as blood alcohol concentration began to decline. This is in contrast to the recovery of impairment typically seen with motor tasks as BAC declines. This information is important,

and may be helpful in alerting the public to the dangers of moderate alcohol consumption. The findings also may be useful for making policy decisions regarding the legality of operating machinery at different blood alcohol levels. For example, lingering impairment of the ability to orient to visual stimuli when cognitive processing is required, compared to the time needed for motor skills to recover may have particular importance. Presently, it is illegal to drive a vehicle at BACs above 80 mg/100ml. While basic motor skills may have recovered as BACs decrease below this level, and the ability to reflexively orient attention may be intact, the ability to orient attention to stimuli when cognitive processing is involved may still be impaired. Thus, accidents could still occur when complex tasks involving thought processes and visual orienting (e.g. driving) are undertaken, as impairment in the present research was observed at BAC levels below the legal driving limit. The lack of an observed relationship between subjective feelings of stimulation or sedation and changes in RT under alcohol further complicates this scenario. If internal subjective intoxication cues are used to determine whether one is able to perform a task, and people's subjective experiences of intoxication are unrelated to actual performance, poor decisions may be being made regarding whether or not to perform a specific task. Further research is needed to determine the robustness and generalizability of these findings, and to determine the parameters within which they occur.

Summary

The present research showed that performance on a reflexive attention task that involved little to no information processing was not impaired by a moderate dose of alcohol. In contrast, performance on two attention tasks that involved conscious, controlled cognitive processing was impaired by alcohol. The amount of information processing involved in the

tasks did not appear to play a significant role in determining the intensity of impairment. Rather the mode of processing (reflexive vs controlled) appeared to be the more important factor in determining alcohol impairment. More specifically, recent findings in neuroimaging research raise the possibility that spatial working memory may be impaired by alcohol on endogenous orienting tasks. Spatial working memory tasks, by nature, are likely to require an intentional, controlled mode of processing. Thus, this idea is consistent with the finding that the endogenous orienting tasks, which involved a controlled processing mode, were specifically impaired by alcohol. The results of this research have important possible implications for activities performed in the "real world", outside the laboratory.

REFERENCES

Allport, A. (1989). Visual Attention. In: M. Posner (Ed.), Foundations of Cognitive Science (pp. 631-682). Cambridge, Massachusettes: The MIT Press.

Asknes, E. (1954). Effects of small doses of alcohol upon performance in a link trainer. Journal of Aviation Medicine, 25, 680-688.

Beirness, D., & Vogel-Sprott, M. (1984). Alcohol tolerance in social drinkers: Operant and classical conditioning effects. Psychopharmacology, 84 (3), 393-397.

Borges, G., Cherpitel, C., & Rosovsky, H. (1998). Male drinking and violence-related injury in the emergency room. Addiction, 93 (1), 103-112.

Bjerver, K., & Boldberg, L. (1950). Effect of alcohol ingestion on driving ability: Results of practical road tests and laboratory experiments. Quarterly Journal of Studies on Alcohol, 11, 1-30.

Bushman, B., & Cooper, H. (1990). Effects of alcohol on human aggression: An integrative research review. Psychological Bulletin, 107 (3), 341-354.

Cherpitel, C. (1999). Emergency room and primary care services utilization and associated alcohol and drug use in the United States general population. Alcohol & Alcoholism, 34 (4), 581-589.

Cherpitel, C. (1996). Drinking patterns and problems and drinking in the event: An analysis of injury by cause among casualty patients. Alcoholism: Clinical & Experimental Research, 20 (6),1130-1137.

Cherpitel, C. (1994). Injury and the role of alcohol: County-wide emergency room data. Alcoholism: Clinical & Experimental Research, 18 (3), 679-684.

Cherpitel, C. (1992). The epidemiology of alcohol-related trauma. Alcohol Health & Research World, 16 (3), 191-196.

Chiles, D., & Jennings, A. (1970). Effects of alcohol on complex performance. Human Factors, 12 (6), 605-612.

Cohen, J., & Cohen, P. (1975). Applied multiple regression/correlation analysis for the behavioral sciences. Hillsdale, NJ: Erlbaum.

Collins, W., & Chiles, W. (1980). Laboratory performance during acute alcohol intoxication and hangover. Human Factors, 22, 445-62.

DeWit, H., Metz, J., Wagner, N., & Cooper, M. (1990). Behavioral and subjective effects of ethanol: Relationship to cerebral metabolism using PET. Alcoholism: Clinical and Experimental Research, 14 (3), 482-489.

Dildy-Mayfield, J., & Harris, R. (1995). Neurobiology of alcohol's actions and the addictive process. In B. Tabakoff & P. Hoffman (Eds.), Biological aspects of alcoholism: Implications for prevention and policy (vol. 4, pp.189-223). Toronto: Hogrefe & Huber Publishing..

Doweiko, H. (1990). Concepts of chemical dependency. Belmont, CA: Brooks/Cole Publishing Company.

Earlywine, M., & Erblich, J. (1996) A confirmed factor structure for the Biphasic Alcohol Effects Scale. Experimental and Clinical Psychopharmacology, 4 (1), 107-113.

Eckardt, M., File, S., Gessa, G., Grant, K., Guerri, C., Hoffman, P., Kalar, H., Koob, G., Li, T., Tabakoff, B. (1998). Effects of moderate alcohol consumption on the central nervous system. Alcoholism: Clinical and Experimental Research, 22 (5), 998-1040.

Erwin, C., Weiner, E., Linnoila, M., Truscott, T. (1978). Alcohol-induced drowsiness and vigilance performance. Journal of Studies on Alcohol, 39, 505-516.

Feldman, R., Meyer, J., & Quenzer, L. (1997). Principles of neuropsychopharmacology (pp.625-671). Sunderland, MA: Sinauer Associates, Inc.

Fernandez-Duque, D., & Posner, M. (1997). Relating the mechanisms of orienting and alerting. Neuropsychologia, 35(4), 477-486.

Fillmore, M., Carscadden, J., & Vogel-Sprott, M. (1998). Alcohol, cognitive impairment and expectancies. Journal of Studies on Alcohol, 59: 174-179.

Fillmore, M., Mulvihill, L., & Vogel-Sprott, M. (1994). The expected drug and its expected effect interact to determine placebo responses to alcohol and caffeine. Psychopharmacology, 115, 383-388.

Fillmore, M. & Vogel-Sprott, M. (1996). Evidence that expectancies mediate behavioural impairment under alcohol. Journal of Studies on Alcohol, 57(6), 598-603.

Fillmore, M., & Vogel-Sprott, M. (1995). Expectancies about alcohol-induced motor impairment predict individual differences in responses to alcohol and placebo. Journal of Studies on Alcohol, 56, 90-98.

Finnigan, F., & Hammersley, R. (1992). The effects of alcohol on performance. In D.M. Jones, & A.P. Smith (Eds.), Handbook of human performance. (pp.73-126). London: Academic Press Ltd.

Finn, P., Justus, A., Mazas, C., & Steinmetz, A. (1999). Working memory, executive processes and the effects of alcohol on go/no-go learning: Testing a model of behavioral regulation and impulsivity. Psychopharmacology. Special Issue: Impulsivity, 146 (4), 465-472.

Fisk, A., & Schneider, W. (1982). Type of task practice and time-sharing activities predict performance deficits due to alcohol ingestion. In: Proceedings of the human factors society 26th annual meeting (pp.926-930). Santa Monica, California: Human Factors Society.

Fogarty, J. (2001). Cognitive and motor skills differ in sensitivity to alcohol impairment. Unpublished Ph.D. Thesis.

Folk, C., Remington, R., & Johnston, J. (1992). Involuntary covert orienting is contingent on attentional control settings. Journal of Experimental Psychology: Human Perception and Performance, 18 (4), 1030-1044.

Foo, H., & Lemon, J. (1997). Acute effects of kava, alone or in combination with alcohol, on subjective measures of impairment and intoxication and on cognitive performance. Drug and Alcohol Review, 16, 147-155.

Gibson, W. (1985). Effect of alcohol on radial maze performance in rats. Physiology & Behavior, 35 (6), 1003-1005.

Gustafson, R. (1986). Alcohol and vigilance performance: Effect of small doses of alcohol on simple visual reaction time. Perceptual and Motor Skills, 62, 951-955.

Henderson, M., & MacQuistan, A. (1993). The spatial distribution of attention following an exogenous cue. Perception & Psychophysics, 53 (2), 221-230.

Hindmarch, I. (1980). Psychomotor function and psychoactive drugs. British Journal of Clinical Pharmacology, 10, 189-209.

Hindmarch, I., Kerr, J., & Sherwood, N. (1991). The effects of alcohol and other drugs on psychomotor performance and cognitive function. Alcohol and Alcoholism, 26, 71-79.

Holloway, F. (1995). Low-dose alcohol effects on human behavior and performance. Alcohol, Drugs and Driving, 11 (1), 39-56.

Howell, D. (1992). Statistical methods for psychology (3rd ed.). Belmont, California: Duxbury Press.

Hunt, W. (1993). Neuroscience Research: How has it contributed to our understanding of alcohol abuse and alcoholism? A review. Alcoholism: Clinical and Experimental Research, 17 (5), 1055-1065.

Huntley, M. (1973). Alcohol influences upon closed-course driving performance. Journal of Safety Research, 5, 149-164.

Johnston, W., & Dark, V. (1986). Selective attention. Annual Review of Psychology, 37, 43-75.

Jones, B., & Jones, M. (1976). States of consciousness and alcohol. Alcohol Health and Research World, Fall, 10-15, as cited in Giancola, P., Reagin, C., van Weenen, R., & Zeichner, A. (1998). Alcohol-induced stimulation and sedation: Relation to physical aggression. The Journal of General Psychology, 125 (4), 297-304.

Jonides, J. (1981). Voluntary versus automatic control over the mind's eye movement. In: J. Long & A. Baddeley (Eds.), Attention and Performance IX (pp.187-203). Hillsdale, NJ: Erlbaum.

Kerr, J., & Hindmarch, I. (1998). The effects of alcohol alone or in combination with other drugs on information processing, task performance and subjective responses. Human Psychopharmacology, 13, 1-9.

Klein, R. (1994). Perceptual-motor expectancies interact with covert visual orienting under conditions of endogenous but not exogenous control. Canadian Journal of Experimental Psychology, 48 (2), 167-181.

Klein, R., & Hansen, E. (1990). Chronometric analysis of apparent spotlight failure in endogenous visual orienting. Journal of Experimental Psychology: Human Perception and Performance, 16 (4), 790-801.

Klein, R., & Hansen, E. (1987). Spotlight failure in covert visual orienting. Bulletin of the Psychonomic Society, 25 (6), 447-450.

Koelega, H. (1995). Alcohol and vigilance performance: A review. Psychopharmacology, 118, 233-249.

Lamb, M, & Robertson, L. (1987). Effect of acute alcohol on attention and the processing of hierarchical patterns. Alcoholism: Clinical and Experimental Research, 11 (3), 243-248.

Lemon, J., Chesher, G., Fox, A., Greeley, J., & Nabke, C. (1993). Investigation of the "hangover" effects of an acute dose of alcohol on psychomotor performance. Alcoholism: Clinical and Experimental Research, 17 (3), 665-668.

Linnoila, M., Erwin, C., Cleveland, W., Logue, P., & Gentry, W. (1978). Effects of alcohol on psychomotor performance of men and women. Journal of Studies on Alcohol, 39 (5), 745-758.

Linnoila, M., Stapleton, J., Lister, R., Guthrie, S., & Eckardt, M. (1986). Effects of alcohol on accident risk. Pathologist, 40, 36-41.

Marks, D , MacAvoy, M. (1989). Divided attention performance in cannabis users and non-users following alcohol and cannabis separately and in combination. Psychopharmacology, 99, 397-401.

Martin, C., Earleywine, M., Musty, R., Perrine, M., & Swift, R. (1993). Development and validation for the biphasic alcohol effects scale. Alcoholism: Clinical and Experimental Research, 17 (1), 140-146.

Maylor, E., & Rabbitt, P. (1993). Alcohol, reaction time and memory: A meta-analysis. British Journal of Psychology, 84, 301-317.

Maylor, E., Rabbitt, P., James, G., & Kerr, S. (1992). Effects of alcohol, practice, and task complexity on reaction time distributions. The Quarterly Journal of Experimental Psychology, 44A (1), 119-139.

Maylor, E., Rabbitt, P., James, G., & Kerr, S. (1990). Effects of alcohol and extended practice on divided-attention performance. Perception and Psychophysics, 48 (5), 445-452.

McCormick, P (1997). Orienting attention without awareness. Journal of Experimental Psychology: Human Perception and Performance, 23 (1), 168-180.

McKim, W. (1996). Drugs and behavior: An introduction to behavioral pharmacology (3rd ed.). Toronto: Prentice Hall Canada Inc.

Millar, K., Finnigan, F., & Hammersley, R. (1999). Is residual impairment after alcohol an effect of repeated performance? Aviation, Space and Environmental Medicine, 70 (2), 124-130.

Mitchell, M. (1985). Alcohol-Induced impairment of central nervous system function: Behavioral skills involved in driving. Journal of Studies on Alcohol, Suppl. 10, 109-116.

Morrow, D., Leirer, V., & Yesavage, J. (1990). The influence of alcohol and aging on radio communication during flight. Aviation, Space and Environmental Medicine, 61, 12-20.

Morrow, D., Leirer, V., Yesavage, J., & Tinklenberg, J. (1991). Alcohol, age, and piloting: Judgment, mood and actual performance. International Journal of Addictions, 26, 669-83.

Morrow, D., Yesavage, J., Leirer, V., Dolhert, N., Taylor, J., Tinklenberg, J. (1993). The time-course of alcohol impairment of general aviation pilot performance in a frasca simulator. Aviation, Space, and Environmental Medicine, 64, 697-705.

Moskowitz, H. (1984). Attention tasks as skills performance measures of drug effects. British Journal of Clinical Pharmacology, 18, 51S-61S.

Moskowitz, H., & Burns, M. (1981). The effect of alcohol and caffeine, alone and in combination on skills performance. Cited in Moskowitz, H. (1984). Attention tasks as skills performance measures of drug effects. Journal of Clinical Pharmacology, 18, 51S-61S.

Moskowitz, H., & Sharma, S. (1974). Effects of alcohol on peripheral vision as a function of attention. Human Factors, 16, 174-180

Muller, H., & Rabbitt, P. (1989). Reflexive and voluntary orienting of visual attention: Time course of activation and resistance to interruption. Journal of Experimental Psychology: Human Perception and Performance, 15, 315-330.

Mulvihill, L. (1999). Behavioural inhibition under alcohol, effects of reinforcement and the setting. Unpublished Ph.D. Thesis.

Mulvihill, L., Skilling, T., & Vogel-Sprott, M. (1997). Alcohol and the ability to inhibit behavior in men and women. Journal of Studies on Alcohol, 58, 600-605.

National Institute on Alcohol Abuse and Alcoholism, U.S. Department of Health and Human Services. (1999). Alcohol and the workplace. Alcohol Alert, No.44. Rockville, MD.

National Institute on Alcohol Abuse and Alcoholism, U.S. Department of Health and Human Services. (1997). Youth drinking: Risk factors and consequences, Alcohol Alert, No.37. Rockville, MD.

National Institute on Alcohol Abuse and Alcoholism, U.S. Department of Health and Human Services. (1996). Drinking and driving, Alcohol Alert, No.31. Rockville, MD.

National Institute on Alcohol Abuse and Alcoholism, U.S. Department of Health and Human Services. (1994). Alcohol related impairment. Alcohol Alert, No.25. Rockville, MD.

Newman, D, Speake, D., Armstrong, P., & Tiplady, B. (1997). Effects of ethanol on control of attention. Human Psychopharmacology, 12, 235-241.

Posner, M. (1980). Orienting of attention. Quarterly Journal of Experimental Psychology, 32, 3-25.

Posner, M., & Cohen, Y. (1984). Components of visual orienting. In H. Bouma & D Bouwhuis (Eds.), Attention and Performance X (pp.531-556). London: Lawrence Erlbaum & Associates.

Posner, M., Nissen, M., & Ogden, W. (1978). Attended and unattended processing modes: The role of set for spatial location. In: H. Pick & B. Saltzman (Eds.), Modes of Perceiving and Processing Information (pp.137-157). Hillsdale, NJ: Erlbaum.

Posner, M., & Raichle, M. (1997). Images of Mind. New York, NY: Scientific American Library.

Posner, M., & Petersen, S. (1990). The attention system of the human brain. Annual Review of Neuroscience, 13, 25-42.

Posner, M., Snyder, C., & Davidson, B. (1980). Attention and the detection of signals. Journal of experimental psychology: General, 109 (2), 160-174.

Posner, M., Walker, J., Friedrich, F., & Rafal, R. (1984). Effects of parietal injury on covert orienting of attention. The Journal of Neuroscience, 4 (7), 1863-1874.

Post, R., Chaderjian, M., & Maddock, R. (2000). Effect of alcohol on exogenous precueing of attention. Journal of Studies on Alcohol, 61 (2), 232-238.

Rafal, R., Calabresi, P., Brennan, C., & Sciolto, T. (1989). Saccade preparation inhibits reorienting to recently attended locations. Journal of Experimental Psychology: Human Perception and Performance, 4, 673-685.

Rall, T. (1991). Hypnotics and Sedatives: Ethanol. In: A., Gillman, C. Goodman, T Rall, C. Nies, & T. Taylor (Eds.), The pharmacological basis of therapeutics (pp.370-382). New York: Pergamon Press.

Rammsayer, T. (1995). Extraversion and alcohol: Eysenck's drug postulate revisited. Neuropsychobiology, 32, 197-207.

Ray, O. (1983). Drugs, society and human behavior (3rd ed.). St. Louis, MO: C. V. Mosby.

Remington, R. (1980). Attention and saccadic eye movements. Journal of Experimental Psychology: Human Perception and Performance, 6 (4), 726-744.

Rohrbaugh, J., Stapleton, J., Parasuraman, R., Frowein, H., Adinoff, B., Varner, J., Zubovic, E., Lane, E., Eckardt, M., & Linnoila, M. (1988). Alcohol intoxication reduces visual sustained attention. Psychopharmacology 96, 442-446.

Rosen, A., Rao, S., Caffarra, P., Scaglioni, A., Bobholz, J., Woodley, S., Hammeke, T., Cunningham, J., Prieto, & T., Binder, J. (1999). Neural basis of endogenous and exogenous spatial orienting: A functional MRI study. Journal of Cognitive Neuroscience, 11(2), 135-152.

Rosetti, Z., Longu, G., Mercuro, G., Hmaidan, Y., & Gessa, G. (1992). Biphasic effect of ethanol on noradrenaline release in the frontal cortex of awake rats. Alcohol & Alcoholism, 27 (5), 477-480.

Schulte, T., Muller-Oehring, E., Strasburger, H., Warzel, H., & Sabel, B. (2001). Acute effects of alcohol on divided and covert attention in men. Psychopharmacology, 154, 61-69.

Schwartz, J., Speed, N., Gross, M., Lucey, M. et al. (1993). Acute effects of alcohol administration on regional cerebral blood flow: The role of acetate. Alcoholism: Clinical & Experimental Research, 17 (6) 1119-1123.

Shepherd, M., & Muller, H. (1989). Movement versus focusing of visual attention. Perception & Psychophysics, 46 (2), 146-154.

Smith, A., Kendrick, A., & Maben, A. (1992). Effects of caffeine, lunch and alcohol on human performance, mood and cardiovascular function. Proceedings of the Nutrition Society, 51, 325-333.

Stephens, C. (1987). Alcohol consumption and casualties: Drinking in the event. Drug & Alcohol Dependence, 20 (2), 115-127.

Talland, G. (1966). Effects of alcohol on performance in continuous attention tasks. Psychosomatic Medicine, 28, 596-604.

Tarnowski, A. (1996). The influence of number of stimuli and motivation on visual attention processes. Polish Psychological Bulletin, 27 (3), 281-289.

Theeuwes, J. (1991). Exogenous and endogenous control of attention: The effect of visual onsets and offsets. Perception and Psychophysics, 49, 83-90.

Van Selst, M., & Jolicoeur, P. (1994). A solution to the effect of sample size on outlier elimination. The Quarterly Journal of Experimental Psychology, 47A (3), 631-650.

Van Zomeren, A., & Brouwer, W. (1994). Clinical neuropsychology of attention (pp.7-62). New York, New York: Oxford University Press.

Vogel-Sprott, M. (1992). Alcohol, tolerance and social drinking: Learning the consequences. New York: Guilford Press.

Vogel-Sprott, M., & Fillmore, M. (1993). Impairment and recovery under repeated doses of alcohol: Effects of response-outcomes. Pharmacology Biochemistry and Behavior, 45, 59-63.

Yantis, S., & Johnston, J. (1990). On the locus of visual selection: Evidence from focused attention tasks. Journal of Experimental Psychology: Human Perception and Performance, 16 (1), 135-149.

Yesavage, J, & Leirer, V. (1986). Hangover effects on aircraft pilots 14 hours after alcohol ingestion: a preliminary report. American Journal of Psychology, 143, 1546-50.

Zador, P. (1991). Alcohol-related relative risk of fatal driver injuries in relation to driver age and sex. Journal of Studies on Alcohol, 52 (4), 302-310.

APPENDICES

Appendix A: Exploratory Studies

Appendix A-1

Exploratory Study 1: Drug-free Evaluation of Task O

The adequacy of the exogenous covert orienting task (Task O) used in the present dissertation was initially examined by testing the performance of four university student volunteers under drug-free conditions. This task was modelled on one described by Fernandez-Duque and Posner (1997), which provided valid and invalid cues that were more centrally located than many exogenous covert orienting tasks, so as to minimize eye movement. The present exploratory study attempted to determine whether the measures in this version of the task replicated the cuing effects observed by Fernandez-Duque and Posner; namely, RT to valid trials was shorter than RT to invalid trials, which was shorter than RT to trials where no cue was presented. This study also examined performance on the task under repeated conditions to determine if task performance changed with practice.

Apparatus and Measures

A computerized covert orienting task was used which measured reaction time to target stimuli after the presentation of visual-spatial warning cues, and when no warning cue was presented. Participants were seated directly in front of a computer screen and keyboard, at a distance of 85 cm from the screen. All stimuli were presented in the center of the visual field to minimize eye movement. A 0.1 cm dot subtending 0.07 degrees of visual angle served as a central fixation point and was presented for 750 ms. On the cue trials, a cue (a 1.28 cm white circle) subtending 0.86 degrees in visual angle, with the center at an eccentricity of 2.17

degrees of visual angle was presented at random intervals of between 600 and 1000 ms following the offset of the fixation point at one of four locations (upper, right, lower, left). The cue remained on the screen for 400 ms, until the target was presented. The target, measuring 1.28 cm, subtending 0.86 degrees in size, with its center at an eccentricity of 1.31 degrees, was either a plus sign (+) or a capital letter x (X). The target was also presented in one of four locations on the screen (upper, right, lower, left), at the same eccentricity for each location. The target remained on the screen until a response key was pressed or 1500 ms had elapsed, at which point a new trial began. Participants were instructed to press the "n" key on the keyboard if the target was a +, and the "m" key if the target was an "X". Participants were instructed to use whichever hand they preferred, but to use two fingers from only one hand. All participants chose to use their right hand Reaction time to the target stimulus was measured in milliseconds (msec).

A total of 112 trials were presented during a block. Fifty-six cue trials were presented in a ratio of approximately 80% valid trials to 20% invalid trials. On a valid trial, the cue and the target were presented in the same location. Forty-four valid trials were presented during a block with 11 trials occurring at each target location (upper, right, lower, left). An invalid trial occurred when the cue and the target occurred at different locations. Twelve invalid trials were presented during a block, with three trials occurring at each target location. No cues were presented on 56 trials. Each of the two target stimuli was presented on an equal number of trials under valid, invalid and no cue conditions.

When they arrived at the laboratory, task instructions were read to participants (Appendix A-2) and they performed an initial set of 20 practice trials. The experimenter

monitored performance on this practice block to ensure that participants understood the instructions and were performing the task correctly. The experimenter then left the room and participants completed three blocks of 112 trials on the task lasting approximately 6 minutes each block, with a 5 minute break between blocks. The experimenter entered the room between blocks to set the computer for the next block of trials.

Results

The results of this exploratory study replicated the findings of Fernandez-Duque and Posner (1997). Reaction time to valid trials was shorter than RT to invalid trials, which was shorter than RT to no cue trials, for all 3 blocks. This study examined only RTs on trials where a correct response to the target was made. The mean RTs (SD) for each cue condition on each block are presented in Table 1. The results also showed that one practice block of trials was necessary before performance on valid and invalid trials became stable.

Table 1: Mean RT and SD (msec.) to Three Cue Conditions on each Block

	Valid		Invalid		No Cue	
	Mean	SD	Mean	SD	Mean	SD
Block 1	450	83.29	464	47.07	473	56.12
Block 2	421	70.95	436	51.99	474	68.37
Block 3	421	57.59	439	43.39	470	80.94

While RT to no cue trials remained relatively stable over the three blocks, RT to trials with valid and invalid cues was considerably longer on block 1, but became stable for blocks 2 and 3. The effect of practice on the first block for the cuing trials indicates that the task involves some learning. This possibility had not been reported previously and it was not clear what was

being learned. It may be that participants needed this practice to learn that the cue predicted the location of the target most of the time (80%) and that it was useful to pay attention to the cue. This information was not explicitly included in the task instructions for the two Exploratory Studies but was subsequently added for the Preliminary and Main Experiments.

Exploratory Study 2: Evaluation of Task O under Alcohol

This study explored the effect of a moderate dose of alcohol on performance. As the effect of a moderate dose of alcohol on performance of this exogenous covert orienting task had never been examined, it was unknown whether RT would be impaired. It was possible that, given the reflexive nature of the exogenous orienting task (similar to basic RT tasks), a moderate dose of alcohol would not affect performance on the task. However, if impairment did occur, it was not known whether this may vary as blood alcohol concentration increased and decreased. As such, tests on the task were scheduled to occur during rising, peak and declining BACs.

Participants

Three male, right-handed volunteers between the ages of 19 and 22 were recruited from a "subject pool" of university students. Initial contact was made by telephone and volunteers were asked if they would agree to participate in a study examining the effect of alcohol on a computerized task (Appendix C-1). Individuals with uncorrected vision problems, or who were currently taking prescription medication were excluded from the study. The participants were paid fifteen dollars for their participation. Ethics approval was obtained for this study from the Office of Human Research of the University of Waterloo.

Apparatus and Measures

The covert orienting task (Task O) was used to measure response reaction time under valid, invalid and no cue conditions.

Blood Alcohol Concentrations (BACs)

Blood alcohol concentrations (BACs) were measured using a Stephenson Model 900A Breathalyzer.

Drinking Habit Questionnaire (Vogel-Sprott, 1992). This questionnaire (Appendix C-3) provided a measure of participants' current use of alcohol in terms of dose (ml absolute alcohol/kg) per drinking occasion, and the weekly frequency of these occasions. Two additional questions asked if participants had ever been convicted for impaired driving, and if they had ever experienced problems due to their drinking. These two questions were included in order to identify and exclude any individual who might have alcohol-related problems.

Procedure

Training Session Participants performed a practice block of trials on the task to ensure that it was learned and performance was stable prior to any treatment. Each participant was tested individually. When they arrived at the laboratory, participants were given a general explanation of the study. Informed Consent was then obtained (Appendix C-2), and the Drinking Habit Questionnaire was completed. Task instructions were then read to participants (Appendix A-2) and they performed an initial set of 20 trials. The experimenter monitored performance on this practice block to ensure that participants understood the instructions and were performing the task correctly. The experimenter then left the room and participants performed one block of 112 trials lasting approximately six minutes. Participants then were

weighed and an appointment was made to return for the treatment session. It was explained that they would be required to abstain from alcohol and other drugs for twenty-four hours prior to the treatment session in order to prevent confounding effects of prior drugs in the participants' bloodstream. In order to standardize the rate of absorption of alcohol, participants were also required to abstain from food and drink, apart from sips of water, for four hours prior to the experimental session and to avoid certain foods during the meal prior to fasting. To assist compliance with the eating and fasting requirements, a menu of permissible and nonpermissible foods prior to fasting (Appendix C-4) was given to all participants.

Treatment Session The treatment session occurred within one week following the training session. At the outset of this session, adherence to the fasting instructions was verbally confirmed and a baseline breath sample was taken to verify that the participant's BAC was zero prior to the session. The task instructions were reviewed and the participant performed an initial set of 20 practice trials, with the experimenter in the room, in order to confirm that the participant remembered how to perform the task. The experimenter then left the participant alone in the room to perform one block of trials (This and all subsequent blocks took approximately six minutes to complete). This block provided a pre-treatment baseline measure of the participants' drug-free performance prior to receiving alcohol. The participant then received 0.62 g/kg of absolute alcohol divided equally into three drinks containing one part alcohol and two parts carbonated mix. Drinks were served at 20 minute intervals, and each drink was consumed within five minutes. A block of trials on the task was performed at 10, 30, 50, 65, 95, 110, and 130 minutes after drinking began. Previous studies with this dose showed that this trial regimen should encompass times when BACs rise to a peak, and begin to

decline slightly. Breath samples to measure BACs were obtained at 20, 40, 60, 70, 90, and 135 minutes after drinking began.

At the conclusion of the treatment trials participants remained in the lab for coffee or tea and snacks, were informed of their current BAC and were told that they should not drive or operate any other machinery for at least several hours. They were debriefed (Appendix C-13) provided with an information letter (Appendix C-14) describing some effects of alcohol on the body and effects of alcohol on behaviour at several BACs, and were provided with transportation home if needed.

Criterion Measures

Reaction time measures for valid, invalid and no-cue trials were obtained for each participant on each test block. Only RTs on trials where a correct response to the target was made, were included in analyses. Reaction time measures obtained from the block of trials prior to receiving alcohol during the treatment session served as drug-free baseline measures. Reaction time measures obtained from the next seven blocks of trials constituted the alcohol treatment measures. To be consistent with the drug-free cognition literature involving such tasks, the data was trimmed for all participants using the non-recursive procedure with moving criterion suggested by Van Selst and Jolicoeur (1994).

Results

Blood Alcohol Concentrations (BAC)

The mean BACs of participants during treatment are presented in Table 1. The means show that the BACs rose to a peak of 86 mg/100 ml at 70 minutes after drinking began and subsequently declined. The first three blocks of trials (at 10, 30 and 50 minutes) occurred

while the BAC was rising, the fourth block occurred during the peak BAC, and the last three blocks (at 95, 110, and 130 minutes) occurred while the BAC was falling.

Table 1: Means and Standard Deviations for Blood Alcohol Concentrations (mg/100ml) As a Function of Time After Drinking Commenced

	Time					
	20	40	60	70	90	135
Mean	29.0	48.0	65.0	86.0	74.0	57.0
(SD)	(16.0)	(11.0)	(9.0)	(38.0)	(12.0)	(4.0)

Reaction Time Analyses

An examination of the mean RT over the eight blocks (Table 2) indicated that performance on valid and invalid trials did not appear to vary systematically over time as blood alcohol concentration changed. However, reaction time to no cue trials increased on the final three blocks of trials, as BAC was falling.

Table 2: Means and Standard Deviations for Reaction Time (msec.) On Valid, Invalid and No-Cue Trials Over 8 Blocks

	Drug-free	B1	B2	B3	B4	B5	B6	B7
Valid								
Mean	414	379	409	419	409	422	424	408
(SD)	(66.59)	(33.81)	(59.73)	(41.44)	(49.04)	(51.19)	(31.40)	(37.66)
Invalid								
Mean	426	426	411	432	442	410	438	414
(SD)	(62.62)	(38.42)	(23.51)	(78.02)	(81.56)	(45.40)	(15.88)	(43.67)
No Cue								
Mean	439	446	455	435	442	468	471	462
(SD)	(48.78)	(36.81)	(34.75)	(34.84)	(32.12)	(14.35)	(14.36)	(22.97)

To explore this, a oneway repeated analysis of variance (ANOVA) was performed for no-cue trials, using the drug-free block, the mean of the RT on the three blocks on the rising limb of the BAC curve, the block at the peak of the BAC curve, and the mean of the RT on the three blocks on the declining limb of the BAC curve. The analysis revealed no significant block effect $F(3,6)=1.978$, $p=0.287$. The mean reaction times on the drug-free, rising, peak, and falling blocks of trials for the three cue conditions are presented in Figure 1. The figure shows that performance varies over time for all three cue types but that this variability does not relate in any logical manner to the blood alcohol concentration curve. Multiple comparisons between the drug-free RT and the rise, peak and fall RTs, respectively, revealed no significant difference between RT at drug-free baseline and RT under treatment at any point on the BAC curve ($ps \geq 0.316$). The same analyses were conducted using valid and invalid trials separately and these analyses also revealed no significant differences in RT under alcohol compared to drug-free performance on this task ($ps \geq 0.465$) see Tables 3-5 for the complete analyses.

Since there was no evidence of any strong effect of the changing BACs on the measures of performance, the results from the treatment blocks were averaged in order to provide a measure of the mean effect of the dose. This provided an opportunity to make some exploratory comparisons between the alcohol treatment group ($n=3$) and the drug-free group ($n=4$) that had previously been tested.

Oneway Analyses of Variance of Reaction Time Drug-Free and at Rising, Peak and Falling BACs

Table 3: Valid Trials

Source	DF	MS	F	p	G-G
Within Subjects					
Block	3	136.356	0.827	0.525	0.465
Error	6	164.880			

G-G Epsilon: 0.370
H-F Epsilon: 0.498

Table 4: Invalid Trials

Source	DF	MS	F	p	G-G
Within Subjects					
Block	3	284.674	0.413	0.750	0.604
Error	6				

G-G Epsilon: 0.379
H-F Epsilon: 0.547

Table 5: No-Cue Trials

Source	DF	MS	F	p	G-G
Within Subjects					
Block	3	483.265	1.978	0.219	0.287
Error	6	244.382			

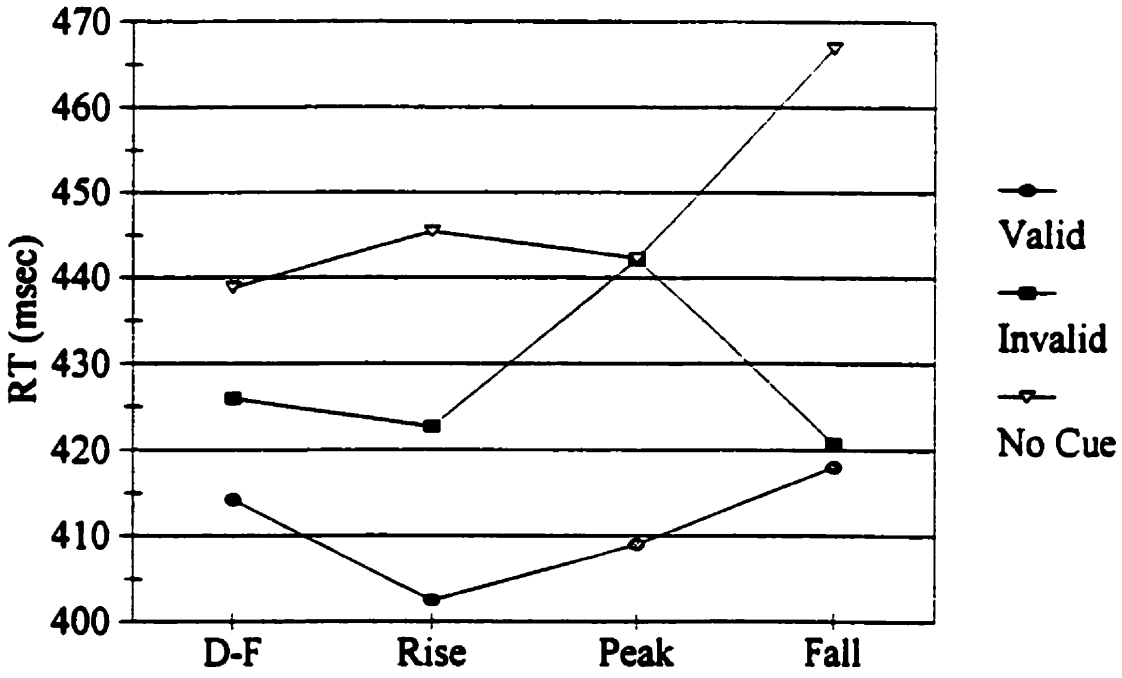
G-G Epsilon: 0.389
H-F Epsilon: 0.598

Contrasts:

Drug-Free vs. Rise				
Hypothesis	1	132.801	0.354	0.612
Error	2	374.934		
Drug-Free vs. Peak				
Hypothesis	1	36.471	0.100	0.781
Error	2	363.391		
Drug-Free vs. Fall				
Hypothesis	1	2381.586	1.762	0.316
Error	2	1351.454		

The control group consisted of the drug-free data from the participants in the first exploratory study who performed three 112 trial blocks during one session. The computer task they performed was identical in every respect to that of the alcohol group. It should be noted that this is not a "true" control group since the participants in this group did not perform the task the same number of times or over the same time period as did those in the alcohol group. These participants were used solely as a preliminary comparison group. For the purposes of the analyses in this study, block two of the control group served as the equivalent of the drug-free baseline block of the alcohol group, and block three of the control group served as the equivalent of the average of the seven treatment blocks of the alcohol group. Block one of the control group was not included in the analyses as performance on this task did not stabilize until one block had been performed. This block is the equivalent of the familiarization block that the alcohol group performed during their first session.

Figure 1: Mean RT for Alcohol Group Over Baseline, Rise, Peak & Fall



An examination of the data revealed that both groups showed the same pattern of responses as that described by Fernandez-Duque and Posner (1997) (RT to valid trials shorter than invalid trials which are shorter than no cue) on the "drug-free" trial, thus making the two groups comparable.

Group Analyses

In order to investigate whether reaction times for the three cue conditions differed under alcohol compared to control, oneway analyses of covariance (ANCOVA) were performed for each cue type on the reaction time scores under treatment for the two groups, with the drug-free trial serving as the covariate. The ANCOVA for valid trials revealed no significant difference between the control and alcohol groups, $F(1,4)=0.233$, $p=0.654$. The analysis of invalid trials also revealed no significant group differences, $F(1,4)=0.112$, $p=0.755$ Similarly, the ANCOVA for no-cue trials revealed no significant difference between the group means, $F(1,4)=1.946$, $p=0.236$. The complete analyses are presented in Tables 6-8 and the adjusted means are presented in Table 9.

Oneway Analyses of Covariance on the Reaction Times under Treatment for Alcohol and Control Groups, with the Drug-Free Trial Serving as the Covariate

Table 6: Valid Trials

Test for Homogeneity of Variance

Source	DF	MS	F	p
Group	1	348.344	0.868	0.420
Covariate	1	12225.979	30.465	0.012
Group X Covariate	1	404.608	1.008	0.389
Error	3	401.307		

ANCOVA

Source	DF	MS	F	p
Group	1	93.833	0.233	0.654
Covariate	1	13378.106	33.268	0.004
Error	4	402.132		

Table 7: Invalid Trials

Test for Homogeneity of Variance

Source	DF	MS	F	p
Group	1	66.545	0.257	0.647
Covariate	1	6233.895	24.047	0.016
Group X Covariate	1	76.979	0.297	0.624
Error	3	259.241		

ANCOVA

Source	DF	MS	F	p
Group	1	23.892	0.112	0.755
Covariate	1	6176.256	28.905	0.006
Error	4	213.675		

Table 8: No-Cue Trials

Test for Homogeneity of Variance

Source	DF	MS	F	p
Group	1	1526.177	8.309	0.063
Covariate	1	8812.688	47.978	0.006
Group X Covariate	1	1304.334	7.101	0.076
Error	3	183.682		

ANCOVA

Source	DF	MS	F	p
Group	1	902.505	1.946	0.236
Covariate	1	16404.085	35.365	0.004
Error	4	463.845		

Table 9: Adjusted Mean Reaction Time for Each Group for Each Cue Condition

	Valid	Invalid	No Cue
Alcohol	410	426	469
Control	417	422	445

A power analysis using the adjusted means from the ANCOVA was performed in order to determine approximately how many participants would need to be tested on the task under alcohol in order to result in a significant difference between the treatment and control groups on no-cue trials, given that the slowing seen during declining BACs for the alcohol group is not an artifact of fatigue. The analysis suggested that a sample size of 14 participants per group would be sufficient to reveal a significant difference between the means of the alcohol and control groups on the no-cue trials (with a power of approximately 0.81).

Conclusion:

Overall, it appears that alcohol does not have a significant effect on performance on this task. The lack of significance obtained from these analyses could be due to the very small sample size. It is possible that a much larger sample size may show a significant difference between the treatment and control groups on the declining BAC limb for no-cue trials. It is also possible that a real control group, with tests occurring on the same time line as the treatment group, may not significantly differ from the treatment group when measurements taken over time are analyzed. The longer reaction times for no cue trials on the declining limb may simply be a function of fatigue. There is no clear indication that alcohol affects

performance on the valid or invalid trials.

It is possible that this task involves primarily reflexive attentive processes, similar to those involved in simple reaction time. Research has suggested that performance on basic reaction time tasks is not typically impaired by alcohol at low to moderate doses (e.g., Linnoila et al., 1978). However, performance on other attention tasks has been impaired under alcohol (i.e., vigilance and divided attention tasks). Many of these tasks are quite complex and involve more information processing than does this basic covert orienting task. The ability to process information may interact with attentional processes when alcohol is involved. Since this covert orienting task generally reproduces the pattern of results that Posner observed with his task, and appears to be relatively impervious to the effects of alcohol, it will provide a useful base from which to examine the effect of manipulating information processing demands on attention.

Appendix A-2

Task Instructions for Exploratory Studies 1 and 2:

I'd like you to watch the screen in front of you. When I start the task, a small circle will briefly appear in the center of the screen. I'd like you to focus on the circle and then press a specific key when a plus sign or an X appears. Whenever you see a plus sign I'd like you to press the n key as fast as you can. Whenever you see an X, I'd like you to press the m key as fast as you can. You may use two fingers from whichever hand you wish to press the keys, but you may only use one hand. You may occasionally see other things on the screen but you should only press the key when you see a + or an X. We'll do a brief practice block first and then you'll run through the real thing.

Appendix B: Preliminary Experiment

Appendix B-1

Introduction

The present study examined the effects of manipulating information processing demands on attentional processes measured by the exogenous covert orienting task (Task O). "Exogenous" refers to a task in which attention is drawn by a peripheral stimulus, such as a light, in the same vicinity as a subsequent target. "Endogenous" refers to a task that typically uses centrally presented cues, such as an arrow, to convey information about the target location. Thus, attention is directed by a cognitively central decision based on processing the information conveyed by the cue. As a result endogenous tasks may slow reaction time (RT) to targets to a greater degree than exogenous tasks. This was tested by devising two endogenous covert orienting tasks using central numerical cues that had to be processed to identify the location of the target. One was a "numerical identification task" (Task N). The other aimed to increase the information processing demands of the numerical cues, and was an "arithmetic task"(Task A). This study tested whether the effects of the three tasks on attentional processes were consistent with a manipulation of information processing in a drug-free state, before performance under alcohol was examined. The following hypotheses were tested:

1. For valid trials, mean RT on Task A should be longer than mean RT on Task N which should be longer than mean RT on Task O.
2. For invalid trials, mean RT on Task A should be longer than mean RT on Task N which should be longer than mean RT on Task O.

3. For no-cue trials, the mean RT may not differ on the three tasks because the absence of any cue makes these trials identical on the tasks.

4. The pattern of performance on Task O should be the same as previously found, with mean RT to valid trials being shorter than mean RT to invalid trials, which should be shorter than mean RT to no-cue trials.

Performance on Tasks N and A may also show this pattern of RT to the three cue conditions, but this will depend on the extent to which the information processing demands of Tasks N and A slow RT to valid and invalid cues.

Method

Participants

Eight male and eight female volunteers between the ages of 18 and 22 (M = 19.94 years, SD = 1.29) were recruited from a "subject pool" of university students. Initial contact was made by telephone and volunteers were asked if they would agree to participate in a study that involved responding to visual-spatial information on a computer screen. All individuals were right-handed, and no one with uncorrected vision problems was included in the study. Participants were paid five dollars for their participation. Ethics approval was obtained for this study from the Office of Human Research of the University of Waterloo.

Apparatus and Measures

1. Original Exogenous Covert Orienting Task (O) A computerized task was used to measure reaction time to target stimuli after the presentation of visual-spatial warning cues, and when no warning cue was presented. This task is based on a paradigm developed by Fernandez-Duque & Posner (1997). Participants were seated directly in front of a computer

screen and keyboard, at a distance of 85 cm from the screen. All stimuli were presented near the centre of the visual field to minimize eye movement. A pictorial representation of the timeline of events during a trial on this task and the others used in the experiment is presented in Figure 1 of the Main Experiment.

A 0.1 cm dot subtending 0.07 degrees of visual angle served as a central fixation point and was presented for random time periods of between 1100 and 1500 ms. On the cue trials, a cue (a 1.28 cm white circle) subtending 0.86 degrees of visual angle, with the centre at an eccentricity of 2.17 degrees of visual angle was presented for 1000 ms immediately following the offset of the fixation point at one of four locations (upper, right, lower, left). The cue remained on the screen until the target was presented. The target, measuring 1.28 cm, subtending 0.86 degrees of visual angle, with its centre at an eccentricity of 1.31 degrees was either a plus sign (+) or a capital letter x (X). The target was also presented in one of four locations on the screen (upper, right, lower, left), at the same eccentricity for each location. The target remained on the screen until a response key was pressed or 1500 ms had elapsed, at which point a blank screen appeared for 1000 ms and then a new trial began. Participants were instructed to press the "n" key on the keyboard if the target was a +, and the "m" key if the target was an "X." They were instructed to use two fingers of one hand, and all used their right hand. Reaction time to the target stimulus was measured in milliseconds (msec.).

Following practice trials, a test on the task consisted of 112 trials. Fifty-six cue trials were presented in a ratio of approximately 80% valid trials to 20% invalid trials. A valid trial occurred when the cue and the target were presented in the same location. An invalid trial presented the target in a different location than the cue. Forty-four valid trials were presented

during a test with 11 trials occurring at each target location (upper, right, lower, left). Twelve invalid trials were presented during a test, with three trials occurring at each target location. No cues were presented on 56 trials. Each of the two target stimuli was presented on an equal number of trials in each cue condition.

2. Endogenous Numerical Identification Task (N) This task was identical to Task O in all respects except for the characteristic and location of the cues. In this task the valid and invalid cues were represented by the numbers one to four that appeared individually in the centre of the screen. The numbers were 0.5 cm in size and subtended 0.34 degrees of visual angle. Each number corresponded to a particular quadrant of the screen. (top=1, right=2, bottom=3, left=4). The quadrant numbers were clearly labeled on the front frame of the computer monitor in 3 centimeter high digits that were placed in the centre of the corresponding part of the monitor frame. On the 44 valid trials, the numerical cue identified the quadrant in which the target would subsequently appear. On the 12 invalid trials, the number incorrectly predicted the quadrant in which the target would appear. The proportion of valid to invalid trials remained the same as in the original task (80% to 20% respectively), and the remaining 56 trials presented no cues.

3. Endogenous Arithmetic Task (A) This task was designed to involve more information processing than Task N. It was identical to Task N except that the cue presented in the centre of the screen to indicate the location of the target was a basic mathematical equation. The equations consisted of two numbers between zero and six and were solved by addition or subtraction. The equations were 1.28 cm in size and subtended 0.86 degrees of visual angle. On valid trials, solving the equation predicted the location of the target. For

example, the equation in the centre of the screen might read 1+3, indicating the target will appear in quadrant four. The equations were simple enough for university students to solve without difficulty. On invalid trials the solution to the equation did not identify the quadrant in which the target subsequently appeared. The remaining 56 trials of a test presented no cues.

Procedure

Testing occurred on an individual basis. Upon arriving at the testing room, participants were given a general description of the study and were asked to read and sign the study consent form. They were then seated in front of the computer screen and the instructions for Task O were read to them by the experimenter (Appendix C-8). Participants then performed 20 familiarization trials on Task O, and the experimenter observed their performance in order to verify that the task instructions had been understood and the task was being performed correctly. After participants were familiarized with the task, the experimenter left the room and they practiced the task by performing 112 trials.

The experimenter then re-entered the room to provide instruction on Task N before 20 familiarization trials and 112 practice trials were performed. This familiarization and practice then were repeated for Task A. A one-and-a-half-minute break separated the practice on each task (see Appendix C-8 for task instructions for Tasks N and A).

After all three tasks had been practiced, participants rested for another one and a half minutes before testing commenced. The first test consisted of 112 trials on each task with a one-and-a-half-minute break between tasks. The order in which tasks were tested was counterbalanced and was matched across gender. All possible task orders were administered. After a three-minute rest, a second test, also consisting of 112 trials on each task, was

administered. A participant performed the tasks in the same order on both tests. When the tests were completed, the participants were paid and debriefed.

Criterion Measures and Data Analyses

A participant's mean RT for correct responses to valid, invalid and no-cue trials, respectively, were calculated for each cue condition, on each test of each task. All RT measures for each participant were trimmed using the non-recursive procedure with moving criterion suggested by Van Selst and Jolicoeur (1994).

The effect of task on the mean RT to each cue condition was tested separately, using Gender (male and female) by Task (O, N and A) by Test (tests 1 and 2) analyses of variance (ANOVA).

All tasks in this study required the participant to respond by pressing a specific key depending on which one of two targets was presented. It was possible that increasing the information processing demands of Task O affected the accuracy of these responses as well as reaction time. To explore this possibility the accuracy of responses to the target stimuli on each task was examined for valid, invalid, and no-cue trials on the two tests.

Accuracy scores for valid trials were computed for each participant by determining the total number of accurate responses, out of a total of 44 possible responses, for each of the three tasks on the two tests. Accuracy scores for invalid trials were computed for each participant by determining the total number of accurate responses, out of a total of 12 possible responses, for each of the three tasks on the two tests. Accuracy scores for no-cue trials were computed for each participant by determining the total number of accurate responses, out of a total of 56 possible responses, for each of the three tasks on the two tests. The effect of task

on the mean accuracy scores for each of the three cues was tested separately, using a Gender (male and female) by Task (O, N and A) by Test (tests1 and 2) ANOVA.

The RT of the three cue conditions within each task was examined using Gender (male and female) by Test (tests 1 and 2) by Cue (valid, invalid, no cue) ANOVAs.

Results

Task Effects on Each Cue Condition

Valid Trials

A 2(gender) x 3(task) x 2(test) ANOVA was performed on the RTs to the valid trials on the three tasks during the two tests. The results revealed only a significant main effect of task, $F(2,28)=3.858$, $p=0.033$. No other main effects or interactions were significant (p-values ≥ 0.190) (Table 1). An examination of the mean RTs for each task, averaged over the two tests (Figure 2a) revealed that they are in the predicted order with RTs on Task A longer than those on Task N which are longer than those on Task O. Means and standard deviations of RTs on each task, averaged over the two tests, are presented in Appendix B-2 Table 1. These findings are consistent with the prediction that tasks requiring more information processing result in longer reaction times to the valid trials.

Figure 2a: Mean RT to Valid Trials on 3 Tasks, Averaged Over 2 Tests

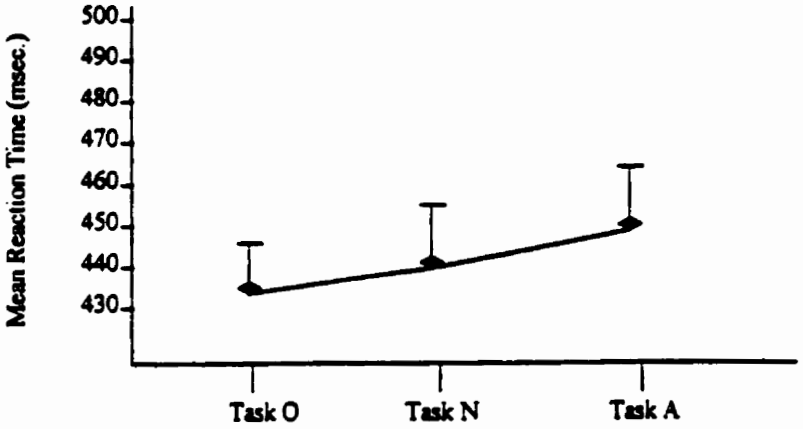


Figure 2b: Mean RT to Invalid Trials on 3 Tasks, Averaged Over 2 Tests

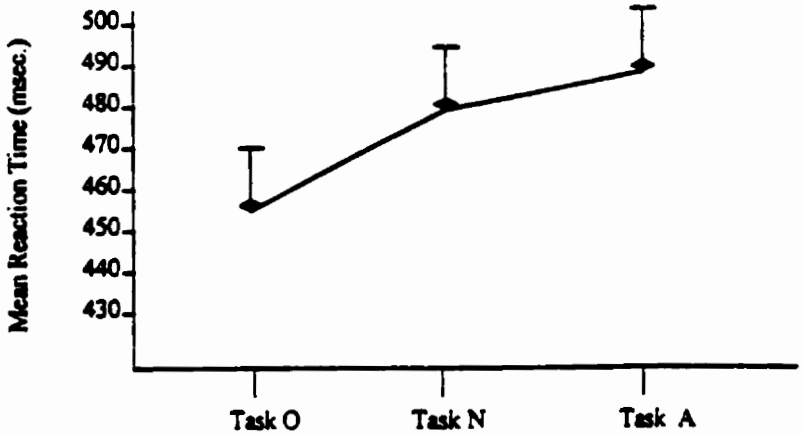


Figure 2c: Mean RT to No-Cue Trials on 3 Tasks, Averaged Over 2 Tests

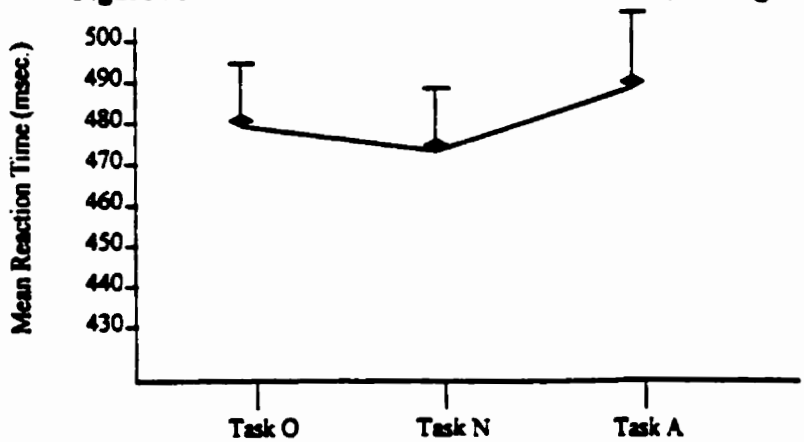


Table 1: Analysis of Variance of Mean RT to Valid Trials on Three Tasks As a Function of Test and Gender

Source	DF	MS	F	p
Between Subjects				
Gender	1	361.267	0.023	0.883
Error	14	15997.348		
Within Subjects				
Task	2	2296.576	3.858	0.033
Task x Gender	2	1049.002	1.762	0.190
Error	28	595.327		
Test	1	351.939	0.446	0.515
Test x Gender	1	313.095	0.397	0.539
Error	14	789.172		
Task x Test	2	408.365	1.130	0.337
Task x Test x Gender	2	132.340	0.366	0.697
Error	28	361.489		

Invalid Trials

A 2(gender) x 3(task) x 2(test) ANOVA was performed on the RTs to the invalid trials on the three tasks during the two tests. The results revealed only a significant main effect of task, $F(2,28)=7.373$, $p=0.003$. No other main effects or interactions were significant (p-values ≥ 0.108) (Table 2). An examination of the mean RTs for each task, averaged over the two tests (Figure 2b) confirmed that the means are in the predicted order with RTs on Task A longer than those on Task N which are longer than those on Task O. The means and standard deviations of RTs for the three tasks, averaged over the two tests, are presented in Appendix B-2, Table 2. This finding is consistent with the prediction that invalid cues that require more

information processing slow reaction time to a greater degree.

Table 2: Analysis of Variance of Mean RT to Invalid Trials on Three Tasks As a Function of Test and Gender

Source	DF	MS	F	p
Between Subjects				
Gender	1	1157.801	0.056	0.817
Error	14	20809.394		
Within Subjects				
Task	2	8154.958	7.373	0.003
Task x Gender	2	422.253	0.382	0.686
Error	28	1106.029		
Test	1	2931.013	1.592	0.228
Test x Gender	1	540.503	0.294	0.596
Error	14	1841.512		
Task x Test	2	1634.849	2.415	0.108
Task x Test x Gender	2	237.026	0.350	0.708
Error	28	677.068		

No-Cue Trials

A 2(gender) x 3(task) x 2(test) ANOVA was performed on the RTs to the no-cue trials on the three tasks during the two tests. The results revealed a significant main effect of task, $F(2,28)=4.287$, $p=0.024$ and a significant test x gender interaction, $F(1,14)=4.903$, $p=0.044$. No other main effects or interactions were significant (p-values≥ 0.740) (Table 3). An examination of the mean RTs for each task, averaged over the two tests (Figure 2c) revealed that RTs were shortest on Task N and longest on Task A. The means and standard deviations of RTs on each task, averaged over the two tests, are presented in Appendix B-2, Table 3.

Table 3: Analysis of Variance of Mean RT to No-Cue Trials on Three Tasks As a Function of Test and Gender

Source	DF	MS	F	p
Between Subjects				
Gender	1	1928.730	0.095	0.763
Error	14	20360.034		
Within Subjects				
Task	2	1946.144	4.287	0.024
Task x Gender	2	138.022	0.304	0.740
Error	28	454.005		
Test	1	3.945	0.007	0.932
Test x Gender	1	2587.111	4.903	0.044
Error	14	527.649		
Task x Test	2	13.957	0.027	0.973
Task x Test x Gender	2	51.585	0.100	0.905
Error	28	517.662		

The significant test x gender interaction is illustrated by the mean RTs of men and women on each of the tests (Appendix B-3, Figure 1). On test 1, RTs of the males tended to be longer than those of the females, but on test 2, RTs of men and women were very similar.

The main purpose of the present study was to determine if performance on the three tasks was consistent with a manipulation of information processing before the effect of alcohol is tested. Because the alcohol research will examine the performance of male social drinkers only, the mean RT to the no-cue trials for the eight men was examined separately in a 3(task) x 2(test) ANOVA. The results revealed no significant main effects or interaction (p-values$\geq$0.103) (see Appendix B-2, Table 4a). The means and standard deviations of RTs on each task, averaged over the two tests for males, are presented in Appendix B-2, Table 5.

Thus, when the data for the males were examined alone, performance on the no-cue trials did not significantly differ for the three tasks and this was consistent over the two tests.

It should be noted, however, that the order of the means for the males on the three tasks was consistent with the original findings using data from both males and females, although the differences between the task means were less extreme for males. In order to determine that the lack of task effect in the analysis using the RTs from the males was not simply due to a loss of power as a result of the decreased sample size, the data from the female participants were also examined separately to see if the data from this group would primarily account for the order effect seen in the combined sample. The results from this analysis also revealed no significant main effects or interaction, although the task effect did approach significance ($F(2,14)=3.206$, $p=0.071$) (see Appendix B-2, Table 4b). The means and standard deviations of the RTs on each task, averaged over the two tests for females, are presented in Appendix B-2, Table 5. An examination of the means revealed that they are also in the same direction as the original combined sample, with RTs shortest on Task N, longer on Task O and longest on Task A. The differences between the task means for the females are much greater than for the males. Thus, it appears that the mean RTs for the three tasks on no-cue trials are relatively stable for males, but are much less so for females.

Analyses of Accuracy Data A 2(gender) x 3(task) x 2(test) ANOVA was performed on the accuracy scores for the 44 valid trials. The results revealed a significant main effect of task, $F(2,28)=11.735$, $p<0.001$. No other main effects or interactions were significant (p-values ≥ 0.167) (Appendix B-2, Table 6). An examination of the accuracy scores on the three tasks, averaged over the two tests revealed that responses to Task 0 were most accurate

($\bar{x}$=43.281, SD=0.912), responses to Task N were less accurate ($\bar{x}$=42.250, SD=1.378) and responses to Task A were least accurate ($\bar{x}$=41.594, SD=1.734). In terms of percent accuracy, this represented 98.366 percent, 96.023 percent and 94.532 percent, respectively. Percent accuracy on valid trials for each of the three tasks are presented in Appendix B-3, Figure 2a. Although accuracy was high, it decreased as the information processing demands of the tasks increased.

A 2(gender) x 3(task) x 2(test) ANOVA was performed on the accuracy scores for the 12 invalid trials. The results revealed a significant main effect of task, $F(2,28)=3.514$, $p=0.043$, and a main effect of test, $F(1,14)=5.040$, $p=0.041$. No other main effects or interactions were significant (p-values $\geq$ 0.266) (Appendix B-2, Table 7). An examination of accuracy scores on the three tasks averaged over the two tests revealed that responses to Task 0 were most accurate ($\bar{x}$=11.813, SD=0.403), responses to Task N were less accurate ($\bar{x}$=11.594, SD=0.688) and responses to Task A were least accurate ($\bar{x}$=11.406, SD=0.455). Once again percent accuracy was high, with the above scores representing 98.442 percent, 96.617 percent and 95.050 percent, respectively. Percent accuracy on invalid trials for each of the three tasks are presented in Appendix B-3, Figure 2b. Response accuracy to invalid trials decreased as the information processing demands of the tasks increased. An examination of the accuracy scores on the two tests, averaged over the three tasks revealed that responses were less accurate on test 1 ($\bar{x}$=11.479, SD=0.530) than test 2 ($\bar{x}$=11.729, SD=0.349).

A 2(gender) x 3(task) x 2(test) ANOVA was performed on the accuracy scores for the 56 no-cue trials. The results revealed that no main effects or interactions were significant (p-values $\geq$ 0.070) (Appendix B-2, Table 8a). The percentage of correct responses on the three

tasks averaged over the two tests are presented in Appendix B-3, Figure 2c. Responses on no-cue trials for Task O were 97.545 percent correct, responses for Task N were 96.988 percent correct, and responses for Task A were 98.046 percent correct. The means and standard deviations for the accuracy scores on the three tasks, averaged over the two tests, are presented in Appendix B-2, Table 8b.

RT to Cues Within a Task

Exogenous Covert Orienting Task (O)

A 2(gender) x 2(test) x 3(cue) ANOVA was performed on the RTs to the three cue conditions on Task O during the two tests. The results revealed a significant main effect of cue, $F(2,28)=29.708$, $p<0.001$. No other main effects or interactions reached $p=0.05$ (Table 4). An examination of the mean RTs for each cue condition, averaged over the two tests (Figure 3a) showed that they are in the predicted direction, with the mean for valid trials being the shortest, the mean for invalid trials being in the middle, and the mean for the no-cue trials being the longest. This trend had been obtained in the pilot investigation of Task O. The means and standard deviations for the RTs on the three cue conditions, averaged over the two tests, are presented in Appendix B-2, Table 9.

One interaction approached $p=0.05$ (cue x gender, $F(2,28)=3.291$, $p=0.052$). An examination of the mean RTs for each cue condition, averaged over the two tests, for each gender separately (Appendix B-3, Figure 3) showed that the mean RTs to the cues for both males and females showed the aforementioned order, but males had shorter RT's for valid trials than females, and females had shorter RTs than males for invalid- and no-cue trials.

Figure 3a: Task O Mean RT for 3 Cue Conditions, Averaged Over 2 Tests

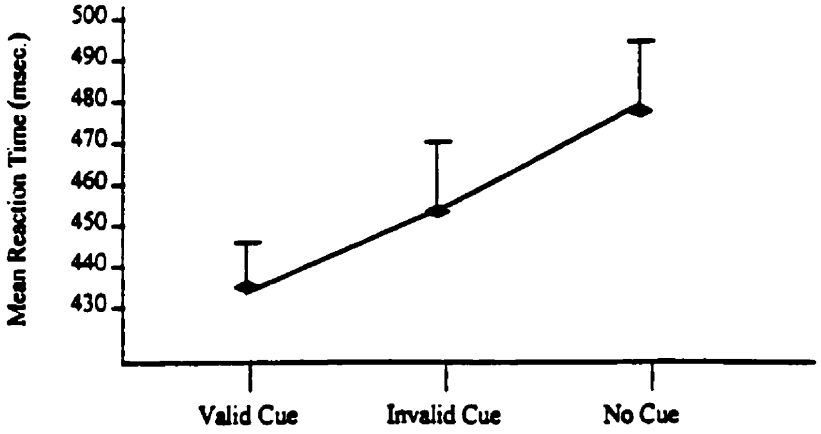


Figure 3b: Task N Mean RT for 3 Cue Conditions, Averaged Over 2 Tests

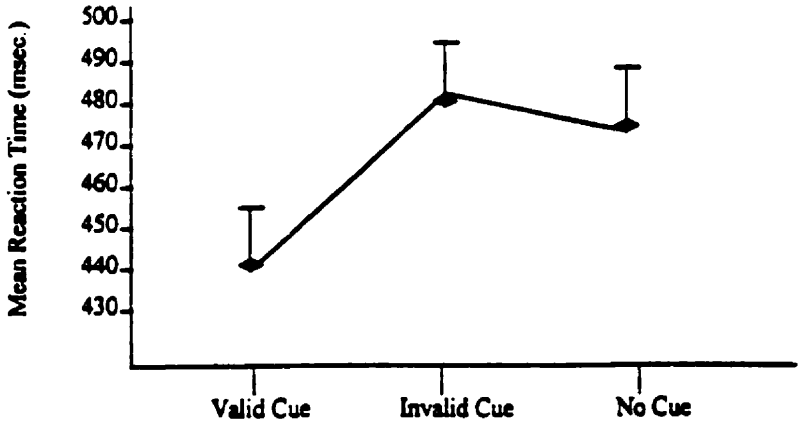
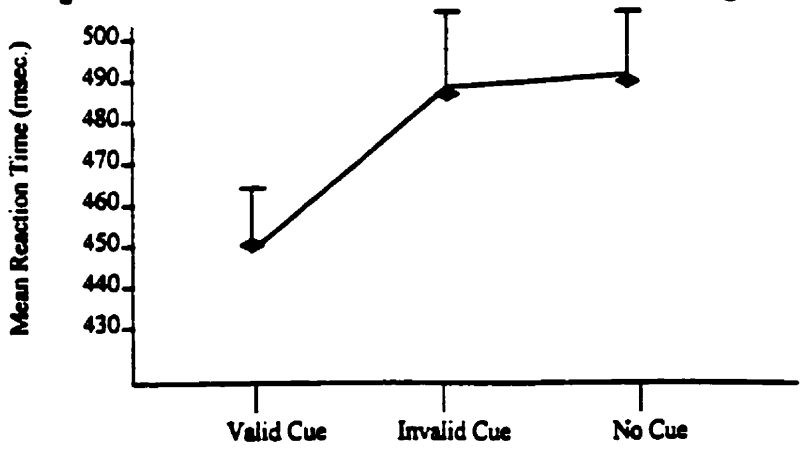


Figure 3c: Task A Mean RT for 3 Cue Conditions, Averaged Over 2 Tests



The means and standard deviations for the RTs on the three cue conditions, averaged over the two tests, for each gender, are presented in Appendix B-2, Table 10.

Table 4: Analysis of Variance of Mean RT on Task O for Three Cue Conditions As a Function of Test and Gender

Source	DF	MS	F	p
Between Subjects				
Gender	1	26.850	0.002	0.966
Error	14	14569.180		
Within Subjects				
Test	1	177.806	0.159	0.696
Test x Gender	1	2035 502	1.816	0.199
Error	14	1121.023		
Cue	2	18006.617	29.708	<0.001
Cue x Gender	2	1994.563	3.291	0.052
Error	28	606.127		
Test x Cue	2	117.397	0.529	0.595
Test x Cue x Gender	2	108.790	0.490	0.618
Error	28	221.958		

Endogenous Numerical Identification Task (N)

A 2(gender) x 2(test) x 3(cue) ANOVA was performed on the RTs to the three cue conditions on Task N for the two tests. The results revealed a significant main effect of cue, $F(2,28)=16.268$, $p=0.000$. No other main effects or interactions were significant (p-values $\geq$ 0.253) (Table 5). An examination of the mean RTs for each cue condition, averaged over the two tests (Figure 3b) showed that the mean RT to valid trials was the shortest, and longer RTs

occurred to invalid and no-cue trials. The means and standard deviations for the cue effect are presented in Appendix B-2, Table 11. A paired-samples t-test was performed on the mean RTs for invalid and no-cue trials, averaged over test and gender. No significant difference was found, $t(1,15)=0.717$, $p=0.485$.

Table 5: Analysis of Variance of Mean RT on Task N for Three Cue Conditions As a Function of Test and Gender

Source	DF	MS	F	p
Between Subjects				
Gender	1	1468.831	0.077	0.786
Error	14	19130.694		
Within Subjects				
Test	1	18.070	0.021	0.886
Test x Gender	1	1215.171	1.421	0.253
Error	14	855.022		
Cue	2	13832.491	16.268	<0.001
Cue x Gender	2	356.119	0.419	0.662
Error	28	850.267		
Test x Cue	2	0.915	0.002	0.998
Test x Cue x Gender	2	8.984	0.023	0.977
Error	28	390.536		

Endogenous Arithmetic Task (A)

A 2(gender) x 2(test) x 3(cue) ANOVA was performed on the RTs to the three cue conditions on Task A for the two tests. The results revealed a significant main effect of cue, $F(2,28)=12.224$, $p=0.000$. No other main effects or interactions were significant (p-values $\geq$ 0.125) (Table 6). An examination of the mean RTs for each cue, averaged over the two tests

(Figure 3c) revealed that the mean RT to valid trials was the shortest, and the mean RTs to invalid and no-cue trials were longer. The means and standard deviations for the cue effect are presented in Appendix B-2, Table 12. A paired-samples t-test was performed on the mean RTs for invalid and no-cue trials, averaged over test and gender. No significant difference was found, $t(1,15)=-0.434$ $p=0.670$.

Table 6: Analysis of Variance of Mean RT on Task A for Three Cue Conditions As a Function of Test and Gender

Source	DF	MS	F	p
Between Subjects				
Gender	1	238.077	0.011	0.919
Error	14	22439.043		
Within Subjects				
Test	1	3822.850	2.297	0.152
Test x Gender	1	139.973	0.084	0.776
Error	14	1664.071		
Cue	2	14826.655	12.224	<0.001
Cue x Gender	2	115.616	0.095	0.909
Error	28	1212.897		
Test x Cue	2	1572.943	2.238	0.125
Test x Cue x Gender	2	328.208	0.467	0.632
Error	28	702.833		

Discussion

This experiment used three orienting tasks that were designed to vary in information processing demands, and tested the hypothesis that attentional processes will be slower when greater information processing is required. Task A was devised to involve the most

information processing. Task N was intermediate and Task O required the least information processing. In accord with the hypothesis that longer RTs to valid trials and to invalid trials occurred on tasks with more information-processing requirements, RT on Task A was longer than RT on Task N and RT on Task O was the shortest.

A test on each task included a set of trials without any cue. As the cue manipulated information, and no-cue trials were identical across tasks, there was no basis for predicting any task effect on RT when the cue was absent. However, a main effect of task was obtained, and indicated that the no-cue RT was shortest on Task N, where information-processing demands were intermediate. This result is at variance with the RT to valid and invalid cues that manipulated information processing. It is unclear why this effect occurred. It is possible that there was some sort of carryover effect on no-cue trials because they were mixed in with the valid and invalid trials. However, the interpretation of RT to no-cue trials was further complicated by a test x gender interaction that revealed that the RT for males was longer than the RT for females on test 1, whereas the RTs for males and females were essentially the same on test 2. Because the next study examining the effects of alcohol will use only male participants, separate analyses of the data from men and women were conducted and each analysis obtained no significant effects. Thus, a replication of the results would be required to determine if no-cue trials are affected by the tasks.

The results from the accuracy data were consistent with the hypothesis that information processing was manipulated in the three tasks. For both valid and invalid trials, accuracy was lowest on tasks that required the greatest information processing. There was no task effect for accuracy on no-cue trials on which cues manipulating information processing were absent.

The pattern of RT to the three cues on Task O was found to confirm the results of the first exploratory study. The mean RT to valid trials was shorter than the mean RT to invalid trials, which was shorter than the mean RT to no-cue trials. The results indicate that valid exogenous cues speed performance by predicting the arrival and location of a target. An invalid cue predicts the arrival of the target, but the location is incorrect. In this instance, reactions to the target are longer, but still shorter than if no cue is present. The shorter RT to invalid than no-cue conditions suggests an increase in alertness by simply warning that the target is coming. This is sufficient to speed performance, even though the cue predicts the wrong target location.

It was unclear how the relative RT to the three cues would change on Tasks N and A in which endogenous cues conveyed varying degrees of information about the location of the target. RT to valid trials on Tasks N and A were shorter than the RT to invalid trials, and this is consistent with the findings on Task O. However, Tasks N and A lengthened RT to valid and invalid trials. As a result the RT to invalid trials on Tasks N and A did not differ from the RT to no-cue trials. Thus, it seems that on tasks with greater information processing demands, simply knowing that a target is coming while being provided with an incorrect target location, does not improve reaction time to the target, compared to not having any knowledge of the target. However, knowing that a target is coming and being provided with the correct location still speeds reaction time.

It is common in the drug-free cognition literature for the RT data from covert orienting tasks to be trimmed in some manner in order to reduce the variability in the data that is due to nonexperimental influences. However, there are several reasons that this procedure may be

counterproductive for investigations of the effect of alcohol on covert orienting. A classic paper discussing several trimming procedures (Van Selst and Jolicoeur, 1994) states that trimming is used to limit the sample to those trials that were being performed in a homogeneous manner by a participant, "without an undue influence of extraneous influences such as lapses of attention leading to longer response times or anticipation effects leading to shorter response times"(p.631). However, in the present research, the effect of alcohol on these tasks is unknown and it may be that such lapses of attention are actually caused by alcohol. Thus, trimming the data may remove the effect that is the focus of research interest. As such, the analyses in the Main Experiment, which examined the effect of alcohol on these covert orienting tasks, are based on untrimmed data.

Appendix B-2

Table 1: Mean Reaction Times and Standard Deviations to the Valid Trials Averaged Over Two Tests for Three Tasks

	Task O	Task N	Task A
Mean	435.027	442.162	451.903
(SD)	(43.939)	(56.567)	(54.522)

Table 2: Mean Reaction Times and Standard Deviations to the Invalid Trials Averaged Over Two Tests for Three Tasks

	Task O	Task N	Task A
Mean	457.181	480.694	487.642
(SD)	(51.689)	(55.716)	(70.951)

Table 3: Mean Reaction Times and Standard Deviations to No-Cue Trials Averaged Over Two Tests for Three Tasks

	Task O	Task N	Task A
Mean	482.436	474.966	490.559
(SD)	(53.816)	(59.075)	(60.105)

Table 4a: Analysis of Variance of Mean RT for Eight Men to No-Cue Trials On Three Tasks as a Function of Test

Source	DF	MS	F	p
Task	2	563.057	1.299	0.304
Error	14	433.565		
Test	1	1194.506	3.525	0.103
Error	7	338.860		
Task x Test	2	58.480	0.128	0.880
Error	14	455.174		

Table 4b: Analysis of Variance of Mean RT for Eight Women to No-Cue Trials On Three Tasks as a Function of Test

Source	DF	MS	F	p
Task	2	1521.108	3.206	0.071
Error	14	474.444		
Test	1	1396.550	1.949	0.205
Error	7	716.438		
Task x Test	2	7.061	0.012	0.988
Error	14	580.149		

Table 5: Mean Reaction Times and Standard Deviations to No-Cue Trials Averaged Over Two Tests for Three Tasks for Male and Female Participants (n=8)

	Task O		Task N		Task A	
	Males	Females	Males	Females	Males	Females
Mean	486.057	478.816	481.818	468.115	493.534	487.584
(SD)	(58.271)	(52.731)	(70.680)	(48.736)	(70.213)	(52.833)

Table 6: Analysis of Variance of Mean Accuracy Scores for Valid Trials on Three Tasks As a Function of Test and Gender

Source	DF	MS	F	p
Between Subjects				
Gender	1	1.500	0.183	0.676
Error	14	8.214		
Within Subjects				
Test	1	1.500	1.385	0.259
Test x Gender	1	0.000	0.000	1.000
Error	14	1.083		

Task	2	23.156	11.735	0.000
Task x Gender	2	0.219	0.111	0.895
Error	28	1.973		
Task x Test	2	3.469	1.911	0.167
Task x Test x Gender	2	0.781	0.430	0.655
Error	28	1.815		

Table 7: Analysis of Variance of Mean Accuracy Scores for Invalid Trials On Three Tasks as a Function of Test and Gender

Source	DF	MS	F	p
Between Subjects				
Gender	1	0.375	0.387	0.544
Error	14	0.970		
Within Subjects				
Test	1	1.500	5.040	0.041
Test x Gender	1	0.000	0.000	1.000
Error	14	0.298		
Task	2	1.323	3.514	0.043
Task x Gender	2	0.406	1.079	0.354
Error	28	0.376		
Task x Test	2	0.594	1.390	0.266
Task x Test x Gender	2	0.094	0.220	0.804
Error	28	0.427		

Table 8a: Analysis of Variance of Mean Accuracy Scores for No-Cue Trials on Three Tasks as a Function of Test and Gender

Source	DF	MS	F	p
Between Subjects				
Gender	1	0.510	0.059	0.812
Error	14	8.671		

Within Subjects				
Test	1	1.760	2.015	0.178
Test x Gender	1	0.844	0.966	0.342
Error	14	0.874		
Task	2	2.823	2.923	0.070
Task x Gender	2	0.323	0.334	0.719
Error	28	0.966		
Task x Test	2	0.010	0.011	0.989
Task x Test x Gender	2	0.594	0.653	0.528
Error	28	0.909		

Table 8b: Mean Accuracy Scores for No-Cue Trials (out of a total of 56) and Standard Deviations for the Three Tasks Averaged Over Two Tests

	Task O	Task N	Task A
Mean	54.625	54.313	54.906
(SD)	(1.432)	(1.401)	(0.987)

Table 9: Mean Reaction Times and Standard Deviations on Task O for Three Cue Conditions Averaged Over Two Tests

	Valid	Invalid	No Cue
Mean	435.027	457.181	482.436
(SD)	(43.939)	(51.689)	(53.816)

Table 10: Mean Reaction Times and Standard Deviations on Task O for Three Cue Conditions Averaged Over Two Tests for Males and Females

	Valid		Invalid		No Cue	
	Males	Females	Males	Females	Males	Females
Mean	426.583	443.471	463.591	450.771	486.057	478.816
(SD)	(41.920)	(47.082)	(60.469)	(44.440)	(58.271)	(52.731)

Table 11: Mean Reaction Times and Standard Deviations on Task N for Three Cue Conditions Averaged Over Two Tests

	Valid	Invalid	No Cue
Mean	442.162	480.694	474.966
(SD)	(56.567)	(55.716)	(59.075)

Table 12: Mean Reaction Times and Standard Deviations on Task A for Three Cue Conditions Averaged Over Two Tests

	Valid	Invalid	No Cue
Mean	451.903	487.642	490 559
(SD)	(54.522)	(70.951)	(60.105)

Appendix B-3

Figure 1: Mean RT of Males and Females (n=8) to No-Cue Trials on 2 Tests Averaged Over 3 Tasks

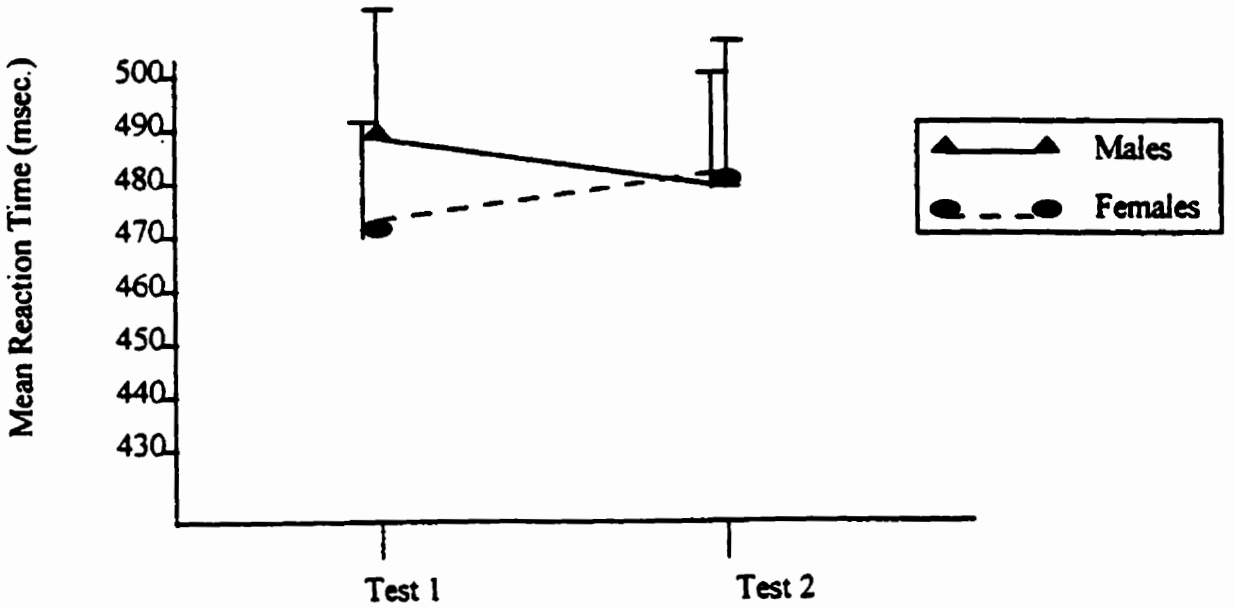


Figure 2a: Mean Percent Accuracy for Valid Trials on 3 Tasks, Averaged Over 2 Tests

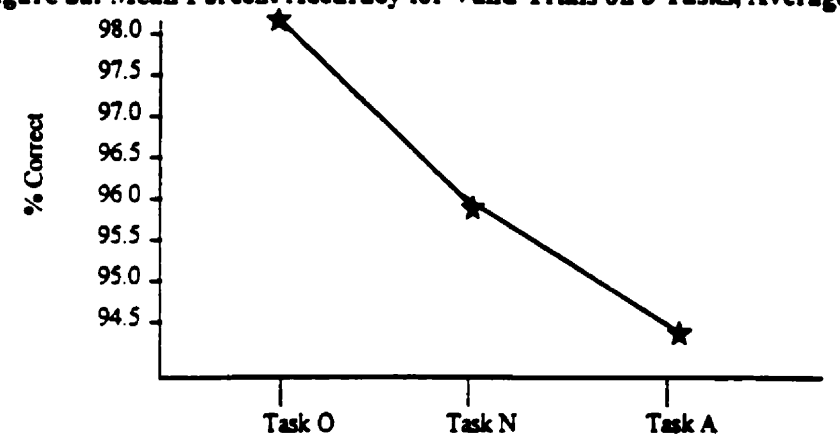


Figure 2b: Mean Percent Accuracy for Invalid Trials on 3 Tasks, Averaged Over 2 Tests

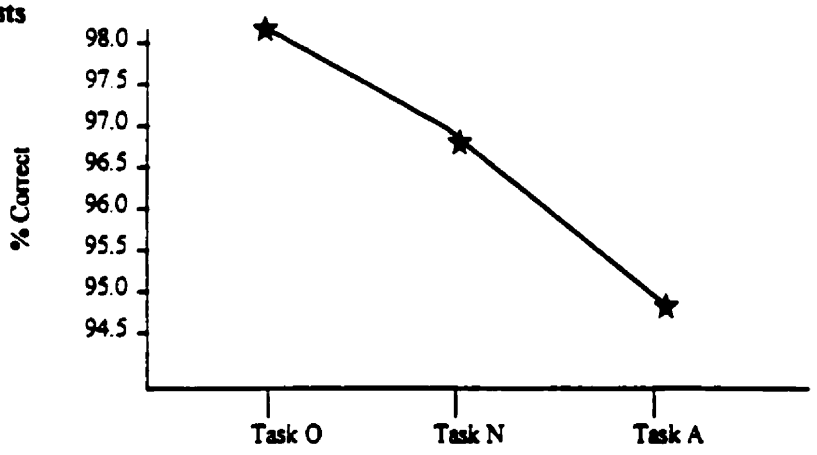
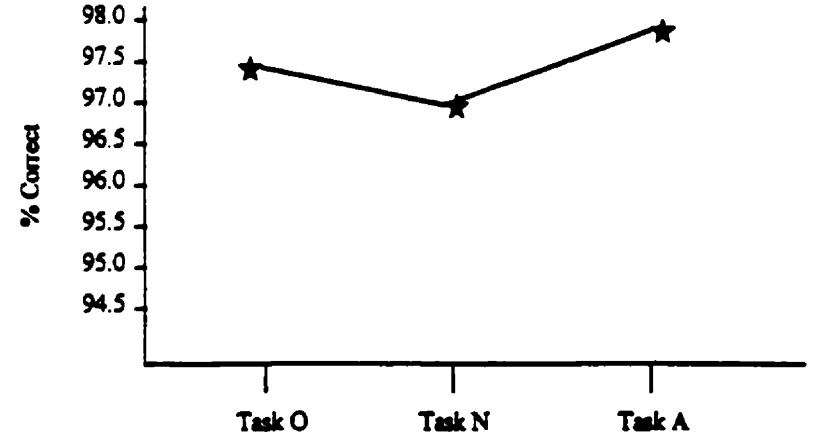


Figure 2c: Mean Percent Accuracy for No-Cue Trials on 3 Tasks, Averaged Over 2 Tests



Appendix C: Main Experiment - Experimental Materials

Appendix C-1

Phone Interview:

Hello, _____ I'm _____ and I'm phoning from the University of Waterloo Department of Psychology. You expressed an interest in participating in psychology experiments. I'm calling to tell you a bit more about the research we are doing.

In our lab we are measuring the effects of alcohol on a computerized task that requires responding to visual-spatial information on a computer screen. You will be asked to respond to targets on the computer screen as fast as you can. The experiment involves attending two sessions. The first session takes about 30 minutes and you'll just practice the task and get familiarized with the lab. The second session will take approximately 3 hours. During this session you will receive alcohol in the form of a mixed drink. You will be paid $15 at the end of the second session. We are selecting individuals whose body weights fall between a range of 130-200 pounds (50-90 kg) and are at least 19 years of age. Are you interested in participating? Have you ever participated in an alcohol study before or a study that involved any other drugs, such as caffeine? What did you do in that study? What was the task?

A breathalyser machine will measure your breath samples in order to estimate your blood alcohol concentration at different times. We use mild doses of alcohol, which will not make you sick. However, you must not drive or operate other machinery after completing the experiment. If you need transportation home it will be provided for you. After the experiment you remain in the lab until your blood alcohol level returns to a safe level.

Although the doses of alcohol used in this experiment are not harmful, alcohol may have some physical side effects. Thus, it is important that you do not have any medical problems such as diabetes or epilepsy. Similarly, it is important that you are not taking any medication: this includes regular use of cold or allergy medications, aspirin or antihistamines, or over-the-counter drugs, such as "wake-up" pills.

It is also important that you abstain from drinking alcohol for 24 hours prior to the second session. In addition, you should not eat any food during the 4 hours before the second session and abstain from fluids, apart from sips of water, for 2 hours before the second session. Your stomach should be empty because stomach contents can affect the absorption of alcohol. Do you have any questions? Please meet me on the fourth floor of the psychology building by the elevators on [date] [time].

Appendix C-2

Informed Consent Letter:

I, _____, age _____ hereby state that I have volunteered to consume a mild dose of alcohol and will perform a test on a computer task. The purpose of this study is to examine how alcohol may affect performance on a visual-spatial task. My participation will require 3.5 hours (½ an hour this session and 3 hours for the test session that is to be scheduled). I understand that I will be asked to respond to targets on a computer screen as fast as I can, after which I will receive a dose of alcohol and be asked to perform the task again.

I understand that the dose of alcohol is mild, and that my blood alcohol concentration (BAC) will be below approximately 0.08g%. During the study, I will provide breath samples to a Breathalyser to verify my BAC throughout the study. I also will be asked to complete brief questionnaires by reporting on my drinking habits, indicating any problems I may have experienced with drinking, and rating effects that I expect from alcohol. I understand that I may decline to answer any questions that I prefer not to answer.

I understand that it is important that I am in good health, and that I have no problems associated with drinking alcohol. I am not currently taking any medication. I agree to abstain from alcohol for at least 24 hours so that no prior exposure to alcohol could affect the results, and I agree to fast for 4 hours prior to receiving alcohol to ensure that stomach contents do not affect the absorption of alcohol. I also understand that at the conclusion of the study, my blood alcohol level may be above zero and I am advised to remain in the lab area until it returns to a safe level as determined by the experimenter. I also agree not to drive any vehicle (including a car or a bicycle) or operate any other machinery for at least 2 hours after leaving the experiment.

I understand that all records, tests and personal data are confidential, and will be used in research reports that do not disclose the identity of any individual. I understand that any personal identifiers, linking participants to their reports on questionnaires, will be detached and destroyed as soon as participation is completed. All paper records will be destroyed by shredding, and only data stored on computer will remain.

I consent to what is proposed to be done. I agree of my own free will to participate in this experiment. The consent is given freely and I understand that I am free to withdraw from the experiment at any time, for any reason. I understand that I shall receive a remuneration of $15 for taking part in this study, and that if I do not complete the study a prorated amount will be provided ($5 per hour).

This research is being conducted by Judith Carscadden, under the supervision of Dr. M. Vogel-Sprott, who may be reached at the Department of Psychology, ext. 2666. This project has been reviewed and received ethics clearance through the Office of Human Research. If you have any questions or concerns about your participation, please call this office at 885-1211, extension 6005.

Signed this _____ day of _____, 19_____.

_____

Participant's Name

_____

Participant's Signature

_____

Witness

Appendix C-3

Drinking Habits Questionnaire:

Below are some questions which are primarily concerned with your personal drinking. Most ask you to answer according to what is most typical or usual for you. Please try to answer each question as honestly as possible.

1) Please estimate the number of years that you have been drinking alcohol. Estimate to the nearest month.

_____ years _____ months

2) How often, on average, do you drink alcohol? (Choose only one)

A) Only on special occasions, how many times per year? _____
B) Monthly, how often? _____
C) Weekly, how often? _____
D) Daily, how often? _____

3) What alcohol beverage do you usually drink? _____

4) In terms of the beverage indicated in question 3, what is the AVERAGE quantity you drink in a single drinking occasion? (Choose only one)

A) WINE (estimate ounces) 1 2 3 4 5 6 7 8 9 10 or _____
B) BEER (bottles) 1 2 3 4 5 6 7 8 9 10 or _____
C) BEER (draft glasses) 1 2 3 4 5 6 7 8 9 10 or _____
D) LIQUOR (assume 1.5 ounces per drink and estimate the number of drinks) 1 2 3 4 5 6 7 8 9 10 or ____

5) How long does your typical drinking occasion last? (Complete only one)

A) _____ MINUTES
B) _____ HOURS
C) _____ DAYS

6) Have you ever had a conviction for impaired driving? YES NO

7) Have you ever experienced any problems related to your drinking? YES NO

8) Age _____ Weight _____ Height _____ Handedness: r _____ l_____

Appendix C-4

Eating Guidelines:

Please eat a light meal followed by 4 hours of fasting before you come in for your appointment. For example, if your appointment is at 4:00 p.m., have a light snack at about 12:00 p.m. and then eat nothing for 4 hours. Below is a list of suggested foods and a list of foods to avoid. In general, avoid all dairy products and all greasy, fried foods (e.g. anything with butter). Thank you for your cooperation.

Suggested Foods:	**Foods to Avoid:**
breads, buns, muffins	all dairy products (e.g., cheese, butter, yogurt,
fruits, vegetables	ice-cream, margarine, or milk)
seafood (nothing packed in oil)	mayonnaise
meat or poultry (broiled, baked or barbecued)	fried hamburgers
hard or soft boiled eggs	fried eggs
toast with jam (no butter)	bacon
salad (no dressing)	french fries, chips
sandwiches (luncheon meats, with mustard only)	donuts
soup (not creamed)	peanut butter
pickles	

Your next appointment is at _____ on _____. (PAS, 4th Floor)

Appendix C-5

Biphasic Alcohol Effects Scale:

Instructions: The following adjectives describe feelings that are sometimes experienced.

PLEASE RATE THE EXTENT TO WHICH YOU ARE EXPERIENCING THESE FEELINGS AT THE PRESENT TIME.

	Not At All					Moderately				Extremely
Difficulty Concentrating	0	1	2	3	4	5	6	7	8	9	10
Down	0	1	2	3	4	5	6	7	8	9	10
Elated	0	1	2	3	4	5	6	7	8	9	10
Energized	0	1	2	3	4	5	6	7	8	9	10
Excited	0	1	2	3	4	5	6	7	8	9	10
Heavy Head	0	1	2	3	4	5	6	7	8	9	10
Inactive	0	1	2	3	4	5	6	7	8	9	10
Sedated	0	1	2	3	4	5	6	7	8	9	10
Slow Thoughts	0	1	2	3	4	5	6	7	8	9	10
Sluggish	0	1	2	3	4	5	6	7	8	9	10
Stimulated	0	1	2	3	4	5	6	7	8	9	10
Talkative	0	1	2	3	4	5	6	7	8	9	10
Up	0	1	2	3	4	5	6	7	8	9	10
Vigorous	0	1	2	3	4	5	6	7	8	9	10

Appendix C-6

Drink Strength Questionnaire:

Participant # _____

Regarding the alcohol you have consumed, rate the strength of its effect by comparing it to bottles of beer (5% alcohol by volume) OR fluid ounces of liquor (40% alcohol by volume). ONE STANDARD DRINK CONTAINS 1.5 OUNCES OF ALCOHOL.

BOTTLES OF BEER (5%) Circle the total number of BOTTLES	OR	OUNCES OF LIQUOR (40%) Circle the total number of OUNCES
0.0		0.0
0.5		0.5
1.0		1.0
1.5		1.5
2.0		2.0
2.5		2.5
3.0		3.0
3.5		3.5
4.0		4.0
4.5		4.5
5.0		5.0
5.5		5.5
6.0		6.0
6.5		6.5
7.0		7.0
7.5		7.5
8.0		8.0
8.5		8.5
9.0		9.0
9.5		9.5
10.0		10.0

Appendix C-7

Explanation of the Study - Training Session:

General Description of the Study

To ensure that each participant has the same understanding of the experiment, I will be reading information and instructions to you. While this is formal, it ensures that we remember to explain everything the same way to everyone.

First of all, I'd like to thank you for volunteering to participate in this study. I hope that you'll find it to be an interesting experience. It is very important that you are fully aware of the requirements for participation before we begin the study.

The total time required of you will be around 3.5 hours. Today's session will take about half an hour to complete and will involve practising the task and getting familiar with the lab. During the second session you'll receive alcohol and perform the task. This will take about 3 hours.

The purpose of this study is to examine the effect that alcohol has on the performance of a computerized task. The pay for participating in the experiment is $15 which you will receive at the end of the second session.

That is a general explanation of what is involved in the study. Now I'm going to explain some of the requirements for participating.

Timing is very important in this experiment. You will be asked to perform the task at specified times, and during the drinking session you will be asked to drink each of the drinks within a certain time period. At times, I may have to interrupt your conversation, reading, or other activities. Your cooperation with the time schedule is very important.

There are a number of requirements that pertain to the second session, as I explained on the phone. First, stomach contents affect the absorption of alcohol. We want everyone to absorb the alcohol as similarly as possible so we have some strict rules about eating prior to the drinking session. It is important that you eat breakfast or a light lunch four hours before the start of the second session but after this meal, we ask that you not drink anything, apart for sips of water, for the rest of the four hours prior to the start of the drinking session. I'll give you more details about this at the end of the session. We also ask that you not take any drugs (such as alcohol, aspirin or antihistamines) for 24 hours before the second session.

Do you have any questions? If you agree with these conditions, please read and sign this consent form, and then we can begin.

Appendix C-8

Task Instructions - Training Session:

Task O

I'd like you to watch the screen in front of you. When you press the spacebar you will see a small dot in the center of the screen. At times, the dot will disappear and a larger circle will appear in one of these 4 quadrants (show). The location of this circle will tell you in which quadrant a target will appear.

The target will be either a + sign or an X. Whenever you see a + sign I'd like you to press the n key as fast as you can. Whenever you see an X I'd like you to press the m key as fast as you can.

The circle will correctly tell you where the target will appear most of the time, but not all of the time. It will be of great benefit to you and you should always use this information to determine where the target will appear so you can respond to the target faster.

On some trials, no circle will appear and the screen will be blank except for the tiny dot. You are to still press the correct key as fast as you can as soon as the target appears.

Targets and circles will appear in this area of the screen (show with finger on screen).

You may use whichever hand you wish, but use two fingers from the same hand.

It's very important that you not move your eyes when you do the task. Keep them focused on the center of the screen.

Any questions?

We'll do a short practice block so you can see how it works.

[participant performs practice block]

Any questions?

Now we'll do a block of trials just like this. The block will take about 6 minutes to complete and then the words "Please Wait" will appear on the screen. At that point, just open the door and I'll be right in.

Task N

This next task is similar to the one you just learned, but there are no circles and there is

an additional component. Once again, I'd like you to watch the screen in front of you. When you press the spacebar you will again see a small dot in the center of the screen. At times, the dot will disappear and be replaced by a number between 1 and 4 which will appear in the center of the screen. The numerical value of this number will tell you in which of these 4 quadrants (show) a target will appear. The number will correctly tell you where it will appear most of the time, but not all of the time. Like the circles, using the number to determine where the target will appear will be of great benefit and you should always use it to determine where the target will appear so you can respond to the target faster.

The target will again be either a + sign or an X.

So, for example, if the number 4 appears on the screen, this would indicate that the target may appear in quadrant number 4 (show). When the target appears, you would press the correct key. Targets will appear in this vicinity (show with finger on screen).

On some trials, no number will appear on the screen and the screen will be blank except for the tiny dot. You are to still press the correct key as fast as you can as soon as the target appears. Again, it's very important that you don't move your eyes. Keep them focused on the center of the screen.

We'll do a short practice block so you can see how it works.

[participant performs practice block]

Any questions?

Now we'll do a block of trials just like this. The block will take about 6 minutes to complete and then the words "Please Wait" will appear on the screen. At that point, just open the door and I'll be right in.

Task A

Now we'll do another similar task. The only difference between this task and the previous one is that instead of a single number appearing on the screen to tell you the target location, a short math equation will appear in the center of the screen. The equation will consist of 2 numbers between 0 and 6 and will involve either addition or subtraction. The solution to the equation will tell you in which quadrant the target will appear. As in the previous two tasks, the solution to the equation will correctly tell you where the target will appear most of the time. Thus, this information will be of great benefit and you should always use it to determine where the target will appear so you can respond to the target faster.

For example, 2+1 may appear on the screen. The solution to the equation is 3, indicating that the target may appear in quadrant 3 (point).

Any questions?

We'll do a brief practice block so you can see how it works.

[participant completes practice block]

Any questions?

Now we'll do a block of trials just like this. The block will take about 6 minutes to complete. Please open the door when the words "Please Wait" appear on the screen.

Appendix C-9

Study Reminders:

I have a few things to tell you about the next session. First of all, as I said before, it is important that you eat breakfast or a light lunch four hours before the start of the second session. For example, if you are coming for a session at 6 p.m., you would have lunch or a snack at 2 p.m. There are two restrictions on what you eat in that meal. 1) Do not have milk or milk products such as yogurt or cheese. 2) Do not have fatty or greasy foods such as fried eggs, bacon, french fries, or fats such as butter, mayonnaise or peanut butter. Here is a menu that specifies what you may eat which you can take home as a reminder.

Eating Guidelines

It is important that you do at something light, but after this meal, please remember not to eat or drink anything, apart from sips of water, for the rest of the four hours prior to the start of the drinking session. Also, as I already mentioned, please don't take any drugs (such as alcohol, aspirin or antihistamines) for 24 hours before the second session.

At the conclusion of the second session, your blood alcohol level may be above zero, so for safety we caution you against operating any machinery, including driving or riding a bike. You should make alternative arrangements, and if you have any difficulties in this respect, we can arrange a ride for you. Do you have any questions?

Also, during the drinking session you will perform the same three tasks at intervals with rest breaks between sets. These rest intervals will vary in length so you might want to bring some books or things to work on during the rests.

Appendix C-10

Introductory Statement - Experimental Session:

For this experiment, it is important that you have not taken any medication. And since the absorption and metabolism of alcohol can be influenced by existing levels of alcohol in the bloodstream, it is important that you have abstained from alcohol for 24 hours prior to this experiment as well as food and drinks, other than water, for the last 4 hours. Did you have any problems adhering to these restrictions? When did you last eat and what was your last meal?

As I have mentioned before, the purpose of this experiment is to study the effects of alcohol on the performance of a computerized task. You will do a brief reminder block on each task to re-familiarize yourself with them. Then, you'll perform a six minute block of trials on each task. Once you have finished, you will receive a dose of alcohol in the form of two mixed drinks. You'll then perform some more trials on the computer over the next couple of hours. Throughout the session I will be asking you to provide breath samples to measure your Blood Alcohol Concentration. The mouthpieces we use are all sterilized. I can tell you what your Blood Alcohol Concentrations are, only at the end of the session. In addition, you will be paid $15 for your participation at the end of this session. Do you have any questions?

Appendix C-11

Experimental Session Task Instructions:

Reminder Trials

The task requirements are the same as they were in the first session. I'm just going to take a minute to review each task with you.

Task O

I'd like you to watch the screen in front of you. When you press the spacebar you will see a small dot in the center of the screen. At times, the dot will disappear and a larger circle will appear in one of these 4 quadrants (show). The location of this circle will tell you in which quadrant a target will appear.

The target will be either a + sign or an X. Whenever you see a + sign I'd like you to press the n key as fast as you can. Whenever you see an X I'd like you to press the m key as fast as you can.

The circle will correctly tell you where the target will appear most of the time, but not all of the time. It will be of great benefit to you and you should always use this information to determine where the target will appear so you can respond faster.

On some trials, no circle will appear and the screen will be blank except for the tiny dot. You are to still press the correct key as fast as you can as soon as the target appears.

You may use whichever hand you wish to press the key, but use two fingers from the same hand.

Remember, it's very important that you don't move your eyes when you do the tasks. Keep them focused on the center of the screen.

Any questions?

We'll do a short block so you can remember how it works.

[participant completes reminder block]

Task N

This next task does not have circles but has a single number appearing in the center of the screen to tell you where the target will appear. Once again, I'd like you to watch the screen in

front of you. When you press the spacebar you will again see a small dot in the center of the screen. At times, the dot will disappear and be replaced by a number between 1 and 4 which will appear in the center of the screen. The numerical value of this number will tell you in which of these 4 quadrants (show) a target will appear. The number will correctly tell you where it will appear most of the time, but not all of the time. Like the circles, using the number to determine where the target will appear will be of great benefit and you should always use it to determine where the target will appear so you can respond to the target faster.

On some trials, no number will appear on the screen and the screen will be blank except for the tiny dot. You are to still press the correct key as fast as you can as soon as the target appears.

We'll do a short reminder block so you can remember how it works.

[participant completes reminder block]

Task A

The only difference between this next task and the previous one is that instead of a single number appearing on the screen to tell you the target location, a short math equation appears in the center of the screen. The equation consists of 2 numbers between 0 and 6 and involves either addition or subtraction. The solution to the equation tells you in which quadrant the target will appear. As in the previous two tasks, the solution to the equation will correctly tell you where the target will appear most of the time. Thus, this information will be of great benefit and you should always use it to determine where the target will appear so you can respond faster.

We'll do a short block so you can remember how it works.

[participant completes reminder block]

Drug Free Blocks

Now that you remember how to do the them, we'll do one block of trials on each task. Like last session, each block takes about six minutes to complete. Please open the door when it says please wait after the first task and I'll come in and reset for the next task. The first task will be _____.

Appendix C-12

Temporal Schedule of Events During the Treatment Session:

-30 Min. - BAES #1 (Drug-Free)
-25 Min. - Pre-Treatment Baseline Blocks (Tasks O,N,A)
0 Min. - Drink #1
5 Min. - Drink #2
6 Min. - Rest
23 Min. - BAC 1
25 Min. - Test 1 (Tasks O,N,A)
50 Min. - BAES#2
55 Min. - BAC 2
56 Min. - Rest
70 Min. - BAC 3
88 Min. - BAC 4
90 Min. - Test 2 (Tasks O,N,A)
115 Min. - BAES#3
120 Min. - BAC 5

Appendix C-13

Debriefing:

We are interested in how university students respond to information that is presented visually by computers. We are collecting data from a large number of students that will be used to provide a representative normal sample of respondents so that we can examine differences within this group. In particular, we are looking at the accuracy of responses and speed with which people react to the information. Drugs, like alcohol, may affect responses to information in different ways. Alcohol is a depressant drug and may impair the ability to respond accurately and quickly. To examine its effects, we administered a mild amount of alcohol to test a participant's performance. To understand how alcohol affects performance, we compare a participant's performance under alcohol to his performance drug-free. Any differences between these conditions in responses will help us to understand exactly how alcohol affects the ability to perform visual/spatial tasks.

We are also interested in studying the types of effects people expect from alcohol. The scales that you completed will help us gather this information.

Do you have any questions?

We ask that you do not discuss the details of this experiment with anyone. Potential participants who have prior knowledge about the experiment cannot be used as their data would contaminate the outcome of the results.

We have prepared an information sheet on alcohol that may be of interest to you. It gives you some factual information on alcohol and also lists the typical effects alcohol has upon people at different Blood Alcohol Concentrations (BACs). You can take a copy home if you like.

As mentioned before, we require that you remain in the lab area until your blood alcohol level falls to a safe level. Your blood alcohol concentration at this time is _____%. We remind you not to operate any machinery for the next two hours. Also you must not drive home (this includes riding a bike). Are you planning on remaining on campus? (If not) How are you planning to return home?

Appendix C-14

Information for Participants:

Despite the wide variety of alcohol beverages, all are composed of ethyl alcohol and water. Because alcohol is already liquid, it does not have to dissolve in the stomach as does a drug in a tablet form. Thus it is rapidly and completely absorbed by simple diffusion across membranes. The rate of absorption is determined by both the amount of food in the gastro-intestinal tract and the nature of the beverage consumed.

In general, the more concentrated the alcohol is, the more rapid its absorption, [i.e., diluted alcoholic beverages (such as beer) are absorbed more slowly than are concentrated drinks (such as cocktails)]. Food in the stomach retards the absorption, firstly, because it will dilute the concentration of the alcohol and secondly, it covers some of the stomach membranes through which alcohol is absorbed. Also, a full stomach will prolong emptying time. Thus, blood alcohol levels will rise faster for an individual who has fasted than for a person who has just eaten a large meal. However, the alcohol will still be completely absorbed except that for the person who has eaten, it will be somewhat delayed.

Elimination of alcohol from the organism (e.g. via lungs, liver, and kidneys) is a gradual process. In humans, elimination proceeds in a linear fashion at the rate of approximately 10 ml. of absolute alcohol per hour (about an ounce of liquor). Thus, the slope of the blood alcohol curve during the absorption phase, commonly referred to as the ascending limb, is steeper than the slope of the elimination phase (descending limb).

Considerable evidence is available which suggests that the effects of alcohol are quite different under ascending as opposed to descending BACs.

BLOOD ALCOHOL CONCENTRATION (BAC)

The following effects of alcohol occur because of its action upon the brain. Alcohol's effects are fairly predictable from the amount in the bloodstream. Therefore, if you know a person's BAC you can roughly predict what effects alcohol will be having upon him or her. Here are some examples:

- At 20 mg% (.02 BAC) light and moderate drinkers begin to feel some effects. This is the approximate BAC reached after one drink.
- At 40 mg% (.04 BAC) most people begin to feel relaxed.
- At 60 mg% (.06 BAC) judgement is somewhat impaired; people are less able to make rational decisions about their capabilities (e.g. to drive).
- At 80 mg% (.08 BAC) there is a definite impairment of muscle coordination and driving skills; legally impaired in Ontario
- At 100 mg% (.10 BAC) there is clear deterioration of reaction time and control; legally impaired in most of the United States.
- At 120 mg% (.12 BAC) vomiting occurs unless this level is reached slowly.
- At 150 mg% (.15 BAC) balance and movement are impaired. This BAC level means that the equivalent of one-half pint of whisky is circulating in the bloodstream.

- At 300 mg% (.30 BAC) many people lose consciousness
- At 400 mg% (.40 BAC) most people lose consciousness, some die
- At 450 mg% (.45 BAC) breathing stops, death occurs.

From: Miller, W.R., & Munoz, R.F. (1976). *How to Control Your Drinking*, Prentice-Hall, Inc.

Appendix D: Main Experiment Procedural Checks

Appendix D-1

Oneway Between Groups Analysis of Variance of Each Drinking Habit Measure:

Dose				
Source	DF	MS	F	p
Group	1	0.084	0.176	0.677
Error	34	0.479		

Duration				
Source	DF	MS	F	p
Group	1	1.204	0.323	0.574
Error	34	3.727		

Frequency				
Source	DF	MS	F	p
Group	1	2.682	0.843	0.365
Error	34	3.182		

Appendix D-2

Analysis of Variance of Drug-Free Baseline RT on Three Cue Conditions, for Two Groups on Three Tasks:

Table 1: Valid Trials

Source	DF	MS	F	p
Between Subjects				
Group	1	9457.532	1.004	0.323
Error	34	9419.266		
Within Subjects				
Task	2	4485.997	10.854	<0.001
Task x Group	2	1106.945	2.678	0.076
Error	68	413.290		

Table 2 Invalid Trials

Source	DF	MS	F	p
Between Subjects				
Group	1	21231.327	1.876	0.180
Error	34	11319.668		
Within Subjects				
Task	2	8199.471	5.472	0.006
Task x Group	2	55.034	0.037	0.964
Error	68	1498.544		

Table 3: No-Cue Trials

Source	DF	MS	F	p
Between Subjects				
Group	1	6794.266	0.650	0.426
Error	34	10447.232		

Within Subjects				
Task	2	40.108	0.088	0.915
Task x Group	2	265.026	0.585	0.560
Error	68	453.222		

Analysis of Variance of Drug-Free Baseline Log-Transformed RT on Three Cue Conditions, for Two Groups on Three Tasks:

Table 4: Valid Trials

Source	DF	MS	F	p
Between Subjects				
Group	1	0.063	1.446	0.237
Error	34	0.044		
Within Subjects				
Task	2	0.023	11.251	<0.001
Task x Group	2	0.005	2.290	0.109
Error	68	0.002		

Table 5 Invalid Trials

Source	DF	MS	F	p
Between Subjects				
Group	1	0.094	2.139	0.153
Error	34	0.044		
Within Subjects				
Task	2	0.034	6.232	0.003
Task x Group	2	0.000	0.025	0.975
Error	68	0.005		

Table 6: No-Cue Trials

Source	DF	MS	F	p
Between Subjects				
Group	1	0.032	0.793	0.379
Error	34	0.040		
Within Subjects				
Task	2	0.000	0.168	0.845
Task x Group	2	0.001	0.555	0.577
Error	68	0.002		

Appendix D-3

Mean Accuracy Scores (and Percent Accuracy) on Three Tasks at Drug-Free Baseline and 2 Tests under Alcohol for 2 Groups

Table 1: Valid Trials (out of a total of 44 trials)

	Task O		Task N		Task A	
	Mean	(%)	Mean	(%)	Mean	(%)
Alcohol						
Baseline	42.722	97.095	42.444	96.464	42.389	96.339
Test 1	42.167	95.834	41.000	93.182	41.111	93.434
Test 2	42.556	96.718	41.222	93.686	41.944	95.327
Placebo						
Baseline	43.111	97.980	43.000	97.727	42.500	96.591
Test 1	43.222	98.232	42.944	97.600	42.444	96.464
Test 2	43.389	98.611	42.500	96.591	42.000	95.455

Table 2: Invalid Trials (out of a total of 12 trials)

	Task O		Task N		Task A	
	Mean	(%)	Mean	(%)	Mean	(%)
Alcohol						
Baseline	11.833	98.608	11.556	96.300	11.444	95.367
Test 1	11.444	95.367	11.167	93.058	11.278	93.983
Test 2	11.778	98.150	11.444	95.367	11.500	95.833
Placebo						
Baseline	11.944	99.533	11.778	98.150	11.889	99.075
Test 1	11.667	97.225	11.889	99.075	11.833	98.608
Test 2	11.889	99.075	11.833	98.608	11.944	99.533

Table 3: No-Cue Trials (out of a total of 56 trials)

	Task O		Task N		Task A	
	Mean	(%)	Mean	(%)	Mean	(%)
Alcohol						
Baseline	54.500	97.321	54.500	97.321	54.556	97.421
Test 1	53.611	95.734	53.722	95.932	54.444	97.221
Test 2	53.167	94.941	53.333	95.238	54.167	96.727
Placebo						
Baseline	54.500	97.321	55.000	98.214	54.722	97.718
Test 1	55.222	98.611	55.222	98.611	55.222	98.611
Test 2	54.889	98.016	54.833	97.916	54.944	98.114

Appendix E: Mean (SD) Blood Alcohol Concentrations for Group A

Means and Standard Deviations for Blood Alcohol Concentrations (mg/100ml) as a Function of Time After Drinking Commenced

	Time (minutes after drinking)				
	24	55	70	89	120
Mean (SD)	72.0 (13.0)	91.0 (10.0)	89.0 (9.0)	80.0 (9.0)	73.0 (9.0)

The average BAC for a given test was interpolated by using the BACs taken prior to and following the test, calculating the rate of change in BAC per minute during that time period, determining the time at which the midpoint of the test occurred (12.5 minutes after the BAC was taken), multiplying the per minute rate by this length of time, and adding this total to the BAC taken prior to the test.

Appendix F: Means, Standard Deviations, and Supplementary Analyses for Valid Trials

Appendix F-1

Table 1: Mean Change in RT (SD) on Valid Trials for Two Groups on Three Tasks, Averaged Over Two Tests

	Task O	Task N	Task A
Alcohol			
Mean	-3.14	-11.12	-10.72
(SD)	(24.45)	(33.84)	(27.52)
Placebo			
Mean	-1.00	4.74	18.02
(SD)	(17.65)	(31.82)	(30.25)

Table 2: Mean Change in RT (SD) on Valid Trials for Two Groups on the Three Tasks for Two Tests:

	Task O		Task N		Task A	
	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
Alcohol						
Mean	-0 04	-6.24	-6 70	-15.54	-7.59	-13 84
(SD)	(26.84)	(31.57)	(39.01)	(37.74)	(31.23)	(31.96)
Placebo						
Mean	0.61	-4.60	4.18	5.30	15.50	20.54
(SD)	(21.06)	(21.28)	(37.27)	(35.06)	(26.54)	(43 12)

Appendix F-2

Simple effects of group for each task from group x task interaction for valid trials: Howell (3rd ed. p.450-452) notes that this is essentially a one-way analysis of variance with no repeated measures. Thus, subject differences are confounded with experimental error. In this case, he suggests the appropriate error SS is SS w/in cell, which is derived from the formula: SS w/in group from the overall analysis + SS task x w/in group (the interaction error term from the overall analysis).

Therefore, SS w/in cell=93499.66+67634.976

$$\text{MS w/in cell} = \frac{\text{SS w/in cell}}{\text{df for the w/in group error + df for the task x within group error}}$$

$$= \frac{161134.636}{34 + 68}$$

$$= 1579.7513$$

Furthermore, Howell says that the MS w/in cell represents 2 heterogeneous sources of error, so one should calculate the relevant df against which to evaluate F. Thus, F_{obt} should be evaluated against $F_{.05}(a\text{-}1, f')$

$$f' = \frac{(u+v)^2}{\frac{u^2}{df_u} + \frac{v^2}{df_v}}$$

where u=SS w/in groups, v=SS task x w/in groups, df_u=34, df_v=68

thus, $f' = \frac{(93499.66+67634.976)^2}{257123130+67271911.45}$

$=80.0394$

Thus, $F_{.05}(1, 80.039)$ was used.

Appendix F-3

A 2(Group) X 2(Test) x 3(Task) ANOVA of log transformations of RT scores was performed for valid trials comparing performance at drug-free baseline and on the mean of the two treatment tests for the three tasks (Table 1). The results revealed that there was a significant main effect of task, $F(2,68)=13.985$, $p<0.001$, and a significant test x group interaction, $F(1,34)=5.262$, $p=0.028$. The test x task x group interaction approached significance, $F(2,68)=2.993$, $p=0.057$. The means and standard deviations of the log transformations of the RT scores for each group, on each task, for the baseline and treatment tests, and the RTs converted from this transformation are presented in Table 2. Figures 1a and 1b present the log means from the analysis. Higher scores represent longer reaction times. The figures show that for both groups, the baseline task order (RTs to Task O being shorter than to Task N which were shorter than those to Task A) remained during treatment. In addition, the two groups performed differently from baseline to treatment on the three tasks. For Group A, RT increased from baseline to treatment to an equal extent for Tasks N and A and very slightly increased for Task O. For Group P, RT decreased for Tasks N and A from baseline to treatment, with a greater decrease on Task A than Task N, and very slightly increased on Task O. These results are consistent with the results of the analyses using change in RT presented in the body of the thesis.

Table 1: 2(Group) x 2(Test) x 3(Task) ANOVA of Log Transformations of RT Scores on Valid Trials at Drug-Free Baseline and the Mean of the Two Treatment Tests on Three Tasks

Source	DF	MS	F	p
Between Subjects				
Group	1	0.052	0.617	0.438
Error	34	0.084		
Within Subjects				
Test	1	0.000	0.082	0.777
Test x Group	1	0.016	5.262	0.028
Error	34	0.003		
Task	2	0.032	13.985	<0.001
Task x Group	2	0.002	0.941	0.395
Error	68	0.002		
Test X Task	2	0.001	1.236	0.297
Test x Task x Group	2	0.003	2.993	0.057
Error	68	0.001		

Table 2: Mean (SD) Log-Transformations of RT Scores and RT Converted from Log Values on Valid Trials for 2 Groups on 3 Tasks at Drug-Free Baseline and on the Mean of Two Treatment Tests

	Task O		Task N		Task A	
	Baseline	Treatment	Baseline	Treatment	Baseline	Treatment
Alcohol						
Mean	6.087	6.098	6.105	6.129	6.116	6.138
(SD)	(0.168)	(0.139)	(0.149)	(0.152)	(0.149)	(0.151)
RT	440	445	448	459	453	463
Placebo						
Mean	6.118	6.123	6.145	6.133	6.189	6.151
(SD)	(0.088)	(0.088)	(0.099)	(0.108)	(0.070)	(0.086)
RT	454	456	466	461	487	469

Figure 1a: Log Transformations of RT for Group A on Three Tasks at Baseline and Two Treatment Tests Combined

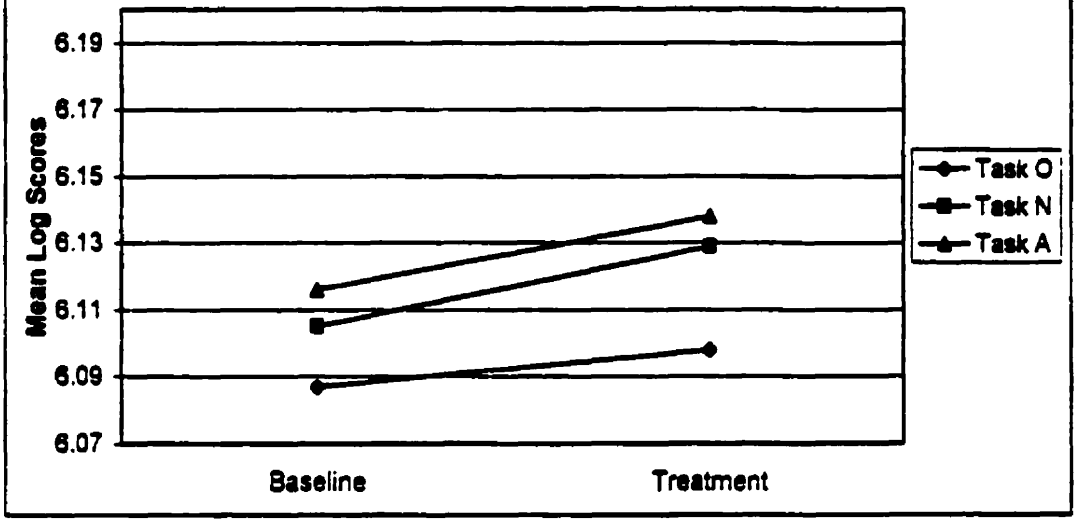
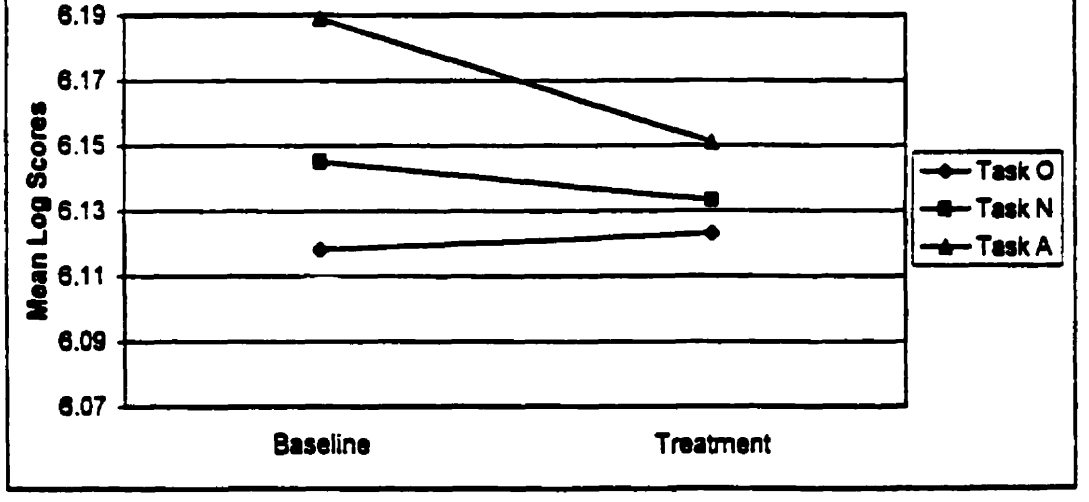


Figure 1b: Log Transformations of RT for Group P on Three Tasks at Baseline and Two Treatment Tests Combined



Appendix F-4

Table 1 Analysis of Variance of Mean Change in RT for Group P on Valid Trials for Three Tasks on Two Tests

Source	DF	MS	F	p
Within Subjects				
Test	1	2.758	0.003	0.959
Error	17	1000.750		
Task	2	3734.095	4.042	0.027
Error	34	923.924		
Test x Task	2	240.929	0.805	0.456
Error	34	299.427		
Contrasts				
Task O vs Task N				
Hypothesis	1	3269.170	3.538	0.069
Error	34	923.924		
Tasks O+N Combined vs Task A				
Hypothesis	1	79810.779	86.382	<0.001
Error	34	923.924		

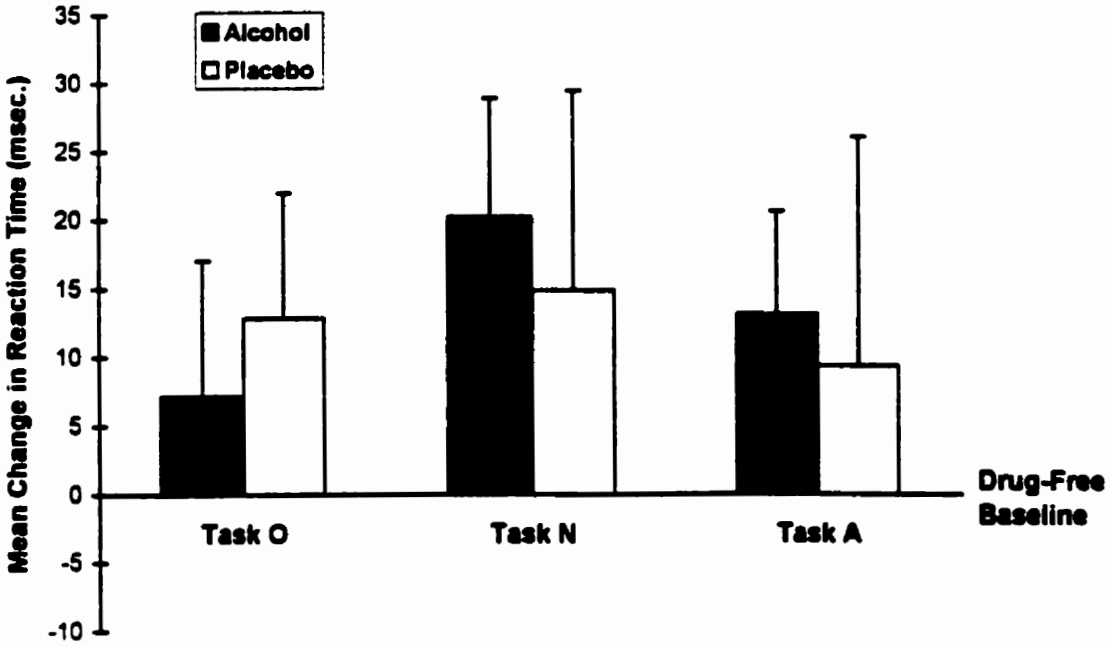
Appendix G: Means, Standard Deviations and Supplementary Analyses for Invalid Trials

Appendix G-1

Mean Change in RT(SD) for Invalid Trials for Two Groups on Three Tasks for Two Tests:

	Task O		Task N		Task A	
	Test1	Test2	Test1	Test2	Test1	Test2
Alcohol						
Mean	7.29	7.08	19.67	20.79	18.70	7.56
(SD)	(42.72)	(50.03)	(40.06)	(43.60)	(31.23)	(44.79)
Placebo						
Mean	9.21	16.46	22.35	7.42	1.19	17.54
(SD)	(45.85)	(38.27)	(62.24)	(67.73)	(82.22)	(67.71)

Figure 1: Mean Change in RT on Invalid Trials for 2 Groups on 3 Tasks, Averaged Over 2 Tests



Appendix G-2

Table 1: 2(Group) x 2(Test) x 3(Task) ANOVA of Log Transformations of RT Scores on Invalid Trials at Drug-Free Baseline and the Mean of the Two Treatment Tests on Three Tasks

Source	DF	MS	F	p
Between Subjects				
Group	1	0.179	1.948	0.172
Error	34	0.092		
Within Subjects				
Test	1	0.040	7.742	0.009
Test x Group	1	0.000	0.028	0.868
Error	34	0.005		
Task	2	0.055	10.781	<0.001
Task x Group	2	0.001	0.212	0.809
Error	68	0.005		
Test X Task	2	0.002	0.501	0.608
Test x Task x Group	2	0.000	0.081	0.922
Error	68	0.003		

Table 2: Mean (SD) Log-Transformations of RT Scores and RT Converted from Log Values on Invalid Trials for the Entire Sample (N=36) on 3 Tasks at Drug-Free Baseline and on the Mean of Two Treatment Tests

	Task O		Task N		Task A	
	Baseline	Treatment	Baseline	Treatment	Baseline	Treatment
Mean	6.165	6.147	6.213	6.176	6.223	6.197
(SD)	(0.137)	(0.115)	(0.138)	(0.151)	(0.135)	(0.153)
RT	476	467	499	481	504	491

Appendix H: Means, Standard Deviations and Supplementary Analyses for No-Cue Trials

Appendix H-1

Mean Change in RT and Standard Deviations for No-Cue Trials for Two groups on Three Tasks for Two Tests:

	Task O		Task N		Task A	
	Test1	Test2	Test1	Test2	Test1	Test2
Alcohol						
Mean	10.08	4.21	9.14	12.92	-0.84	-2.03
(SD)	(27.25)	(33.70)	(30.75)	(27.53)	(36.11)	(39.72)
Placebo						
Mean	10.72	6.22	10.93	8.85	5.48	10.29
(SD)	(20.56)	(19.97)	(32.38)	(34.92)	(28.88)	(43.16)

Appendix H-2

Table 1: 2(Group) x 2(Test) x 3(Task) ANOVA of Log Transformations of RT Scores on No-Cue Trials at Drug-Free Baseline and the Mean of the Two Treatment Tests on Three Tasks

Source	DF	MS	F	p
Between Subjects				
Group	1	0.049	0.685	0.414
Error	34	0.072		
Within Subjects				
Test	1	0.009	4.211	0.048
Test x Group	1	0.001	0.418	0.522
Error	34	0.002		
Task	2	0.001	0.500	0.609
Task x Group	2	0.001	0.334	0.717
Error	68	0.002		
Test X Task	2	0.001	1.024	0.365
Test x Task x Group	2	0.001	0.517	0.598
Error	68	0.001		

Table 2: Mean (SD) Log-Transformations of RT Scores and RT Converted from Log Values on No-Cue Trials for the Entire Sample (N=36) on 3 Tasks at Drug-Free Baseline and on the Mean of Two Treatment Tests

	Task O		Task N		Task A	
	Baseline	Treatment	Baseline	Treatment	Baseline	Treatment
Mean	6.210	6.196	6.206	6.186	6.204	6.199
(SD)	(0.114)	(0.100)	(0.121)	(0.111)	(0.125)	(0.115)
RT	498	491	496	486	495	492

Appendix I: Analyses Comparing RTs on Valid and Invalid Trials for Three Tasks

Table 1: Analysis of Variance of Log-Transformed RTs on Task O for Two Groups on Three Tests for Two Cue Conditions

Source	DF	MS	F	p
Between Subjects				
Group	1	0.076	0.949	0.337
Error	34	0.080		
Within Subjects				
Cue	1	0.110	26.510	<0.001
Cue x Group	1	0.006	1.510	0.228
Error	34	0.004		
Test	2	0.001	0.308	0.736
Test x Group	2	0.001	0.307	0.737
Error	68	0.004		
Cue x Test	2	0.005	3.178	0.048
Cue x Test x Group	2	0.000	0.220	0.803
Error	68	0.002		

Table 2: Mean (SD) Log-Transformations of RT Scores and RT Converted from Log Values on Task O for Two Groups on Three Tests for Valid and Invalid Trials

	Baseline	Test 1	Test 2
Alcohol			
Valid	6.087	6.091	6.105
(SD)	(0.168)	(0.143)	(0.142)
RT	440	442	448
Invalid	6.137	6.121	6.127
(SD)	(0.141)	(0.151)	(0.099)
RT	463	455	458
Placebo			
Valid	6.118	6.117	6.128
(SD)	(0.088)	(0.089)	(0.095)
RT	454	454	459

Invalid	6.193	6.176	6.161
(SD)	(0.131)	(0.119)	(0.110)
RT	489	481	474

Table 3: Analysis of Variance of Log-Transformed RTs on Task N for Two Groups on Three Tests for Two Cue Conditions

Source	DF	MS	F	p
Between Subjects				
Group	1	0.091	0.978	0.330
Error	34	0.093		
Within Subjects				
Cue	1	0.189	17.103	<0.001
Cue x Group	1	0.034	3.054	0.090
Error	34	0.011		
Test	2	0.008	1.722	0.186
Test x Group	2	0.001	0.299	0.743
Error	68	0.005		
Cue x Test	2	0.012	5.097	0.009
Cue x Test x Group	2	0.005	2.175	0.121
Error	68	0.002		

Table 4. Mean (SD) Log-Transformations of RT Scores and RT Converted from Log Values on Task N for Two Groups on Three Tests for Valid and Invalid Trials

	Baseline	Test 1	Test 2
Alcohol			
Valid	6.105	6.119	6.138
(SD)	(0.149)	(0.158)	(0.154)
RT	448	454	463
Invalid	6.182	6.141	6.142
(SD)	(0.147)	(0.142)	(0.122)
RT	484	465	465

Placebo			
Valid	6.145	6.134	6.132
(SD)	(0.099)	(0.111)	(0.114)
RT	466	461	460
Invalid	6.245	6.195	6.223
(SD)	(0.126)	(0.166)	(0.180)
RT	515	490	504

Table 5: Analysis of Variance of Log-Transformed RTs on Task A for Two Groups on Three Tests for Two Cue Conditions

Source	DF	MS	F	p
Between Subjects				
Group	1	0.107	1.290	0.264
Error	34	0.083		
Within Subjects				
Cue	1	0.180	10.745	0.002
Cue x Group	1	0.008	0.458	0.503
Error	34	0.017		
Test	2	0.008	1.656	0.199
Test x Group	2	0.012	2.553	0.085
Error	68	0.005		
Cue x Test	2	0.002	0.691	0.504
Cue x Test x Group	2	0.006	1.984	0.145
Error	68	0.003		

Table 6: Mean (SD) Log-Transformations of RT Scores and RT Converted from Log Values on Task A for Two Groups on Three Tests for Valid and Invalid Trials

	Baseline	Test 1	Test 2
Alcohol			
Valid	6.116	6.133	6.143
(SD)	(0.149)	(0.146)	(0.163)
RT	453	461	465

Invalid	6.193	6.158	6.178
(SD)	(0.152)	(0.127)	(0.151)
RT	489	472	482
Placebo			
Valid	6.189	6.156	6.144
(SD)	(0.070)	(0.084)	(0.101)
RT	487	472	466
Invalid	6.252	6.237	6.210
(SD)	(0.113)	(0.195)	(0.159)
RT	519	511	498

Appendix J: BAES Means, Standard Deviations and Analyses

Appendix J-1

Table 1: Mean (SD) Rating (out of a total of 70) on the Stimulant and Sedative Subscales of the BAES for 2 Groups on 3 Tests

Alcohol Group			
	Baseline	Rising Limb	Falling Limb
Sedative	12.61	20.28	27.00
(SD)	(12.43)	(14.39)	(15.65)
Stimulant	27.83	37.00	23.94
(SD)	(13.12)	(13.55)	(11.56)

Placebo Group			
	Baseline	Rising Limb	Falling Limb
Sedative	7.78	17.11	18.61
(SD)	(6.96)	(11.40)	(13.15)
Stimulant	30.61	24.17	21.61
(SD)	(11.61)	(14.08)	(10.94)

Table 2: Analysis of Variance of Baseline Ratings on the Sedation and Stimulation Subscales of the BAES in Two Groups

Source	DF	MS	F	p
Between Subjects				
Group	1	19.014	0.148	0.703
Error	34	128.393		
Within Subjects				
Subscale	1	6517.014	51.520	<0.001
Subscale x Group	1	260.681	2.061	0.160
Error	34	126.494		

Appendix J-2

Table 1: Mean (SD) Change in Rating from Drug-Free Baseline on the Stimulant and Sedative Subscales of the BAES for 2 Groups on 3 Tests

	Rising Limb	Falling Limb
Alcohol Group		
Sedative	7.67	14.39
(SD)	(12.09)	(14.61)
Stimulant	9.17	-3.89
(SD)	(14.22)	(10.45)
Placebo Group		
Sedative	9.33	10.83
(SD)	(9.76)	(12.49)
Stimulant	-6.44	-9.00
(SD)	(7.57)	(5.91)

Table 2: Pearson Product-Moment Correlations (and p-values)Between Change in Sedation and Stimulation from Drug-Free Baseline, and Mean Change in RT for Valid Trials on Task A for Alcohol and Placebo Participants

	Stimulation		Sedation	
	Rise	Fall	Rise	Fall
Alcohol	0.14	-0.23	-0.24	-0.12
(p-value)	(0.584)	(0.366)	(0.332)	(0.623)
Placebo	-0.06	-0.27	0.28	0.18
(p-value)	(0.822)	(0.283)	(0.265)	(0.482)

Table 3: Summary of Hierarchical Regression Analysis for Task A with Change in RT on Valid Trials during Rising BACs as the Dependent Variable and Group, Stimulation Rating, and Group by Rating Interaction as Predictors (N=36)

Variable	B	SE B	Standard B	F	p
Step 1					
Group	23.087	9.660	0.379	5.713	0.023
Step 2					
Group	26.088	11.962	0.429	4.756	0.036
Rating	0.192	0.442	0.086	0.190	0.666
Step 3					
Group	24.578	12.530	0.404	3.848	0.059
Rating	0.807	1.389	0.359	0.338	0.565
GroupxRating	-0.504	-1.077	-0.299	0.219	0.643

Note. R^2 = 0.144 for Step 1, ΔR^2 = 0.005 for Step 2; ΔR^2= 0.006 for Step 3.

	B	SE B	Standard B	T	p
Constant	-34.949	19.195	0.000	-1.821	0.078
Group	24.578	12.530	0.404	1.962	0.059
Rating	0.807	1.389	0.359	0.581	0.565
GroupxRating	-0.504	1.077	-0.299	-0.468	0.643

Analysis of Variance

Source	DF	MS	F	p
Regression	3	1717.608	1.949	0.142
Residual	32	881.135		

Table 4: Summary of Hierarchical Regression Analysis for Task A with Change in RT on Valid Trials during Falling BACs as the Dependent Variable and Group, Sedation Rating, and Group by Rating Interaction as Predictors (N=36)

Variable	B	SE B	Standard B	F	p
Step 1					
Group	34.385	12.651	0.422	7.388	0.010
Step 2					
Group	34.744	12.948	0.427	7.200	0.011
Rating	0.101	0.486	0.033	0.043	0.837
Step 3					
Group	23 856	17.797	0.293	1.797	0.190
Rating	-1.154	-1.485	-0.378	0.604	0.443
GroupxRating	0.883	0.986	0.439	0.801	0.378

Note: R^2 =0.179 for Step 1; ΔR^2 =0.001 for Step 2; ΔR^2=0.020 for Step 3

	B	SE B	Standard B	T	p
Constant	-33.789	28.644	0.000	-1.180	0.247
Group	23.856	17.797	0.293	1.340	0.190
Rating	-1.154	1.485	-0.378	-0.777	0.443
GroupxRating	0.883	0.986	0.439	0.895	0.378

Analysis of Variance

Source	DF	MS	F	p
Regression	3	3966.298	2.660	0.065
Residual	32	1491.048		

Appendix K: Main Experiment - Experimental Data

The raw data are presented by participant.
X = No BAC measure (placebo participant)

Line 1:

1) Treatment Assignment (1=Alcohol, 2=Placebo)
2) Age
3) # of months drinking regularly
4) Frequency of alcohol consumption (# occasions per week)
5) Dose of alcohol (ml absolute alc/kg)
6) Duration of typical drinking occasion (in hours)
7) Drink Rating on Drink Strength Questionnaire
8) BAC #1
9) BAC #2
10) BAC #3
11) BAC #4
12) BAC #5

Line 2:
1) Pre-treatment baseline RT, Task O, valid trials
2) Pre-treatment baseline RT, Task O, invalid trials
3) Pre-treatment baseline RT, Task O, no cue trials
4) Pre-treatment baseline RT, Task N, valid trials
5) Pre-treatment baseline RT, Task N, invalid trials
6) Pre-treatment baseline RT, Task N, no cue trials
7) Pre-treatment baseline RT, Task A, valid trials
8) Pre-treatment baseline RT, Task A, invalid trials
9) Pre-treatment baseline RT, Task A, no cue trials

Line 3:
1) Test 1 RT, Task O, valid trials
2) Test 1 RT, Task O, invalid trials
3) Test 1 RT, Task O, no cue trials
4) Test 1 RT, Task N, valid trials
5) Test 1 RT, Task N, invalid trials
6) Test 1 RT, Task N, no cue trials
7) Test 1 RT, Task A, valid trials
8) Test 1 RT, Task A, invalid trials
9) Test 1 RT, Task A, no cue trials

Line 4:
1) Test 2 RT, Task O, valid trials
2) Test 2 RT, Task O, invalid trials
3) Test 2 RT, Task O, no-cue trials
4) Test 2 RT, Task N, valid trials
5) Test 2 RT, Task N, invalid trials
6) Test 2 RT, Task N, no-cue trials
7) Test 2 RT, Task A, valid trials
8) Test 2 RT, Task A, invalid trials
9) Test 2 RT, Task A, no-cue trials

Line 5:
1) Change from baseline RT for Test 1, Task O, valid trials
2) Change from baseline RT for Test 1, Task N, valid trials
3) Change from baseline RT for Test 1, Task A, valid trials
4) Change from baseline RT for Test 2, Task O, valid trials
5) Change from baseline RT for Test 2, Task N, valid trials
6) Change from baseline RT for Test 2, Task A, valid trials
7) Change from baseline RT for Test 1, Task O, invalid trials
8) Change from baseline RT for Test 1, Task N, invalid trials
9) Change from baseline RT for Test 1, Task A, invalid trials

Line 6:
1) Change from baseline RT for Test 2, Task O, invalid trials
2) Change from baseline RT for Test 2, Task N, invalid trials
3) Change from baseline RT for Test 2, Task A, invalid trials
4) Change from baseline RT for Test 1, Task O, no-cue trials
5) Change from baseline RT for Test 1, Task N, no-cue trials
6) Change from baseline RT for Test 1, Task A, no-cue trials
7) Change from baseline RT for Test 2, Task O, no-cue trials
8) Change from baseline RT for Test 2, Task N, no-cue trials
9) Change from baseline RT for Test 2, Task A, no-cue trials

Line 7:
1) Pre-treatment baseline # correct responses, Task O, valid trials
2) Pre-treatment baseline # correct responses, Task O, invalid trials
3) Pre-treatment baseline # correct responses, Task O, no-cue trials
4) Pre-treatment baseline # correct responses, Task N, valid trials
5) Pre-treatment baseline # correct responses, Task N, invalid trials
6) Pre-treatment baseline # correct responses, Task N, no-cue trials
7) Pre-treatment baseline # correct responses, Task A, valid trials
8) Pre-treatment baseline # correct responses, Task A, invalid trials
9) Pre-treatment baseline # correct responses, Task A, no-cue trials
10) Test 1 # correct responses, Task O, valid trials
11) Test 1 # correct responses, Task O, invalid trials
12) Test 1 # correct responses, Task O, no-cue trials
13) Test 1 # correct responses, Task N, valid trials
14) Test 1 # correct responses, Task N, invalid trials
15) Test 1 # correct responses, Task N, no-cue trials
16) Test 1 # correct responses, Task A, valid trials
17) Test 1 # correct responses, Task A, invalid trials
18) Test 1 # correct responses, Task A, no-cue trials
19) Test 2 # correct responses, Task O, valid trials
20) Test 2 # correct responses, Task O, invalid trials
21) Test 2 # correct responses, Task O, no-cue trials
22) Test 2 # correct responses, Task N, valid trials
23) Test 2 # correct responses, Task N, invalid trials
24) Test 2 # correct responses, Task N, no-cue trials
25) Test 2 # correct responses, Task A, valid trials
26) Test 2 # correct responses, Task A, invalid trials
27) Test 2 # correct responses, Task A, no-cue trials

Line 8:
1) Pre-treatment baseline Sedation Rating
2) Pre-treatment baseline Stimulation Rating
3) Test 1 Sedation Rating
4) Test 1 Stimulation Rating
5) Test 2 Sedation Rating
6) Test 2 Stimulation Rating

Group: Alcohol

---

1 21 50 2.5 2.148 4 3.0 84 95 84 73 64
401.210 391.670 437.070 415.900 436.180 456.980 412.790 509.170 480.430
418.980 401.500 469.770 427.580 472.500 476.130 460.900 437.000 514.380
416.020 471.170 460.170 491.900 468.100 478.320 440.420 441.640 479.050
-17.770 -11.680 -48.110 -14.810 -76.000 -27.630 -9.830 -36.320 72.170
-79.500 -31.920 67.530 -32.700 -19.150 -33.950 -23.100 -21.340 1.380
43 12 55 40 11 54 42 12 53 43 12 53 40 12 55 41 12 55 43 12 53 42 10 53 43 11 56
13 24 33 16 30 15

---

1 19 17 2.0 1.342 5 3.0 68 101 90 82 72
346.020 417.000 431.540 384.020 480.250 416.870 393.890 418.750 424.930
407.490 426.920 451.150 442.270 462.640 432.830 429.000 426.080 463.040
388.020 430.500 441.620 418.160 468.670 424.330 422.190 475.420 423.110
-61.470 -58.250 -35.110 -42.000 -34.140 -28.300 -9.920 17.610 -7.330
-13.500 11.580 -56.670 -19.610 -15.960 -38.110 -10.080 -7.460 1.820
43 11 56 42 12 55 44 12 55 43 12 55 44 11 53 41 12 56 44 12 55 44 12 55 43 12 56
29 31 40 42 44 30

---

1 19 64 0.6 0.692 5 9.5 51 71 91 77 69
488.220 493.750 566.180 473.240 497.090 503.060 509.480 488.580 510.520
453.710 488.440 491.590 439.030 476.600 478.720 488.460 426.700 470.590
520.490 478.270 585.450 538.090 507.910 515.560 554.570 513.560 554.860
34.510 34.210 21.020 -32.270 -64.850 -45.090 5.310 20.490 61.880
15.480 -10.820 -24.980 74 590 24.340 39 930 -19.270 -12.500 -44.340
41 12 55 42 11 50 42 12 52 41 9 54 38 10 54 41 10 54 35 11 44 33 11 45 42 9 49
11 19 43 35 48 3

---

1 19 13 2.0 0.688 3 3.5 60 73 91 83 73
424.290 473.000 467.170 430.330 461.830 431.960 459.260 597.330 474.960
402.980 387.270 461.150 460.170 428.750 470.250 487.430 554.250 472.280
415.070 432.450 450.060 458.350 488.750 435.820 412.490 495.830 419.230
21.310 -29.840 -28.170 9.220 -28.020 46.770 85.730 33.080 43.080
40.550 -26.920 101.500 6.020 -38.290 2.680 17.110 -3.860 55.730
42 12 52 43 12 53 43 12 52 42 11 53 40 12 53 42 12 54 42 11 51 40 12 55 43 12 53
5 47 28 37 44 25

---

1 19 42 2.0 1.809 6 6.5 84 97 94 92 85
441.830 483.830 508.850 498.210 458.920 487.630 503.790 498.360 464.850
447.740 479.080 503.330 452.850 461.080 484.800 469.640 451.500 484.550
480.260 472.330 516.270 469.440 509.180 459.680 498.710 497.420 520.630
-5.910 45.360 34.150 -38.430 28.770 5.080 4.750 -2.160 46.860
11.500 -50.260 0.940 5.520 2.830 -19.700 -7.420 27.950 -55.780
41 12 55 43 12 56 38 11 55 42 12 51 41 12 54 39 10 55 43 12 55 41 11 53 41 12 54
16 28 15 30 21 27

---

1 19 41 1.0 1.503 5 4.5 94 108 95 77 70
501.650 524.250 601.560 510.390 537.500 548.930 479.180 522.080 554.290
519 740 513.090 549.330 521.660 510.090 578.230 539.470 495.000 545.240
502.190 436.420 502.590 480.330 476.830 524.920 519.730 484.330 529.430
-18.090 -11.270 -60.290 -0.540 30.060 -40.550 11.160 27.410 27.080
87.830 60.670 37.750 52.230 -29.300 9.050 98.970 24.010 24.860
43 12 55 44 12 54 44 12 52 43 11 54 41 11 56 43 10 55 42 12 51 4012 53 41 12 56
0 39 9 36 21 29

---

1 20 54 1.0 1.114 3 2.5 95 95 106 102 97
380 770 447.270 503.670 386.090 512.500 482.850 380.440 555.080 483.000
387.840 443.500 508.200 420.560 451.580 458.910 398.670 512.580 459.710
357.840 416 640 458.610 422.740 503.750 478.040 388.590 530.580 467.250
-7.070 -34 470 -18.230 22.930 -36.650 -8.150 3.770 60.920 42.500
30.630 8.750 24.500 -4.530 23.940 23.290 45.060 4.810 15.750
40 11 55 43 12 55 43 12 55 43 12 55 43 12 54 42 12 55 44 11 56 43 12 51 41 12 56
1 30 5 34 8 37

---

1 20 56 1.0 0.859 3 6.5 79 97 92 88 77
499.330 476.920 554.950 466.140 502.080 541.550 491.400 498.580 547.460
495.810 504.600 545.090 514.550 478.000 545.580 519.650 535.080 554.320
531.800 527.580 543.580 513.200 473.830 526.870 528.230 535.830 545.040
3.520 -48.410 -28.250 -32.470 -47.060 -36.830 -27.680 24.080 -36.500
-50.660 28.250 -37.250 9.860 -4.030 -6.86011.370 14.680 2.420
43 12 55 43 12 55 42 12 56 42 10 53 40 12 53 40 12 53 44 12 55 44 12 53 43 12 54
5 33 28 45 50 28

---

1 20 46 3.0 0.714 4 5.0 67 94 84 78 75
631.880 679.670 609.090 598.400 620.000 664.750 606.860 593.420 666.270
569.930 574.420 576.490 599.070 636.000 568.870 559.950 558.000 587.150

556.640 544.580 598 540 604.340 560.360 584.290 555.410 632.080 598.310
61.950 -0.670 46.910 75.240 -5.940 51.450 105.250 -16.000 35.420
135.090 59.640 -38.660 32.600 95.880 79.120 10.550 80.460 67.960
43 12 56 43 12 56 43 12 56 43 12 55 44 12 55 43 10 55 44 12 52 44 11 55 44 12 54
15 48 29 37 20 27

---

1 22 96 10.5 0.518 2 4.0 81 94 96 77 72
396.410 424.450 453.270 396.210 423.730 455.760 413.720 417.560 438.520
401.290 424.670 430.810 420.340 428.220 428.110 407.440 421.450 439.980
413.740 441.580 490.690 411.150 420.000 462.670 419.640 404.330 443.310
-4.880 -24.130 6.280 -17.330 -14.940 -5.920 -0.220 -4.490 -3.890
-17 130 3.730 13.230 22.460 27.650 -1.460 -37.420 -6.910 -4.790
44 11 56 42 11 55 43 9 54 41 12 48 35 9 53 39 11 54 42 12 51 41 11 54 42 12 54
4 20 7 57 28 18

---

1 19 36 0.1 1.156 5 1.5 58 82 80 70 60
384.000 405.330 443.910 397.370 432.360 461.110 392.370 461.170 446.960
367.390 400.090 415.620 347.850 387.450 417.420 383.080 441.090 432.220
393.050 417.250 439.090 372.840 411.180 414.750 378.050 401.420 430.110
16.610 49.520 9.290 -9.050 24.530 14.320 5.240 44.910 20.080
-11.920 21.180 59.750 28.290 43.690 14.740 4.820 46.360 16.850
44 12 53 43 11 55 41 12 56 44 11 53 39 11 53 40 11 55 44 12 56 43 11 56 39 12 55
12 43 2 61 10 30

---

1 19 3 1.0 1.814 4 5 3.0 86 87 79 78 66
540.050 527.420 571.930 549.080 559.450 583.670 551.000 583.180 479.690
561.680 559.500 571.420 586.770 583.270 561.430 580.100 530.830 541.110
491.240 504.670 527.840 538.120 497.670 538.680 621.930 604.200 586.850
-21.630 -37.690 -29.100 48.810 10.960 -70.930 -32.080 -23.820 52.350
22.750 61.780 -21.020 0.510 22.240 -61.420 44.090 44.990 -107.160
43 12 55 40 11 52 42 11 54 41 12 55 43 11 53 42 12 55 41 12 56 41 12 53 44 10 53
0 4 1 4 3 0

---

1 19 32 0.8 1.175 3.5 5.0 64 78 72 69 68
501.260 465.420 495.830 461.050 622.270 508.430 478.410 500.640 491.660
480.830 473.730 478.370 526.980 498.580 498.740 471.600 494.270 508.800
515.620 499.330 499.510 512.950 488.080 502.470 499.810 504.830 489.850
20.430 -65.930 6.810 -14.360 -51.900 -21.400 -8.310 123.690 6.370
-33.910 134.190 -4.190 17.460 9.690 -17.140 -3.680 5.960 1.810
43 12 53 39 11 54 39 11 53 41 11 54 41 12 54 40 11 51 42 12 53 41 12 53 42 12 53

17 27 35 45 33 34

---

1 22 51 0.3 1.073 4 2.0 69 104 104 88 82
374.410 392.580 455.020 413.250 382.830 442.180 413.650 399.750 437.630
399.670 371.250 433.840 379.240 391.400 447.130 370.710 390.170 407.040
386.090 385.580 442.020 363.020 357.750 437.690 402.050 373.330 432.180
-25.260 34.010 42.940 -11.680 50.230 11.600 21.330 -8.570 9.580
7.000 25.080 26.420 21.180 -4.950 30.590 13.000 4.490 5.450
44 12 56 44 12 55 43 12 56 43 12 55 41 10 56 42 12 55 43 12 55 41 12 55 43 12 56
50 26 37 48 43 41

---

1 19 14 2.0 1.144 4 4.0 68 91 93 80 70
538.300 544.580 526.710 577.590 589 500 553.530 540.880 579.640 581.430
530.370 558.330 524.460 512.840 515.450 530.200 532.090 563.920 531.750
518.360 510 830 535.730 559.770 532.830 502.550 564.930 577.820 555 780
7.930 64.750 8.790 19.940 17.820 -24.050 -13.750 74.050 15.720
33.750 56.670 1.820 2.250 23.330 49.680 -9.020 50.980 25.650
43 12 55 44 12 55 43 11 56 43 12 56 43 11 55 44 12 55 44 12 55 44 12 56 44 11 55
3 45 1 38 6 36

---

1 19 12 0 625 0.453 0.750 6 0 61 83 86 80 72
432.400 442.170 475.570 440.700 464.500 488.250 458.570 513.730 495.550
437.980 527.670 511.310 473.980 492.000 499.870 494.440 517.000 541.410
473.840 488.420 524.440 507.550 484.180 502.610 510.070 453.640 517.770
-5.580 -33.280 -35.870 -41.440 -66.850 -51.500 -85.500 -27.500 -3.270
-46.250 -19.680 60.090 -35.740 -11.620 -45.860 -48.870 -14.360 -22.220
43 12 56 44 12 55 44 11 56 40 12 54 44 11 55 39 11 56 43 12 54 42 11 54 42 11 56
24 10 25 35 35 10

---

1 19 57 1.0 0.783 2 6 57 101 92 80 71
395.200 419.580 425.320 394.090 425.550 443.160 408.360 416.170 427.000
381.980 396.330 417.110 397.180 417.830 445.710 427.240 436.080 452.830
415.260 417.730 422.230 412.730 399.600 450.120 413.140 464.000 439.420
13.220 -3.090 -18.880 -20.060 -18.640 -4.780 23.250 7.720 -19.910
1.850 25.950 -47.830 8.210 -2.550 -25.830 3.090 -6.960 -12.420
44 12 53 43 11 56 44 12 56 43 12 54 38 12 49 41 12 54 43 11 53 37 10 52 35 12 50
16 15 15 44 35 27

---

1 21 78 2.0 2.060 4 2 72 87 81 67 65
352.020 404.170 383.960 360.950 391.550 390.750 343.190 351.400 374.840
364.560 351.450 391.130 350.720 352.600 374.040 353.980 377.000 388.620
366.000 410.330 397.400 358.000 375.250 389.520 356.470 378.270 384.290
-12.540 10.230 -10.790 -13.980 2.950 -13.280 52.720 38.950 -25.600
-6.160 16.300 -26.870 -7.170 16.710 -13.780 -13.440 1.230 -9.450
42 12 50 42 11 56 43 10 55 41 11 53 43 10 52 41 11 53 43 12 52 41 12 54 43 11 55
6 12 12 22 7 14

Group: Placebo

---

2 19 68 1.5 3.657 9.5 0 5 X X X X X
478.420 594.250 551.880 507.550 644.830 595.380 484.670 612.750 578.430
508.390 614.080 584.300 598.860 769.830 628.590 497.950 863.750 613 520
505.750 607.250 539.230 507.600 774.000 597.960 476.430 817.250 557.610
-29.970 -91.310 -13.280 -27.330 -0.050 8.240 -19.830 -125.000 -251.000
-13.000 -129.170 -204.500 -32.420 -33.210 -35.090 12.650 -2.580 20.820
43 12 56 44 12 56 43 12 56 44 12 56 44 12 56 43 12 56 44 12 56 43 12 56 42 12 56
10 33 22 32 38 16

---

2 19 40 2.0 0.683 2 1.5 X X X X X
467.800 465.750 482.630 513.840 478.420 543.110 506.730 504.830 530.420
483.590 485 000 495.760 479.890 509.080 532.330 537.000 501.750 556.960
488.270 495.750 502.360 501.680 554.080 527.150 473.890 509.420 506.250
-15.790 33.950 -30.270 -20.470 12.160 32.840 -19.250 -30.660 3.080
-30.000 -75.660 -4.590 -13.130 10.780 -26.540 -19.730 15.960 24.170
44 12 56 44 12 56 44 12 55 44 12 55 44 12 55 44 12 56 44 12 55 44 12 55 44 12 56
17 34 28 20 18 28

---

2 19 40 1 1.652 4 1.5 X X X X X
456.420 472.330 468.100 435.540 478.170 447.320 460.690 489.080 469.810
431.730 404.270 453.430 452.050 450.750 481.300 481.900 496.420 490.750
455.860 438.550 487.960 428.170 461.330 472.040 449.820 450.750 473.760
24.690 -16.510 -21.210 0.560 7.370 10.870 68.060 27.420 -7.340
33.780 16.840 38.330 14.670 -33.980 -20.940 -19.860 -24.720 -3.950
43 12 52 41 12 53 42 12 53 41 11 54 41 12 54 40 12 55 43 11 54 41 12 55 39 12 55
3 41 22 31 31 32

---

2 19 35 0.625 1.350 4 2 X X X X X

427.700 464.580 448.510 402.420 466.170 437.640 448.790 501.330 415.560
419.760 413.640 415.690 413.930 422.250 412.860 411.220 404.670 433.300
401.480 399.420 418.450 404.880 431.580 422.140 429.330 414.250 446.690
7.940 -11.510 37.570 26.220 -2.460 19.460 50.940 43.920 96.660
65.160 34.590 87.080 32.820 24.780 -17.740 30.060 15.500 -31.130
44 12 55 43 12 55 43 12 54 42 11 55 42 12 56 41 12 56 42 12 53 41 12 56 39 12 55
3 36 13 28 26 26

---

2 20 42 0.250 0.683 51.5 X X X X X
417.600 419.330 458.750 375.290 498.170 431.130 447.550 589.910 482.060
398.770 482.080 459.280 391.700 499.420 464.930 423.480 466.670 448.760
457.270 467.670 481.630 395.950 454.080 440.310 477.280 520.330 512.530
18 830 -16.410 24.070 -39.670 -20.660 -29.730 -62.750 -1.250 123.240
-48.340 44.090 69.580 -0.530 -33.800 33.300 -22.880 -9.180 -30.470
43 12 56 41 12 53 42 11 53 43 12 53 44 12 54 42 12 54 44 12 56 41 12 54 43 12 51
5 25 29 7 22 8

---

2 19 46 0.500 0.789 4 2 X X X X X
420.520 473.500 483.960 461.560 545.910 515.160 516.910 602.910 519.620
451.390 447.450 462.330 477.000 552.000 472.740 466.980 572.080 529.130
440.640 507.500 468.310 471.490 509.250 486.870 461.760 469.250 492.340
-30.870 -15 440 49.930 -20.120 -9.930 55.150 26.050 -6.090 30.830
-34.000 36.660 133.660 21.630 42.420 -9.510 15.650 28.290 27.280
44 12 53 43 11 56 44 11 53 44 11 55 43 12 54 41 12 55 44 12 55 43 12 53 41 12 56
26 42 34 43 32 29

---

2 20 78 1.0 1.879 6 2 X X X X X
487.770 543.830 507.770 479.770 486.750 491.340 510.840 504.330 460.250
459.980 452.250 485.860 472.000 487.670 483.140 492.370 457.330 492.640
477.320 489.580 512.130 466.110 529.420 495.450 465.720 446.910 466.160
27.790 7.770 18.470 10.450 13.660 45.120 91.580 -0.920 47.000
54.250 -42.670 57.420 21.910 8.200 -32.390 -4.360 -4.110 -5.910
44 12 56 43 12 56 43 12 56 44 12 56 44 12 56 43 12 56 44 12 55 44 12 53 43 11 55
13 43 27 35 34 35

---

2 20 74 3.0 1.735 7 3 X X X X X
428.250 446.420 487.940 444.480 471.830 453.000 478.110 465.580 462.130
440.840 501.670 497.630 447.050 440.170 439.140 448.930 434.580 465.210
458.400 426.580 495.850 414.880 426.420 433.160 463.240 479.420 484.820
-12.590 -2.570 29.180 -30.150 29.600 14.870 -55.250 31.660 31.000

19.840 45.410 -13.840 -9.690 13.860 -3.080 -7.910 19.840 -22.690
44 12 54 42 12 54 44 12 56 44 12 54 42 12 56 42 12 56 43 12 54 43 12 55 42 12 56
1 7 0 0 0 0

---

2 19 87 2.0 2.065 7 2.5 X X X X X
552.860 603.670 587.830 527.420 561.080 558.710 537.530 568.330 590.700
548.200 577.580 569.110 504 090 531.750 533.630 496.430 538.420 524.820
535.000 560.250 556.130 524.090 553.670 540.820 495.840 514.250 511.260
4.660 23.330 41.100 17.860 3.330 41.690 26.090 29.330 29.910
43.420 7.410 54.080 18.720 25.080 65.880 31.700 17.890 79.440
44 12 54 43 12 55 43 12 54 44 12 56 44 12 56 44 12 55 44 12 55 44 12 55 44 12 53
8 42 14 46 32 27

---

2 20 27 1.0 1.182 4 2 X X X X X
436.660 410.830 450.270 445.980 449.640 465.770 496.980 496.500 460.890
434.750 460.000 452.750 437.420 399.500 458.320 463.720 460.420 448.020
429.340 447.580 464.150 434.950 432.750 422.360 447.550 454.830 424.930
1.910 8.560 33.260 7.320 11.030 49.430 -49.170 50.140 36.080
-36.750 16.890 41.670 -2.480 7.450 12.870 -13.880 43.410 35.960
44 12 56 44 11 56 44 12 56 44 11 56 43 12 56 43 12 54 44 12 53 42 12 56 44 12 56
1 37 16 33 27 28

---

2 20 29 1.0 0.478 1 1.5 X X X X X
502.930 535.250 579.490 507.280 524.330 551.790 538.530 570.330 591.130
500.770 541.330 545.980 520.550 604.500 588.090 539.300 649.420 567.950
549.800 513 920 559.290 602.590 687.250 649.570 648.770 553.750 705.020
2.160 -13.270 -0.770 -46.870 -95.310 -110.240 -6.080 -80.170 -79.090
21.330 -162.920 16.580 33.510 -36.300 23.180 20.200 -97.780 -113.890
43 12 53 43 12 56 43 12 55 43 12 56 44 12 55 44 12 56 44 12 55 44 12 56 44 12 55
11 27 10 37 11 34

---

2 19 46 0.750 0.454 3 2 X X X X X
431.560 463.670 467.140 442.550 489.400 469.930 432.570 450.830 481.460
413.950 433.090 477.630 389.500 411.400 442.540 402.110 444.640 450.980
425.460 449.750 465.530 404.980 420.640 460.260 398.950 436.580 436.500
17.610 53.050 30.460 6.100 37.570 33.620 30.580 78.000 6.190
13.920 68.760 14.250 -10.490 27.390 30.480 1.610 9.670 44.960
39 12 51 42 10 56 35 12 52 41 11 54 40 10 54 36 11 54 41 12 55 42 11 54 37 12 52

3 24 11 15 2 13

---

2 19 14 0.039 0.418 0.500 3.500 X X X X X
463.520 542.080 596.510 497.930 732.580 623.720 506.950 630.080 631.910
495.500 559.000 596.000 452.500 595.580 585.130 479.120 612.080 590.070
467.670 491.270 589.020 432.870 647.500 560.730 455.450 638.170 597.930
-31.980 45.430 27.830 -4.150 65.060 51.500 -16.920 137.000 18.000
50.810 85.080 -8.090 0.510 38.590 41.840 7.490 62.990 33.980
42 12 55 43 12 54 41 12 56 44 12 56 42 12 56 42 12 56 43 11 55 39 12 55 38 12 56
11 20 27 15 27 15

---

2 19 30 2.0 1.455 4 2 X X X X X
378.000 395.170 468.470 463.910 489.000 492.500 491.470 447.420 460.670
390.680 417 450 457 090 394.520 443.250 422.910 440.000 364.670 429.580
374.740 412.170 439.740 416.350 453.920 484.750 406.500 445.000 404.460
-12 680 69.390 51.470 3.260 47.560 84.970 -22.280 45.750 82.750
-17.000 35.080 2.420 11.380 69.590 31.090 28.730 7.750 56.210
44 12 53 44 12 56 43 12 54 44 11 56 44 12 54 44 12 53 43 12 54 40 12 55 44 12 56
5 21 18 3 9 15

---

2 19 119 0.375 0.378 0.333 4 X X X X X
442.820 527.080 518.160 454.700 514.250 493.850 513.840 506.170 523.170
454.330 489.080 498.840 487.120 439.580 477.360 503.590 503.820 519.630
446.860 490.330 517.320 478.650 493.830 487.240 463.370 484.330 484.750
-11.510 -32.420 10.250 -4.040 -23.950 50.470 38.000 74.670 2.350
36.750 20.420 21.840 19.320 16.490 3.540 0.840 6.610 38.420
44 12 56 43 12 54 43 12 54 43 12 56 42 12 56 44 11 56 44 12 56 43 12 54 41 12 55
1 11 0 11 0 11

---

2 19 53 2.0 2.005 6 3 X X X X X
431.350 453.670 465.000 418.200 443.500 444.320 424.610 434.170 438.090
439.340 461.080 455.420 438.680 458.670 461.160 448.520 495.830 462.730
423.300 428.330 460.480 437.700 410.080 452.800 442.200 452.000 444.360
-7.990 -20.480 -23.910 8.050 -19.500 -17.590 -7.410 -15.170 -61.660
25.340 33.420 -17.830 9.580 -16.840 -24.640 4.520 -8.480 -6.270
43 12 56 44 12 56 44 12 56 44 12 55 44 12 56 44 12 55 43 12 56 43 12 56 44 12 56
0 47 0 41 3 37

---

2 21 68 0.5 1.220 4 2 X X X X X
472.220 460.090 529.910 527.930 529.000 560.060 506.980 499.000 547.750
438.100 448.670 506.750 495.640 428.170 495.730 475.650 539.830 542.200
462.720 433.000 530.440 527.020 505.500 502.660 473.000 486.830 538.520
34.120 32.290 31.330 9.500 0.910 33.980 11.420 100.830 -40.830
27.090 23.500 12.170 23.160 64.330 5.550 -0.530 57.400 9.230
41 11 53 44 12 52 40 12 56 41 12 55 42 12 55 43 12 55 43 12 55 44 10 53 43 12 54
6 40 33 23 20 27

---

2 20 54 4.0 0.705 3 1.5 X X X X X
506.670 609.420 565.140 523.980 549.250 542.930 493.000 523.250 530.450
482.050 527.330 510.610 502.610 506.330 540.950 509.520 569.000 509.660
486.020 525.670 517.520 484.890 473.500 522.090 497.910 507.670 501.380
24.620 21.370 -16.520 20.650 39.090 -4.910 82.090 42.920 -45.750
83.750 75.750 15.580 54.530 1.980 20.790 47.620 20.840 29.070
43 12 56 43 12 56 44 12 56 44 12 56 44 12 55 44 11 56 44 12 56 44 12 56 44 12 56
16 21 4 15 3 8
