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# THE EFFECTS OF ALCOHOL-RELATED VISUAL STIMULI ON INHIBITORY CONTROL AND ATTENTIONAL BIAS: TESTING THE ROLES OF CLASSICAL CONDITIONING AND SEMANTIC PRIMING

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THE EFFECTS OF ALCOHOL-RELATED VISUAL STIMULI ON INHIBITORY  
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THESIS

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A thesis submitted in partial fulfillment of the  
requirements for the degree of Master of Science in the  
College of Arts & Sciences  
at the University of Kentucky

By

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Lexington, Kentucky

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2015

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## ABSTRACT OF THESIS

### THE EFFECTS OF ALCOHOL-RELATED VISUAL STIMULI ON INHIBITORY CONTROL AND ATTENTIONAL BIAS: TESTING THE ROLES OF CLASSICAL CONDITIONING AND SEMANTIC PRIMING

Alcohol research has shown that alcohol-related stimuli can disrupt behavioral control and attract more attention in alcohol drinkers. Stimuli typically used in tasks assessing these mechanisms are likely representative of an individual's history. Responses to visual stimuli that no longer closely resemble an individual's history may help shed light on whether these behaviors are due to classical conditioning or processes such as semantic priming. Hypotheses were tested using typical visual stimuli and modified, abstract versions in these tasks. 41 participants were exposed to these stimuli types while using a visual dot probe task. The difference in degree of attentional bias between real and modified stimuli was determined using gaze time. Individuals participated in two versions of the attentional bias-behavioral activation (ABBA) task. Proportion of inhibitory failure differences between versions was examined for the effects of stimuli modification on behavioral control. Results demonstrated that the sample did not exhibit an attentional bias to alcohol. Visual probe results yielded no differences between real and modified stimuli on attentional bias. ABBA performance indicated no differences as a result of image abstraction or stimuli type. Reasons for these findings and comparisons to similar research inquiries using the tasks the current thesis utilized were explored.

**KEYWORDS:** Alcohol, Attentional Bias, Inhibitory Control, Classical Conditioning, Semantic Priming

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June 16, 2015

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## Chapter One: Introduction

Alcohol research largely focuses on the impact that alcohol consumption has on behavioral and cognitive functioning. Although there is little dispute that the positive rewarding effects of a drug motivates drug-taking and contributes to drug dependence, research in recent decades has also identified the role of several cognitive factors in the development of drug addiction. In recent years, alcohol abuse research has paid considerable attention primarily to two cognitive mechanisms: attentional bias and behavioral control (Field & Cox, 2008; Stacy & Wiers, 2010; Fillmore, 2003). It has been observed that alcohol abusers tend to focus more of their attention (have an attentional bias) towards alcohol-related stimuli than do non-abusers (Field & Cox, 2008). This bias is believed to encourage continued consumption of the drug. Consumption of alcohol also leads to a difficulty in regulating behavior, such as suppressing the urge to consume more alcohol. This struggle with behavioral control is also a common characteristic of alcohol abusers (Lyvers, 2000; Fillmore, 2003). It has been posited that these two cognitive factors may work together and influence one another (Field & Cox, 2008; Weafer & Fillmore, 2012).

### *Attentional Bias*

Attentional bias is believed to be the result of classical conditioning in heavy drinkers due to their history of consumption (Field & Cox, 2008). Associations with alcohol consumption occur alongside the presence of alcohol-related cues, including the alcohol itself, which makes these cues more relevant to heavy drinkers than to others. It is for this reason that alcohol abusers pay more attention to alcohol-related stimuli over those who do not drink or are not heavy drinkers (Marczinski et al., 2007).

Substance-related stimuli, or cues, elicit classically conditioned responses in substance abusers according to the incentive motivation model (Franken, 2003). These responses may be physiological or subjective and may elicit craving and increased motivation for substance use (Ryan, 2002a). This occurs due to frequent pairings of substance-related cues with the administration of that substance and, over time, these cues become associated with consumption of the and motivation to consume (Robinson & Berridge, 1993). Substance-related stimuli therefore become increasingly salient to substance abusers. In turn, when such stimuli are encountered, those individuals attend to these types of cues much more than non-abusers.

Although it is believed that attentional bias to substance-related cues may elicit subjective craving, some theorize that experiences of craving may increase an individual's attentional bias (Field & Cox, 2008). As a substance user experiences increased cravings, substance-related cues become more salient and the individual focuses on these stimuli more intently. As more and more attention is allocated to these stimuli, the substance-user may experience an even greater desire to consume the drug resulting in a reciprocal relationship.

Eye-tracking tasks have been the most recent breakthrough in attempting to study attentional bias in the laboratory (Miller & Fillmore, 2010). In assessing for attentional bias, tasks such as the visual dot probe and the scene inspection paradigm are often used (Field & Cox, 2008; Weafer & Fillmore, 2012). These tasks implement eye-tracking technology in order to determine where an individual is looking and, primarily, the amount of time an individual spends fixating on an image. In the visual dot probe task, both alcohol-related and neutral stimuli are presented simultaneously on a computer

screen. Individuals are asked to look at both images before they disappear and a target is presented in place of one of the images to which the participant then responds. Eye-tracking software monitors the amount of time an individual focuses on each of these images. Longer fixation times on alcohol-related images compared to the neutral images is believed to indicate attentional bias (Miller & Fillmore, 2010).

### *Behavioral Control*

In addition to attentional bias, a considerable amount of research has focused on the impacts of alcohol on behavioral control. Behavioral control has been described with a focus on two processes, an activational process and an inhibitory one (Gray, 1976). Activational processes direct the execution of certain behaviors, whereas inhibitory processes are responsible for preventing undesirable behaviors from being carried out. It is believed that these two processes work opposite of one another, with an individual's behavior being the outcome of one process outweighing the other.

Past research has shown that alcohol consumption can lead to difficulties with behavioral control, causing individuals to become more impulsive and disinhibited (Poulos et al., 1998; Fillmore, 2003). Using a cued go/no-go task, Marczinski and Fillmore (2003) found that participants who consumed alcohol had greater impairment of their inhibitory control compared to those under placebo. A cued go/no-go task operates by presenting a stimulus cue followed by a go or no-go target stimulus that requires a response to be either executed (go) or suppressed (no-go). The cue provides information concerning the probability that a go or no-go target will be presented. The cue-target relationship is manipulated so that cues have a high probability of correctly signaling a target and a low probability of incorrectly signaling a target. Correct cues tend to

facilitate response execution and response inhibition. Failures to inhibit responses are measured and account for the individual's performance in the inhibitory process. For example, responses to go targets are faster when they are preceded by a go cue. Similarly, the likelihood of suppressing a response to a no-go target is greater when it is preceded by a no-go cue. The authors demonstrated that alcohol impaired inhibition and execution when cues incorrectly signaled actions in a cued go/no-go task.

This difficulty with regulating behavior, primarily inhibition, in alcohol abusers is believed to contribute to ongoing abuse of the substance (Vogel-Sprott, et al., 2001; Fillmore, 2007). Among alcohol users, heavy drinkers demonstrate greater inhibitory impairment than individuals who drink less (Marczinski et al., 2007). Weafer and Fillmore (2008) also showed that continued alcohol consumption could be predicted by alcohol-induced disinhibition.

#### *Interactions between Attentional Bias and Inhibitory Control*

Some researchers have shown that attentional bias and behavioral control are associated with one another (Robinson & Berridge, 1993; Field & Cox, 2008; Rose & Duka, 2008). Field et al. (2007) demonstrated a positive correlation between attentional bias and impulsivity in adolescents. Field and Cox (2008) hypothesize that impulsive substance users, that is, users with low levels of inhibitory control, may find substance-related stimuli to be particularly salient and thus have a high degree of attentional bias towards substance-related cues. Additionally, the authors suggest that behavioral control and attentional bias are related in that a high level of attentional bias in an individual may lead them to act more impulsively.

The go/no-go task has occasionally been modified in such a way that alcohol-related and neutral images are used as cues prior to the go or no-go targets (Noel et al., 2007; Rose & Duka, 2008; Nederkoorn et al., 2009, Weafer & Fillmore, 2012). This differs from the typical go/no-go task in that cues usually take the form of shapes and colors that would not be expected to be of particular relevance to any participant. Each of these modified tasks uses visual stimuli in the form of photographs of alcohol or neutral cues.

Weafer and Fillmore (2012) were among the first to study the impact of alcohol-related cues on behavioral control. Using a modified go/no-go task, the attentional bias-behavioral activation (ABBA) task, the study aimed to merge research on attentional bias and behavioral control. The study tested the hypothesis that individuals demonstrating a higher degree of attentional bias also exhibit lower levels of inhibitory control to alcohol-related cues. The authors found that failures to inhibit responses were more frequent after being presented with alcohol-related cues in the ABBA task than following neutral cues.

Although the disruptive effects of alcohol-related cues on inhibitory control have been demonstrated, what remains to be determined is whether alcohol-related cues influence behavioral control due to their acquisition of incentive properties through classical conditioning or if these cues prime the semantic concept. Past research demonstrating the impact of substance-related cues on behavioral control has led some investigators to hypothesize that classical conditioning is the process by which these cues acquire properties that lead to increased impulsivity (Noel et al., 2007; Rose & Duke, 2008; Nederkoorn et al., 2009). Others, however, believe that alcohol-related cues and concepts acquire salient and disinhibiting properties by way of implicit cognition and

semantic priming (Bauer & Cox, 1998; Austin & Smith, 2008; Stacy & Wiers, 2010).

### *Semantic Priming*

Another perspective on the acquired salience and relevance of alcohol-related cues is that of semantic priming or implicit cognition. Semantic priming describes the phenomenon of an idea or concept being triggered by the presentation of a stimulus that is within the same category. According to semantic priming, exposure to alcohol-related stimuli should incite the idea of alcohol in an individual. The theory behind this argument is that implicit memories and associations exist in the mind of a heavy drinker such that alcohol-related cues of any sort, even distantly related ones, trigger an automatic reaction (Austin & Smith, 2008). An example of the way an individual may think if they have been semantically primed is that when they come across the word "draft" their immediate thought may be of beer as opposed to a selection process or an early version of writing.

Semantic priming has often been tested using the addiction-Stroop task (Ryan, 2002b; Cox et al., 2006). The addiction-Stroop task is a modified version of the classic Stroop test (Stroop, 1935). Using addiction related words, performance interference is determined by calculating the difference between participants' performance when presented with substance-related words and their performance to neutral words. This task demonstrates how performance suffers due to a participant's being distracted by a stimulus that that they are instructed to ignore during the task. This task tests the semantic response to substance-related cues because words are being used as opposed to pictures or other stimuli that could represent an individual's conditioning history, and therefore elicit a conditioned response.

### *Classical Conditioning or Semantic Priming?*

The argument for classical conditioning focuses on the premise that a substance-related cue, an initially neutral stimulus, is paired with the substance, an unconditioned stimulus, and consumption of the substance results in the unconditioned response, the effect of the drug. In the case of alcohol use, a common effect is a decrease in inhibitory control. Over time, alcohol-related cues become associated with the effects of drinking alcohol and the cues themselves become a conditioned stimulus, leading to a similar response an individual may have following alcohol consumption. That is, alcohol-related cues now cause a similar disruption of inhibitory control that is caused by alcohol use.

Where classical conditioning motivates researchers to use stimuli representing an individual's history to invoke the conditioned response, semantic priming suggests that such a stimulus may be unnecessary: the concept itself should be enough to elicit a response. According to classical conditioning, a stimulus used is assumed to be within the realm of an individual's stimulus generalization. This generalization exists despite their knowing the stimulus is not part of their real history. Semantic priming, on the other hand, does not require a stimulus representative of history, but can instead have something more abstract or distinct that still prompts the meaning. In short, semantic priming does not require the presence of a conditioned stimulus that is necessary in classical conditioning.

Real alcohol images, such as photographs, likely resemble stimuli that drinkers have actually used. These images are likely to prompt a conditioned response in a heavy drinker because such stimuli so closely approximate their conditioning history. In this regard, tasks such as the visual dot probe and ABBA have used real alcohol images to

evoke a conditioned reaction which contributes to subsequent attentional bias and behavioral disruptions. How then, can it be determined if the very idea of alcohol plays a role in those two domains? How can the semantic concept of alcohol be triggered without using stimuli that simply evoke this conditioned response?

Utilizing images that still represent alcohol, but are no longer real-world representations of the substance is one way to isolate semantic priming from a conditioned response. Abstract versions of the photographs already used by the visual dot probe and ABBA tasks should mitigate the real-world and conditioned properties of the image. This thesis compared the degree to which abstract and real alcohol-related images each evoked attentional bias and also disrupted inhibitory control. This was tested by exposing subjects to abstract and real alcohol-related images in the visual dot probe task that measures attentional bias to alcohol and the ABBA task that measured the disruptive effects of alcohol-related images on subjects' inhibitory control. In order to test abstract-versus-real images, the real alcohol images used in the visual dot probe and ABBA tasks were transformed to appear as abstractions (i.e., paintings) of the original, real image. Thus each real image had an abstract counterpart. Although the photographs are modified, great care was taken to ensure that these images still obviously represented alcohol and matched the real-world images in complexity, but were also clearly no longer photographs which would resemble stimuli from an individual's drinking history.

#### Purpose of the Study

The current thesis aimed to clarify our understanding of the nature of the visual stimuli used in tasks such as the visual dot probe and the ABBA. Although previous studies have shown that alcohol-related stimuli can disrupt behavioral control (Weafer &

Fillmore, 2012) and attract more attention (Miller & Fillmore, 2010) in alcohol drinkers, it is uncertain what exactly is causing these phenomena. Weafer and Fillmore (2012) suggested that an alcohol-related cue elicits the incentive salience properties of alcohol which triggers activation and reduces inhibition in an individual. This study asked whether attentional bias and disinhibition in response to alcohol-related cues is due purely to classical conditioning to specific visual stimuli that are representative of one's prior drinking history or if it is due to priming of the semantic concept of alcohol elicited by a more general set of stimuli that are not necessarily part of one's prior drinking experience. To test this research inquiry, the current study examined how drinker's attentional bias can be elicited and their inhibitory control disrupted by visual stimuli that are likely to represent their real-world drinking history (i.e. photographs of alcohol such as those already used in most behavioral control tasks) versus "abstract" visual stimuli that represent alcohol, but no longer retain the same real-world attributes as photographs. In the case of the current thesis the abstract images were images that appear as paintings of alcohol. If the two types of stimuli lead to similar disinhibition effects, then it is likely that priming the semantic concept of alcohol is sufficient to disrupt inhibitory control, and that visual images of actual alcoholic beverages, assumed to act as conditioned stimuli, are not needed to evoke this response. Because the abstract stimuli are not ones the subject should have a visually-oriented conditioned response to, it is likely that the disinhibition occurred due to a process of priming the semantic concept of alcohol. If, however, disinhibition is due solely to a conditioned history to the visual images of alcohol, then only real-world stimuli, and not abstractions, should lead to disinhibiting effects.

In addition to evaluating the role of semantic priming on inhibitory control, the thesis also sought to examine the degree to which abstract alcohol-related stimuli elicit attentional bias like their real-world counterparts. Weafer and Fillmore (2012) measured attentional bias using the SIP and compared those results to behavioral control results from their ABBA task. The current study employed two versions of the visual dot probe as a measure of attentional bias with each version utilizing either abstract or real images. The abstract image visual dot probe task used abstract images similar to those that used in the modified form of the ABBA task. Using the abstract images allowed, for the first time, the assessment of whether or not attentional bias can be elicited using non-real-world images of alcohol.

### *Hypotheses*

Generally speaking, it was hypothesized that individuals would demonstrate an attentional bias to alcohol-related stimuli compared to neutral stimuli. In addition, alcohol-related go cues are anticipated to result in more inhibitory failures than neutral go cues. This study also assessed the degree to which attentional bias and inhibitory control occurs as a result of classical conditioning based on images likely to represent an individual's drinking history or if it is due to priming of the semantic concept of alcohol elicited by a more general set of stimuli that are not necessarily part of one's prior drinking experience. In order to do this, real-world alcohol images that are likely to be representative of an individual's drinking history were used to maximize the likelihood of eliciting a conditioning response. Abstract images were also used in order to compare attentional bias and inhibitory control in response to the two types of stimuli. Real alcohol images are expected to elicit greater attentional bias and poorer inhibitory

control, as it is hypothesized that classical conditioning is the source of such phenomenon in response to alcohol-related stimuli. However, if there is no difference between real-world and abstract images, this would suggest that semantic priming is sufficient to elicit attentional bias to alcohol and disrupt inhibitory control in the context of alcohol-related stimuli.

Notably if semantic priming is sufficient to produce both attentional bias and disinhibition, this does not mean that conditioning is not also responsible. That is, semantic priming could be an “emergent property” of conditioning. Evidence for semantic priming would not necessarily rule out conditioning. Conditioned (i.e., real image) alcohol stimuli may no longer be necessary to elicit attentional bias and disinhibition because conditioning has led to such stimulus generalization that anything that triggers the general concept of alcohol (even a spoken word) is sufficient to evoke attentional bias and disinhibition.

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## Chapter Two: Methods

### Participants

Forty-one adult drinkers (24 men and 17 women) participated in this study. Recruiting took place through fliers and other forms of advertising. Interested persons were screened via telephone to be sure they meet inclusion criteria. Inclusion criteria included being of legal drinking age, having normal or corrected visual and alcohol consumption at least once per week. Exclusion criteria included SMAST scores that indicated severe levels of alcohol addiction.

### Materials and measures

#### *Attentional bias-behavioral activation task (ABBA)*

The ABBA task is designed to measure how inhibitory control is disrupted by alcohol cues. This task is a measure of behavioral control and is a modified cued go/no-go reaction time task that is operated by E-prime software on a PC. Instead of using traditional go/no-go cues, the ABBA task uses alcohol-related and neutral images. A trial of the ABBA task involves: (1) presentation of a fixation point for 800 ms; (2) a blank white screen for 500 ms; (3) a cue image (alcohol or neutral), displayed for a variable length of time; (4) a go (green box) or no-go (blue box) target visible until a response is made or 1 second has passed; and (5) 700 ms between each trial. For an example of a trial, see Figure 1.

Two versions of the ABBA task were used: the real image ABBA task and abstract image ABBA task. The tasks are identical to one another aside from the abstract ABBA task utilizing abstract versions of the same stimuli used in the original task. These abstract variants of the stimuli are the photographs featured in the ABBA task altered

using the FotoSketcher program to look like paintings (for an example comparison of images, see Figure 2). Alcohol-related images are always of beer and the neutral images are arbitrary images of objects unrelated to alcohol such as a box of tissues or a shoe.

When a green target was presented (a go target) during a trial, the participant was instructed to respond to this by pressing the response key on the PC keyboard as quickly as possible. Their reaction time was recorded by the software. When a blue target was presented (a no-go target) during a trial, the participant was to make no response, but wait for 1 second to pass. If a response was made and the participant presses the response key, an error message was shown.

The real image and abstract image ABBA tasks each have two conditions: an alcohol go condition wherein alcohol images are paired with go targets 80% of the time, or a neutral go condition wherein neutral images are paired with go targets 80% of the time. An individual should demonstrate a decreased reaction time throughout the task in response to whichever stimuli (neutral or alcohol) the go condition is paired with most often. This allows for comparisons to be made between activation and inhibition for the two different stimuli. Additionally, inhibitory control should be poorer following go cues. Weafer and Fillmore (2012) demonstrated a greater frequency of inhibitory failures following alcohol images compared to neutral images, indicating that this poor performance tends to be enhanced even more when the go cues are alcohol-related (see Figure 1 for an example of an alcohol-related go cue).

A test took approximately 15 minutes to complete, consisting of 250 trials across five blocks of 50 trials. The computer recorded if responses were made for each trial and

the reaction time for each response. Also recorded by the computer were errors when responses are made to no-go targets and failing to respond to a go target.

### *Visual dot probe task*

The visual dot probe task is a measure of attentional bias operated on the Tobii T120 eye tracker and E-prime software on a PC. Two images are displayed on the Tobii monitor following a 500 ms fixation point for 1 second. When these two images disappear a visual target appears on one side of the screen behind where one of the pictures previously had been. The participant has 1 second to respond to this target by pressing one of two keys corresponding to a respective side of the screen, indicating which side the target appeared on. The visual dot probe task compares the reaction time in response to a target appearing where an alcohol-related image had been against reaction time in response to the target replacing a neutral image. Eye tracking is also a part of this visual dot probe task, where time spent staring at each image will be recorded by the computer for comparison between the two types of stimuli as an additional measure of attentional bias in addition to reaction time. Attentional bias is indicated by this measure if average gaze time to alcohol images is greater than the average gaze time to neutral images.

The task consisted of 10 simple alcohol-related images matched to 10 simple neutral images, similar to but unique from those used in the ABBA tasks. Simple images contain only the alcoholic or neutral stimuli by themselves. Additionally, 20 neutral filler images were used, consisting of 10 neutral-neutral image pairs. All 10 alcohol-neutral image pairs were presented over 80 trials, and the same was done for all 10 neutral-neutral filler pairs so that habituation to alcohol can be reduced. Just as with the ABBA

tasks, two versions of the visual dot probe task were presented to all participants: a version as it traditionally exists using the real image stimuli and a modified version with the stimuli altered as abstract images. This task took approximately 10 minutes to complete.

#### *Barratt impulsiveness scale (BIS)*

The BIS is a 34-item self-report questionnaire measures the personality dimension of impulsivity, thought to contribute to both behavioral disinhibition in response to alcohol and risk for alcohol abuse (Fillmore, 2007; Finn et al., 1994; Sher & Trull, 1994). Sample items include “I plan tasks carefully,” “I am self-controlled,” and “I act ‘on impulse’.” Participants indicate how typical each of the statements is for them on a four-point Likert scale (“rarely/never,” “occasionally,” “often,” or “almost always/always”). Higher scores indicate greater total levels of impulsiveness. In addition to a total score, six factors can be obtained from the questionnaire that assess different aspects of impulsivity, including attention (focusing on the task at hand), motor impulsiveness (acting on the spur of the moment), self-control (planning and thinking carefully), cognitive complexity (enjoying challenging mental tasks), perseverance (a consistent life style), and cognitive instability (thought insertions and racing thoughts). The BIS can demonstrate whether an individual’s impulsiveness may be related to both their alcohol use and their inhibitory control. It is possible that an individual's score on the BIS will be related to their inhibitory failures on the ABBA task. Impulsivity scores as likely to be positively correlated with inhibitory failures, as individuals who are more impulsive would probably find inhibiting responses more difficult than less impulsive individuals.

### *Temptation and restraint inventory (TRI)*

The TRI (Collins & Lapp, 1992) is a 15-item self-report scale that measures a drinker's general traitlike preoccupation with the temptation to drink and with attempts to restrain oneself from drinking. The items concern the frequency of preoccupation with daily temptations to drink and attempts to control consumptions. Items are rated in a scale that ranges from 1 (never) to 9 (always). Factor analysis has identified the dimension of cognitive preoccupation with the temptation to drink as a distinct factor in the TRI (Collins et al., 1996). The factor is represented by the 9-item Cognitive and Emotional Preoccupation (CEP) scale of the TRI. A total score on the CEP scale is derived by summing the ratings to the 9 items. Higher scores indicate greater cognitive preoccupation with drinking. The TRI provides valuable information regarding a participant's views and behavior around alcohol, which may relate to their use history, attentional bias regarding alcohol. It is possible that scores on the CEP scale of the TRI will be related to an individual's gaze time to alcohol on the visual dot probe task. CEP scores are likely to be positively correlated with attentional bias alcohol as individuals who are more preoccupied with thoughts of alcohol would probably view alcohol-related stimuli as more appetitive than those scoring lower on the CEP.

### *Time line follow-back (TLFB)*

The TLFB is a retrospective calendar that participants fill out that tracks their drinking behavior for the past 90 days (TLFB; Sobell & Sobell, 1992). This assesses daily patterns of alcohol consumption. Participants estimated the number of drinks they consumed and over how many hours for each of the 90 days they are asked to consider. This information was used to determine blood alcohol content (BAC) for each day of

drinking. A day where BAC met or exceeded .80 mg/mL was considered a binge drinking day (NIAAA, 2004). Three measures are obtained through the use of the time line follow-back: (1) binge days; (2) drinking days; and (3) total drinks consumed.

*Alcohol use disorders identification test (AUDIT)*

The AUDIT is a screening instrument that is used to identify at-risk problem drinkers (AUDIT; Saunders, et al., 1993). The 10-item self-report questionnaire consists of 10 items about drinking patterns, negative psychosocial outcomes, and other indicators of alcohol use disorder. Scores on this measure can range from 0 (no alcohol-related problems) to 40 (severe alcohol-related problems). A cutoff score of 6 or higher for women and 8 or higher for men provides the greatest degree of accuracy for identifying problem drinkers (Reinert & Allen, 2002).

*Personal drinking habits questionnaire (PDHQ)*

The PDHQ is a questionnaire that provided information regarding participants' alcohol consumption and was used to determine binge drinker status (PDHQ; Vogel-Sprott, 1992). Compared to the TLFB, the PDHQ provides a more detail about typical drinking habits and overall drinking history. Participants recorded both history of alcohol use (number of months of regular drinking), as well as information regarding current, typical drinking habits, including (a) frequency (the typical number of drinking occasions per week), (b) quantity (the number of standard alcoholic drinks [e.g., 1.5 oz of liquor] typically consumed per occasion), and (c) duration (time span in hours of a typical drinking occasion). This information, along with gender and body weight, was used to estimate the resultant BAC typically achieved during a drinking episode for each participant. This was done using well-established, valid anthropometric-based BAC

estimation formulae that assume an average clearance rate of 15 mg/dl per hour of the drinking. Participants met binge drinker status if their estimated resultant BAC was 0.08% (80 mg/100 ml) or higher, and they met non-binge drinker status if their resultant BAC was below 0.08%.

### Procedure

Volunteers responding to advertisements for this study underwent an intake-screening by telephone. They were told that the purpose of the study was to examine performance on cognitive tasks. Volunteers were asked to report alcoholic beverage preference, where individuals reporting consumption of at least once per week were eligible to become participants. Participants arrived for a testing session in the Behavioral Pharmacology Laboratory of the Department of Psychology. All participants were tested individually. Participants were given informed consent at the start of the first testing session and were measured for height and weight and their BAC level, which must be at zero, determined via breath samples measured by an Intoxilyzer, Model 400. Participants were randomly divided into one of two groups: half assigned to the alcohol go condition for the ABBA task and the other half assigned to the neutral go condition. Group assignment was done by alternating as participants arrive for their first session. For a diagram of the study procedure and order of events, refer to Figure 3.

### *Session One (Attentional Bias)*

In this session, participants became acquainted with the visual dot probe task by performing an abbreviated, short version of the test that required approximately two minutes to complete. After this familiarization, subjects were then tested in both the real image and abstract image versions of the visual probe task with approximately 10

minutes between each test. The task order was counterbalanced across subjects. There were approximately five to ten minutes between each test that during which time questionnaires (drinking habits, drinking history, health and medical background and impulsivity) were completed. The first session was concluded upon completion of the second visual dot probe task.

### *Second Session (Inhibitory Control)*

After an inter-session interval of between two and seven days, participants returned for the second session. In the second session, participants were treated as two groups based on their assignment to alcohol-go or neutral-go conditions for the ABBA task. Target condition assignment was independently counterbalanced for each gender, alternating assignment based on the order participants were screened after they had completed the phone screener (see above). In this session, participants were familiarized with and completed the ABBA task which measured behavioral control in response to real and abstract alcohol-related stimuli. The ABBA task required participants to be divided into two groups responding to different target conditions (see Figure 3), which was not required by the tasks performed in session one. They were once again tested for BAC levels. Participants first performed a full-length (fifteen minute) familiarization ABBA task to practice the measure. They then performed both forms of the ABBA task with real-world and abstract stimuli independently staying consistent with their target condition (alcohol go or neutral go). The orders of the real versus abstract version were counter-balanced across participants. Between each test participants were given a ten minute break in which they are allowed to read magazines or relax in the experiment

room. When both tasks were finished, participants were debriefed and compensated for their participation.

**Table 1.** Demographics, trait impulsivity, temptation and self-reported drinking habits.

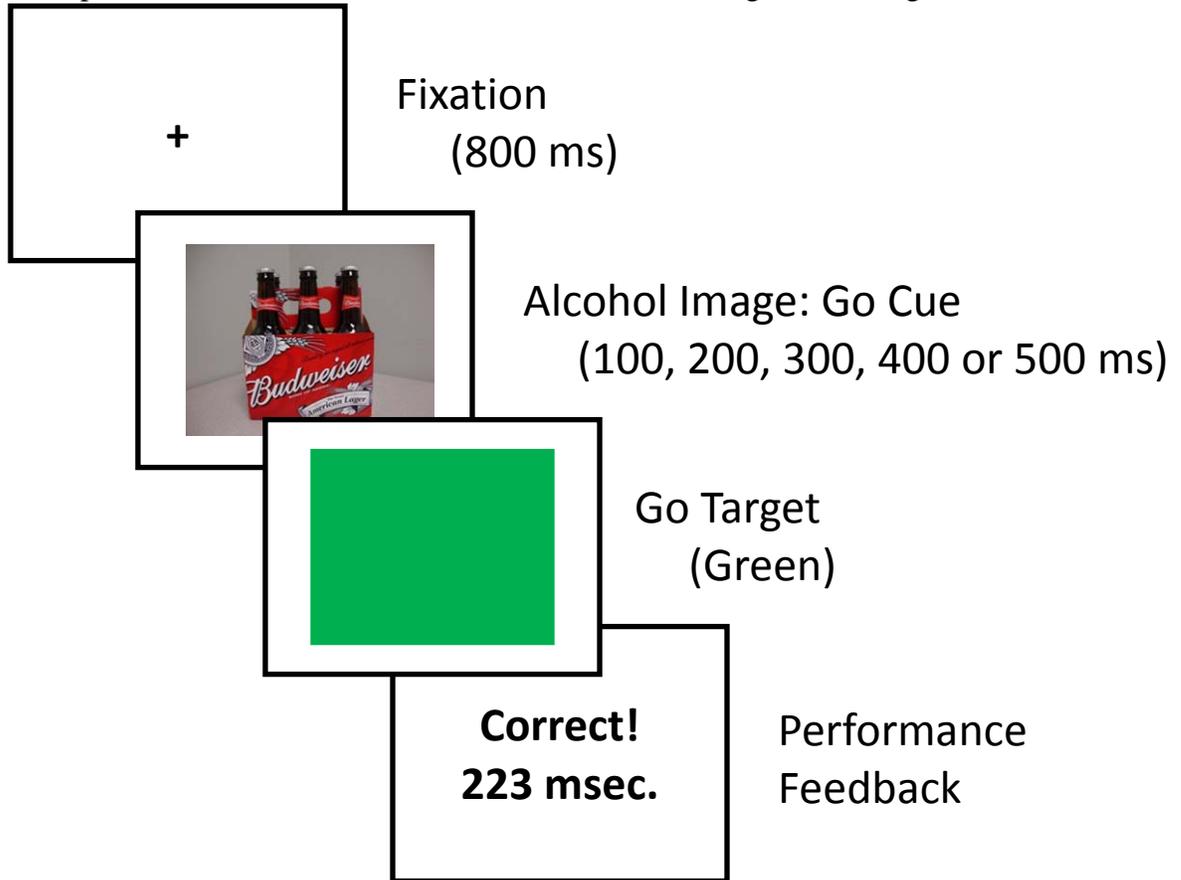
	Mean	(SD)
<b>Demographics</b>		
Gender (M:F)	24:17	
Age	23.7	4.0
<b>Impulsivity/Temptation</b>		
BIS Total	63.9	9.7
TRI CEP	24.6	12.5
<b>Drinking Habits</b>		
<b>PDHQ</b>		
History	80.4	49.9
Frequency (weekly)	2.3	1.2
Drinks per occasion	5.2	2.4
Duration to drink	3.4	1.5
<b>TLFB</b>		
Drinking Days	27.8	12.8
Total Drinks	156.3	124.1
Binge Days	13.8	12.7
Drunk Days	12.6	11.1
SMAST	2.4	4.2
AUDIT	11.7	6.7

**Table 2.** Attentional bias, demographics, trait impulsivity, temptation and self-reported drinking habits between the 25 individuals with an attentional bias to alcohol-stimuli and the 16 with a neutral-stimuli bias.

	Alcohol Bias		Neutral Bias	
	Mean	(SD)	Mean	(SD)
Attentional Bias	57.7	47.1	-58.4	49.2
Gender (M:F)	16:9		8:8	
Age	23.4	3.9	24.1	4.3
<b>Impulsivity/Temptation</b>				
BIS Total	65.2	10.6	61.9	7.8
TRI CEP	27.3	13.9	20.5	9.1
<b>Drinking Habits</b>				
<b>PDHQ</b>				
History	80.8	51.1	79.6	49.8
Frequency (weekly)	2.5	1.4	2.0	1.0
Drinks per occasion	5.3	2.5	5.1	2.4
Duration to drink	3.6	1.7	3.1	1.2
<b>TLFB</b>				
Drinking Days	29.7	13.1	24.7	11.9
Total Drinks	176.9	131.8	124	106.9
Binge Days	15.9	13.6	10.5	10.6
Drunk Days	14.2	11.4	10.1	10.6
SMAST	3.3	5.0	0.9	1.6
AUDIT	13.0	7.2	9.6	5.4

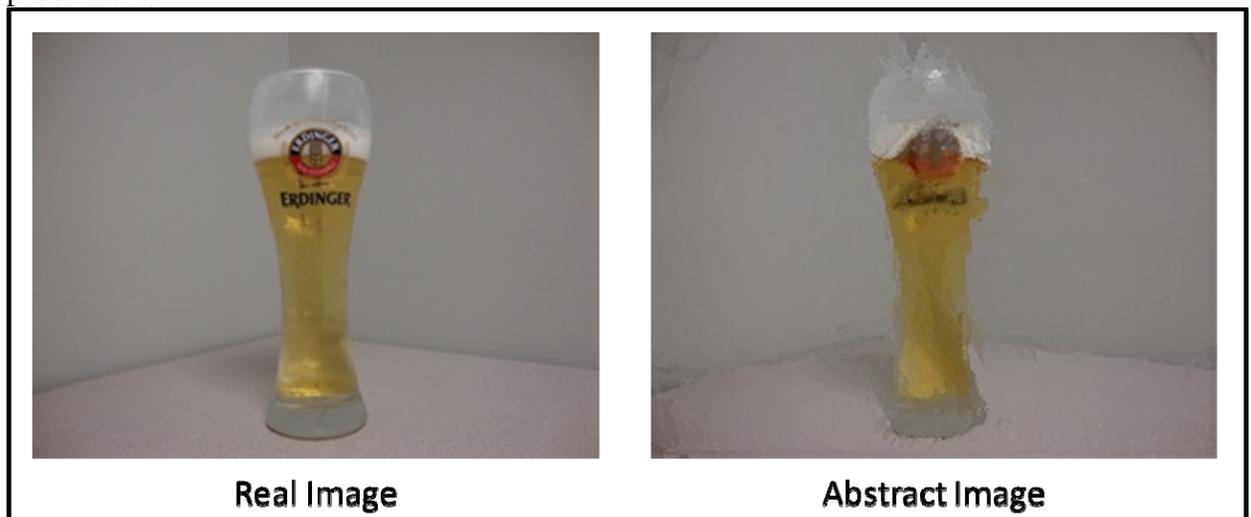
**Figure 1.**

Example of one trial in the ABBA task where alcohol images serve as go-cues.



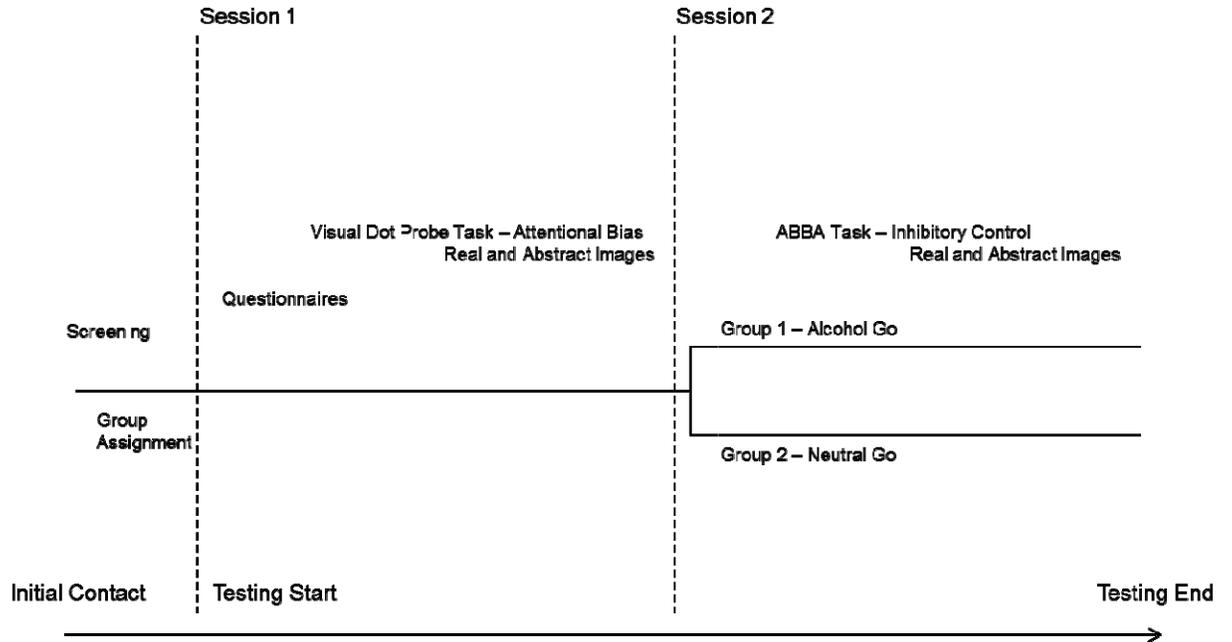
**Figure 2.**

Real and abstract image comparison similar to stimuli used for both the ABBA and visual probe tasks.



**Figure 3.**

Timeline of task procedure starting from when a participant makes initial contact with the laboratory and continuing until the conclusion of the study. This figure illustrates the order in which sessions and tasks were completed as well as where target group conditions became relevant in the second session during the ABBA task.



## Chapter Three: Results

### Criterion Measures and Data Analyses

#### Visual dot probe task

##### *Attentional bias*

Attentional bias was ascertained by observing longer gaze times to alcohol-related stimuli compared with neutral images. This comparison was examined for real images and for abstract images. The mean gaze for alcohol and neutral images, averaged over a total of 40 images for each stimuli type, was obtained for each subject in both the real and abstract tests. Mean gaze times were examined by 2 image abstraction (real vs. abstract) x 2 stimulus type (alcohol vs. neutral) analysis of variance (ANOVA). This analysis tested whether real-world or abstract images elicit different levels of attentional bias. A main effect of stimuli was expected, (i.e. alcohol > neutral stimuli), and would demonstrate attentional bias. A main effect of abstraction would indicate that the degree to which images represent real-life elicits a differing amount of gaze time regardless of the stimuli. Such a main effect would indicate that participants spent more time looking at one type of image (real or abstract) over the other. The interaction was also tested to determine if attentional bias to alcohol related cues was greater for real images versus abstract images. If real and abstract images do not differ in the degree of attentional bias they elicit, then no main effect of abstraction or an interaction should be observed. Attentional bias scores were determined by subtracting the gaze time spent on alcohol images from the average gaze time spent on neutral images, averaged across 40 images for each stimuli type.

## ABBA Task

### *Inhibitory failures*

Inhibitory failures were indicated as the proportion of times an individual failed to inhibit their response to no-go targets. Performance comparisons of the ABBA were analyzed with a 2 stimulus type (alcohol vs. neutral) x 2 image abstraction (real vs. abstract) x 2 cue (go vs. no-go) ANOVA to identify main effects of cue, stimulus type and image abstraction and assess for an interaction between any of the three. A main effect of cue was expected and would indicate that go cues result in greater inhibitory failures than do no-go cues. An interaction between cue and stimulus type is also expected and would indicate that alcohol go cues lead to greater inhibitory failures than do neutral go cues. A main effect of abstraction would demonstrate whether or not real images elicit a greater proportion of inhibitory failures than abstract images, regardless of cue or stimulus type. An overall interaction would determine if inhibitory failures to alcohol-go targets are greater for real images than for abstract images when compared to failures to neutral-go targets for either level of image abstraction.

### *Reaction time*

Reaction time was measured as the amount of time taken in response to a go-target. Performance comparisons between the alcohol go condition and the neutral go condition of the ABBA was analyzed by a 2 (stimulus type) x 2 (image abstraction) x 2 (cue) ANOVA to identify main effects of cue, stimulus type and image abstraction and assess for an interaction between the two. A main effect of cue is expected and would indicate that go cues illicit faster reaction times than do no-go cues. A main effect of stimulus type is expected would clarify if alcohol-related cues results in faster reaction

times than do neutral cues. An interaction between cue and stimulus type is expected and would demonstrate that reaction times to alcohol go cues are shorter than to neutral go cues. A main effect of abstraction would indicate that real images elicit a greater faster reaction time than abstract images, regardless of stimulus type or cue. An overall interaction would indicate that reaction time to alcohol-go targets is faster than to neutral-go targets for real images than for abstract ones.

#### Demographics, trait impulsivity and drinking habit measures

Participants' demographic data, trait impulsivity and self-reported drinking habits are presented in Table 1. The alcohol-go and neutral-go groups did not significantly differ in age, race, AUDIT and SMAST scores or any measure of alcohol consumption according to the TLFB. Much of the sample reported frequent alcohol use both by typical drinking habits and in the 90 days prior to being tested in addition to elevated AUDIT scores, suggesting high-risk drinking habits for many individuals in the sample. In addition to alcohol use, some participants reported past month use of nicotine, marijuana, sedatives and stimulants.

#### Visual dot probe performance

##### *Attentional bias*

Attentional bias scores are plotted in Figure 4. A 2 (image abstraction) x 2 (stimuli type) ANOVA revealed no main effects of abstraction or stimuli on fixation time,  $p_s > .10$ . Moreover, the image abstraction x stimuli type interaction was not significant,  $F(1,40)=0$ ,  $p=.98$ . These results suggest that the sample did not demonstrate an overall attentional bias to alcohol stimuli regardless of image abstraction.

## ABBA task performance

### *Inhibitory failures*

The proportion of inhibitory failures following go cues can be found in Figure 5. This figure shows greater inhibitory failures following go cues compared to no-go cues for real images and abstract images. A 2 stimulus type (alcohol vs. neutral) x 2 image abstraction (real vs. abstract) x 2 cue (go vs. no-go) ANOVA for inhibitory failures found no main effects of stimulus type or image abstraction,  $ps > .60$ , meaning that the proportion of inhibitory failures did not differ depending on whether alcohol or neutral images served as cues or real or abstract images were seen. A main effect of cue (go or no-go) was found,  $F(1,38)=53.62$ ,  $p < .001$ . This main effect indicated that inhibitory failures were significantly greater when following go cues compared to no-go cues. No significant interaction between any of the factors was found,  $ps > .56$ .

### *Reaction time*

Mean reaction times for the alcohol-go and neutral-go groups are shown in Figure 6. This figure demonstrates that mean RT following go cues for both real and abstract images was faster in response to go cues than to no-go cues. A 2 (stimulus type) x 2 (image abstraction) x 2 (cue) ANOVA for reaction time revealed no main effect of stimulus type or image abstraction,  $ps > .51$ , meaning that reaction times did not differ depending on whether alcohol or neutral images served as cues or real or abstract images were seen. A main effect of cue was found,  $F(1,38)=98.35$ ,  $p < .001$ . This main effect demonstrates that reaction time following go cues was significantly shorter than reaction time following no-go cues. No interactions between any of the factors were found,  $ps > .07$ .

## Impulsivity and Preoccupation

### *BIS*

The mean total score on the BIS can be found in Table 1. High scores on the BIS are indicative of impulsivity. The Pearson  $r$  correlation was tested between BIS scores and inhibitory failures for both the go and no-go cues in either image abstraction condition. No significant correlation was found, indicating no relationship between impulsiveness and inhibitory failures,  $ps>.11$ .

### *TRI*

The mean score on the CEP scale of the TRI can be found in Table 1. Higher CEP scores suggest a higher level of cognitive preoccupation with alcohol. The Pearson  $r$  correlation was tested between CEP scores and attentional bias scores in both image abstraction conditions. No significant correlation was found, indicating no relationship between cognitive preoccupation as assessed by the TRI and attentional bias, regardless of abstraction,  $ps>.06$ .

## Supplemental Results

Primary results targeting the hypotheses of this thesis were non-significant. Attentional bias to alcohol could not be established in this sample regardless of image abstraction. In the ABBA task, there appeared to be no difference between alcohol versus neutral cues with respect to subjects' inhibitory failures or their reaction times regardless of whether or not the images were real or abstracted, and regardless of whether the images served as go cues or as no-go cues. Due to the fact that findings from this thesis failed to replicate findings from other studies, primarily those of Weafer and Fillmore (2012), additional analyses were conducted in order to determine if there was any

apparent reason for non-significant findings. The goal of these analyses was to determine if there were any power, methodological or individual difference explanations that might indicate why results failed to replicate.

### *Power analyses*

With typical a mean difference of 30 milliseconds and standard deviation of the differences of 60 found using paired-sample t-tests with results of the visual dot probe task, at an alpha level of .05, a power analysis determined that a sample size of 34 would be necessary with an effect size of .5. Using the mean difference of 12.386 and standard deviation of the difference of 74.304 obtained in this sample of 41 for the same task and analysis, a power analysis determined that a sample size of 285 would be required. This analysis also determined that the current effect size is .16 for this data.

Using a mean difference between alcohol and neutral go-cues for proportions of inhibitory failures of .12, and a pooled standard deviation of .11 found by Weafer and Fillmore (2012) for between-sample t-tests when utilizing findings from the ABBA task, a power analysis at an alpha level of .05 determined that a sample size of 30 would be necessary for differences to be found. This also yielded an effect size of 1.09. Using the mean difference scores of .022 and the standard deviation of .09 found in this sample of 40, the same power analysis determined that a sample size of 528 would be necessary and yielded a current effect size of .24. In considering reaction times, using a mean difference of 15 milliseconds and a standard deviation of 17, power analysis at an alpha level of .05 suggested a sample size of 44 with an effect size of .88. Using the mean difference of 17 milliseconds and the standard deviation of 35 found in this sample of 40, the same power analysis determined that a sample size of 136 would be necessary along with determining

that the effect size for the current data is .48. Altogether, these analyses indicate that the current thesis had a sufficiently sized sample to obtain significant findings based on prior research, but effect sizes yielded by the data are substantially smaller than those found in other studies using similar tasks.

### *Attentional bias*

The primary inconsistency between this thesis and findings from other studies is the lack of attentional bias to alcohol seen in this sample (Miller & Fillmore, 2010; Roberts et al., 2014). In the real image condition, which will be the condition of focus because it replicated the task as it is presented in all other research, 16 individuals demonstrated an attentional bias to neutral images. An attentional bias to neutral images is determined by subtracting the total time spent fixating on neutral images from the total time spent on alcohol images. A negative difference indicates a bias toward neutral stimuli. Comparisons between these 16 individuals and the remaining 25 who demonstrated an attentional bias to alcohol on attentional bias scores, demographics, impulsivity, temptation to drink, and drinking habits can be found in Table 2. This table indicates that the two groups have equally strong attentional bias to the opposite stimuli, but are comparable in every other measure. With as much as 39% of the sample demonstrating an attentional bias to the neutral stimuli to the same degree that alcohol attentional bias is found in the remaining participants, this phenomenon helps to explain the fact that no attentional bias to alcohol stimuli was found for the whole sample. Attentional bias measures were not significantly correlated to any measures of drinking habits,  $ps > .05$ . Additionally, comparing the 16 individuals who displayed an attentional bias to neutral images to the rest of the sample, no demographic or drinking habits

measurement differences were found,  $ps>.05$ . Of these 16 individuals, 8 were male and 8 were female.

### *Order effects*

The effects of abstraction order (real images first vs. abstract first) on attentional bias in the visual dot probe task was examined in a 2 (image abstraction) x 2 (stimuli type) x 2 (abstraction order) ANOVA. There was no significant main effect or interactions involving order,  $ps>.13$ . In the ABBA task, a 2 (cue) x 2 (image abstraction) x 2 (abstraction order) ANOVA of inhibitory failures in the alcohol-go condition indicated no significant main effect or interactions involving abstraction order,  $ps>.09$ . Likewise, the 2 (cue) x 2 (image abstraction) x 2 (abstraction order) ANOVA of inhibitory failures in the neutral-go condition indicated no significant main effect or interactions involving abstraction order,  $ps>.71$ . Altogether, it appears that the order of image abstraction did not impact the findings.

### *Drinking habits*

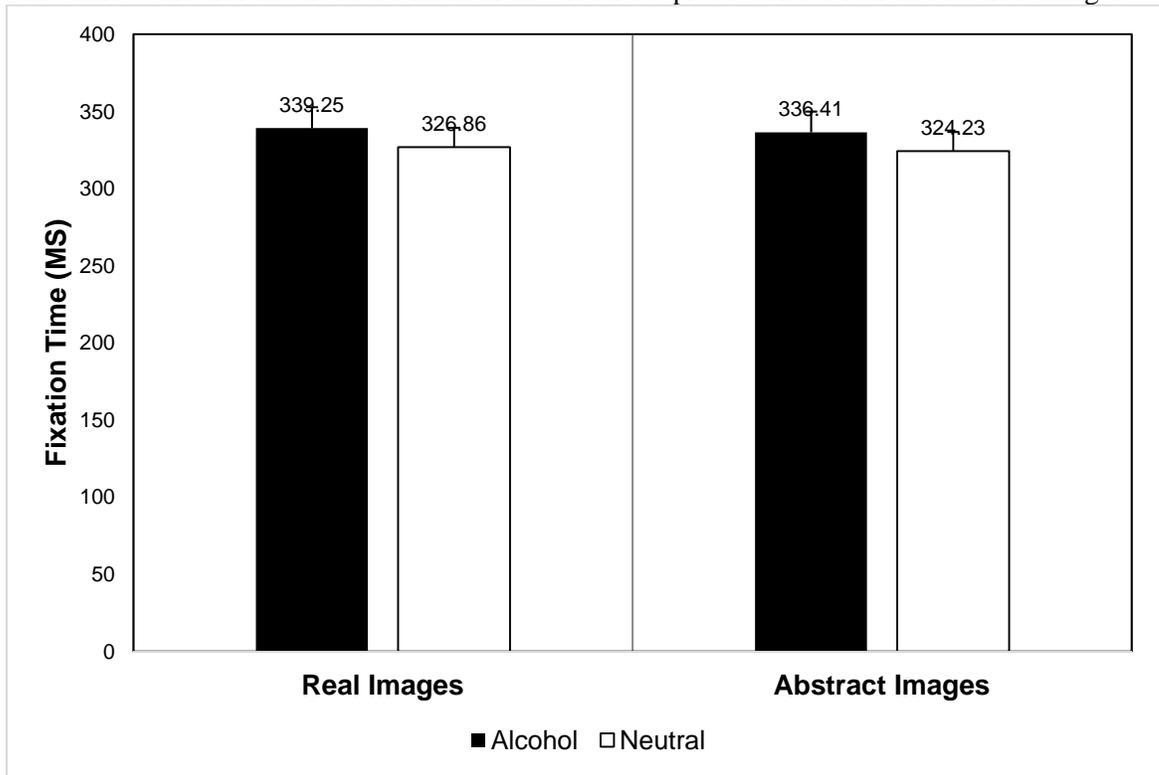
Reported drinking habits in this sample were comparable to those found by Weafer and Fillmore (2012). It is possible that drinking habits are related to task performance such that heavier drinkers demonstrate more attentional bias or poorer inhibitory control. Between-groups t tests revealed no significant differences between alcohol and neutral go cue conditions,  $ps>.13$ . Drinking habits were not significantly correlated with attentional bias or inhibitory failures or reaction time on the ABBA task,  $ps>.10$ . AUDIT scores and TLFB measures of total drinks, binge days and drunk days were significantly correlated with the CEP scores on the TRI,  $ps<.03$ . No drinking habit measures were correlated with BIS scores,  $rs=.52-.68$ ,  $ps>.09$ .

### *Gender differences*

Gender make up of the sample can be found in Table 1. Differences between males and females were analyzed using between-groups t tests, all of which indicated no significant differences between males and females on drinking habits, impulsivity, temptation, attentional bias or inhibitory control or reaction time on the ABBA task,  $ps > .12$ .

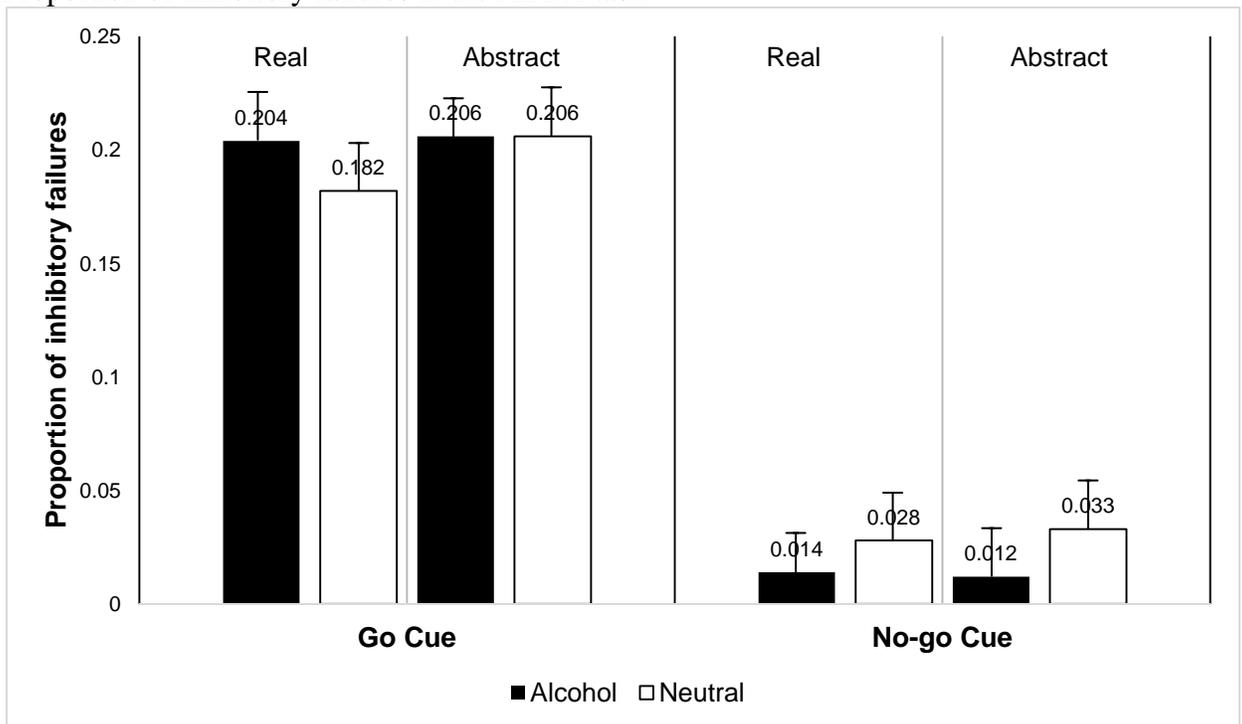
**Figure 4.**

Gaze time to alcohol and neutral stimuli in the visual dot probe task for real and abstract images.

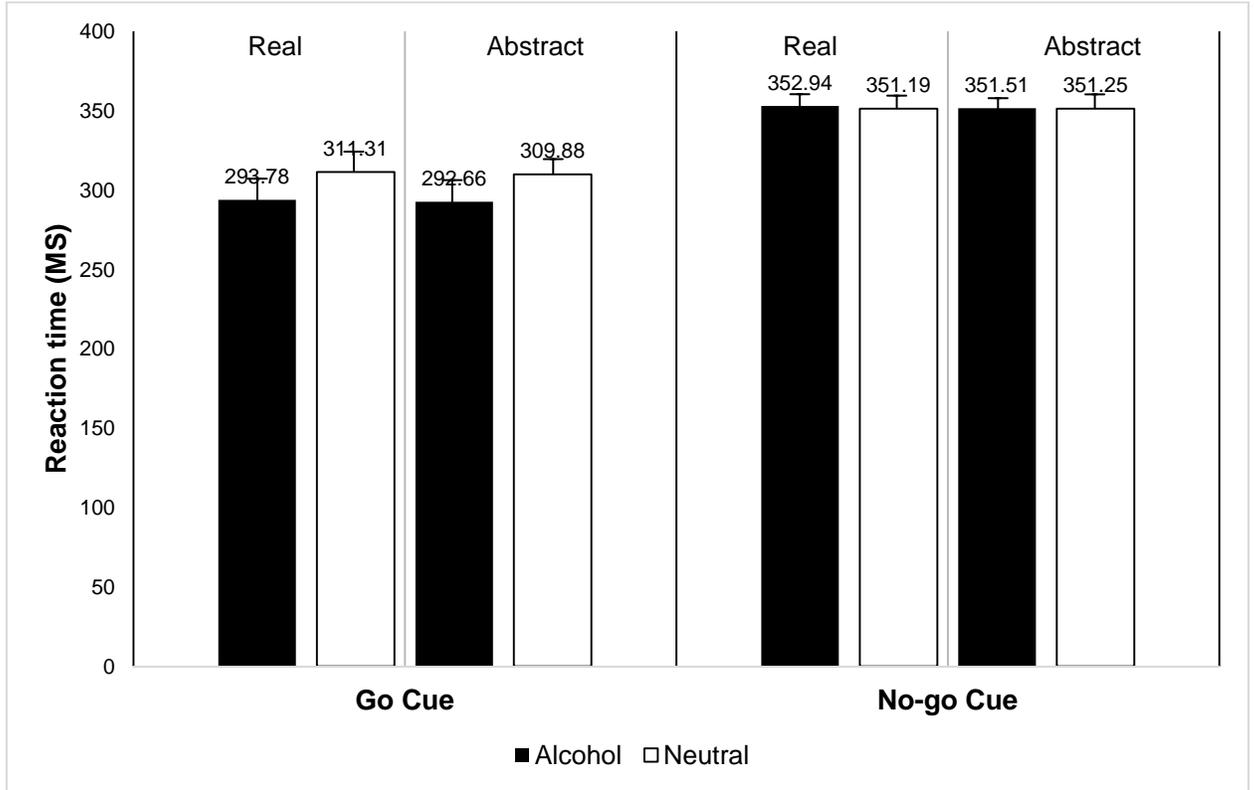


**Figure 5.**

Proportion of inhibitory failures in the ABBA task.



**Figure 6.**  
Mean reaction times in the ABBA task.



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## Chapter Four: Discussion

This thesis examined the degree to which abstract and real alcohol-related images each evoked attentional bias and also disrupted inhibitory control. This was tested by using real and abstract alcohol-related visual stimuli on the visual dot probe and ABBA tasks used to assess performance on the aforementioned domains in adults who are non-dependent, social drinkers. Findings yielded no significant differences between real-world and abstract images. Additionally, there was no evidence for attentional bias to alcohol-related images (real or abstract) and no evidence that alcohol-related images increase disinhibition in subjects.

Weafer and Fillmore (2012) demonstrated both an attentional bias to alcohol-related stimuli as well as impairment in behavioral control following alcohol stimuli in the ABBA task. The real image condition in the current thesis used the same tasks and images that have been used many times in previous studies that have found significant attentional bias to alcohol and impaired behavioral control (Field & Cox, 2008; Weafer & Fillmore, 2012). The current study, however, failed to replicate findings of attentional bias or impacts on behavioral control in the real-world image condition. Likewise, abstract images failed to yield significant results in either task.

Due to this failure to replicate fairly common findings, additional analyses were ran to determine what may explain the null findings. The data obtained in this thesis are fairly irregular, consisting of low effect sizes and weak power. Power analyses indicated that the sample size used in this study was sufficient to obtain significant results based on means and standard deviations typically found from previous research when using the same tasks (Miller & Fillmore, 2010; Weafer & Fillmore, 2012). Analyses run using the

means and standard deviations from the current study indicate that a substantially larger sample than usual would be required. These analyses indicate that the current study yielded substantially smaller effect sizes than is typically seen when utilizing these tasks. The highest effect size found using power analyses from this thesis was .48, whereas the effect size found by Weafer and Fillmore (2012) was .63.

Of the 41 individuals participating in this study, 16 demonstrated equally strong attentional bias to neutral images in the real-world condition of the visual dot probe task compared to those with an attentional bias to alcohol. These 16 individuals were compared to the remaining 25 who demonstrated this alcohol attentional bias to determine what, if anything, differentiated the groups. No significant differences were found on any measures of drinking habits, impulsivity, temptation to drink, nor significant demographic differences. Because these 16 comprised such a large proportion of the overall sample, this explains why attentional bias was not found in this study despite the fact that, on average, individuals fixated on alcohol images longer than neutral ones regardless of abstraction.

The influence of abstraction order was another potential concern because it is conceivable that seeing one abstraction condition may influence response to the later, different condition, even on the same task. An individual exposed to abstract images prior to their seeing the real images may respond differently to the stimuli than an individual in the opposite situation. This could be due to differences that abstract and real images might illicit, assuming abstraction would lead to differences in perception or responding. There was no significant effect of order found, meaning that performance was not dependent on whether individuals were exposed to the tasks in the real image condition

before the abstract one or vice-versa. The steps taken to counterbalance order across subjects was meant to ensure that order would not play a role, or isolate the effect if it were to.

Drinking habits and gender differences were also considered as potential confounds to the data obtained. It is possible that those who drink more heavily will have an attentional bias to alcohol and respond differently to alcohol-related stimuli in the ABBA task. Correlations between drinking habits and task performance indicated no significant relationships between the two, suggesting that even heavier drinkers responded similarly to lighter ones in this sample. Gender was thought to also be a potential contributor to the nature of the data. Males and females might respond differently to alcohol-related stimuli and have different degrees of impulsivity or temptation to drink alcohol. Between-groups t tests, however, yielded no significant differences, implying that gender did not play a role in these data.

Altogether, the findings obtained from this study fail to shed new light on the role of alcohol-related visual stimuli used in alcohol abuse research. Hypotheses were not supported and significant results could not be replicated from previous research. It remains unclear as to why replication was not achieved for this sample or with this testing procedure, as power analyses, individual differences and order effects all failed to indicate anything significant about the data obtained. Future studies investigating this inquiry may target a heavier drinking population, as those individuals tend to demonstrate higher levels of attentional bias and inhibitory failures (Rubio et al., 2008). Overall, the role of classical conditioning or semantic priming in responses to alcohol-related visual stimuli cannot be discussed with the data from the current study.

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Monem, R. G. & Fillmore, M. T. (2015). Alcohol-related visual cues impede the ability to process auditory information: Seeing but not hearing. (Under Review).

Roberts, W., Monem, R.G., & Fillmore, M.T. (2015). Multisensory stop-signals can reduce the disinhibiting effects of alcohol in healthy adults. (In Progress).