ALCOHOL PREFERENCES AND EVENT-RELATED POTENTIAL INDICES OF CUE REACTIVITY TO ALCOHOL IMAGES

by

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TABLE OF CONTENTS

Page

LIST OF FIGURES

Figure **Page**

LIST OF ILLUSTRATIONS

Illustration **Page**

LIST OF ABBREVIATIONS

Abbreviation	Description
AUD	Alcohol use disorder
BD	Binge drinking
BDs	Binge drinkers
CPT	Continuous performance task
DA	Dopamine
EEG	Electroencephalograph
ERP	Event-related potential
GABA	Gamma-aminobutyric-acid
IAT	Implicit association test
NAc	Nucleus accumbens
NIAAA	National Institute on Alcohol Abuse and Alcoholism
SUD	Substance use disorder
VTA	Ventral tegmental area

ABSTRACT

Previous research on attentional biases to alcohol images has used heterogenous sets of stimuli (e.g. a beer can in isolation, a group of people drinking, etc.). However, beverage preference plays an important part in determining an individual's alcohol use pattern and thus might be expected to influence attentional biases. The purpose of this study was to determine if beverage preferences affect event-related potential (ERP) indices of cue reactivity to different types of alcohol images (e.g. beer, wine, and liquor) in binge drinkers (BDs). The secondary purpose was to examine the possibility of gender differences in cue reactivity. Fourteen BDs (7 male, 7 female) completed a modified Go/No-Go task using preferred and non-preferred alcohol-related stimuli, and nonalcoholic beverages as control stimuli. It was predicted that reactivity preferred beverages would be enhanced, manifested as higher N2 and P3 ERP amplitudes relative to non-preferred. Male BDs were predicted to have impaired response inhibition and higher reactivity to preferred images than female BDs. Larger N2, but not P3, amplitudes to preferred alcohol-related stimuli were observed, indicative of increased attentional capture. Female BDs produced larger No-Go P3 amplitudes in response to alcohol-related stimuli, indicating they had greater response inhibition than males to these stimuli. These findings suggest that beverage preference is a factor in the attentional bias of BDs. The results provide new information which could prove beneficial in preventing and treating alcohol use disorders (AUD).

I. LITERATURE REVIEW

Among college students, the alcohol consumption pattern known as binge drinking (BD) is commonplace, and associated with health, behavioral, legal, and socioeconomic problems (Kanny, Liu, Brewer, & Lu, 2013). BD patterns have a strong association with the development of alcohol use disorders (AUD; Chassin, Pitts, & Prost, 2002; McCarty et al., 2004; Stolle, Sack, & Thomasius, 2009). Because of the strong association found between BD and the development of AUD (Chassin, Pitts, & Prost, 2002; McCarty et al., 2004; Stolle, Sack, & Thomasius, 2009), it is believed that BD is a potential precursor in the development of AUD (Petit et al., 2013). BD has become progressively more common among both adolescents and college students. Studies within the United States and the United Kingdom have found that roughly 40% of college students meet the criteria for BD (Gill, 2002; Wechsler et al., 2002).

An influential and underlying mechanism in the development of an AUD is cue reactivity to alcohol-related images. Cue reactivity is a subjective and physiological reaction to meaningful stimuli (Carter & Tiffany, 1999), especially heightened responsivity/arousal to addiction-related stimuli in individuals with AUDs wherein alcohol-related stimuli tend to capture and hold attention. This cue reactivity towards alcohol-related stimuli is also found among BDs and believed to lead BDs to perpetuate their drinking habits to the point of dependence (Petit et al., 2013). Therefore, it is believed to be a potential marker of risk for an AUD (Herrmann et al., 2000, 2001; Petit et al. 2013). Studying cue reactivity has been central in understanding the development and maintenance of addiction and craving. Understanding cue reactivity among BDs could aid in determining risk factors associated with AUDs, potentially providing

information beneficial to the development of individually tailored interventions for AUD prevention and/or treatment.

According to the National Institute on Alcohol Abuse and Alcoholism (NIAAA), BD is defined as the act of consuming enough alcoholic drinks (4 or more for women, 5 or more for men) to raise blood alcohol concentration to 0.08 within the span of 2 hours (NIAAA, 2014). BD has become progressively more common among both adolescents and college students. Compared to other illicit substances used among adolescents and young adults, BD is the most common and problematic form of drug consumption (López-Caneda et al., 2013). Binge drinkers (BDs) tend to be white, male, freshmen in college, and attend a college heavily influenced by athletics, fraternities, or sororities (Capece & Lanza-Kaduce, 2013), although gender differences may be shrinking (Johnston, O'Malley, Bachman, & Schulenberg, 2006). Factors predictive of BD include living outside the family house, never being married, and having a grade point average equal to or less than a "B" (Courtney & Polich, 2009). College students in particular are more likely to engage in BD because their interactions with adults/parents are limited, alcohol is widely available, and underage drinking laws are inconsistently enforced in collegiate environments (NIAAA, 2013).

According to White et al. (2006), BD is likely to occur during the transition from leaving home and going to college, such that drinking patterns are maintained or increase over time. This is likely the result of social pressures, expectations about the college experience, and a lack of information regarding alcohol and BD (NIAAA, 2013). Peer influence is particularly problematic for younger drinkers because they tend to view BD as innocuous (Maurage, Pesenti, Philippot, Joassin, & Campanella, 2009). Larimer,

Turner, Mallett, and Geisner (2004) found rates of alcohol use among college students to be positively associated with the understanding and acceptability of alcohol use among their peers. This is especially true of individuals in Greek organizations who are not only more likely to drink more than non-Greeks, but also to encourage/support others to engage in BD, viewing higher consumption levels as normal (Sher, Bartholow, & Nanda, 2001). Continued alcohol use during this transition also stems from the fact college drinkers are less informed as to the actual damage that BD may inflict on their brain and general health (Maurage et al., 2009). Furthermore, inexperienced drinkers may not consider their consumption patterns to be indicative of BD (Capece & Lanza-Kaduce, 2013).

BD in early adolescence (around the age of 14) has been found to be associated with an increased risk of having a BD pattern in adulthood and developing an AUD (Hingson, Heeren, & Winter, 2006). BD at any age increases the risk of alcohol-related problems (e.g., fighting, drunk driving, destruction of property, legal problems, etc.), which ultimately leads to potentially adverse legal, socioeconomic, educational (e.g., missing class, lower grades, failing class, dropping out, etc.; Jennison, 2004), and health consequences (e.g., sexually transmitted diseases, alcohol poisoning, suicide, pancreatic inflammation, hypertension, cardiovascular disorders, accidental injuries, etc.; Courtney & Polich, 2009; Maurage et al., 2009). Compared to college students who do not binge drink, students that do are more likely experience alcohol-related problems at least one point while in college (Jennison, 2004). Long-term risks of BD include adverse consequences to the immune system, heart, liver, and other organ systems (Crabbe, Harris, & Koob, 2011).

Among BDs, cue reactivity in response to alcohol-related stimuli is thought to be potentiated, particularly among those with an AUD (Petit, Kornreich, Noël, Verbanck, & Campanella, 2012). Both direct and indirect contact with alcohol are believed to shape associations between alcohol and its rewarding effects (Petit et al., 2013). Subsequent choices and decisions are influenced by these associations in memory that are learned through experiences (Stacy & Wiers, 2010). These principles form the basis of dual-process models, which are used extensively in addiction research to understand the development of drug use. According to these models, addictive behaviors are the result of two cognitive processes (implicit and explicit), which are associated with alcohol-related cognitions and subsequent consumption. Implicit processes are automatic associations that influence behavioral outcomes, as well as cognitive and affective processing (Larsen, Engels, Wiers, Granic, & Spijkerman, 2012). Explicit processes are slow, intentional cognitions that can be controlled and are involved in delayed reward (Wiers et al., 2007). Dual process models propose that problematic drinking arises in part because of increased automatic reactions (implicit processes) to alcohol-related stimuli and a decrease in controlled (explicit) processes (Stacy & Wiers, 2010), resulting in cravings and drug-seeking behaviors (van Duijvenbode, Didden, Bloemsaat, & Engels, 2012). As a result of prolonged and continued alcohol use, the implicit, automatic processes become sensitized to alcohol, while controlled processes are weakened (Stacy & Wiers, 2010). Thus, neurological adaptations in pathways associated with reward, cognitive control, emotion, and motivation, reinforce the use and abuse of alcohol (Petit, Kornreich, Verbanck, & Campanella, 2013; Wiers & Stacy, 2006).

In the initial stages of reinforcement, dopamine (DA) is released from the ventral

tegmental area (VTA) in response to new motivationally-relevant events (e.g. natural reinforcers, drug/punishment cues), enervating the nucleus accumbens (NAc) and mediating the rewarding effects of the stimulus (Advokat, Comaty & Julien, 2014). As a result, associations between the behavior and rewarding stimulus become established (Advokat et al., 2014). When alcohol is consumed, it enhances the effect of DA in the terminals of the nucleus NAc by stimulating DA release from the VTA (Petit et al., 2013). The rewarding and euphoric effects of DA then reinforce alcohol consumption (Petit et al., 2013). If an experience with alcohol is rewarding, coactivation of the hippocampus and amygdala will enhance the encoding of the experience into memory. Once encoded, these associations are reactivated by exposure to the rewarding stimulus, which can then promote subsequent consumption, or craving (Boggan, 2003). After repeated exposure to and consumption of alcohol, hypofrontality (the reduction of activity in prefrontal areas) develops (Advokat et al., 2010). Because prefrontal structures play a critical role in executive function, individuals have less self-control and are more likely to act on their impulses or cravings (Advokat et al., 2014). The neuroadaptations described above cause the reward system to become hypersensitive to drug-related stimuli and the drugs themselves (Petit et al., 2013). An incentive value is attributed to alcohol-related stimuli, resulting in the development of an attentional bias towards them (Stacy & Wiers, 2010) and an increased desire to consume them (Petit et al., 2011).

Attentional bias occurs when focus is directed towards a specific stimulus at the expense of others (Weafer & Fillmore, 2013). Essentially, the impulsive processes become stronger over time and inhibiting these processes becomes increasingly more difficult (van Duijvenbode et al., 2012). The physiological reactions (e.g., increased heart

rate, increased salivation; Petit 2013) and cravings (i.e., the desire to consume; Papachristou, Nederkoorn, Havermans, van der Horst, & Jansen, 2012) that are characteristic of dependent alcoholics increase in response to alcohol-related cues (e.g., scents, pictures, and words). Having greater reactivity towards drug-related stimuli is therefore associated repeated exposure and use of the drug, accompanied by decreases in executive function (Advokat et al., 2014). As a result, cue reactivity is considered to be a factor in the development and maintenance of substance use disorders and relapse (Petit et al., 2012).

Compared to explicit measures of attitudes towards alcohol use, implicit measures have been found to possess stronger validity in measuring alcohol-related attitudes because they are less susceptible to social desirability effects (Cohn et al., 2012). Implicit processes are most predictive of attitudes, as well as behavior, in situations where motivation to control behavior (explicit processes) is poor and cognitive resources are taxed (Stacy & Wiers, 2010). Therefore, processes that do not involve deliberate recollection, self-presentation, or demand characteristics are less likely to be used when indirectly measuring cognition (i.e., using implicit measures). Implicit measures (e.g., event-related potentials; ERPs) can be used to indirectly measure attitudes by capturing the spontaneous processes produced by a given stimulus (e.g., cue reactivity; Stacy & Wiers, 2010), which are less affected by social desirability than explicit measures (e.g. self-report). Of the implicit behavioral measures of automatic association that are commonly used (e.g. the IAT), ERPs have the advantage of not being completely dependent on motor responses, and have the ability to detect neurocognitive responses to presented stimuli (Petit et al., 2011). Therefore, while there may not be a significant

difference at the behavioral level, ERPs may reveal significant differences in cue reactivity at a cognitive level.

Event-related potentials (ERPs) have played an important role in elucidating the timing of cognitive responses relevant to alcohol-related stimuli. As such, they have considerable utility in measuring and understanding both time course and magnitude of attentional biases to addiction-related cues. ERPs are derived from electroencephalographic (EEG) recordings to assess the instantaneous electrical activity of the cortex in response to a presented stimulus. They are particularly useful when investigating the effects and influences of alcohol on cognitive processes (e.g., working memory and attention; Crego et al., 2009, 2010; Goudriaan, Grekin, & Sher, 2007). Oddball and Go/No-Go paradigms are the more common tasks used in ERP studies to assess attentional bias. An oddball paradigm is a continuous performance task that requires participants to detect a rare target stimulus from frequently presented non-target stimuli (Petit et al., 2011). A Go/No-Go task, on the other hand, assesses an individual's ability to inhibit their response to rare non-target stimuli that appear in a stream of frequently-presented targets that require a behavioral response (Fillmore, 2013). Stimuli are continuously presented and participants must either perform a response (Go) or withhold a response (No-Go; Lewis, 2012). This task allows for the study of not only response inhibition (N2) and cue reactivity (P3; Kutas, Kiang, & Sweeney, 2012), but also the motivational relevance of stimuli, which is the main factor attributed to commission and omission errors (Yechiam et al., 2006). In addition to behavioral responses, the amplitude, latency, and scalp topography of various ERP components elicited in response to targets and non-targets are assessed in response to a presented

stimulus type. Amplitude is interpreted as an index of the neural resources used to process a stimulus, while latency is interpreted as an indication of the onset of processing (Luck, 2005). The ERP components most commonly examined in the context of attentional biases are the P100 (P1), N200 (N2), and the P300 (P3).

The P1 component is used to index automatic processes associated with early visual processing and is observed around 100 milliseconds (ms) at posterior electrodes (P7, P8, POz, Oz, O1 and O2; Campanella, & Philippot, 2006; Luck, 2005; Petit et al., 2011). The P1 is sensitive to visual attention and physical stimulus parameters (Hillyard, Vogel, & Luck, 1998), producing larger amplitudes for attended stimuli. Enhanced P1 amplitudes to alcohol-related stimuli have been interpreted as the fast detection of motivationally relevant stimuli (Petit et al., 2011). In a recent study by Petit et al. (2011) using the oddball paradigm, the authors found that in response to the alcohol-related stimuli, larger P1 amplitudes were observed in the BD group compared to control group. This was interpreted as an unconscious or automatic shift in attention towards the alcohol-related stimuli, indicative of attentional biases (Petit et al., 2011).

The two ERP components associated with processes of working memory and attention, as well as most relevant to the current study, are the N2 and P3 waveforms (Easdon et al., 2005; George et al., 2004; Gevins, & Cutillo, 1993; Gevins et al., 1996; Olbrich et al., 2000, 2002). The N2 component is a negative waveform that is often followed by the P3 waveform. The N2 peaks at the midline central electrodes (FC1, FCz, FC2, F1, Fz, F2) between 180 and 350ms in response to a presented stimulus (Euser & Franken, 2012; Petit et al., 2012). The N2 component has been found to be associated with controlled attention and the processing of emotionally significant stimuli (Carretié,

Hinojosa, Martín-Loeches, Mercado, Tapia, 2004; Dickter, Forestell, Hammett, & Young, 2014). Recently, Crego et al. (2009) conducted a study examining vigilance among BDs via a Continuous Performance Task (CPT) using abstract figures as stimuli. In this task, stimuli were presented rapidly, and participants were instructed to respond if a stimulus appeared twice in a row. Crego et al. (2009) found larger N2 amplitudes for repeated stimuli compared to non-repeated stimuli. The large N2 observed for repeated stimuli was significantly larger among BDs compared to non-BD controls, indicating an increase in effortful processing in this group.

With respect to Go/No-Go tasks, there is still debate regarding whether the No-Go N2 indexes response inhibition (Bartholow, Pearson, Dickter, Sher, Fabiani, & Gratton, 2005; Eimer, 1993; Jodo & Kayama, 1992; Lavric, Pizzagalli, & Forstmeier, 2004) or conflict monitoring (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Nieuwenhuis, Yeung, Van Den Wildenberg, & Ridderinkhof, 2003). According to the response inhibition view, larger amplitudes result from successfully withholding a response (Eimer, 1993; Jodo & Kayama, 1992; Lavric, Pizzagalli, & Forstmeier, 2004). This has been found to be true for Go/No-Go tasks using letters, symbols, and shapes as stimuli (Nieuwenhuis et al., 2003). In this context, a larger No-Go N2 amplitude is believed to reflect inhibition activation (Falkenstein et al., 1999; Jodo & Kayama, 1992). A reduced N2 amplitude is thought to indicate difficulty in response inhibition (Chen, Tien, Juan, Tzeng, & Hung, 2005, 2008; Pandey et al., 2012). According to the conflict-monitoring view, the N2 amplitude is produced in response to competing behaviors (withholding a response vs. responding; Botvinick et al., 2001; Braver et al., 2001; Nieuwenhuis et al., 2003). Compared to controls, alcohol dependent participants displayed a smaller N2

amplitude in the commission of a Go/No-Go task that used a triangle pointing up as the Go stimulus and a tringle pointing left or right as No-Go stimuli (Pandey et al., 2012). This reduced N2 amplitude among alcohol dependent participants is thought to be indicative of dysfunctional cognitive processing (Pandey et al., 2012).

In addition to being linked to response inhibition, the N2 is also believed to indicate effortful processing and the allocation of attentional resources to motivationally-significant stimuli (Petit et al., 2012; Crego et al., 2009; Pandey et al., 2012). However, research investigating the association between the N2 component and attentional bias among BDs is limited. As mentioned earlier, while Petit et al. (2011) found BDs, compared to non-BD controls, produced larger P1 amplitudes in response to alcohol-related cues compared to non-alcohol-related stimuli, there was no difference found in N2 amplitudes. The authors interpreted these findings as BDs having greater unconscious, but not conscious, detection of alcohol-related cues (Petit et al., 2011). In a recent study by Dickter et al. (2014), the authors studied the N2 in the context of attentional bias among college students, using alcohol-related stimuli and non-alcohol-related stimuli that were either active (e.g. someone drinking a beer) or inactive (e.g. beer bottle in isolation). Of the 54 participants, 33 were identified through the use of the Escape Questionnaire as being escape drinkers (i.e., people who drink to avoid negative moods; Cahalan et al. 1969). Compared to their non-escape drinking counterparts, escape drinkers drank more per drinking episode and produced larger N2 amplitudes in response to active alcohol-related stimuli than to inactive alcohol-related stimuli. Escape drinkers were believed to have allocated more attentional resources to the active alcohol stimuli, indicating that they were more salient and more emotionally significant than inactive

stimuli. This study did not, however, find a significant N2 difference between alcohol and non-alcohol-related stimuli (Dickter et al., 2014). A significant difference may have been found between alcohol and non-alcohol-related stimuli had participants' preferred alcoholic beverages been used as stimuli. The current study was designed to determine the role that alcohol preferences plays role in attentional biases in the context of N2 amplitudes. To the best of the author's knowledge, the present study is the first to examine the N2 in both the context of attentional biases and response inhibition among BDs.

The P3 wave is used to measure attentional biases, which are marked by an increase in amplitude to reward-related stimuli (Herrmann et al., 2000; Namkoong, Lee, Lee, Lee, & An, 2004; Petit et al., 2011; Petit et al., 2012). The P3 wave is a positive wave that peaks approximately between 300 and 600 milliseconds after stimulus presentation (Crego et al., 2010, 2012; Petit et al., 2013; Polich, 2004). It is the most commonly used ERP component in measuring cognitive effects resulting from alcoholism (López-Caneda et al., 2013) and is associated with activation of the arousal system (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000). The P3 wave is elicited in the evaluation of stimuli, and associated with memory and attentional processes in tasks requiring a response (implicit or explicit response; 2012; Polich, 2007). Research has found the P3 latency and amplitude of young adults to be significantly associated with their history of BD during adolescence (Ehlers, Phillips, Finnerman, Gilder, Lau, & Criado, 2007). Some research has also observed a similar increased P3 latency in alcohol dependent populations (Cadaveira, Grau, Roso, & Sánchez-Turet, 1991; Pfefferbaum, Ford, White, & Mathalon, 1991), suggesting BD and AUD are related (Enoch, 2006).

The P3 amplitude is associated with emotion processing, with lower amplitudes in response to neutral stimuli and larger for emotionally significant stimuli (Herbert, Junghofer, & Kissler, 2008; Schupp, Öhman, Junghöfer, Weike, Stockburger, & Hamm, 2004). P3 amplitude is also associated with the ability to control responses to irrelevant stimuli and respond to relevant stimuli (Porjesz & Begleiter, 2003). Compared with non-BDs, young adults with a BD pattern display larger P3 amplitudes to alcohol-related images on visual oddball tasks. This indicates BDs have an enhanced cue-reactivity towards alcohol-related stimuli (Petit et al., 2013). In another oddball paradigm, after maintaining a 2-year BD pattern, P3 amplitudes were positively associated with the intensity and amount of alcohol consumption, while being negatively associated with the initial age of regular drinking (López-Caneda et al., 2013). These results were believed to be due to changes in neural activity involved with working memory and attentional processes, which could be indicative of an impairment of neurophysiological functions due to a prolonged pattern of BD (López-Caneda et al., 2013).

The P3 component elicited in oddball tasks (tasks in which the frequently occurring stimuli are ignored) may be functionally distinct from the P3 produced in Go/No-Go tasks because of the added response inhibition element. In Go/No-Go studies, a frontocentral No-Go P3 is believed to be related to response inhibition while the parietal Go P3 is associated with response activation (Eimer, 1993). Smaller frontocentral No-Go P3 amplitudes, therefore, are indicative of impaired response inhibition, which has been found among alcohol dependent populations and high-risk individuals in studies using letters as stimuli (Cohen et al., 1997a; Cohen et al., 1997b; Kamarajan et al., 2005a; Pfefferbaum et al., 1991). In a recent Go/No-Go study, which used circles as stimuli

(their positioning on the screen indicating whether or not it was a Go or No-Go trial), alcohol dependent participants were found to have significantly lower frontocentral P3 amplitudes for both Go and No-Go trials compared to non-alcoholic controls (Kamarajan et al., 2005a). This suggests that there are decrements in response inhibition and activation among alcohol dependent participants.

Potential gender differences in the attentional processing of BDs have also been studied using the P3 component, but studies have yielded inconsistent findings. A recent longitudinal oddball study, which used a white square as the frequent non-target stimulus and a white star as the infrequent target stimulus, examined possible P3 gender differences among BDs (López-Caneda et al., 2013). In doing so, the authors found that females had longer P3 latencies at the 2-year follow-up than males. The possibility of a gender difference in cue reactivity of BDs using an oddball task was also explored by Petit and colleagues (2013). They investigated potential gender differences in cue reactivity toward alcohol-related stimuli in BDs and found that the alcohol-related stimuli evoked higher P3 amplitudes in male BDs than in females. However, Crego et al. (2009) conducted a visual identical-pairs continuous performance task (CPT) using abstract figures as stimuli and found no significant gender differences in the amplitude of both the N2 and P3 among BDs. This difference may result from the different stimuli used in each study. Compared to the abstract figures used in the Crego et al. (2009) study which found no differences, Petit et al. (2013) used alcohol-related stimuli and found that BDs had an attentional bias toward those particular stimuli. When BDs view alcohol-related stimuli, as mentioned earlier, the reward pathway is activated, influencing their decision-making (Petit et al., 2012). Although much is known about ERP correlates of attentional biases to

alcohol (e.g., higher P3 amplitudes to alcohol-related stimuli in drinkers), more research is needed in establishing whether or not these correlates of attentional biases differ by gender.

Beverage preferences may be especially relevant to the issue of gender differences and cue reactivity, as well as cue reactivity in general. Current research examining cue reactivity to alcohol-related stimuli through implicit measures has relied on heterogeneous stimuli sets, with alcohol-related stimuli differing in the types of alcoholic beverages (e.g., beer, liquor, and wine) and the situations in which they are depicted (e.g., a group of people drinking, a single liquor bottle, and a group of liquor and beer bottles; Lindgren, Westgate, Kilmer, Kaysen, & Teachman, 2012). However, beverage preference has been found to play an important part in determining an individual's alcohol use pattern (Del Rio, Prada, & Alvarez, 1995). An individual's alcohol preference is influenced by their individual differences, resulting from direct and indirect experiences with different forms of alcohol (e.g., beer, wine, or liquor; Petit et al., 2013). As a result, an individual's alcoholic beverage preference should be directly related to their attentional biases for that drink in particular. Therefore, if alcohol-related stimuli contain a variety of beverages with only a subset of preferred drinks, resultant indices (behavioral and/or ERP) of cue reactivity may be attenuated. Few studies have examined the role of preferences in drinking behaviors and how preferences may moderate cue reactivity to alcohol-related stimuli.

In a study of 108 individuals between the ages of 16 and 20, beer was found to be the most commonly consumed drink during BD episodes, followed by liquor, and then wine (Naimi, Brewer, Miller, Okoro, & Mehrotra, 2007). In contrast, analysis of data

from a 2007 survey of alcohol preferences, liquor was found to be the most preferred among adolescents, followed by beer, malt beverages, and wine (Siegel, Naimi, Cremeens, & Nelson, 2011). Siegel et al. (2011) found that liquor had higher preference rates not only in older adolescents (18 years and older), but also adolescents with risky alcohol use patterns (e.g., BD) or who engaged in other risky behaviors. The discrepancy between these results may be due to the difference in age, or the fact that market shares and advertisement of liquor has been increasing over time, thus increases young adults' exposure to them, subsequently resulting in an increased probability of future liquor consumption (Naimi et al., 2007). Nevertheless, both studies demonstrate the variability of alcohol preferences across individuals. Because people develop preferences for, or biases towards, alcohol-related stimuli through repeated use, selective learning associated with preferred beverages may not generalize to non-preferred alcoholic beverages. Therefore, individuals may show evidence of enhanced attentional biases toward preferred beverages, which may be a more sensitive marker of risk for AUD than current measures elicited by heterogeneous stimulus sets.

The influence of individual beverage preferences on implicit measures of alcohol-related attitudes was addressed in a recent study using a variation of Implicit Association Test (IAT; Lindgren et al., 2012). The authors performed an alcohol approach and alcohol excitement IAT among BDs, non-BDs, and non-drinkers. The two IATs measured the associations toward images of participants' preferred alcohol beverage versus control images of water. Prior to the IAT, participants were shown 15 possible alcoholic beverage images (e.g., liquor, red wine, cocktails, imported beers, keg beer, etc.) to be used in their IATs. BD and non-BD were asked to select 4 images of the

alcoholic beverages that they most often consumed, while non-drinkers were asked to select 4 images of whose most often offered to them. A gender difference was found in participants' selection of their preferred beverage, with men having selected more beer images than women, while women chose more images of wine and liquor. Lindgren et al. (2012) found IAT scores were significantly influenced by drinker status, with BDs scoring higher than non-drinkers on both tests (Lindgren et al., 2012). Higher scores indicated stronger alcohol-approach and alcohol-excitement associations. Participant IAT scores were not found to have a significant difference in the images selected (Lindgren et al., 2012). This may have been due to the fact that only images of preferred alcoholic beverages and control water images were used in the IAT. Had non-preferred alcoholic beverages been included, a comparison of IAT scores to preferred and non-preferred alcoholic drinks may have indicated a more positive attitudes toward preferred beverages. Subtle differences in responses to different alcoholic beverages may have also been observed if a more sensitive and robust implicit measure, such as ERPs, had been used.

To summarize, the majority of studies using implicit measures to study attentional biases to alcohol in drinkers do not take alcohol beverage preference into account; rather, they have used a heterogeneous set of alcohol images. As a result, these studies may not have maximized each participant's attentional biases. While Lindgren et al. (2012) did address the influence of individual beverage preferences on implicit measures of alcohol-related attitudes, the conclusions regarding the role of preference were limited due to the use of images of preferred alcoholic beverages vs. water. Therefore, the primary aim of this study was determine whether individual beverage preference should be considered in the selection of stimuli when studying the cue reactivity to alcohol-related stimuli in BDs.

It is hypothesized that images of preferred alcoholic beverages will produce significantly greater cue reactivity relative to images of non-preferred alcoholic beverages, which should be observable in ERP components sensitive to attention (e.g., the N2 and P3).

The gender differences found among BDs' P3 amplitudes in the studies mentioned earlier could be attributed, at least in part, to the different stimuli used. In the study by Petit et al. (2013), the authors used alcohol-related images, which consisted of various alcoholic beverages (e.g., liquor bottles, wine glasses) depicted in various situations and settings (e.g., a person drinking a beer, a person passed out while drinking). Crego et al. (2009), on the other hand, used abstract figures as stimuli. Compared to the non-alcohol-related stimuli used in some studies, BDs have an established attentional bias to alcohol-related stimuli that activates the reward pathway when viewed, subsequently influencing cognition and decision-making (Petit et al., 2012). Measuring the attentional bias of BDs by beverage preference may therefore provide a more sensitive estimate of differences in attentional biases between males and females.

Therefore, the secondary purpose of this study was to determine if a gender effect exists when beverage preference is taken into account. Research suggests that once males reach adulthood, they have an increased risk of developing an AUD (Young et al., 2005). Males also more frequently report alcohol intoxication (Benningfield et al., 2009) and drinking heavily (i.e., BD) than females (Meyer, Rumpf, Hapke, Dilling, & John, 2000). However, studies have found alcohol abuse among women is increasing and as a result, gender differences for late adolescents and college student BDs are less clear (Grucza, Bucholz, Rice, & Bierut, 2008; Grucza, Norberg, & Bierut, 2009; Holdcraft & Iacono,

2002; Johnston et al., 2006). Female BDs have been found to be more sensitive to alcohol's neurotoxic effects (Hommer, Momenan, Kaiser, & Rawlings, 2001; Medina et al., 2008; Schweinsburg et al., 2003), to have decreased spatial working memory (Hartley, Elsabagh, & File, 2004; Townshend & Duka, 2005), and to have abnormal overall brain activity patterns while soberly performing spatial working memory and vigilance tasks compared male BDs (Caldwell et al., 2005). Despite increased sensitivity to the effects of alcohol among women, it was believed that males would show significantly higher cue reactivity towards alcohol-related images than their female counterparts. It follows that gender differences in cue reactivity to alcohol stimuli may develop among BDs, with males having an increased vulnerability to alcohol-related cues, leading to higher rates of problem drinking. Studying attentional bias and controlling for beverage preferences may further our understanding of BD and possible markers of risk for future AUDs, providing information that could aid in the treatment and prevention of problem drinking.

To test these hypotheses, this study used a modified Go/No-Go task to determine if attentional bias is modulated by an individual's alcoholic beverage preference. A Go/No-Go task was chosen because of its capacity to assess an individual's ability to inhibit responses (N2) to rare non-target stimuli (Fillmore, 2013), as well as cue reactivity towards the different alcohol-related stimuli (P3; Kutas, Kiang, & Sweeney, 2012) and their motivational relevance (Yechiam et al., 2006). In the Go/No-Go task, alcohol-related images and non-alcohol-related images were used to test BDs inhibition capacity (e.g. withholding an incorrect response) toward the alcohol-related images. Cue reactivity and conflict monitoring were measured in response to preferred and non-

preferred alcoholic beverages (beer, wine, or liquor). As reviewed above, after repeated exposure to alcohol, attentional biases develop which should be stronger for preferred beverages. A stronger cognitive bias was expected in response to preferred beverage images; therefore, this study focused on ERP components associated with different aspects of attention (N2 and P3).

To examine how cue reactivity of BDs differs as a function of beverage preference, the N2 was used to index attentional capture and processing emotionally significant stimuli. A larger N2 amplitude was predicted in response to preferred alcohol-related stimuli. Previous research has found males to have an increased risk of developing an AUD (Young et al., 2005) resulting from increased exposure to alcohol related stimuli (Benningfield et al., 2009; Meyer et al., 2000). For this reason, the N2 amplitude was predicted to be larger for correct responses to preferred alcohol-related stimuli in males than in females. The N2 was also expected to be sensitive to response inhibition, being larger for No-Go vs. Go trials, especially No-Go trials associated with preferred beverages.

This study also examined the P3 component because of its utility in measuring attentional biases and sensitivity to response inhibition. Due to repeated exposure to preferred alcoholic beverages, the P3 component was predicted to have a larger amplitude in response to preferred alcohol-related stimuli, indicating an attentional bias towards them. A smaller No-Go P3 was believed to occur in response to preferred alcohol-related stimuli, indicating dysfunctional response inhibition. A larger Go P3 amplitude in response preferred alcohol-related stimuli was also predicted, indicating increased working memory and/or endogenous attentional resources being used to access

memory efficiently (López-Caneda et al., 2013). Findings were expected to be reversed for P3 Go amplitudes in response to non-preferred alcohol-related stimuli. Based on previous findings that men were more likely to develop AUD (Young et al., 2005), males were expected to have faster reaction times and larger P3 amplitudes to preferred alcohol-related stimuli as compared to females.

II. METHOD

Participants

A total of 16 BDs (7 male, 9 female) between the ages of 21 and 35 who met the criteria for BD were recruited from the student population at Texas State University. However, only 14 of the 16 participants (7 male, 7 female; M_{age} = 24.71 years) had usable data. Two participants were excluded due to excessive ocular artifacts. Participants were recruited via class announcements in undergraduate Psychology courses, the electronic signboard in the Department of Psychology, and via flyers posted around campus. Recruitment efforts focused on individuals with a BD consumption pattern because BDs are more likely to have developed an alcoholic beverage preference, in addition to having an increased risk of developing AUD.

Individuals interested in volunteering for this study were screened for eligibility with a telephone interview. During the interview, participants were screened for alcohol beverage preference, skin sensitivity, a history of psychiatric conditions, and normal or corrected-to-normal vision. Participants were excluded if they had sensitive skin, were under the age of 21 or older than 35, had an Axis I psychiatric diagnoses, or did not qualify as a BD. Individuals were also excluded if they report having had a seizure, loss of consciousness for longer than 20 minutes, neuropathology, or concussion within the past year. Those who met the criteria for inclusion were scheduled for a lab visit. The individuals were compensated $10 for every hour spent in the lab. Because of the slow initial recruitment, compensation was increased to $15 an hour. Materials and procedures used in this study were approved by the Texas State University – San Marcos Institutional Review Board.

Self-Report Measures

During the telephone interview, basic demographic information (e.g. age, gender) was collected to determine if an individual met the age requirements (between 21 and 35 years of age) and determine their alcoholic beverage preference. The phone interview was also used to determine participant handedness, whether or not they had corrected-to-normal vision, or sensitive skin, as well as their medical history. Those with a recent history of concussion or seizures, broken arm, or any other handicaps that would prevent them from performing the computer task were excluded from the study. Participants also completed the Binge Drinking Questionnaire (BDQ), to determine if participants met the definition of being a BD. Participants meeting the criteria then completed the Quantity Frequency Index (QFI). During their lab visit, participants again completed the BDQ and the QFI to determine if their drinking habits had changed since the phone interview. Participants also completed the Barratt Impulsivity Scale (BIS-11) during their lab visit to measure their motor impulsivity.

The BDQ, which is an adaptation of the Cranford, McCabe, & Boyd (2006) questionnaire, is an 11-item measure used to determine if participants meet the criteria for BD (see Appendix C; Read, Beattie, Chamberlain, & Merrill, 2008; Velazquez, Poulos, Latimer, & Pasch, 2012). Participants meeting the criteria of BD and have had a BD episode in the past month were included in this study. The QFI (see Appendix A; Cahalan, Cisin, & Crossley, 1969) of alcohol use is a 12-item measure commonly used to assess an individual's level of alcohol consumption over the past 6 months and determine the drinking status of participants (Sinha et al., 2008). The QFI is a widely used questionnaire and is considered a valid measurement of current drinking patterns.

Participants' responses to QFI were also used to determine if they met the criteria for BD. The QFI, along with a standalone alcohol beverage question that was included in the demographic portion of the phone interview, were used to establish their preferred alcohol preference. The BIS-11 (see Appendix B; Patton & Stanford, 1995) is a 30-item measure that uses a 5-point Likert response scale and is widely used in the assessment of trait impulsivity (Steinberg, Graham, O'Brien, Woolard, Cauffman, & Banich, 2009). The BIS-11 was not used during the phone interview for inclusionary purposes. It was given to participants during the experimental session, prior to performing the Go/No-Go tasks. The BIS-11 was divided into five factors: attention, cognitive instability, motor, perseverance, self-control, cognitive complexity. We focused on possible gender differences in motor impulsivity.

Stimuli

The stimuli used in this experiment consisted of 120 alcohol-related images for each of the 3 alcohol preferences and 120 non-alcohol-related images. Alcohol-related stimuli were divided into three subsets of images: beer, wine, and liquor. In the subset of beer, images included those of beer cans, beer bottles and glasses of beer. The subset of wine included images of wine bottles, boxed wine, glasses of wine, champagne bottles, and champagne glasses. The subset of liquor included images of various bottles of liquor (e.g. whisky, vodka, tequila), as well as martini glasses, whisky glasses, shot glasses, and margarita glasses (all of which were depicted with liquor in them). All images were of beverages in isolation against a white background and were retrieved via Google image search (see Appendix D). Image sets were equated for contrast and luminance with Adobe Photoshop CS6 (64 bit) and resized to 8 X 8 centimeters.

Go/No-Go Task

Participants performed a modified Go/No-Go task, in which alcohol-related images and non-alcohol-related images were presented in succession to test participants' ability to withhold responding to non-target images. Depending on the block, participants were required to respond when a Go stimulus (alcohol/non-alcohol images) was presented, while refraining from responding when a No-Go stimulus (non-alcohol/alcohol images) was presented. Each trial was preceded by a short fixation period (a "+" presented for 400 milliseconds), signaling the beginning of the trial. An alcoholic or non-alcoholic image was then displayed for 1500 milliseconds, or until the participant responded. After each stimulus, participants received feedback indicating a correct (an image of a green check mark) or incorrect response (an image of a red "x"). Participants pressed the "1" button to start the next trial. The task was broken up into smaller runs to give participants a chance to rest if necessary. The task was made up of 4 blocks of 240 trials, each broken into 2 shorter runs of 120 trials. The order of the blocks was counterbalanced across participants and the ratio of Go stimuli to No-Go stimuli in each block was set at 90:30 for Go and No-Go trials, respectively. In two of the four blocks, images of participants' preferred alcoholic beverages and non-alcoholic drinks were presented; one with preferred alcohol images as Go stimuli and the other with non-alcoholic images as Go stimuli. The remaining two blocks consisted of images of non-preferred alcoholic beverage and non-alcoholic beverages.

Electrophysiological Recording

EEG data was collected continuously from 64 channels using sintered Ag/AgCl QuikCaps, the SynAmps2 system and Acquire version 4.5 (Neuroscan, Compumedics

USA). Impedances were maintained at or below 5 kOhms for all participants. EEG was recorded with a sampling rate of 1000 Hz for 1100 milliseconds, starting 100 milliseconds prior to stimulus onset. Trials were excluded if they had muscle or eye movement artifacts above 100 or below -100 μV. One second stimulus-locked averages with a 100 millisecond pre-stimulus baseline were used to represent ERPs to the various stimulus types. Data was filtered offline with a bandwidth of 0.01Hz to 35Hz and re-referenced offline to linked mastoids. Participants with fewer than 16 artifact-free trials per trial type were discarded, resulting in the exclusion of 2 participants

For each of the four trials (preferred alcohol Go, preferred alcohol No-Go, non-preferred alcohol Go, non-preferred alcohol No-Go), ERPs were derived for the different image types and target status. Examination of the grand-averaged ERPs revealed that the P1 referenced to linked mastoids was difficult to isolate and identify at Oz; therefore, P1 amplitudes were not examined in the current study. Subsequent analyses focused on the N2 and P3 ERPs components. The N2 was identified as a negative peak occurring between 190 and 230 ms over frontocentral areas. The N2 voltage values associated with this latency epoch were obtained from the Fz, F1, F2, FCz, FC1, and FC2. The P3 was identified as a positive peak occurring between 550-650 ms over centroparietal sites, and voltage values associated with this latency were obtained from the Pz, P3, P4, CP1, CP2, and CPz electrodes.

Procedure

The telephone screening interview took approximately 15 minutes to explain the procedures used in the study, screen for exclusion criteria (e.g., age, drinking history, skin sensitivity), and to schedule a lab visit for those who met the criteria for this study.

During the phone interview, once verbal consent was obtained, basic demographic information (e.g. age, gender), drink preferences, and their basic medical background was recorded. The QFI and BDQ were then administered over the phone to determine if they met the qualification of being a BD. Those identified as a BD and having had a BD episode in the past month were eligible for this study.

After the initial phone interview, individuals who qualified for the study scheduled a time and day to come to the ERP lab (UAC 261) for one, approximately 2 hour, experimental session. Participants were asked to abstain from drinking 24 hours prior to their lab visit. They were also asked to continue their regular tobacco and/or caffeine intake. These guidelines were to help reduce any possible withdrawal effects. Upon arrival to the lab and prior to participation, the procedures were reiterated, and the participant had the opportunity to ask any questions regarding the study. Informed consent was then obtained and the signed consent forms were then kept in a locked file. A copy of the consent form was offered to the participant for their records.

The session consisted of three basic stages: capping the participant, questionnaires, and a computer task during which EEG was recorded. The capping process consisted of attaching the EEG electrodes and filling the electrodes with Nuprep, which took approximately 45 minutes to complete. During this process participants completed the BIS-11, the QFI, and the BDQ. Participants then completed the Go/No-Go computerized task, which took approximately 50-60 minutes to complete.

Participants were seated in an armchair, housed in a soundproof, radiofrequency shielded chamber. The armchair was approximately 1.6 meters away from a 19" computer screen with a keyboard placed in front of participants. They were instructed to

fixate on the center of the computer screen, while abstaining from blinking and moving during each trial. At the beginning of each block, participants were informed of the target (Go) stimuli for that particular block and instructed to press the "1" button as fast as they could whenever a target stimulus appeared. Prior to the start of the first block, participants performed a practice block made up of 12 trials in order to familiarize themselves with the task and the experimental environment. The stimuli used in this practice block were similar to those being used in the experimental block; however, these pictures were not used in the experimental blocks. Data from the practice block were not included in the analyses.

Between runs, participants were given an opportunity to take a break, at which time, water, soft drinks and snacks were offered. With breaks, the task took no longer than 90 minutes to complete. After completing the Go/No-Go task, the recording equipment (EEG) was removed. Participants were then debriefed, provided with the opportunity to wash their hair, and compensated for their time.

Data Analysis

For basic demographic information, *t*-tests were conducted in order to compare gender differences on the continuous variables age, age at first drink, QFI, days since last drink prior to testing session, and BIS-11 motor impulsivity score.

In order to examine and determine if gender (male v. female) influenced behavioral indices (reaction time and accuracy), a $2\times2\times2\times2$ repeated measures analysis of variance (ANOVA) was conducted for both Go and No-Go trials. These ANOVAs used gender as a between-subjects factor, and trial type (Go and No-Go), preference condition (preferred and non-preferred), and image type (alcohol and non-alcohol) as

within-subject factors.

ERP analyses focused on the amplitudes of the N2 and P3 (dependent variables) in response to Go and No-Go stimuli in order to determine if there was a significant difference in cue reactivity of preferred alcoholic beverages. N2 and P3 amplitudes in response to different stimulus types were each assessed using a repeated measures ANOVA. A 2×2×2×2×3 repeated measures ANOVA was conducted for average N2 amplitudes between 190ms and 230ms over the FC1, FCz, and FC2 electrodes. In this ANOVA, and trial type (Go and No-Go), preference condition (preferred and non-preferred), image type (alcohol and non-alcohol), and electrode (FC1, FCz, and FC2) as within-subject factors. A 2×2×2×2×2×3 repeated measures ANOVA was conducted for a late P3 peaking between 550 and 650ms on the FC1, FCz, FC2, CP1, CPz, and CP2 electrodes. The ANOVA used gender as a between-subjects factor, and trial type (Go vs. No-Go), preference (preferred vs. non-preferred), image type (alcohol vs. non-alcohol), anterior/posterior (frontocentral vs. centroparietal electrode sites), and laterality (left, central, vs. right) as within-subject factors. In order to further interpret higher order interactions, separate ANOVAs were performed. Interactions were interpreted using Bonferroni-corrected ANOVAs and/or t-tests where appropriate. In the event of violations of sphericity, degrees of freedom were adjusted with Geisser-Greenhouse corrections.

III. RESULTS

Background Characteristics

T-tests were used to compare males and females on the following continuous variables: age, age at first drink, QFI, days since last drink prior to testing session, and motor impulsivity. There was no significant gender difference found for age (p = .9), age at first drink (p = .71), QFI (p = .93), days since last drink (p = .26), or motor impulsivity (p = .91; Table 1). Of the three beverage types, men chose more beer (71.4%) as their preferred beverage over wine (0%) and liquor (28.6%). Women, on the other hand, chose more wine (42.9%) as opposed to beer (28.6%) and liquor (28.6%). A Chi-Square test was performed and found the relationship between gender and preference was not significant [$\chi^2(2) = 4.29, p = .12$].

Table 1. ***Background characteristics of participants*****: Means (Standard Deviations)**

	Males (*n*=7)	Females (*n*=7)	Significance (*p)*
% Preferred			< .05
Beer	5 (71.4%)	2 (28.6%)	
Wine	0 (0.0%)	3 (42.9%)	
Liquor	2 (28.6%)	2 (28.6%)	
Age	24.86 (2.12)	24.57 (5.19)	.9
Age at first drink	12.71 (2.43)	13.429 (4.28)	.71
QFI	2.27 (2.84)	2.15 (1.87)	.93
Days since last drink	2.57 (2.37)	6.43 (8.38)	.26
Motor Impulsivity	18.71 (3.86)	19 (5.03)	.91

Behavioral Data

A 2×2×2×2 ANOVA was conducted on accuracy data, with gender as a between-subjects factor, and trial type (Go and No-Go), preference condition (preferred and non-preferred), and image type (alcohol and non-alcohol) as within-subject factors. There were no significant effects for gender [$F(1, 12) = .44, p = .52, \eta^2 = .04$], preference [$F(1, 12) = 2.02, p = .18, \eta^2 = .14$], or image type [$F(1, 12) = 1.23, p = .29, \eta^2 = .09$]; however, there was a significant effect of trial type [$F(1, 12) = 26.88, p < .001, \eta^2 = .69$], indicating that overall accuracy was greater for Go trials (98.8%) relative to No-go trials (91.9%). No interaction between gender × preference condition [$F(1, 12) = 0.66, p = .43, \eta^2 = .05$] or gender × image type [$F(1, 12) =$

$0.24, p = .66, \eta^2 = .02$] was found.

A 2×2×2 ANOVA was conducted on reaction times, with gender as a between-subjects factor, and trial type (Go and No-Go), preference condition (preferred and non-preferred), and image type (alcohol and non-alcohol) as within-subject factors. There were no significant differences in reaction times as a function of trial type [$F(1, 12) = 0.002, p = .96, \eta^2 < .01$], preference [$F(1, 12) = 3.36, p = .09, \eta^2 = .219$], of image type [$F(1, 12) = 0.02, p = .89, \eta^2 < .01$].

ERP data

Two participants were excluded from analysis due to excessive artifacts present in their EEG data. The P100 waveform could not be identified reliably with the linked mastoids reference used to identify the N2 and P3; therefore, analyses are focused on the N2 and P3 waveforms, which were readily identifiable. N2 amplitudes were identified as occurring between 190ms and 230ms for FC1, FCz, and FC2 electrodes. The F1, Fz, and F2 electrodes were not included in this analysis because the peak of the N2 was maximal over the FC sites. A late P3 peaking was identified as occurring between 550 and 650ms on the FC1, FCz, FC2, CP1, CPz, and CP2 electrodes. The ERP grand-averages at the frontocentral (see Figure 1) and the centroparietal midline sites (see Figure 2) for preferred Go/No-Go and non-preferred Go/No-Go trials.

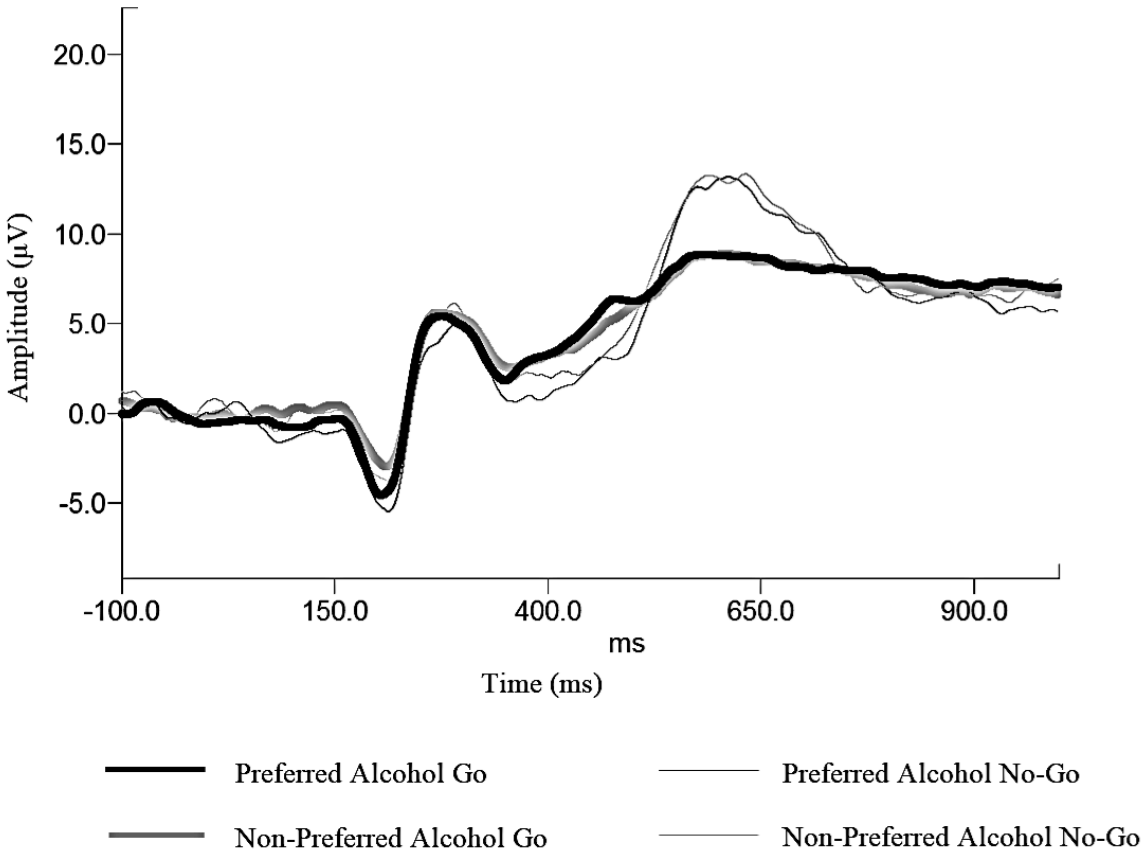


Figure 1. **FCz grand averages for ERPs to preferred and non-preferred beverages**

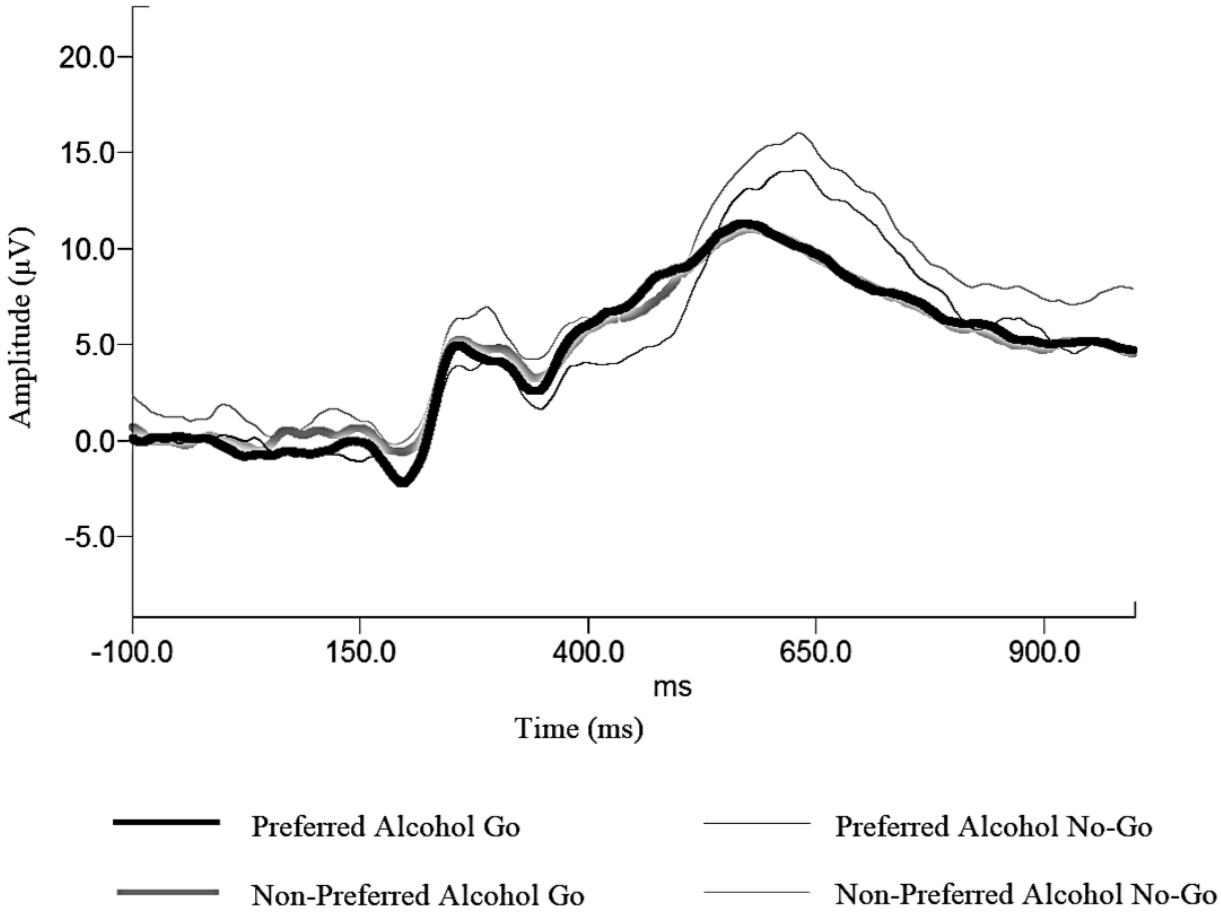


Figure 2. **CPz grand averages for ERPs to preferred and non-preferred beverages**

N200

A 2×2×2×2×3 repeated measures ANOVA was conducted that used gender as a between-subjects factor, and trial type (Go and No-Go), preference condition (preferred and non-preferred), image type (alcohol and non-alcohol), and electrode (FC1, FCz, and FC2) as within-subject factors. The ANOVA revealed a significant main effect of preference condition [$F(1, 12) = 9.31, p = .01, \eta^2 = .44$], with the preferred condition ($M = -3.71\mu V,\ SE = .74$) eliciting a significantly higher N2 amplitudes than the non-preferred condition ($M = -2.85\mu V,\ SE = .72$). A significant interaction was observed

between preference and image type [$F(1, 13) = 5.12, p = .04, \eta^2 = .3$]. A t-test revealed preferred alcohol images elicited significantly larger N2 amplitude compared to non-preferred alcohol images (p = .04; see Figure 3). All other differences were non-significant (ps > .09). Overall, the data shows that the N2 amplitude is sensitive to preference as opposed to trial type, indicating that it is not affected by control processes associated with response inhibition.

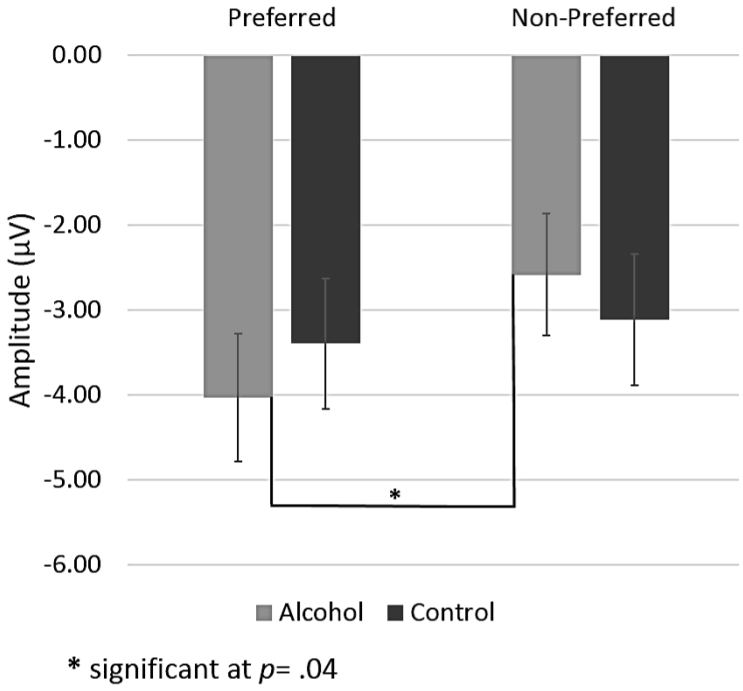


Figure 3. **N2 preference and image type interaction**

P300

A 2×2×2×2×2×3 repeated measures ANOVA was conducted that used gender as a between-subjects factor, and trial type (Go and No-Go), preference (preferred and

non-preferred), image type (alcohol and non-alcohol), anterior/posterior (frontocentral vs. centroparietal electrode sites), and laterality (left, central, right) as within-subject factors. The ANOVA revealed a main effect of anterior/posterior electrode site [$F(1, 12) = 7.89, p = .02, \eta^2 = .4$], in which the posterior electrode grouping (CP1, CPz, CP2) had a larger amplitudes ($M = 11.33\mu V,\ SE = 1.38$) compared to the anterior electrode grouping (FC1, FCz, FC2; $M = 10.21\mu V,\ SE = 1.34$). There was also a main effect of laterality [$F(2, 11) = 26.01, p < .001, \eta^2 = .83$], in which central electrodes (CPz and FCz) had higher amplitudes ($M = 11.32\mu V,\ SE = 1.38$) compared to electrodes overlying the left hemisphere (FCz, CPz; $M = 10.17\mu V,\ SE = 1.36$) and right hemisphere ($CP_2, FC_2;\ M = 10.83\mu V,\ SE = 1.3$). Since the P3 peak amplitude was centrally distributed, the laterality level was removed to simplify analyses and to assist with the interpretation of higher order interactions. Therefore, only FCz and CPz sites were used in subsequent analyses.

To examine the data at FCz and CPz, a 2×2×2×2 repeated measures ANOVA was conducted with gender as a between-subjects factor, and trial type (Go and No-Go), preference (preferred and non-preferred), image type (alcohol and non-alcohol), and central anterior/posterior electrodes (FCz and CPz) as within-subject factors. There was a main effect of anterior/posterior [posterior amplitude > anterior; $F(1, 12) = 12.25, p = .004, \eta^2 = .51$], as well as an interaction between trial type × image type [alcohol No-Go > alcohol Go; $F(1, 12) = 18.51, p = .001, \eta^2 = .61$]. Several higher order interactions were also observed. There was an interaction of preference × anterior/posterior × gender [$F(1, 12) = 6.42, p = .03, \eta^2 = .35$], preference × anterior/posterior × gender × image type [$F(1, 12) = 15.12, p = .002, \eta^2 =..56$], and preference × anterior/posterior ×

gender × image type × trial type [$F(1, 12) = 6.37, p = .03, \eta^2 = .35$].

In order to further interpret these higher order interactions, separate ANOVAs were performed for the frontocentral (FCz) and centroparietal (CPz) sites. The 2×2×2 repeated measures ANOVA for electrode FCz was conducted using gender as a between-subjects factor, and trial type (Go and No-Go), preference (preferred and non-preferred), and image type (alcohol and non-alcohol) as within-subject factors. An interaction of trial type × image type [$F(1, 12) = 23.53, p < .001, \eta^2 = .66$] was found (see Figure 4). In No-Go trials, amplitudes for alcohol were larger than for control images [$t(13) = 4.2, p = .001$]; whereas in Go trials, amplitudes to alcohol images were smaller than those for control images [$t(13) = -3.76, p = .002$]. Alcohol images in the No-Go condition elicited P3s of larger amplitude than alcohol images in the Go condition [$t(13) = -4.86, p < .001$]; whereas amplitudes of P3s to control images did not differ across trial types ($p = .10$).

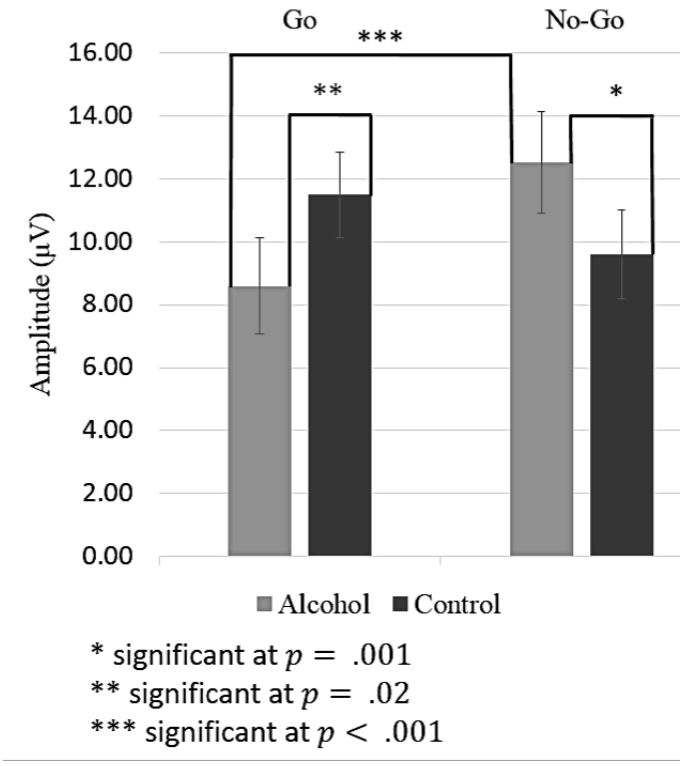


Figure 4. **The interaction between trial type and image type at FCz**

Analyses for electrode CPz revealed a similar trial type × image type interaction [see Figure 5; $F(1, 12) = 9.27, p = .01, \eta^2 = .44$]. In No-Go trials, amplitudes for alcohol were larger than those for control images [$t(13) = 2.58, p = .02$]; whereas in Go trials, amplitudes to alcohol images were smaller than those for control images [$t(13) = -2.17, p < .05$]. Alcohol-related images in the No-Go condition elicited P3s of larger amplitude than alcohol images in the Go condition [$t(13) = -4.02, p < .001$]; whereas amplitudes of P3s to control images did not differ across trial types ($p = .51$). The trial type × image type interaction for CP_z was mitigated by a trial type × image type × gender interaction [$F(1, 12) = 7.12, p = .02, \eta^2 = .37$].

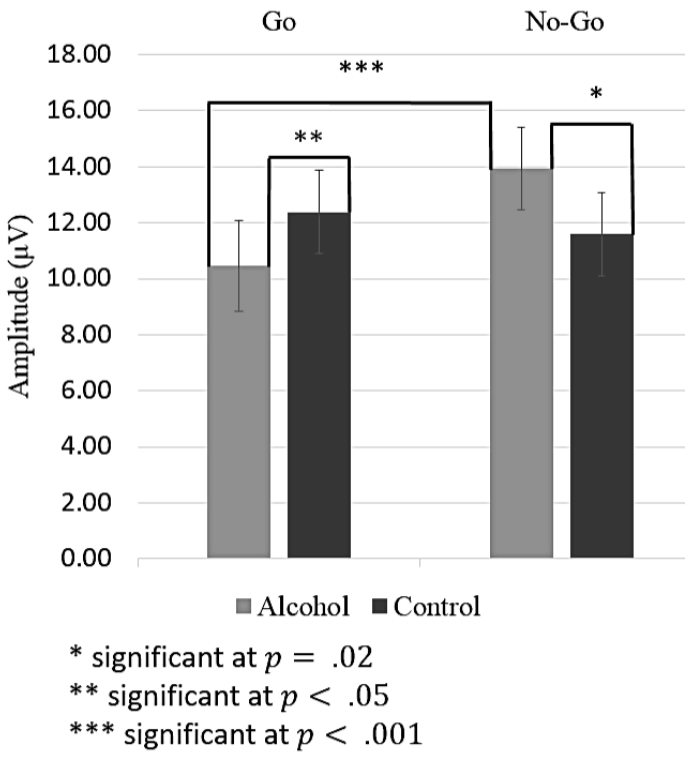
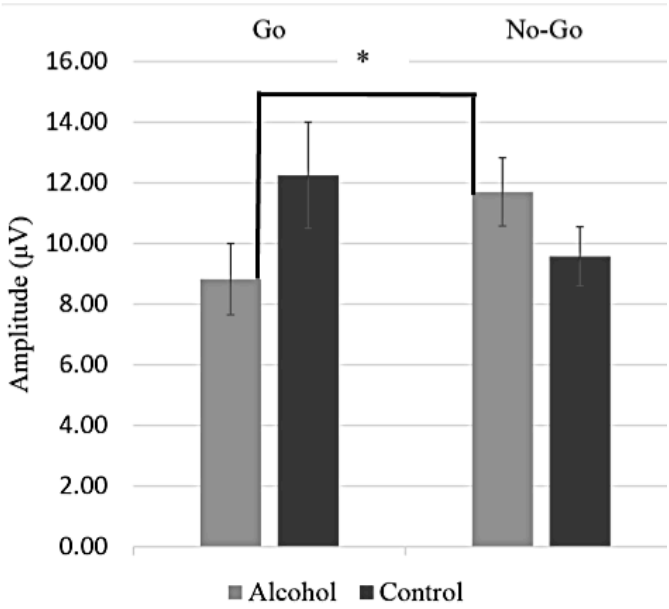


Figure 5. **The interaction between trial type and image type at CPz**

Post-hoc analyses were subsequently conducted, which consisted of separate ANOVAs males and females. Despite the effects noted above, the post-hoc analysis revealed no significant effects for males ($ps > .05$). For females, there were two, 2-way interactions. Trial type interacted with image type [see Figure 6, $F(1, 6) = 6.79, p = .04, \eta^2 = .53$], such that alcohol images elicited larger P3 amplitudes when they were presented in the No-Go condition versus the Go condition [$t(13) = -2.97;\ p = .03$]; all other effects were non-significant. There was a marginally significant interaction of preference × image type [$F(1, 6) = 6.44, p = .04, \eta^2 = .52$], but subsequent post-hoc *t*-tests failed to show significant differences after Bonferroni-correction.



* significant at $p = .03$

Figure 6. **The interaction between trial type and image type for women at CPz**

IV. DISCUSSION

An individual's alcohol preference is influenced by their individual tastes, as well as direct and indirect experiences with different forms of alcohol (e.g., beer, wine, or liquor; Petit et al., 2013). Beverage preference has been found to be an influencing factor in determining an individual's alcohol consumption pattern (Del Rio, Prada, & Alvarez, 1995) and subsequently should enhance attentional bias towards their preferred beverage. Therefore, if alcohol-related stimuli contain a variety of beverages with only a subset of preferred drinks, resultant indices (behavioral and/or ERP) of cue reactivity may be attenuated. The primary aim of this study was to determine if beverage preference was associated with cue reactivity to alcohol-related images in binge drinkers (BDs). It was predicted that a significant preference-related amplitude difference would be seen in the N2 and P3 waveforms elicited via a Go/No-Go task with alcohol and control images. The ERP data collected provided evidence that partially supported this hypotheses, in that there was a significantly larger N2 amplitude in response to preferred alcoholic beverage stimuli versus non-preferred alcoholic beverage images. This is consistent with the findings of Dickter et al. (2014) in that more attentional resources were allocated to the preferred alcohol-related stimuli because of their emotional relevance. In regards to the P3 component, P3 amplitudes were not sensitive beverage preference; rather, they were modulated by response demands associated with the Go/No-Go task.

Gender differences in alcohol beverage preferences and the use of heterogeneous alcohol images in studying the attentional bias among BDs could potentially explain the reason behind the mixed results in the literature. Compared to the non-alcohol-related stimuli used in some studies, BDs have an attentional bias to alcohol-related stimuli

which activates the reward pathway, subsequently influencing health-related decisions like consuming alcohol (Petit et al., 2012). Research has found that there are gender differences in beverage preference among BDs; therefore, measuring the attentional bias of BDs by beverage preference may provide a more sensitive estimate of differences between males and females. Analysis of gender differences with respect to preferences did indicate that the preferred beverage among males was beer, while the preferred beverage of females was wine. However, the differences across preferences as a function gender were not found, potentially due to a lack of statistical power associated with the small N of this study. Because the literature is sparse with regard to gender-related differences in cue-reactivity, the secondary aim of this study was to determine if gender effects exist in cue-reactivity when beverage preference is taken into account. In response to their preferred beverage images, men were predicted to have significantly faster reaction times and have larger N2 and P3 amplitudes compared to females. Although the hypothesis was not supported by the findings of this study, gender differences in the cue-reactivity of alcohol-related stimuli were observed. The findings for each of these research questions will be discussed in greater detail below.

Analysis of the behavioral data revealed that there was a significant difference between Go and No-Go trials in participants' accuracy, with greater accuracy for Go trials. As noted above, a higher N2 amplitude was found among BDs in response to preferred alcohol-related stimuli compared to non-preferred alcohol-related stimuli, with no significant difference between control stimuli. The N2 is believed to indicate conscious application of attentional resources to significant stimuli, which influences the amount of activation associated with incorrect responses (Petit et al., 2012; Crego et al.,

2009). Larger No-Go N2 amplitudes have been interpreted as reflecting response conflict monitoring (Nieuwenhuis et al., 2003), in which the Go/No-Go N2 produced on correct trials is the product of a conflict between responding and inhibiting a response (Eimer, 1993; Jodo & Kayama, 1992; Lavric et al., 2004). However, there was no significant difference found between N2 amplitude and trial type (Go, No-Go), indicating that the N2 was not sensitive to any inhibitory effects in the current study. Rather, these findings indicate that this component was sensitive to attentional capture by preferred stimuli, and not to behavioral response inhibition.

The P3 component was predicted to have a larger amplitude in response to preferred alcoholic beverage images because participants were most likely to have had repeated exposure to them. However, no significant differences were observed between P3 amplitudes to preferred and non-preferred beverages. The ERP data did reveal a significant difference between P3 amplitudes and trial type, as well as a significant difference between amplitude and image type (alcohol and non-alcohol). The larger P3 amplitude in response to alcohol-related stimuli observed in the present study indicates participants have developed an attentional bias toward alcohol in general. This is in line with previous studies, which have found alcohol-dependent individuals also have larger P3 amplitudes in response to alcohol-related stimuli regardless of preferences (Bartholow, Henry, & Lust, 2007; Bartholow, Lust, & Tragesser, 2010, Hansenne et al., 2003, Herrmann et al., 2000, Herrmann et al., 2001; Namkoong et al., 2004; Petit et al., 2011; Petit et al., 2012).

The main effect of trial type for P3 amplitudes was due to larger amplitudes for No-Go stimuli than for Go stimuli. Larger P3 No-Go amplitudes indicate an increase in

neural resources associated with cognitive control (Burden et al., 2009). They are also associated with infrequent stimuli (Yamaguchi & Knight, 1991), suggesting that the importance of a stimulus (i.e., its frequency and/or response status) may be a factor contributing to the difference between P3 amplitudes to No-Go vs. Go trials (Tekok-Kilic et al., 2001). In the current study, P3 amplitudes were found to be larger for No-Go stimuli at both frontocentral and centro-parietal sites, indicating more resources were being used to inhibit responses during these trials. These results do not support the lack of inhibition, as indicated by lower No-Go P3 amplitudes, which have been found in heavy social drinkers (Oddy & Barry, 2009) and in alcohol-dependent individuals (Cohen, Porjesz, Begleiter, & Wang, 1997; Kamarajan et al., 2005a). However, without a light drinking control group, this conclusion cannot be made definitively. Nevertheless, the larger frontocentral P3 amplitudes produced in response to No-Go stimuli more likely to be indicative of effective response inhibition (Pandey et al., 2012; Porjesz & Begleiter, 2003), as opposed to an index of attentional deficiencies.

Previous research suggests that adult males may have an increased risk of developing an AUD; however, gender differences for late adolescents and college-aged binge drinkers are less clear (Grucza et al., 2008; Grucza et al., 2009; Holdcraft & Iacono, 2002). It follows that there may be gender differences in cue reactivity to alcohol stimuli that may develop among BDs. With males more frequently reporting alcohol intoxication (Benningfield et al., 2009) and heavy drinking (e.g. BD; Meyer, Rumpf, Hapke, Dilling, & John, 2000), males are believed to subsequently have an increased vulnerability to alcohol-related cues, leading to higher rates of problem drinking. However, female BDs have been found to be more sensitive to alcohol's neurotoxic

effects (Hommer, Momenan, Kaiser, & Rawlings, 2001; Medina et al., 2008; Schweinsburg et al., 2003), to have decreased spatial working memory (Hartley, Elsabagh, & File, 2004; Townshend & Duka, 2005), and to have abnormal overall brain activity patterns while soberly performing spatial working memory and vigilance tasks compared male BDs (Caldwell et al., 2005). This is likely due to the fact that women have higher BAC than males after drinking the same amount of alcohol (Advokat et al., 2014). Women have lower muscle/fat ratio than men, which results in more alcohol remaining in the blood (Advokat et al., 2014). Therefore, the secondary purpose of this study was to determine if there are gender differences in cue-reactivity in BDs.

Given their higher risk of AUD, it was predicted that males would have faster reaction times, as well as larger N2 and P3 amplitudes, and lower No-Go P3 amplitudes in response to preferred alcohol-related stimuli. The data did not fully support this hypothesis. The results did support the findings made by Crego et al. (2009) that there were no significant gender differences in N2 amplitudes. The absence of a significant gender difference in the cue reactivity of BDs to preferred beverages may be due to the fact that both males and females reported drinking with approximately the same amount and frequency. Therefore, preferential cue reactivity may be the result of exposure and not an inherent gender difference. The gender differences found in previous studies could be the result of pre-existing differences (e.g. quantity and/or frequency of alcohol consumption) or because individual preference was not taken into account.

A gender difference was found in the P3 amplitude for No-Go alcohol-related images, with female BDs eliciting larger amplitudes than male BDs. As previously mentioned, lower No-Go P3 amplitudes are indicative of impaired response inhibition

during No-Go trials, which has been found among alcohol dependent population and those at high-risk of AUD (Cohen et al., 1997a; Cohen et al., 1997b; Kamarajan et al., 2005a; Pfefferbaum et al., 1991). Therefore, these results suggest a possible gender difference in response inhibition (Pandey et al., 2012; Porjesz & Begleiter, 2003), with female BDs recruiting more neural resources for response inhibition for alcohol-related stimuli. However, the exact reasons for this finding require further examination.

The results of this study should be viewed as preliminary due to a number of limitations that remain to be addressed in future studies. The most notable limitation was the sample size. This study was limited to a small sample of fourteen BDs (7 males, 7 females). While other studies have found that, compared to women, men more frequently report alcohol intoxication (Benningfield et al., 2009) and BD (Meyer, Rumpf, Hapke, Dilling, & John, 2000), no such gender differences were found in this study. Analysis of participant beverage preferences also found no significant gender difference. Although the absence of significant gender differences in ERP amplitudes may have been the result of equivalence in alcohol consumption between the two groups, the low statistical power present in this study may have obstructed the ability to detect small to moderate effects. Because the sample size of this study was small and participants were comprised of mostly university students meeting the criteria for BD from a single university, differences might have been observed with a larger and more diverse sample. It is also for these reasons that this study is limited in its generalizability. Because this study only included BDs from a single university, we are unable to conclude that these findings are unique to BDs, especially those who are older than 35. Nevertheless, because BD tends to be most problematic in young, college-aged adults, the results of the current study are

informative, providing evidence that attentional biases to preferred beverages emerge relatively early as drinking patterns are developing in young adults.

A second limitation of this study was early, more automatic attentional biases were not examined because of the inability to identify the P1 waveform using linked mastoids for the reference. Due to time constraints, re-referencing and data extraction were not possible in the current study. However, examination of this component could be fruitful in understanding the development of attentional biases to alcohol and their association with problem drinking. The P1 component is an exogenous ERP component and has been found to index the early visual processing of motivationally relevant stimuli (alcohol-related stimuli) in alcohol dependent popilations (Maurage et al., 2009; Beatty et al., 1997; Schandler et al., 1995; Sullivan et al., 2002; Wegner et al., 2001) and BDs (Petit et al., 2011; Maurage et al., 2009). Research has shown that the differences in P3 observed among BDs and individuals with an AUD originates with earlier perceptual stages (P1; Maurage, Philippot, Verbanck, Noel, Kornreich, Hanak, & Campanella, 2007). When the P1 latency is large, the attentional and decisional stages that follow are subsequently delayed (Maurage et al., 2009). A deficit in the P1 latency or amplitude in response to preferred alcohol-related stimuli may prove to be an electrophysiological index of beverage preference in BDs. Through the use of a different referencing approach, future studies should examine P1 differences as a function of beverage preference. By determining how early attentional components are influenced by drinking behavior and beverage preferences can help better understand the relationship between attentional biases, BD, and AUD so that more effective treatment and prevention programs can be developed.

A third limitation was that the study did not include a latency analyses for ERP components due to academic time constraints. Latencies in ERP components are interpreted as an indication of the onset of processing (Luck, 2005). Abnormalities in latencies serve as a marker for dysfunctional and slow cognitive processing of complex stimuli (Maurage, Noël, & Tomberg, 2010). As mentioned, as the latency of the early visual processing component (P1) increases, there is an increase in the delay in onset of the attentional and decisional stages as indexed by the P3 (Maurage et al., 2009). Research has found the P3 latency and amplitude of young adults to be significantly affected by their history of BD during adolescence (Ehlers, Phillips, Finnerman, Gilder, Lau, & Criado, 2007). Some research has observed similar increases in P3 latency in alcoholics (Cadaveira, Grau, Roso, & Sánchez-Turet, 1991; Pfefferbaum, Ford, White, & Mathalon, 1991), suggesting that BD and AUD are related (Enoch, 2006). The inclusion of latencies in future research could provide important information regarding the speed in which different beverages are processed and how this varies as a function of preference and drinking history.

Finally, this study was also limited in that the family history of AUD was not assessed. Previous research has found the offspring of alcohol dependent individuals produce smaller No-Go P3 amplitudes compared to Go P3 amplitudes (Kamarajan et al., 2005a, Kamarajan et al., 2005b). This reduced No-Go P3, indicative of disinhibition, is believed to be a phenotypic marker for AUD and those at risk of developing AUD (Kamarajan et al., 2005a, Kamarajan et al., 2005b). Assessing participants' family history could explain the gender difference in No-Go P3 amplitudes produced in response to alcohol-related stimuli. The larger No-Go P3 found among female BDs in the present

study could be explained by an absence of AUD in their family and the presence of AUD in the families of the male participants.

In conclusion, to the best of the authors' knowledge, this is the first study to use ERPs to determine whether beverage preference plays a role in the cue-reactivity of BDs and if there are gender differences. This study provides preliminary evidence of amplification in the effortful processing of preferred alcohol-related stimuli among BDs. These findings indicate that the N2 component is sensitive to attentional capture by preferred stimuli, and not to behavioral response inhibition. The cognitive processes underlying cue reactivity among BDs, therefore, appear to be stronger for preferred alcoholic beverages. In contrast, P3 amplitudes were not sensitive to preferences. Rather, they were sensitive to response inhibition, being larger for No-Go than Go trials. With respect to gender differences, after taking preferences into account, few differences were of note, except that female may require more resources to inhibit responding to alcohol-related stimuli.

Studying BDs attentional bias to preferred alcohol-related stimuli could prove beneficial in the development of effective personal treatment and prevention programs that focus on cognitive processes. Treating AUD by reducing attentional biases to alcohol-related stimuli (i.e., reducing their cue-reactivity) has had mixed results (Christiansen, Schoenmakers, & Field, 2015). Studies have found attentional bias modulation does occur with the use of attentional bias tasks that require training (Field et al., 2007; Schoenmakers, Wiers, Jones, Bruce, & Jansen, 2007). However, these findings did not generalize to other attentional bias tasks or novel stimuli (Christiansen, Schoenmakers, & Field, 2015). Measuring an individual's attentional bias to determine

risk of relapse has also yielded mixed results (Snelleman, Schoenmakers, & Mheen, 2015; Spruyt et al., 2013). These studies question the utility of attentional training in the treatment of AUDs. However, it is important to note that the stimuli used to assess attention varied between studies, and individual beverage preference was not taken into consideration. Focusing on attentional biases to preferred beverages in such treatments may provide more successful outcomes and more sensitive markers of risk for relapse. Future research of alcohol cue-reactivity and response inhibition should therefore take into account the alcohol preferences of individual participants when selecting stimuli. Although this study requires replication with a larger sample size of BDs, the results suggest that the use of preferred beverages provides a more sensitive estimate of attentional biases towards alcohol. Furthermore, ERP indices of these biases may be more sensitive markers of risk for developing an AUD or relapse, informing the design and evaluation of alcohol abuse prevention designs and treatment programs

APPENDIX SECTION

Appendix A

Quantity-Frequency Index (alcohol use)

How old were you when:

Took your first drink of alcohol (even if it was given to you as a child)? _____

First got drunk? _____

Began drinking on a regular basis? _____

How many days ago was your last drink? _____

In the previous six months, how often did you have any kind of beverage containing alcohol, whether it was wine, beer, liquor, or any other alcoholic drink?

- Three or more times a day
- Twice a day
- Every day or nearly every day
- Three or four days a week
- One or two days a week
- Two or three times a month
- About once a month
- At least one time in the last 6 months
- No alcohol at all in the last 6 months

In the previous six months, how often did you typically drink Wine?

- Every day
- Five-six days per week
- Three-four days per week

- One-two days per week
- Three times a month or less
- None at all

On a drinking day, how much wine do you typically drink (1/5, glass, 1/2 gallon, etc.)?

_____

Typically, I drink:

Table wine_____ Fortified wine _____

In the previous six months, how often did you typically drink Beer?

- Every day
- Five-six days per week
- Three-four days per week
- One-two days per week
- Three times a month or less
- None at all

On a drinking day, how much beer do you typically drink (cans, bottles, qtrs. 6/12 pack, etc.)? _____

Typically I drink:

3.2 beers _____ 6.0 beers _____

In the previous six months, how often did you typically drink Liquor?

- Every day
- Five-six days per week
- Three-four days per week
- One-two days per week

- Three times a month or less
- None at all

On a drinking day, how much did you typically drink (shot, pint, qt., liter, 1/5, etc.)?

_____

Typically, I drink _____ proof liquor

Appendix B

Barratt Impulsivity Scale

Please rate the extent to which each of them applies to you according to the following scale

1 = never 2 = rarely 3 = sometimes 4) most of the time 5) always

1. _____ I “squirm" at plays or lectures.
2. _____ I am restless at the theater or lectures.
3. _____I don’t “pay attention."
4. _____ I concentrate easily.
5. _____ I am a steady thinker.
6. _____ I act “on impulse."
7. _____ I act on the spur of the moment.
8. _____ I buy things on impulse.
9. _____ I make up my mind quickly.
10. _____ I do things without thinking.
11. _____ I spend or charge more than I earn.
12. _____ I am happy-go-lucky.
13. _____ I am a careful thinker.
14. _____ I plan tasks carefully.
15. _____ I am self-controlled.
16. _____ I plan trips well ahead of time.
17. _____ I plan for job security.

18. _____ I say things without thinking.

19. _____ I like to think about complex problems.

20. _____ I like puzzles.

21. _____ I save regularly.

22. _____ I am more interested in the present than the future.

23. _____ I get easily bored when solving thought problems.

24. _____ I change residences.

25. _____ I change jobs.

26. _____ I am future oriented.

27. _____ I can only think about one problem at a time.

28. _____ I often have extraneous thoughts when thinking.

29. _____ I have “racing" thoughts.

30. _____ I change hobbies.

Appendix C

Binge Drinking Questionnaire

For the next question, a standard alcoholic drink is equal to a 12oz. can of beer, about 4 oz. of wine, and 1 oz. or liquor (a "shot")

When you consume alcohol, how many standard alcoholic drinks do you typically have during one drinking episode (such as on an evening out or a day at the river)?

_____

Since you first started drinking, have you ever engaged in "binge drinking," that is, have you ever consumed 5 or more (4 or more for women) drinks over the course of a drinking episode?

Yes [ ] No [ ]

Typically, when/if you "binge drink," how many drinks do you consume during one drinking episode? _____

When/if you "binge drink," over how many hours do you usually drink? _____

When/if you "binge drink," what types of alcohol do you consume most often? (Can choose more than one)

[ ] Wine

[ ] Beer

[ ] Liquor (shots)

[ ] Mixed drinks

Appendix D

Beverage Stimuli

Beer:

Liquor:

Wine:

Non-Alcoholic:

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