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Attentional Bias in Moderate and Heavy College Drinkers: An Eye-tracking Study

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ATTENTIONAL BIAS IN MODERATE AND HEAVY COLLEGE DRINKERS: AN EYE-TRACKING STUDY

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Abstract

Behavioral economic research regarding alcohol use aims to understand how substance use becomes favored over other rewarding non-substance activities (Meshesha, Dennhardt, & Murphy, 2014). The present study investigated attentional bias as an objective index of the relative valuation of substance-related rewards versus substance-free rewards among college students categorized as either heavy or moderate drinkers. The primary goal of this study was to assess the relative valuation of alcohol-related and alcohol-free rewards using multiple behavioral methods, such as attentional bias for alcohol measured via eye-tracking device, subjective ratings of the pleasantness of alcohol-related and alcohol-free stimuli, and measurement of recent activity participation and enjoyment related to alcohol-related versus alcohol-free activities. The current study tested the hypothesis that various relative reinforcing value indices are associated with each other, and with traditional measures of alcohol severity (e.g., drinking quantity and frequency, alcohol-related problems, and DSM-5 alcohol use disorder symptoms). A Pearson product-moment correlation coefficient revealed no statistically significant relationships between the attentional bias indices and the other relative reinforcing value indices or the traditional measures of alcohol severity. However, a statistically significant negative correlation between craving and fixation on social, non-alcohol appetitive stimuli was found. Additionally, a repeated measures ANOVA indicated that there was no statistically significant relationship between drinking level and attentional bias for alcohol-related stimuli.

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Attentional bias and health behaviors in moderate and heavy college drinkers: An eye-tracking Study

The brain's automatic reward response to stimuli is contingent to the attentional system. That is, various stimuli constantly overwhelm the sensory-perceptual system. However, attentional mechanisms only filter in the most salient or the most rewarding stimuli for further processing (Fadari & Cox, 2006). The tendency for certain types of stimuli to capture attention at the expense of other types of stimuli is called *attentional bias*. Franken's drug relapse model (Franken, 2003) suggests that attentional biases for substance-related stimuli may contribute to drug use and relapse. Put simply, this unconscious, direction specific type of attention fixation has the potential to affect decision-making processes. The current study posits that attentional bias for alcohol-related stimuli has the potential to affect the decision-making processes of young adult college students regarding the act of alcohol consumption.

Alcohol Use Among College Students

It is common to experience increases in the amount and frequency of alcohol consumption during adolescence and young adulthood. It has been suggested that this escalation may coincide with life changes, such as becoming a college student and increased availability of alcohol (Maggs & Schulenberg, 2005). According to a survey conducted by the Substance Abuse and Mental Health Services Administration (2013), young adults who are enrolled full-time in college are more likely than their peers (i.e., part-time students and persons not currently enrolled in college) to report heavy episodic drinking (defined as five or four drinks on one occasion for men and women, respectively). Further, the study revealed that approximately 59.4% of college

studenreport current alcohol use, 39.0% report heavy episodic drinking, and 12.7% report excessive regular alcohol use (defined as five or more drinks on the same occasion for five or more days over a month).

Students who engage in heavy episodic drinking are more likely to engage in high rates of risky behaviors (e.g., driving under the influence of alcohol, unsafe sexual behaviors, aggression, trouble with the police, etc.), experience physical symptoms associated with drinking (e.g., hangovers, alcohol poisoning, etc.), have educational consequences related to drinking (e.g., missed classes, lower grades, dropping out, failure, etc.) and increased rates of mortality and morbidity (Courtney & Polich, 2009; Jennison, 2004; Wechsler, Dowdall, Davenport & Castillo, 1995; Wechsler, Lee, & Nelson, & Kuo, 2002; White & Hingson, 2013).). Additionally, heavy drinking behaviors in young adulthood may also predict an increased risk of alcohol dependence and other alcohol use disorders in adulthood (Chassin, Pitts, & Prost, 2002; Jennison, 2004; Viner & Taylor, 2006; Zucker et al., 1995).

Previous studies have shown that alcohol dependence is correlated with attentional bias for alcohol-related stimuli (Field & Cox, 2008; Field & Eastwood, 2005; Field, Munafo, & Franken, 2009; Townshend & Duka, 2001). However, to the researcher's knowledge, there are no studies that specifically evaluate the relative valuation of alcohol-related and alcohol-free rewards by means of eye-tracking among young adult, "pre-dependent" drinkers. In order to develop effective alcohol abuse prevention and intervention methods, it is important to understand the underlying processes that contribute to heavy drinking behaviors among at-risk college students. Thus, the present study aims to contribute to previous literature on attentional bias as a

novel measure of the relative valuation of substance-related rewards versus substance-free rewards by assessing undergraduate college students who engage in drinking behaviors that may put them at a higher risk for future alcohol abuse or dependence.

Behavioral Economic Theories of Substance Misuse

Behavioral economic theory investigates contextual and decision-making factors that influence the consumption of commodities and has been formally defined as, "the study of the allocation of behavior within a system of constraint" (Bickel, Green, & Vuchinich, 1995; Bickel & Marsch, 2001; Murphy, Correia, & Dennhardt, i*n press*). More simply, behavioral economic theory suggests that individuals make substance-related decisions based on constraints on obtaining access to the substance (e.g., the cost or availability of the substance) and constraints on access to alternative substance-free activities or rewards (Tseng, 2010; Tucker, Vuchinich, Black, & Rippens, 2006). One of the aims of behavioral economic research is to understand how substance consumption becomes a preferred activity over other rewarding activities (Bickel et al., 2007; Loewenstein, 1996; Meshesha, Dennhardt, Murphy, 2014; Redish, 2004; Vuchinich & Heather, 2003). Consequently, behavioral economic research attempts to measure the value of substance-related and substance-free behaviors in order to predict patterns of drinking in college students (Bickel & Marsch, 2001).

Previous experimental studies have provided evidence that substance use is more likely to occur in environments that lack substance-free sources of reinforcement (Meshesha, Dennhardt, Murphy, 2014; Volkow et al., 2003). Further, there is evidence that substance use decreases if access to alternative reinforcers increases (Carroll, Anker, & Perry, 2009; Cosgrove, Hunter, & Carroll, 2002; Higgins, Heil, & Lussier, 2004;

Meshesha, Dennhardt, & Murphy, 2014). However, because substance use is associated with diminished reward response to naturally occurring substance-free rewards (e.g., food), in addicted individuals the reinforcing value of a substance may become greater than natural substance-free reinforcers (Koob, 2006; Tapert et al., 2003; Volkow et al., 2003). For instance, there is evidence that alcohol dependent adults and adolescents show atypical physiological, cognitive, and neural responses to alcohol-related stimuli when compared to other rewarding stimuli (Tapert et al., 2003).

There are several approaches to measuring the relative valuation of alcohol versus alternatives. The *Adolescent Reinforcement Survey Schedule – Substance Use Version* (ARSS-SUV; Murphy, Correia, Colby, & Vuchinich, 2005), for example, uses a substance-related to substance-free ratio to assess the relative reinforcing value of alcohol in the natural environment. The ARSS-SUB asks participants to report activity frequency and enjoyment of those activities using a 5-point Likert scale (0-4). Frequency ratings range from 0 (*zero times per week in the past 30 days*) to 4 (*more than once per day in the past 30 days*), and enjoyment ratings range from 0 (*unpleasant or neutral*) to 4 (*extremely pleasant*). These ratings are then used to measure the reinforcing efficacy of substance use (Correia, Carey, Simons, & Borsari, 2003; Meshesha et al., 2014). Picture rating tasks have also been used to assess the relative reinforcing value of alcohol by presenting substance-related images matched with pleasant substance-free images and asking individuals to rate their relative degree of preference for the images. A recent study (Meshesha, 2014) found that students using prescription opioids without a prescription rated pleasant non-substance related images as less pleasant compared to a control group. A similar preference effect is produced by other drugs, such as alcohol

(Pulido, Mok, Brown, & Tapert, 2009), cocaine (Moeller et al., 2010), and heroin (Franken, Hendricks, Stam, &Van den Brink, 2004).

Attentional Bias and Eye-tracking as a Measure of Reward Value

As mentioned previously, *attentional bias* is the tendency for certain stimuli to maintain attention over other, less-salient stimuli. There are several ways to measure attentional bias, including verbal report, observation of overt behavior, and physiological measurement (Kwak et al., 2006). The measurement of eye movement, specifically initial fixation and fixation duration, has also been used as an indication of attentional bias for certain types of stimuli. Some studies combine direct eye movement measures with indirect measures, such as the dot probe or Stroop tasks to measure attention.

The dot-probe paradigm is popular in the measurement of selective attention and involves presentation of salient and neutral stimuli. After some time, the stimuli will disappear, revealing a target probe. Participants are then instructed to locate the probe when it appears and their reaction time is measured to reveal any selective attentional biases. A substance dot probe paradigm uses substance-related stimuli as the salient stimuli during the task. Towshend and Duka (2001), for example, used two dot probe tasks with alcohol-related stimuli, one with pictures and one with words, to assess attentional bias in heavy drinkers and occasional social drinkers. The study found that only the picture stimuli elicited an effect and that heavy social drinkers showed an attentional bias toward the alcohol-related pictures compared to the occasional social drinkers (Townshend & Duka, 2001).

Similarly, the classic Stroop test indirectly assesses attentional bias using salient stimuli. In the modified alcohol Stroop test, substance-related words (e.g., beer) and

neutral words (e.g., tree) are presented in different colors. The participant is asked to name the colors while ignoring the meaning of the words. Attentional bias occurs when participants name the color of the salient words more slowly than the neutral ones (Fadardi & Cox, 2006). One study that primarily used the alcohol Stroop test revealed that alcohol dependent participants had significantly longer reaction times to respond to the color of the alcohol-related words than to the neutral categories when compared to a non-dependent volunteer group (Sharma, Albery, & Cook, 2001). Further, Bruce and Jones (2004) found a differential attentional bias towards alcohol-related pictorial stimuli between heavier and lighter social drinkers in which heavier social drinkers were more distracted by alcohol related words than lighter social drinkers.

Eye movement monitoring has also been used as a measure for attentional bias. This technique permits visualspatial selective attention to be measured when salient cues are presented. Despite persistent ostentatious visual advertisements for alcoholic beverages, there are surprisingly few studies that implement eye movement monitoring as a method for measuring attentional bias for alcohol (Christensen, 2009). Typically, eye movement monitoring is combined with dot-probe or Stroop tests to measure attentional bias based on attention allocation and ability to preform a task. For example, Christensen (2009) implemented a pictorial dot-probe task combined with eye-tracking measurements to assess attentional bias for alcohol cues. Participants were divided into three groups: abstinent former problem drinkers, current problem drinkers, and social no-problem drinkers. This study found that abstinent former problem drinkers had longer reaction times to dots positioned behind alcohol cues as well as fewer and shorter fixations on alcohol cues. Additionally, the study found that current problem social drinkers showed

greater attentional bias and preference for alcohol cues than the social drinkers but the differences were generally non-significant.

There is evidence that eye-tracking is an effective measurement of attentional bias for other habit forming substances, such as nicotine and food substances (Castellanos et al., 2009; Mogg, Bradley, Field, & Houwer, 2003). Castellanos et al. (2009), for example, explored eye movements and reaction time to food and non-food images across obese and normal-weight participants to determine attentional bias for food-related stimuli. There were two conditions: a fasted condition and a fed condition. The study revealed that both obese and normal-weight individuals demonstrated increased gaze duration for food compared to non-food stimuli during the fasted condition. However, in the fed condition, obese individuals maintained the increased attention to food images, whereas normal-weight individuals did not. Additionally, Mogg et al. (2003) evaluated attentional bias for smoking-related cues across smokers and non-smokers. The results suggested that smokers maintained their gaze for longer on smoking-related pictures than controlled pictures when compared to non-smokers. Thus, in concordance with behavioral economic theory, attentional bias for substance-related images opposed to substance-free images may indicate an association with substance abuse and patterns of diminished reinforcement from substance-free activities.

Present Study

The present study investigated the attention-drawing properties of substance-related stimuli relative to substance-free stimuli. A three-tiered approach was used to evaluate attentional bias as a potential indicator of relative valuation of alcohol-related and alcohol-free rewards. First, it explored the previously established idea that addictive

behaviors are characterized by attentional biases for substance-related stimuli by implementing eye-tracking as a measure of attentional bias (Field & Cox, 2006). Specifically, the present study evaluated the correspondence between eye-tracking based indices of attentional bias and traditional behavioral indices of the relative reinforcing value of alcohol across heavy and moderate drinkers. Second, the present study investigated the relative valuation of alcohol-related and alcohol-free rewards using multiple behavioral methods- attentional bias for alcohol measured via eye-tracking device, subjective ratings of the pleasantness of the respective stimuli, and a measure of recent activity participation and enjoyment related to alcohol versus alcohol-free activities.

Finally, the present study proposed and tested two hypotheses. First, students who frequently engage in heavy drinking behaviors present more attentional bias tendencies toward alcohol-related stimuli and less attentional bias tendencies toward healthy or appetitive stimuli than those students who only engage in moderate, social drinking behaviors. Second, the relative reinforcing value indices as measured by attentional bias are associated with other, traditional measures of alcohol severity such as drinking quantity and frequency, alcohol related problems, and DSM-5 alcohol use disorder symptoms (American Psychiatric Association, 2013). The results of this study will potentially lead to improved understanding of the processes related to the development of alcohol misuse in young adults.

Method

Participants

Participants were 34 University of Memphis undergraduate students, ages 18-25, recruited through the University of Memphis Sona System (an online psychology research sign up system) and through recruitment flyers. Only 31 participants were included in the final data analyses due to errors in the eye tracking data (see Data Analysis). The mean age was 20.8 (*SD* = 1.7) and 8 participants were male.

Eligibility was determined by a brief screening survey that included items regarding student alcohol and drug consumption. Students were only selected to participate in the study if they met specific inclusion criteria. All participants were classified as either moderate level drinkers (consumes at least 1 but less than 7 drinks per week for women and less than 14 drinks per week for men and has reported no heavy drinking episodes in the past month) or as a heavy level drinkers (reports two or more heavy-episodic drinking episodes in the past month of 4/5 or more drinks on one occasion for women/men) using a prescreen survey (NIAAA). Additionally, only those participants who had normal vision or corrected to normal vision using glasses or contacts were included. Participants who abstained from alcohol use, used illicit drugs (amphetamine-type stimulants, cocaine, hallucinogens, opiates, and sedative hypnotics) other than marijuana in the past month, and those who had used marijuana on four or more occasions in the past month, were excluded from the study in order to preserve the integrity of the eye-tracking task.

Materials

Participants were presented with multiple substance (images containing alcohol stimuli) and non-substance (images not containing alcohol stimuli) cues on a computer screen and their eye movements were recorded using a Tobii X2 eye-tracking device, which is a remote desktop eye-tracker that uses infrared to detect the location of the pupil (Duchowski, 2007; www.tobii.com). Subjects' eye movements were calibrated using a calibration procedure in which a red circle is displayed to the top, right, left, and bottom of a central cross.

The first task in the series sequentially presented 60 nonsocial alcohol, 60 social alcohol, 60 healthy/neutral, and 60 appetitive black and white pictures for a total of 240 pictures matched by visual complexity and presence of people (see figure 1). The images were black and white in order to easily control for variations in color in the different images (Duchowski, 2007). The images were pseudo-randomized and presented in pairs (e.g., alcohol image and non-alcohol image) for a total of 120 trials. Additionally, the alcoholic images were equally divided into three groups: wine, beer, and mixed drinks in order to be inclusive of individual preferences. Each set of pictures was presented for 5000 ms before proceeding to a randomly placed engagement task. The engagement task involved a question about the previously presented images with the option to select the left or right image (i.e., "Which image showed a vegetable?"). After the participant completed the engagement task they were able to view the next set of images. The purpose of the engagement task was to maintain the participants' interest and increase focus on the stimuli. Total presentation of stimuli lasted approximately 15 min. Researchers observed total fixation duration for the stimuli and recorded which images

maintained attention using the Tobii X2 eye-tracking device. In addition to the eye-tracking task, participants also completed several other measures that assess alcohol use, alcohol problems, and substance-related and substance-free reinforcement.

Measures

Attentional Bias for Alcohol. Attentional bias was measured by recording total fixation on various alcohol-related and nonalcohol-related stimuli using the Tobii X2 eye tracker, which is a remote desktop eye tracker that uses infrared to detect the location of the pupil. The stimuli consisted of 4 categories of alcohol and non-alcohol black and white images: social alcohol, nonsocial alcohol, healthy (various healthy activities without alcohol), and appetitive non-alcohol (food substances). In order to control for alcohol type preference, the alcohol categories were equally divided into three groups: wine, beer, and mixed drinks. All alcohol and non-alcohol images were collected using Google images and were selected based on an objective measure of quality and clarity of subject. Alcohol and non-alcohol images were matched based on perceptual complexity and objective measures of brightness level when converted to black and white. These aims were accomplished by objectively rating clarity of subject and brightness levels through pilot testing. The eye-tracking task presented 240 images separated into pairs (e.g., social alcohol and social healthy/neutral or nonsocial alcohol and nonsocial healthy/neutral) for a total of 120 trials. The task lasted approximately 15 min.

Relative Reward Indices. *A Pleasant Images Visual Analogue Scale* (VAS; Hayes & Patterson, 1921) was used to measure preference for neutral stimuli or alcoholic stimuli. This task requires participants to provide an intentional rating of the value of color images on a visual analog scale. The VAS measures subjective levels of pleasure

and consists of 11 points (marked 0-10) to indicate level of pleasure (0 = very unpleasant, 10 = very pleasant). During this task, only one image was displayed on the computer screen along with a scale in which the participant can select their preferred rating. Ratings of each picture category (pleasant and alcohol) were summed to assess subjective pleasantness ratings of the images. The final analyses of the present study explored ratings of pleasantness for only substance-free images in order to compare reward value for alcohol to reward value for susbstance-free stimuli.

The *Adolescent Reinforcement Survey Schedule – Substance Use Version (ARSS-SUV; Murphy et al., 2005)* was included in order to establish participant engagement and enjoyment of activities with and without alcohol in the past thirty days. The ARSS has previously been established as a measure for the relative valuation of alcohol versus alternatives (Murphy et al., 2005).

Participants were presented with a list of 32 activities and asked to rate the frequency of participation in and enjoyment associated with each of the activities with and without the use of alcohol or other drugs during the previous 30 days. For example, participants rated (1) how often they went out to eat without using alcohol and how enjoyable they found those experiences and (2) how often they went out to eat while using alcohol and how enjoyable they found these experiences. Enjoyment ratings range from 0 (*unpleasant or neutral*) to 4 (*extremely pleasant*) and frequency ratings range from 0 (*0 times in the past 30 days*) to 4 (*more than once a day*). Frequency and enjoyment ratings were multiplied to obtain a cross-product score (ranging from 0 to 16). The cross-product score provided an approximation of obtained reinforcement. Each of the 32 items was administered twice to obtain separate substance-related and substance-

free frequency, pleasure, and cross-product ratings. The present study focused on the average substance-related cross-product score of reinforcement.

Alcohol Related Measures. *The Penn Alcohol Craving Scale (PACS; Flannery, Volpicelli, & Pettinati, 1999)* was used to measure severity of craving associated with drinking. The PACS is a 5-item, single factor scale that assesses frequency, intensity, and duration of thoughts about drinking. Additionally, it contains questions regarding the individual's ability to resist drinking if alcohol is available and the individual's average craving for alcohol during the previous week. Each question is scaled from 0 to 6.

The Daily Drinking Questionnaire (DDQ; Collins et al., 1985) was used to measure participants' daily consumption of alcohol in a typical week in the past month. The DDQ prompts participants to report the total number of standard drinks they consumed on each day during a typical week in the past month The DDQ is a popular measure of drinking in college students and has been shown to have good reliability and validity (Kivlahan et al., 1990; Meshesha et al., 2014). Participants also reported the number of past-month heavy drinking episodes (5/4 drinks in an occasion for men/women)

The Young Adult Alcohol Consequences Questionnaire (YAACQ; Read et al., 2006) was used to measure alcohol-related problems. The YAACQ is a 49-item self-report measure that dichotomously assesses past six-month alcohol-related consequences. The YAACQ has demonstrated strong psychometric properties including internal consistency, test-retest reliability, and concurrent and predictive validity among college students (Read et al., 2007).

The *Diagnostic and Statistical manual of Mental Disorders (5th ed: DSM-5)* criteria in the form of a questionnaire consisting of 11 questions regarding alcohol use disorder symptoms (AUDS) for alcohol use disorder was used to assess presence of an alcohol use disorder. The presence of at least two alcohol use symptoms indicates an Alcohol Use Disorder. The severity of the AUD is defined as: mild (the presence of 2 to 3 symptoms), moderate (the presence of 4 to 5 symptoms), and severe (the presence of 6 or more symptoms).

Depression, Anxiety, and Stress. The *Depression, Anxiety, and Stress Scale* (DASS-21; Lovibond & Lovibond, 1995). was used to measure depression and anxiety. The DASS-21 is a self-report instrument that consists of three, 7-item subscales: stress, anxiety, and depression. Sample items include "I found it hard to wind down," "I found it hard to relax," and "I found it hard to experience enjoyment or satisfaction." Participants report how much each item applied to them over the past week on a 4-point scale.

Procedures

Eligible and interested students were scheduled for an appointment at the HABIT Lab. Participants were asked to abstain from using substances on the day of their study appointment. Upon arrival, participants were provided written consent forms and were verbally informed of the study's general purpose, risks, benefits, compensation (i.e., hours of credit), and all other pertinent study details prior to beginning the tasks and assessments. Participants were unaware of the focus of the study in order to prevent accidental attention allocation to particular stimuli during the eye-tracking task. Participants were informed in the consent that they could discontinue the study at any time.

The study began after informed consent was obtained. The study lasted approximately 1 hr. and included a brief eye-tracking task that lasted approximately 15 min. and a battery of drinking behavior assessments that lasted approximately 45 min. Upon completion, participants were thanked for their participation and were awarded credit hours, which the researcher granted through the Sona System, or $20. All study components were completed in private laboratory spaces in the University of Memphis Psychology Department. A breathalyzer procedure was set in place for participants suspected of intoxication at the time of their appointment. However, no participants were suspected of intoxication.

All participants completed a brief image-based task (approximately 15 min.) intended to measure strength of preference and attentional bias to stimuli depicting 3 main categories of stimuli: alcohol, non-alcohol healthy/neutral, and non-alcohol appetitive. The non-alcohol healthy/neutral and the non-alcohol appetitive categories were used to compare attentional bias between non-alcohol stimuli and alcohol stimuli. Each of the 3 categories were also divided into social and nonsocial images. This allowed the researchers to isolate the unique influence of heightened preference for alcohol from preference for social reinforcement and general preference for appetitive stimuli. Social images consisted of images depicting people, including those images that contain faces, arms, and hands. In contrast, nonsocial images did not depict people. The alcohol categories depicted various alcoholic beverages in different social and non-social settings. The healthy category consisted of various healthy non-alcohol foods and subjects participating in healthy non-alcohol activities (i.e., people eating salads or people participating in a sport). The appetitive categories consisted of various appetitive foods

(e.g., pizza, cake, etc.) and images of people consuming appetitive foods. The image task was completed in a private research laboratory setting in the Department of Psychology at the University of Memphis.

Data Preparation

The eye movement data was collected using the Tobii X2 eye-tracker. The direction of gaze was determined by total fixation duration on either the left or right picture. Stability within 1º of the visual angle for 100 msec was classified as fixation to that position, and the duration was recorded. Fixations were classified as being directed at the left or right pictures if they were more than 1º wide of the central position on the horizontal plane. Attentional bias was measured by the outcome variable total fixation duration, defined as total time of maintenance of attention on either alcohol or alcohol-free images. Fixation duration values were derived from the proportion of time spent on each image for each trial.

In accordance with similar studies, participants with excessive missing data were excluded from the final analyses to avoid problems of floor effects (Mogg et al., 2003). Thus, data from three participants (all heavy drinkers) were excluded because fixations on the pictures were recorded on fewer than 50% of the 120 trials, which was due to calibration difficulties (e.g., gaze not centrally fixated before picture onset) or because no fixation was detected for either picture. In the final analyses of the data, there were 11 heavy level drinkers and 20 moderate level drinkers. The mean fixation duration was calculated separately for alcohol, appetitive, and healthy pictures for each participant.

SPSS 22 for Windows was used for statistical analyses. All outliers in the relative reward measures and traditional measures of alcohol severity were corrected using the

recommendations of Tabachnick and Fidell (2012), in which any values greater than 3.29 SDs above the mean were changed to one unit greater than the greatest non-outlier value. Additionally, skewed or kurtotic variables were transformed to obtain normal distribution: The DASS-21 depression and anxiety scales, the PACS, the average number of drinks per week and hours per week, and the AUDS were transformed.

Results

Group Demographic and Drinking Differences

Participants were categorized into two drinking levels 1) heavy drinking level and 2) moderate drinking level. Descriptive analyses were used to assess participant characteristics and *t*-tests were used to assess the differences between moderate and heavy drinkers. The group of 10 heavy drinkers consisted of 2 males and 8 females, with a mean age of 20.8 years (*SD* = 1.8). On average, they consumed 10.9 (*SD* = 5.3) alcoholic drinks in a typical week and reported 4.1 (*SD* = 3.3) heavy drinking episodes in the past month. Additionally, 81% *(n* = 9) of participants in the heavy drinking group reported at least 1 AUD symptom. The moderate drinking group consisted of 21 participants (6 males and 15 female), with a mean age of 20.7 (*SD* = 1.6). On average, they consumed 4.1 (*SD* = 4.0) alcoholic drinks in a typical week and reported no heavy drinking episodes in the past month. A single participant in the moderate drinking group reported moderate AUD symptoms (4-5 symptoms). Exploratory analyses were conducted that did not include data from this participant. However, the results of these analyses were not significantly different from the results with the full sample that contained data from this participant. Thus, final analyses included data from all 31 participants.

Attentional Bias as a Function of Drinking Level

The relationships between attentional bias for alcohol related stimuli, the pleasant images stimuli task, the ARSS, the PACS, and the traditional measures of alcohol use severity (drinks per week, alcohol problems, and alcohol use disorder symptoms) were investigated Pearson product-moment correlation coefficient (see table 1). Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity, and homoscedasticity. All measures of relative reinforcement, the traditional measures of alcohol use severity, and the proportion of fixation variables were normally distributed. Additionally, Hierarchial multiple regression was conducted to assess the ability of the DDQ, YAACQ, and PACS to predict fixation duration on social and nonsocial alcohol stimuli, after controlling for the influence of gender. The only significant predictor variable was the PACS (*beta* = .006, p = .040), which is consistent with the correlational findings.

Independent-samples *t*-tests were conducted to compare fixation duration on each type of stimuli (e.g., nonsocial alcohol, social alcohol, nonsocial healthy, social healthy, nonsocial appetitive, social appetitive) for moderate and heavy drinking levels (see table 2 and figures 2-4). Each type of stimuli was compared to all other stimuli. There was no significant difference in scores for heavy (M = .47, SD = .06) and moderate (M = .46, SD = .05) drinkers on duration of fixation on nonsocial alcohol or in scores for heavy (M = .48, SD = .05) and moderate (M = .47, SD = .04) drinkers on duration of fixation on social alcohol stimuli. Due to the majority of participants being female, additional analyses were performed with women only, however, there was no significant difference

in scores for heavy (M = .47, SD = .06) and moderate (M = .47, SD = .05) female drinkers on duration of fixation on nonsocial alcohol or social alcohol stimuli.

Trial Type and Image Type as a Function of Fixation

Finally, a two-way repeated measure analysis of variance (ANOVA) was conducted to explore the impact of trial type and image type on total fixation duration. Trial type (e.g., nonsocial alcohol versus nonsocial healthy, nonsocial alcohol versus nonsocial appetitive, nonsocial appetitive versus nonsocial healthy, social alcohol versus social healthy, social alcohol versus social appetitive, and social appetitive versus social healthy) and individual image type (e.g., alcohol, healthy, appetitive) acted as the independent variables, drinking level acted as the between-subjects factor, and proportion of total fixation duration acted as the dependent variable. Additionally, the author explored covariates, such as the depression, anxiety, and stress subscales of the DASS-21 but found none were significant.

The interactions between trial type (e.g., alcohol versus healthy, alcohol versus appetitive, and appetitive versus healthy), image type (e.g., alcohol, healthy, appetitive), and drinking level (e.g., moderate and heavy) were not statistically significant $F(2, 28) = 1.84$, $p = .168$. There was a statistically significant main effect for trial type $F(2, 28) = 3.26$, $p = .046$; however, the effect size was small (partial eta squared =.10). There was a statistically significant main effect for image type $F(1, 29) = 23.265$, $p < .001$. Specifically, moderate (M = .55, SD = .04) and heavy (M = .53, SD = .07) drinkers allocated more attention to appetitive, non-alcohol images than healthy or alcohol-related images.

Discussion

The present study investigated the relative valuation of alcohol-related and alcohol-free rewards among moderate and heavy college drinkers using multiple behavioral methods. These methods included a measurement of attentional bias for alcohol via eye-tracking device, subjective ratings of the pleasantness of alcohol-related and alcohol-free stimuli, and a measurement of recent activity participation and enjoyment of alcohol-related versus alcohol-free activities. This study tested the hypothesis that eye-tracking based indices of attentional bias and traditional behavioral indices of the relative reinforcing value of alcohol would correspond according to drinking level (i.e., moderate or heavy). Additionally, the current study tested the hypothesis that the previously mentioned relative reinforcing value indices would be associated with each other and with traditional measures of alcohol use severity (e.g., drinking quantity and frequency, alcohol-related problems, and DSM-5 alcohol use disorder symptoms).

The main findings of this study are not consistent with the study hypotheses or with the majority of extant literature. Prior research suggests attentional bias for substances, often measured with Stroop or dot-probe tasks, increases for higher levels of substance use severity (Bruce & Jones, 2004a; Cox, Hogan, Kristian, & Race, 2002; Townshend & Duka, 2001). Studies using eye-tracking paradigms of attentional bias, sometimes used with Stroop or dot-probe tasks, found comparable results (Castellanos et al., 2009; Marks et al., 2014; Mogg et al., 2002). Additionally, the results of this study revealed a lack of correspondence between attentional bias indices of reward value and the other relative reward indices (i.e., the VAS and the ARSS), and most of the traditional

measures of alcohol use severity (i.e., DDQ, YAACQ, AUDS) (see table 1). However, a significant negative correlation between allocation of attention on social appetitive stimuli and alcohol craving was observed.

Craving is defined as a desire for some substance and, like attentional bias, is considered to be an autonomic reaction to certain stimulus conditions, for example, the sight of an alcoholic drink may incite craving. Some models of attentional bias suggest that substance-related cues are automatically detected and can influence substance-seeking behavior in the absence of conscious experience or awareness (Field et al., 2009). These processes are separable from aspects of consciously reportable cognitive processes, such as typical drinks in a week (Field et al., 2009). Previous studies have investigated the relationship between attentional bias and subjective craving in substance use and found associations between attentional bias for substance-related stimuli and subjective craving (Field et al., 2009). However, the findings of the present study indicate that as craving for alcohol increases, attention allocation on social appetitive stimuli decreases. This may indicate a decreased interest in rewarding non-alcohol stimuli due to higher cravings, and thus, higher relative reward value, for alcohol (Meshesha et al., 2014). Alternatively, consistent with behavioral economic theory, heightened responsiveness to drug free-rewards may be protective against alcohol craving.

Another reason for the finding that attentional bias toward alcohol-related stimuli does not vary depending on drinking level may be attributed to saliency and complexity of the substance-related images. When salience of an image is high, it takes less time to encode; when stimulus saliency is low, it takes more time to encode (Miller & Fillmore, 2010). Thus, the finding that heavy drinkers spend less time on alcohol stimuli when

compared to other stimuli (i.e., healthy and appetitive) may demonstrate this effect. Additionally, image complexity may also influence attentional bias. Miller and Fillmore (2010) examined adult drinkers using a visual probe task combined with an eye-tracking measure to determine the effect of image complexity on attentional bias for alcohol-related images and found that drinkers only display attentional bias toward simple alcohol-related images. The present study included solitary objects, such as a bottle of wine or a single fruit, and more detailed scenes, such as multiple alcoholic drinks presented in a nonsocial setting or multiple alcoholic drinks presented in a social setting with multiple people (see Figure 1). Although each trial was matched based on visual complexity and presence of people, the results may be explained in part by differences in visual complexity across separate trials.

Finally, the results of the present study may indicate that there are no attentional differences between heavy-level and moderate-level drinkers for alcohol-related stimuli when compared to other reinforcing stimuli. As mentioned previously, Christensen (2009) conducted a study using a dot probe eye-tracking task and observed that differences in attentional bias for alcohol stimuli between current problem drinkers and non-problem social drinkers were not statistically significant. However, there were significant differences between a former problem drinker abstinent group and the current problem drinker group. This difference was indicated by lower number of fixations and shorter fixation times for alcohol-related stimuli for the abstinent group than the problem drinker group. It is assumed that this phenomenon is driven by a desire to avoid alcohol cues (Christensen, 2009).

Limitations and Future Directions

The results of this study suggest that attentional bias for alcohol-related stimuli, as measured by fixation duration, is not significantly related to drinking level or other, traditional behavioral indices of the relative reinforcing value of alcohol. However, the results of this study should be interpreted cautiously due to the use of a small sample that was recruited from a single university. Additionally, data from three participants was excluded from the final analyses due to incomplete eye-tracking data. The uneven distribution of participants across drinking level was another limitation of this study. There were significantly more participants labeled as moderate drinkers (n = 20) than those labeled as heavy drinkers (n = 11). Further, the sample was 74% female (n = 21). The sample size and uneven distribution may have contributed to inconsistent or null findings. Future replications are necessary with a larger, more evenly distributed sample.

In order to participate in the study, students were required to be classified as a moderate drinker (consumes at least 1 but less than 7 drinks per week for women and less than 14 drinks per week for men and has had no heavy drinking episodes in the past 30 days) or as a heavy drinker (reports two or more heavy-episodic drinking episodes in the past 30 days). Participants who reported no alcohol use in the prescreen survey were excluded. However, despite the inclusion criteria, six participants reported no drinking episodes in a typical week on the DDQ. More specific screening questions about reasons for alcohol use (e.g., special occasions) or typicality of reported drinking episodes may increase the validity of the prescreening measure. Future studies may also consider including those college students who abstain from alcohol in order to compare attention allocation differences between abstainers, moderate drinkers, and heavy drinkers.

Additionally, future studies may consider altering the engagement task, the picture display, the length of the presentation of stimuli, and the amount of trials containing alcohol-related stimuli. The engagement task involved randomly placed questions about previously presented images with the option to select the left or right image (e.g., "Which image showed a vegetable?"). The purpose of the engagement task was to maintain the participants' interest and increase focus on the stimuli. However, the nature of the engagement task may have affected how much attention was allocated to each image. In other words, the expectancy of being required to answer a question about either picture may have influenced participants' to view each image for a similar amount of time. The picture display (i.e. two images of equal size, side by side) may have had a similar effect. Thus, future replications may benefit from a different engagement task, such as a dot-probe task, or an increase in the amount of pictures displayed during each trial. Additionally, the length of presentation of images (5000 ms) may have affected fixation duration. Previous studies using eye-tracking methodology presented images for 2000 ms or less (Castellanos et al., 2009; Christensen, 2009; Mogg et al., 2003). It is also possible that the participants were able to deduce the real intentions of the study during the eye-tracking task, despite the inclusion of distractor trials (healthy stimuli versus appetitive stimuli). A number of participants reported knowing or questioned if the study involved alcohol after the eye-tracking task. Thus, in order to avoid adaptation of attention allocation, future studies may consider adding more distractor trials.

Future eye-tracking studies may consider using other metrics in addition to fixation duration to measure attentional bias for substance related stimuli. Previous studies using eye-tracking data have identified additional, potentially salient information

when paying attention, such as pupil dilation and the number of eye blinks that occur during saccades (Anita, Chantal, & Sandra, 2005). When attending to specific stimuli, pupils tend to dilate and the number of eye blinks decrease. Measuring not only the fixation duration but also the pupil size and number of eye blinks could provide a useful indicator of attentional bias. The Tobii X2 eye-tracker has the capability to record pupil dilation, which may provide data for further research on this topic

Conclusions

This study assessed the relative valuation of alcohol-related and alcohol-free rewards using multiple behavioral methods, such as attentional bias for alcohol measured via eye-tracking device and other traditional behavioral methods, across heavy and moderate level college drinkers. The primary findings were: (1) students who frequently engage in heavy drinking behaviors did not present more attentional bias tendencies toward alcohol-related stimuli compared to healthy or appetitive stimuli than those students who only engage in moderate, social drinking behaviors, and (2) the relative reinforcing value indices as measured by attentional bias were not associated with other, relative reinforcing value indices (i.e., the VAS and the ARSS) or traditional measures of alcohol severity (i.e., the DDQ, the YAACQ, and the AUDS). Surprisingly, attentional bias for alcohol stimuli was also not associated with subjective craving but was negatively correlated with substance-free appetitive stimuli.

Although the results were inconclusive, the present study provides an initial model for future studies using similar eye-tracking methodology to evaluate the relative reward value of alcohol as compared to other substance-free rewarding stimuli across different drinking levels. Replications of this study may contribute to existing literature

of the processes related to the development of risky drinking behaviors in adolescents and young adults.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author.

Anita, J., Chantal, N., & Sandra, M. (2005). Selective visual attention for ugly and beautiful body parts in eating disorders. *Behaviour Research and Thearpy, 43*, 183-196.

Bickel, W. K., Green, L., & Vuchinich, R. E. (1995). Behavioral economics. *Journal of the Experimental Analysis of Behavior*, *64,* 257-262.

Bickel, W. K., & Marsch, L. A. (2001). Toward a behavioral economic understanding of drug dependence: Delay discounting processes. *Addiction, 96*(1), 73-86.

Bickel, W. K., Miller, M. L., Yi, R., Kowal, B. P., Lindquist, D. M., & Pitcock, J. A. (2007). Behavioral and neuroeconomics of drug addiction: competing neural systems and temporal discounting processes. *Drug and Alcohol Dependence, 90*(1), 85-91.

Bruce, G., & Jones, B. T. (2004). A pictorial Stroop paradigm reveals an alcohol attentional bias in heavier compared to lighter social drinkers. *Journal of Psychopharmacology*, *18*(4), 527-533.

Carroll, M. E., Anker, J. J., & Perry, J. L. (2009). Modeling risk factors for nicotine and other drug abuse in the preclinical laboratory. *Drug and Alcohol Dependence, 104*, S70-S78.

Castellanos, E. H., Charboneau, E. Dietrich, M.S., Park, S., Bradley, B. P., Mogg, K., & Cowan, R. L. (2009). Obese adults have visual attention bias for food cue images:

evidence for altered reward system function. *International Journal of Obesity, 33*, 1063-1073.

Chassin, L., Pitts, S. C., & Prost. J. (2002). Binge drinking trajectories from adolescence to emerging adulthood in a high risk sample: Predictors and substance abuse outcomes. *Journal of Consulting and Clinical Psychology, 70*(1), 67-78.

Christensen, R. L. (2009). A multi-level analysis of attentional biases in abstinent and nonabstinent problem drinkers. *Dissertation Abstracts International*, *71*, 20-41.

Colins, R. L., Parks, G. A., & Marlatt, G. A. (1985). Social determinants of alcohol consumption: The effects of social interaction and model status on the self administration of alcohol. *Journal of Consulting & Clinical Psychology, 53*, 189-200.

Correia, C. J., Carey, K. B., Simons, J., & Borsari, B. E. (2003). Relationships between binge drinking and substance-free reinforcement in a sample of college students: A preliminary investigation. *Addictive Behaviors, 28*(2), 361-368.

Cosgrove, K. P., Hunter, R. G., & Carroll, M. E. (2002). Wheel-running attenuates intravenous cocaine self-administration in rats: Sex differences. *Pharmacology, Biochemistry and Behavior, 73*(3), 663-672.

Courtney, K. E., & Polich, J. (2009) Binge drinking in young adults: Data, definitions, and determinants. *Psychological Bulletin, 135*(1), 142-156.

Cox, W. M., Hogan, L. M., Kristian, M. R., & Race, J. H. (2002). Alcohol attentional bias as a predictor of alcohol abusers' treatment outcome. *Drug and Alcohol Dependence*, *68*(3), 237-243.

Duchowski, A. (2007). Eye tracking methodology (2nd ed.). London: Springer.

Fadardi, J. S., & Cox, W. M. (2006). Reversing the sequence: Reducing alcohol consumption by overcoming alcohol attentional bias. *Drug and Alcohol Dependence, 101*, 137-145.

Field, M., & Cox, W. M. (2008). Attentional bias in addictive behaviors: a review of its development, causes, and consequences. *Drug and alcohol dependence*, *97*(1), 1 20. *Neuropsychopharmacology, 14*(6), 503-508.

Field, M., Munafò, M. R., & Franken, I. H. (2009). A meta-analytic investigation of the relationship between attentional bias and subjective craving in substance abuse. *Psychological bulletin*, *135*(4), 589.

Flannery, B. A., Volpicelli, J. R., & Pettinati, H. M. (1999) Psychometric properties of the Penn Alcohol Craving Scale. *Alcohol Clinical Experimental Research, 23*(8),1289-1295.

Franken, I. H. (2003). Drug craving and addiction: integrating psychological and neuropsychopharmalogical approaches. *Neuro-Psychopharmacology & Biological Psychiatry, 27*:563-579.

Franken, I. H., Hendricks, V. M., Stam, C. J., & Van den Brink, W. (2004). A role for dopamine in the processing of drug cues in heroin dependent patients. *European*

Hayes, M.S., & Patterson, D. G. (1921). Experimental development of the graphic rating method. *Psychological Bulletin, 18*, 98-99.

Herrnstein, R. J., & Prelec, D. (1992). A theory of addiction. In G. Loewenstein., & J Elster, (Eds.), Choice Over Time (pp. 331-360). New York: Russell Sage Foundation.

Heyman, G. M. (1996). Resolving the contradictions of addiction. *Behavioral Brain Science, 19*, 561-574.

Higgins, S. T., Heil, S. H., & Lussier, J. P. (2004). Clinical implications of reinforcement as a determinant of substance use disorders. *Annual Review of Psychology, 55*, 431-461.

Jennison, K. M. (2004). The short-term effects and unintended long-term consequences of binge drinking in college: A 10-year follow-up study. *The American Journal of Drug and Alcohol Abuse*, *30*(3), 659-684.

Kivlahan, D. R., Marlatt, G. A., Fromme, K., Coppel, D. B., & Williams, E. (1990). Secondary prevention with college drinkers: Evaluation of an alcohol skills training program. *Journal of Consulting and Clinical Psychology, 58*, 805-810.

Koob, G. F. (2006). The neurobiology of addiction: A neuroadaptational view relevant for diagnosis. *Addiction, 101*(s1), 23-30.

Kwak, S. M., Na, D. L., Kim, G., Kim, G. S., & Lee, J. H. (2006). Use of eye movement to measure smokers' attentional bias to smoking-related cues. *CyberPsychology & Behavior*, *10*(2), 299-304.

Loewenstein, G. (1996). Out of control: Visceral influences on behavior. *Oranizational Behavior and human Decision Processes, 65*(3), 272-292.

Maggs, J. L., & Schulenberg, J. E. (2005). Trajectories of alcohol use during the transition to adulthood. *Alcohol Research and Health, 28*(4), 195-201.

Marks, K. R., Roberts, W., Stoops, W. W., Pike, E., Fillmore, M. T., & Rush, C. R. (2014). Fixation time is a sensitive measure of cocaine cue attentional bias. *Addiction*, *109*(9), 1501-1508.

Meshesha, L. (2014). Substance-free reward among college non-medical prescription opioid users. (Unpublished master's thesis). University of Memphis, Memphis.

Meshesha, L. Z., Dennhardt, A. A., & Murphy, J. G. (2014). Polysubstance use is associated with deficits in substance-free reinforcement in college students. *Journal of Studies on Alcohol and Drugs*, in press.

Miller, M. A., & Fillmore, M. T. (2010). The effect of image complexity on attentional bias toward alcohol-related images in adult drinkers. *Addiction*. *105*(5), 883-890.

Moeller, S. J., Maloney, T., Parvaz, M. A., Alia-Klein, N., Woicik, P. A., Telang, F., Wang, G. J., Volkow, N. D., & Goldstien, R. Z. (2010). Impaired insight in cocaine addiction: laboratory evidence and effects on cocaine-seeking behavior. *Brain, 133*(5), 1484-1493.

Mogg, K., Bradley, B. P., Field, M., & Houwer, J. D. (2003). Eye movements to smoking related pictures in smokers: relationship between attentional biases and implicit and explicit measures of stimulus valence. *Addiction, 98*, 825-836.

Murphy, J. G., Correia, C. J., Colby, S. M., & Vuchinich, R. E. (2005). Using behavioral theories of choice to predict drinking outcomes following a brief intervention. *Experimental and Clinical Psychopharmacology, 13*(2), 93.

Murphy, J. G., Correia, C. J., & Dennhardt, A. A. (*in press)*. Behavioral economic factors in addictive processes. In P. M. Miller (Ed.) The Encyclopedia of Addictive Behaivors. Elsevier: London.

Murphy, J. G., & Mackillop, J. (2006). Relative reinforcing efficacy of alcohol among college student drinkers. *Experimental and Clinical Psychopharmacology, 14*(2), 219-227.

National Institute on Alcohol Abuse and Alcoholism (NIAAA). Drinking levels defined. Retrieved from: http://www.niaaa.nih.gov/alcohol-health/overview-alcohol consumption/moderate-binge-drinking.

Pulido, C., Mok, A., Brown, S. A., & Tapert, S. F. (2009). Heavy drinking relates to positive valence ratings of alcohol cues. *Addiction Biology, 14*(1), 65-72.

Rachlin, H. (1997). Four teleological theories of addiction. *Psychonomic Bulletin & Review, 4*(4), 462-473.

Rachlin, H. (2000). The lonely addict. In W. K. Bickel & R. E. Vuchinich (Eds.), Reframing health behavior change with behavioral economics. Englewood Cliffs, NJ: Prentice Hall.

Read, J. P., Kahler, C. W., Strong, D. R., & Colder, C. R. (2006). Development and preliminary validation of the Young Adult Alcohol Consequences Questionnaire. *Journal of Studies on Alcohol, 67*(1), 169-177.

Redish, A. D. (2004). Addiction as a computational process gone awry. Science, *206* (5703), 1944-1947.

Sharma, D., Albery, I. P., & Cook, C. (2001). Selective attentional bias to alcohol related stimuli in problem drinkers and non-problem drinkers. *Addiction, 96(2)*, 285-295.

Substance Abuse and Mental Health Services Administration. (2013). Results from the 2013 national survey on drug use and health: Summary of national findings. (No. NSDUH Series H-46, HHS Publication No. (SMA) 13-4795). Rockville, MD: Substance Abuse and Mental Health Services Administration.

Tabachnick, B., & Fidell, L. (2012). *Using multivariate statistics* (6th ed.). Boston, MA: Allyn & Bacon.

Tapert, S. F., Cheung, E. H., Brown, G. G., Frank, L. R., Paulus, M. P., Schweinsburg, A. D., Meloy, M. J., & Brown, S. A. (2003). Neural response to alcohol stimuli in adolescents with alcohol use disorder. *Archive of General Psychiatry, 60*, 727-735.

Townshend, J. M., & Duka, T. (2001). Attentional bias associated with alcohol cues: difference between heavy and occasional social drinkers. *Psychopharmacology, 157*, 67-74.

Tseng, A. (2010). Influence of alcohol reinforcement on choice in the moment (Master's thesis). Retrieved from http://etd.auburn.edu/handle/10415/2154.

Tucker, J. A., Vuchinich, R. E., Black, B. C., Viner, R. M., & Taylor, B. (2007). Adult outcomes of binge drinking in adolescence: Findings from a UK national birth cohort. *Journal of Epidemiological Community Health, 61*, 902-907.

Viner, R. M., & Taylor, B. (2007). Adult outcomes of binge drinking in adolescence: Findings from a UK national birth cohort. *Journal of Epidemiological Community Health,61*, 902-907.

Volkow, N. D., Fowler, J. S., & Wang, G. (2003). The addicted human brain: Insights from imaging studies. *Journal of Clinical Investigation, 111*(10), 1444-1451.

Vuchinich, R., & Heather, N. (Eds.). (2003). *Choice, behavioral economics, and addiction*. Amsterdam: Pergamon.

Wechsler, H., Dowdall, G. W., Davenport, A., & Castillo, S. (1995). Correlates of college student binge drinking. *American Journal of Publich Health, 85*(7), 921-926.

Wechsler, H. Lee, J. E., Nelson, T. F., & Kuo, M. (2002). Underage college students' drinking behavior, access to alcohol, and the influence of deterrence policies:

Findings from the Harvard School of Public Health College Alcohol Study. *Journal of American College Health, 50*(5), 22.

Zucker, R. A., Fitzgerald, H. E., & Moses, H. D. (1995). Emergence of alcohol problems and the several alcoholisms: A developmental perspective on etiologic theory and life course trajectory. *Developmental Psychopathology*, *2*, 677-711.

Appendix

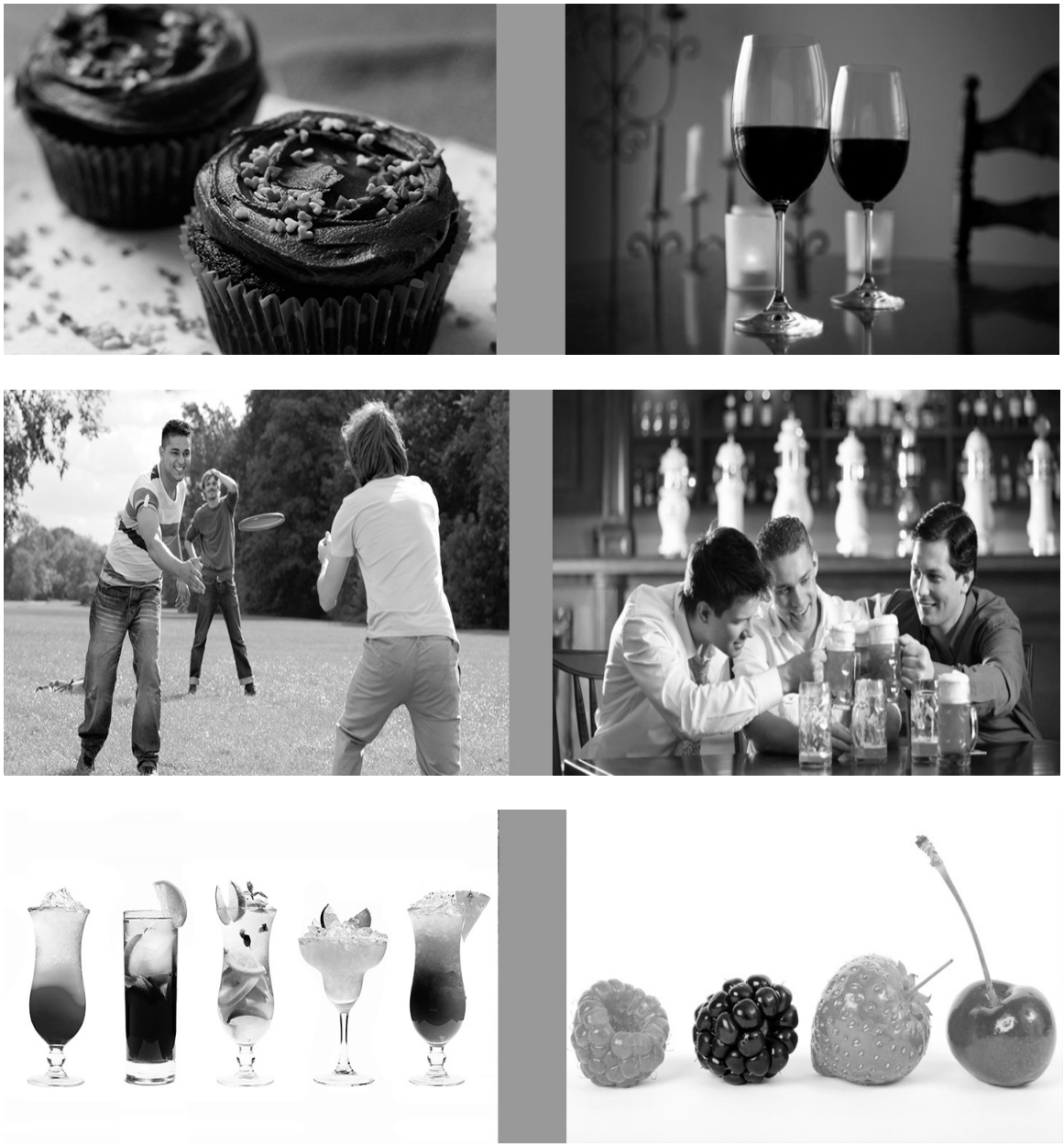

Figure 1. Stimuli examples: nonsocial appetitive versus nonsocial alcohol (wine), social healthy versus social alcohol (beer), and nonsocial alcohol (mixed) versus nonsocial healthy

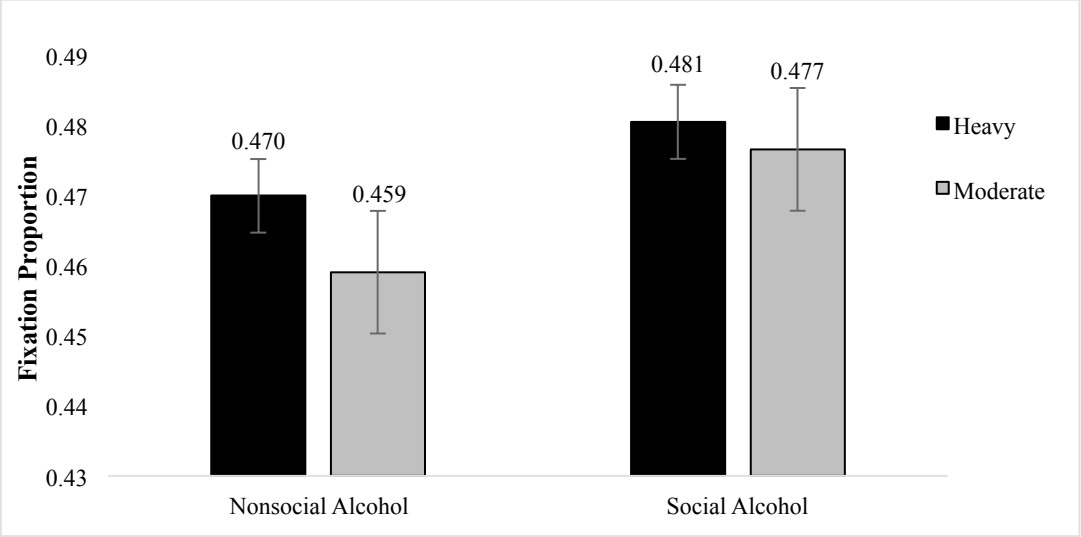

Figure 2. Average fixation proportion by nonsocial and social alcohol stimuli separated by heavy and moderate drinking levels.

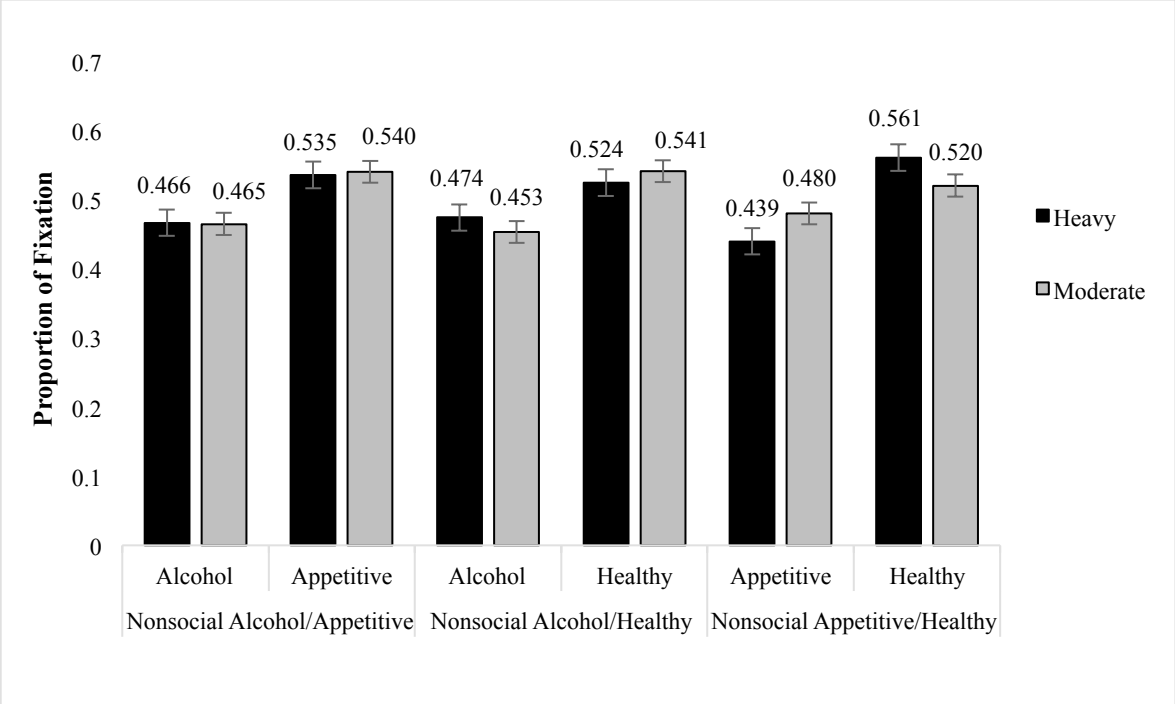

Figure 3. Average proportion of fixation duration by nonsocial stimuli separated by heavy and moderate drinking levels.

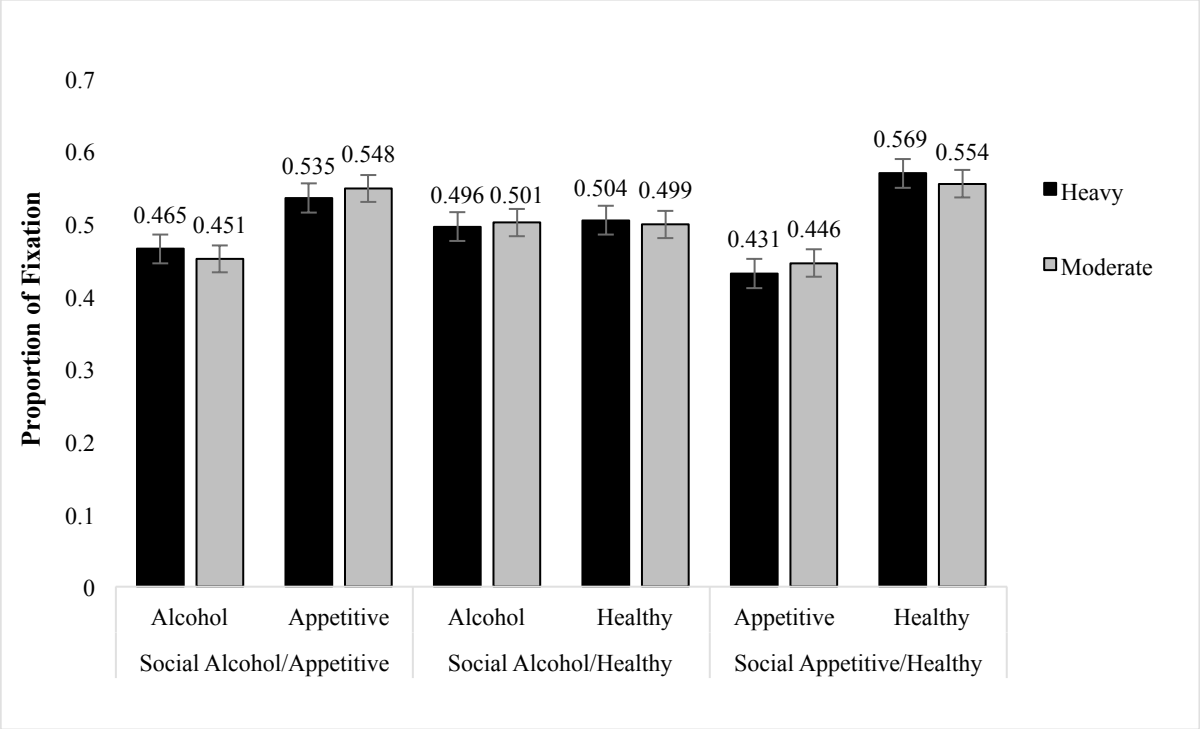

Figure 4. Average proportion of fixation duration by social stimuli separated by heavy and moderate drinking levels.

	M	SD	Correlations											
			1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Nonsocial Alcohol	0.46	0.52	-											
2. Social Alcohol	0.48	0.04	.620**	-										
3. Nonsocial Appetitive	0.53	0.55	-.842**	-.554**	-									
4. Social Appetitive	0.53	0.04	-.577**	-.675**	.559**	-								
5. Nonsocial Healthy	0.54	0.05	-.785**	-.544**	.387*	.484**	-							
6. Social Healthy	0.51	0.05	-.369*	-.845**	.373*	0.262	0.294	-						
7. YAAQ	7.97	7.47	-0.011	-0.044	0.073	0.013	-0.036	0.057	-					
8. PACS	3.55	3.86	0.265	0.276	-0.18	-.484**	-0.273	-0.155	.534**	-				
9. Average Drinks/Week	0.70	0.75	0.001	-0.055	0	-0.124	0.04	0.13	.560**	.751**	-			
10. AUDS	1.13	1.36	-0.188	-0.095	0.182	0.027	0.057	0.076	.714**	.590**	.622**	-		
11. VAS	6.92	0.88	0.273	0.287	-0.222	-0.282	-0.223	-0.205	-0.115	0.276	0.165	-0.063	-	
12. Alcohol Reinforcement	0.21	0.18	-0.013	0.042	-0.096	-0.22	0.103	0.06	.464*	.591**	.596**	.458*	0.012	-

Table 1. Means, standard deviations, and correlations of eye-tracking stimuli and other measures of alcohol use severity
*p < .05, **p <.01 **

Variable	Group	*n*	M	SD	*t*	Sig. (2-tailed)
Nonsocial Alcohol	Heavy	11	.47	.06	*-.675*	.505
	Moderate	20	.46	.05		
Social Alcohol	Heavy	11	.48	.05	*-.603*	.551
	Moderate	20	.47	.04		
Nonsocial Appetitive	Heavy	11	.52	.06	*.509*	.614
	Moderate	20	.53	.05		
Social Appetitive	Heavy	11	.52	.04	*1.243*	.224
	Moderate	20	.54	.04		
Nonsocial Healthy	Heavy	11	.53	.04	*.593*	.806
	Moderate	20	.54	.06		
Social Healthy	Heavy	11	.51	.05	*-.110*	.667
	Moderate	20	.51	.06		

Table 2. Fixation duration differences on all stimuli for heavy and moderate drinkers. Equal variance assumed; *p < .05, **p <.01 **