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# Executive Functioning And Drinking: The Impact Taxing Working Memory Has On Alcohol Consumption

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# EXECUTIVE FUNCTIONING AND DRINKING: THE IMPACT TAXING WORKING MEMORY HAS ON ALCOHOL CONSUMPTION

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## PERMISSION

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ABSTRACT

The prevalence rates of binge drinking and heavy drinking among college-aged students have reached alarming levels. The negative consequences for these behaviors range from relatively minor annoyances (e.g., hangovers) to life-changing incidents (e.g., DUI) to accidental death. Deficits in executive cognitive function (ECF), especially deficits in working memory capabilities, have been linked repeatedly to problematic alcohol use. Given that it appears problematic drinkers with ECF deficits are more susceptible to the effects of alcohol and experience a greater loss of behavior control when experiencing cognitively taxing situations than problematic drinkers with greater ECF, further study of the impact of taxing working memory is warranted. The current study is an attempt to demonstrate the effect that depleting working memory resources has on alcohol consumption. It was hypothesized that participants who underwent working memory depletion would drink significantly more alcohol than participants who did not, and that individuals who experienced working memory depletion and who displayed poorer baseline ECF would drink the most. Twenty-four binge and/or heavy drinkers (66.7% men; *M* age = 22.95) participated in the study. During their visit, participants were randomized to complete either a task designed to deplete working memory resources or a control task that did not deplete working memory resources. After completing this task, participants completed an alcohol taste-rating task. The study hypotheses were supported, as the experimental condition drank significantly more alcohol and, within the experimental condition, individuals with poorer functioning consumed the greatest amount of alcohol. These findings shed light on the cognitive processes that contribute to problematic alcohol use and support the investigation of cognitive interventions for a subset of problematic drinkers.

# CHAPTER I

# INTRODUCTION

In the United States, problematic alcohol use on college campuses has reached alarming levels, and devastating consequences abound for many students. The National Institute of Alcohol Abuse and Alcoholism (NIAAA) defines moderate drinking as no more than 14 drinks per week for men and no more than 7 drinks per week for women; however, 31% of college men consume greater than 21 drinks per week and 19% of college women consume greater than 14 drinks per week (US Department of Health & Human Services, 1990). Further, the research indicates that an alarming proportion of young adults meet criteria for alcohol abuse and alcohol dependence. Dawson, Grant, Stinson, and Chou (2004) looked at over 40,000 individuals and found that among those aged 18-29, 6.9% and 9.2% met criteria for alcohol abuse and alcohol dependence, respectively, and that these prevalence rates were elevated among college students. Similarly, Clements (1999) found that among 306 college undergraduates, 13.1% met DSM-IV criteria for alcohol abuse and 11.4% met criteria for dependence in the previous 12 months. In a more recent study that looked at over 14,000 undergraduate students, 31% met criteria for alcohol abuse and 6% met criteria for alcohol dependence in the previous 12 months (Knight et al., 2002). According to the National Epidemiologic survey on Alcohol and Related Conditions (Hasin, Stinson, Oqburn, & Grand, 2007), approximately 4.7% and 3.8% of American adults met criteria for alcohol abuse and dependence, respectively, in the past year. It is clear that a large proportion of college students are suffering significantly from their alcohol use. Further, these elevated prevalence rates among college students versus the general population are alarming, and makes clear the need for continued study on how to aid this population.

The consequences of alcohol use range from relatively minor inconveniences (e.g., feeling hungover, missing a class, etc.) to more problematic experiences (e.g., doing something regretful, blacking out, getting behind in school or work, getting injured, engaging in unplanned or unprotected sexual activity, feeling depressed or anxious, etc.) to extremely serious events (e.g., involvement with law enforcement, driving while intoxicated, overdosing, etc.; Lopez-Caneda, Holguin, Corral, Doallo, & Cadaveira, 2014; Wechsler, Davenport, Dowdall, Moeykens, & Castillo, 1994). According to Hingson, Zha, and Weitzman (2009), in 2001, 599,000 college students were injured while drinking, 696,000 were hit or assaulted by another drinking student, and 97,000 experienced an alcohol-related sexual assault. One of the most devastating consequences of problematic alcohol use involves traffic accidents, as alcohol-impaired driving accounted for approximately one third of traffic-related deaths in 2010 (National Highway Traffic Safety Administration (NHTSA), 2012). According to the National Center for Health Statistics (NCHS; 2011), among 16-24 year olds, motor vehicle accidents are the leading cause of death. It is likely that alcohol involvement is a large contributor to these accidents. In 2007, alcohol consumption was involved in 23% of fatal crashes for drivers aged 16 to 20 and 41% of fatal crashes for drivers aged 21 to 24 (Mulye et al., 2009). Further, research shows that approximately one in three college drinkers reported driving under the influence (Wechsler et al., 1994) and approximately one in four reported riding with an intoxicated driver (Wechsler, Lee, Nelson, & Lee, 2003).

There is a specific style of drinking that is exceedingly popular on college campuses and is the focus of much research due to the numerous negative outcomes associated with it. Binge drinking has been defined as a pattern of drinking that brings the blood alcohol content (BAC) to .08 or higher within two hours of initiating drinking (NIAAA, 2004). For binge drinking to occur, men must consume five or more drinks per episode and women must consume four or more drinks per episode.

College students are at a particular risk for binge drinking behaviors. Surveys showed that 84.2% of college students reported binge drinking within the previous 90 days (Vik, Carrello, Tate, & Field, 2000) and 44% reported this behavior within the previous two weeks (Wechsler et al, 1994; Wechsler et al., 2000). In their study, Wechsler et al. (2004) also found that 19% of the surveyed students were frequent binge drinkers, meaning they engaged in 3 or more binge drinking episodes in the previous two weeks. In a more recent study, 45% of college males reported having five or more drinks and 31% of females reported having four or more drinks in one occasion in the last two weeks (Johnston, O'Malley, Bachman, & Schulenberg, 2010).

According to the research, it appears that binge drinking carries greater risk and more negative consequences than other styles of drinking. Students who reported engaging in binge drinking were more likely than non-binge drinkers to have an alcohol use disorder, and students who were frequent binge drinkers were at a significantly increased risk for both alcohol abuse and dependence (Knight et al., 2002). Individuals who engage in frequent binge drinking are 25 times more likely to experience alcohol related consequences than those individuals who do not engage in binge drinking (Wechsler et al., 1994). Frequent binge drinkers are approximately seven to ten times more likely to engage in unprotected sex and/or unplanned sex, become involved with law enforcement, experience injury, or damage property. They are also at risk for consequences involving drinking and driving, as these individuals report significantly higher frequencies of risky driving behaviors (i.e., drove after drinking, drove after drinking more than 5 drinks, rode with an intoxicated driver) than non-binge drinkers.

Poor outcomes related to binge drinking also extend into the neurophysiological realm. Alcohol disrupts prefrontal cortex functioning, rendering many of one's executive cognitive abilities (e.g., attention, working memory, inhibitory controls) ineffectual (Ratti, Bo, Giardini, & Soragna, 2002). It is likely that college students are either ignorant or dismissive of these cognitive consequences; however, alcohol-related cognitive functioning deficits pose significant threats to college drinkers for several reasons. First, college students are at a time in their lives when academic performance is of utmost importance, meaning efficient cognitive functioning is required. Further, there is evidence to suggest that brain development continues into the mid-20s (Pujol, Vendrell, Junque, Marti-Vilalta, & Capdevila, 2004). It is hypothesized that the detrimental effects of alcohol are enhanced in developing brains (Witt, 2010), suggesting that some college students may be at increased risk for alcohol-related brain damage. Last, college students are a group that has been shown to display prominent problematic alcohol-use behaviors, especially binge drinking behaviors (Wechsler et al., 2004), again suggesting that they may be at high risk for alcohol-related cognitive impairment. Intact cognitive abilities (e.g., linguistic, spatial, and reasoning abilities, etc.), which are needed to successfully navigate higher education, require effective executive cognitive functioning. The efficiency of processes involved in executive cognitive functioning are susceptible to deterioration with increased alcohol use; therefore, the relationship between executive cognitive functioning and increased alcohol use in college student drinkers warrants further investigation.

## Executive Cognitive Functioning and Alcohol Use

It is fairly well-established that executive cognitive functioning (ECF) is negatively related to alcohol use. ECF is the term for the management system that regulates cognitive processes, including working memory, abstraction, decision-making, problem solving, attention, response inhibition, cognitive flexibility, and planning (Nixon, 1999). Having proficient ECF is protective against addictive behavior because it allows one to reject automatic impulses, interpret incoming stimuli meaningfully, and integrate previous knowledge with new knowledge to make decisions and carry out desired behaviors (Crews & Boettiger, 2009). Heavy drinking has been linked to poorer ECF performance as well as structural and functional changes within the brain (Harper & Matsumoto, 2005). Evidence of altered ECF following increased alcohol consumption includes: poorer inhibitory control (Randall et al., 2004; Townshend & Duka, 2005), poorer spatial working-memory (Weissenborn & Duka, 2003), poorer verbal memory and decreased attention (Tapert, Granholm, Leedy, & Brown, 2002), poorer decision making skills (Bechara, 2001), and decreased cognitive flexibility and psychomotor speed (Houston et al., 2014).

When looking at the specific relationship between binge drinking behavior and impaired ECF, research indicates that young binge drinkers may be demonstrating cognitive deficits that are comparable to deficits found in repeatedly detoxified patients (Duka et al., 2004). One hypothesis for this observation is that binge drinking behavior is similar to the pattern of intoxication, acute withdrawal, period of abstinence, and eventual relapse that alcohol abusing patients experience (Stephens & Duka, 2008). In other words, it may not be just the amount of alcohol consumed, but the intermittent consumption and withdrawal that is responsible for the cognitive deficits found in this group (Hartley, Elsabagh, & File, 2004). For example, five drinks in a two-hour period once a week is more damaging than one drink a night for five nights; the same amount of alcohol is being consumed, but little to no intoxication or withdrawal is experienced in the latter scenario. Although it is beyond the scope of this paper to detail exactly what happens to the brain during binge drinking episodes, this specific pattern of intoxication and withdrawal poses a unique threat to young adults' brains. Research suggests that because of the inhibitory effects of alcohol, excessive alcohol consumption leads to the up-regulation of certain neurotransmitters (Hunt, 1993). In other words, the brain experiences an increased sensitivity to certain neurotransmitters through an increase in the number of receptors for that molecule. Upon alcohol withdrawal, these receptors are still overactive, and the flood of neurotransmitters during withdrawal may be a factor in cellular death. Based on this evidence, it is clear that a sustained binge-drinking pattern of behavior might put one at increased risk for neurotoxicity and the damaging cognitive effects that come with it (Zeigler et al., 2005).

However, most of the research regarding the relationship between heavy alcohol use and ECF deficits is correlational, and the causal relationship between the two variables has not yet been fully determined. There is evidence to suggest that deficits in executive functioning increase an individual's chances of developing addictive behavior and are not necessarily a result of increased alcohol use (Peterson & Pihl, 1990) Research suggests that brain damage significant enough to cause deficits in ECF would require decades of problematic alcohol use (Lyvers, 2000). Therefore, it may actually be the case that impaired ECF precedes heavy alcohol use, in particular among college students who have not yet had time to engage in heavy drinking for decades. Other evidence to support this notion is the fact that approximately half of the problem drinkers in America do not seem to suffer from any cognitive impairments (NIAAA, 1997). It may be the case that some users identified as having poorer executive function had preexisting cognitive impairment, rather than alcohol-induced cognitive impairment. In fact, poorer executive functioning performance in general, as well as poorer performance in specific ECF components, has been shown to predict alcohol use. For example, ECF is lower in youths who are at-risk for substance abuse (Aytaclar, Tarter, Kirisci, & Lu, 1999), and weaker response inhibition in adolescents predicts the onset of alcohol use problems (Nigg et al., 2006). Fernie et al. (2013) found that impulsivity (as measured by response inhibition, risk taking, and delay discounting) was able to predict adolescent alcohol use over a 2-year period. They further found no evidence to suggest that impulsivity changed as a result of heavy drinking in their sample, suggesting that alcohol did not negatively affect this cognitive process.

It is clear that more research is needed to disentangle the relationship between executive functioning and alcohol use. However, in a recent review of recent studies examining adolescent alcohol use and cognitive impairments, Peeters, Vollenbergh, Wiers, and Field (2014) cautiously concluded that poorer ECF, specifically elevated impulsivity, appears to be a risk factor for and not a result of alcohol use.

**Working Memory and Alcohol Use**

There is a cognitive process that affects one's ability to resist impulsive desires and to inhibit behavior: working memory. Working memory is the process that allows for one to temporarily store and manipulate information so that other cognitive tasks such as learning, reasoning, and comprehension can occur (Baddeley, 1992). Processes involved in working memory include encoding information, temporarily storing information, manipulating stored information, maintaining this information over time, and resisting interference while all of these processes are occurring (Finn, 2002). If one's working memory capability is poor or heavily taxed, the ability to fight distraction and impulsive drives is diminished, as higher loads on working memory have been shown to be predictive of more impulsive decision-making (Hinson, Jameson, & Whitney, 2003). In other words, efficient working memory capabilities are required to be able to control behavior in the face of cognitive and emotional distractions and automatic associations (Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010). In addition, efficient working memory serves the purpose of allowing one to actively keep long-term goals and consequences in mind, and draw upon and use previous knowledge while also receiving and interpreting new knowledge (Grenard et al., 2008). Given the role that working memory capacity plays in one's ability to modulate behavior, it appears that weaknesses in working memory capabilities may be one of the most worrisome cognitive deficits when it comes to problematic alcohol use (Crego et al., 2010).

Additionally, there is much evidence to suggest that binge drinking, in particular, is related to poorer working memory. Research comparing binge drinking and non-binge drinking students found evidence of impairments in spatial working memory among the binge-drinking students (Townshend & Duka, 2005; Weissenborn & Duka, 2003). Further, Parada and colleagues (2012) found several differences between binge and non-binge drinking students. Specifically, binge drinking students performed more poorly on a backwards digit span task than non-binge drinkers, indicating a diminished capability to retain and use information stored in verbal working memory. Additionally, the ability to carefully monitor information, which is crucial to efficient working memory, as measured by a test of planning and self-monitoring, was impaired in the binge-drinking group. The same study did not find a difference in cognitive flexibility or planning between the two groups, suggesting that working memory has a particularly important relationship with binge drinking behavior, maybe more so than some other components of ECF. Hartley, Elsabagh, and File (2004) found impaired performance on the Paced Auditory Serial Addition Task (PASAT), which is commonly used to assess working memory in clinical settings (Parmenter, Shucard, Benedict, & Shucard, 2006), for binge drinking students compared to students who did not participate any in alcohol consumption. Other research also supports this link between poorer working memory and binge drinking, as binge-drinking students had difficulties manipulating information in verbal working memory compared to non-binge drinking students (Garcia-Moreno et al., 2008; Garcia-Moreno et al., 2009).

There is currently little research examining the specific role that premorbid poorer working memory plays in drinking behavior. Khurana et al. (2013) found they were able to predict the alcohol use of at-risk adolescents based on baseline working memory ability. Specifically, they found a pre-existing weakness in working memory could be used to predict concurrent alcohol use and also an increased frequency of use over a 4-year follow up period. In other words, for this sample of adolescents, it appeared that those with working memory deficits were at risk of increased alcohol use, and it is unlikely that alcohol use contributed to their working memory deficits.

To further make the case for the importance of working memory's role in problematic alcohol use, it is also important to understand how having better versus worse working memory impacts behavior, and more specifically, alcohol consumption behavior. Environmental cues generate automatic associations for everyone; however, these automatic associations are more likely to influence behavior in individuals with lower working memory capacity (Barrett, Tugade, & Engle, 2004). It is proposed this phenomenon occurs due to weakened controlled processing for those with poorer working memory. Controlled processing refers to the extent automatic processing controls thoughts and behaviors. In other words, individuals with poor working memory are less aware of what influences their behavior, less aware they are able to control their behavior, and less able to counteract automatic processes. For example, when a stimulus in the environment captures attention, a whole host of goals, thoughts, and feelings are automatically activated. The strongest of these goals, thoughts, and feelings then, in turn, mediate one's behavior. Individuals with greater working memory are abler to keep in mind, or activate, relevant goals, thoughts, and feelings while suppressing the less relevant ones.

This same idea holds true for substance use behavior, as researchers found that drug-related associations are stronger predictors of alcohol use for adolescents with poorer working memory than for adolescents with greater working memory (Grenard et al., 2008). In this study, all of the adolescents produced drug-related associations during word association tasks; however, for those with lower working memory, these associations more strongly predicted substance use behavior. These results suggest perhaps those adolescents with greater working memory were better able to inhibit behavior motivated by automatic associations. Further, it has been found that problem drinkers with lower working memory capacity showed a stronger behavioral bias toward alcohol in an Approach-Avoidance Task (AAT) than problem drinkers with greater working memory capacity (Sharbanee, Stritzke, Wiers, Young & Rinck, 2013), suggesting problem drinkers with greater working memory were able to better utilize goal-directed behavior in the face of distracting alcohol-related content. In addition, Thush et al. (2008) examined the role working memory had in drinking decisions made by at-risk adolescents and concluded that perhaps individuals with better working memory capacity were able to make more reasoned drinking decisions, whereas individuals with poorer working memory capacity made more spontaneous and impulsive drinking decisions (e.g., drank because of an urge to feel intoxicated or because of peer pressure, etc.). Another study found the administration of alcohol appears to increase impulsivity (as measured by false alarm rates in a Go/No Go Learning Task) in subjects with low working memory capacity (Finn, Justus, Mazas, & Steinmetz, 1999). This elevated impulsivity was not seen in individuals with greater baseline working memory, suggesting those with poorer working memory may be more susceptible to alcohol's effects and less able to regulate behavior when drinking. This greater susceptibility to alcohol and loss of behavioral control raises serious concerns for these drinkers.

These findings are alarming, as it appears that drinking poses very serious threats for problematic drinkers with poorer working memory capacity, since it may put them at a greater risk of negative outcomes than drinkers with greater working memory. For example, individuals with poorer working memory likely already display difficulty in cognitive control over automatic impulses. When they become intoxicated, this control is weakened even more, and appears to weaken to a greater extent than for someone whose working memory capacity is superior. This greater weakening of cognitive control makes it difficult for these individuals to shift attention toward future goals, engage in effective decision making, and stave off automatic impulses. Therefore, it may be likely these individuals suffer consequences from acute intoxication more frequently and at a greater magnitude than those individuals who can cognitively compensate during intoxication with their greater working memory capacity.

It is clear that working memory is one of the most significant cognitive processes when it comes to alcohol consumption. However, the exact nature of the relationship between working memory and problematic alcohol use, especially binge drinking, needs further clarification. In summary, working memory is related to problematic alcohol use for several hypothesized reasons: 1) Frequent heavy drinking worsens working memory capacity in the long-term; 2) Preexisting working memory deficits make one more vulnerable to addictive behaviors; and 3) Working memory moderates behavior during drinking episodes, in that binge drinkers with poorer working memory likely experience a greater loss of behavioral control compared to those with greater working memory. It is beyond the scope of this paper to disentangle the apparent bidirectional relationship between heavy alcohol use and ECF deficits, but an area of the literature that needs further elaboration is how one's working memory capacity affects concurrent drinking. Every situation one encounters engages working memory to some degree. There are many situations unique to drinking that would appear to place especially heavy loads on one's working memory. If a problem drinker is experiencing these heavily taxing situations while engaging in alcohol consumption, it is likely that those with poorer working memory are at an increased risk for deterioration in behavior regulation.

## Taxing Executive Functioning and Working Memory

There is a limited-resource model of executive functioning, which posits executive functioning processes rely on a finite reserve that can be briefly drained following intensive tasks (Persson, Welsh, Jonides, & Reuter-Lorenz, 2007). ECF performance then suffers on later tasks engaging the same processes. One of the most studied higher-order functions that appears to undergo measurable depletion is self-control, which refers to one's ability to change the way a s/he thinks, feels, or behaves. Adequate self-control is essential to exertion of control over automatic impulses, as self-control requires effort to control behavior and cognitions (Muraven & Baumeister, 2000). There is evidence to suggest that after an act of self-control (e.g., thought suppression), other subsequent, unrelated acts of self-control are worsened (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Muraven & Baumeister, 2000; Muraven, Tice, & Baumeister, 1998).

There is convincing evidence working memory capacity experiences a similar depletion after an intensive task utilizing the process. Anguera et al. (2012) found a decline in spatial working memory performance on a card rotation task following another demanding task also aimed at specifically employing this executive function. The two tasks were different in nature but were correlated measures of spatial working memory. The authors further concluded the decline in performance was not due to general fatigue (as another executive processing performance was unchanged), but was specific to spatial working memory performance. Johns, Inzlicht, and Schmader (2008) found that the attempt to suppress anxiety, which requires one to focus attention and inhibit the impulse to think about the anxiety, resulted in decreased working memory scores on a word span test. In addition, Schmeichel (2007) found that when participants were asked to ignore distracting stimuli and inhibit behavior (both of which require working memory resources), their following performances on working memory tasks were poorer than those participants who did not attempt to ignore distractions or inhibit behavior.

Other research clearly demonstrates that working memory ability draws upon limited resources and can handle only so much information before degradation in performance is seen. For example, Roberts, Hager, and Heron (1994) found when working memory is highly taxed, participants produced inhibition errors in an eye movement task that were comparable to patients with prefrontal dysfunctions. Additionally, response time during a visual search has been shown to increase under high memory loads (De Liaño & Botella, 2010), indicating that perhaps attention, scanning ability, and judgment-making are all slowed by heavier memory loads. Further, under conditions of a high working memory load, participants were more likely to detect an unexpected, unrelated stimulus than participants with a low working memory load (de

Fockert & Bremner, 2011), suggesting a decreased ability to keep attention focused on task-relevant stimuli.

Currently more research is needed to further examine the depletion of working memory and how it impacts different behaviors that rely on proficient working memory capabilities. However, given the parallel between self-control and working memory's roles in one's ability to modulate behavior, it can be argued that working memory performance suffers similarly after heavy taxation and that performance is not restored to pre-task capability for some time after depletion. Given this evidence, the depletion of working memory and the effect of this depletion on drinking behavior warrants further investigation.

## Naturalistic Taxing of Working Memory

Executive functioning processes are in constant use and there are innumerable situations and events that occur during drinking that are likely to draw specifically and heavily upon working memory resources. One of the more alarming situations is participation in drinking games. Drinking games are competitions designed to ensure maximum alcohol intake during a brief time frame (Newman, Crawford, & Nellis, 1991). Drinking game participation has been linked to increased alcohol consumption and the experience of more negative drinking-related consequences (Alfonso & Deschenes, 2013; Engs & Hanson, 1993; Johnson, Wendel, & Hamilton, 1998; Wood et al., 1992).

Although there is not yet research examining the relationship between ECF and drinking games, it appears that many verbal drinking games may tax working memory heavily. Verbal drinking games require participants to comprehend incoming information that is designed to be tricky and/or difficult, attend to the essential parts while blocking out irrelevant information (and other environmental stimuli), maintain the relevant information over time, and then respond correctly (Borsari, 2004). It is clear that drinking games may pose serious threats to players who may already experience working memory deficits. For example, a common verbal drinking game called the Name Game involves players taking turns calling out famous names (Borsari, 2004). Play starts off with the first player calling out the name. The next person then says a name that starts with the first letter of that last name (e.g., Player one: “Denzel Washington,” Player two: “Will Smith,” Player three: “Sigourney Weaver,” etc.). Additional rules include reversing play if the person named has only one name (e.g., Madonna, Cher, etc.) or if the celebrity’s first and last name starts with the same letter (e.g., Sylvester Stallone, etc.). Typically names cannot be repeated without penalty. In this drinking situation, it is crucial that players are able to quickly interpret and encode incoming information (i.e., the previous name and also the first letter of the last name) and come up with a correct response to that information. Players must be able to maintain information over time (e.g., what names have been used, additional rules regarding reversal of game play, etc.). Even without the consumption of alcohol, it is likely that individuals with poorer working memory might perform more poorly in this setting than individuals with greater working memory just because of their less effective working memory abilities. When the consumption of alcohol is added in, drinkers with working memory deficits may be more likely to experience greater alcohol-induced behavioral inhibition. An example of this may be drinking more during game play than the game requires. In other words, drinkers with working memory deficits are at risk of performing more poorly in general (resulting in drinking greater quantities during play) and of experiencing a greater loss of behavioral regulation during alcohol consumption than their counterparts with more efficient working memory. Although it is not the goal of this paper to examine the interplay between drinking games and working memory, the ways that working memory can experience heavy loads, and consequently depletion, during actual drinking sessions must be highlighted to illustrate that it is very likely that working memory resources experience depletion during drinking.

Other examples of real-life situations that arise during drinking that may tax one's working memory include keeping track of a budget while out, keeping track of the amount of alcohol consumed, resisting impulses (e.g., not taking an offered drink, the desire to continue drinking), keeping future goals in mind (e.g., not being late for work the next day), shifting attention away from highly activated stimuli (e.g., fun drinking games) to less salient goals (e.g., preparing for tomorrow's exam), managing simultaneous tasks (e.g., monitoring friends' drinking while also monitoring personal drinking), fighting distraction (e.g., the antics of fellow drinkers, TV, music, text messages/phone calls, etc.), having to engage in problem-solving or decision-making (e.g., how to get home after drinking, whether or not to continue drinking), and keeping in active memory the consequences of one's behavior.

The above are all examples of ways that working memory can be taxed in naturalistic drinking sessions and they certainly do not comprise an exhaustive list. It is known that when working memory experiences heavy loads, a decrease in performance is seen. This phenomenon raises serious concerns regarding the ability of individuals with poorer working memory to effectively engage in the aforementioned tasks (plus any others), since they are less able to cognitively compensate, and may also be more susceptible to the effects of alcohol. The ability to successfully complete these and other tasks is required to avoid many serious negative consequences. Thus, more research is needed to examine the impact that taxing one's working memory has on drinking behavior.

## Current Study

In summary, it is fairly well established that heavy alcohol use is negatively related to ECF, and it appears that working memory is one of the components of ECF most importantly related to problematic alcohol use. The relationship between working memory and alcohol use may be particularly relevant to understanding college binge-drinking behavior, as binge drinking has been linked to deficits in working memory. The current study was an attempt to examine the impact of working memory on alcohol use, specifically the influence of taxing working memory on alcohol consumption. This study was an attempt to mirror the proposed effects that many drinking situations have on working memory capacity while also controlling for the extraneous stimuli and other demands on ECF that are also present during these situations.

Thus, several aims and hypotheses were formulated to achieve these goals. To address the first aim, that the depletion of working memory is related to increased alcohol consumption for problematic drinkers, the first hypothesis was that subjects who experience taxed working memory will drink significantly more alcohol (as measured by total amount consumed, number of sips taken, and breath alcohol level (BAL)) during a taste rating test than subjects who do not experience taxed working memory. The second aim of this study was to demonstrate the risk that poorer ECF poses to alcohol consumption for problematic drinkers. To address this aim, the second hypothesis was that individuals with poorer baseline ECF will drink more during the taste test than will individuals with greater ECF, regardless of whether working memory was taxed. The final aim of the current study was to demonstrate the increased risk that problem drinkers with ECF deficits face when working memory is taxed compared to problem drinkers with greater ECF, who may be better able maintain control over behavior in the face of alcohol-related stimuli. To address this aim, the third hypothesis was that baseline ECF will moderate the relationship between taxed working memory and drinking, such that participants with poorer ECF and who experience depleted working memory will consume the most alcohol. Last, although not a formal hypothesis, the potential impact of several covariates will be examined for their influence on participant behavior and outcome data. As there is evidence to suggest many individuals rely on alcohol as a coping mechanism for negative emotions (Cooper, Frone, Russell, & Mudar, 1995), negative affect was measured and examined for its impact on participants' drinking behaviors. Additionally, the working memory depletion group underwent a more difficult task than the control group. The increased task difficulty, and the potential frustration, had the potential to lead to increased negative affect, which may have influenced alcohol behaviors. In order to account for this potential situation, differences in negative affect between groups were also examined. Nicotine withdrawal and dependence were also examined for their influence on participant behavior as nicotine deprivation has been shown to lead to increased urges to drink (Palfai, Monti, Ostafin, & Hutchison, 2000) and participants were asked to refrain from smoking for eight hours prior to study participation. Last, individuals with a more problematic relationship with alcohol (as measured by the number of recent negative consequences related to alcohol use) may have consumed more or less than their counterparts, regardless of condition. To account for this possibility, a more problematic relationship with alcohol was examined for its impact on behavior. Examination of these variables as covariates allowed for more nuanced conclusions regarding the experimental manipulation.

# CHAPTER II

# METHOD

## Participants

The overall sample (*N*=24) was predominately Caucasian (95.8%), with only one individual identifying as a race other than Caucasian (i.e., Latino/White). The participants' ages ranged from 21 years old to 29 years old (*M* = 22.95, *SD* = 2.33). Men made up 66.7% of the sample. Twenty-two participants (91.67%) reported currently or previously attending a two or four-year college.

Participants were recruited through flyers posted on the University of North Dakota's (UND) campus and in the surrounding community, and through classified ads posted online. All interested participants underwent two telephone-screening processes to determine eligibility.

### Participant Eligibility Criteria

There were several inclusionary and exclusionary criteria to be eligible for participation. First, participants were required to meet criteria for binge drinking (i.e., consuming five or more drinks for males and four or more drinks for females in one sitting) twice during the last month and/or for heavy drinking (15+ drinks for males or 8+ drinks for females in a week) twice in the last month. Binge drinkers and heavy drinkers were recruited as many of these individuals have been shown to display cognitive and executive functioning deficits not proportional to their drinking histories (i.e., deficits associated with decades of heavy alcohol use), and one of the purposes of this study was to find support for the use of intervention treatments aimed at these deficits. In addition, participants were required to be between the ages of 21 and 30. The age range for participants was capped at 30 years of age because binge drinking prevalence begins to fall in the early to mid-30s (Centers for Disease Control and Prevention, 2012), suggesting that individuals who continue to binge drink beyond this age may not represent typical binge drinkers.

Participants were excluded if they had a medical condition (e.g., diabetes, stomach ulcers, etc.) that could be exacerbated by the administration of alcohol or if they were taking a medication (e.g., Klonopin, etc.) that can interact harmfully with alcohol administration. Further, participants were asked if they had ever been advised by a doctor to refrain from drinking alcohol due to any medication or medical condition. If participants were warned about potential negative effects of drinking on their medical condition by a physician, they were excluded from participation.

Participants were excluded if they reported consuming more than five cigarettes (or their equivalent) per day. As participants were asked to refrain from using nicotine for eight hours prior to the study to the stimulating effects of nicotine, heavy or more regular smokers had the potential to experience nicotine withdrawal symptoms during the experimental protocol. As mentioned previously, nicotine withdrawal can lead to increased urges to drink (Palfai et al., 2000). In order to prevent the potential confounding impact of nicotine withdrawal on drinking behaviors, individuals who are regular or heavy smokers were deemed ineligible.

Another exclusionary criterion was having a Body Mass Index (BMI) score that falls outside 18.5 and 29.9 kg/m$^2$. BMI is a routine way to measure whether a person's body weight deviates from a healthy or desirable weight for his/her height. When someone scores under 18.5 $kg/m^2$, he/she is considered underweight, while a person scoring over 29.9 $kg/m^2$ is considered obese (Flegal, Carroll, Kit, & Ogden, 2012). Barquín and Hernández (2008) found that participants with lower BMIs experienced greater intoxication than individuals who consumed the same amount of alcohol but who had higher BMIs. These findings suggest that alcohol is metabolized at a different rate based on body composition; therefore, only participants who were in the normal to overweight weight category for their height were eligible to participate. It is hoped that this exclusionary criterion protected against variability in BAL readings among participants who drink similar amounts of alcohol during the study.

In addition, participants were excluded if they self-reported certain clinical psychiatric diagnoses. These diagnoses must have been received from a health care professional (e.g., psychiatrist, clinical psychologist, family doctor, etc.). These exclusionary psychiatric diagnoses included lifetime psychotic disorders (e.g., schizophrenia, schizoaffective disorder, delusional disorder, etc.) , past-year mood disorders (e.g., major depressive disorder, bipolar I, bipolar II,etc.), past-year anxiety disorders (e.g., agoraphobia, generalized anxiety disorder, social anxiety disorder, etc), excluding specific phobias, lifetime obsessive compulsive disorder (OCD), past-year attention deficit/hyperactivity disorder (ADHD), lifetime neurocognitive disorders due to traumatic brain injury (TBI), and/or a past year eating disorder (e.g., anorexia nervosa or bulimia nervosa). Lifetime psychotic disorders, past-year mood disorders, past-year anxiety disorders, lifetime OCD, past-year ADHD, and lifetime neurocognitive disorders due to TBI were excluded because of the evidence that suggests that, in many cases, these disorders are characterized by varying degrees of cognitive and executive functioning impairment (Castaneda, Tuulio-Henriksson, Marttunen, Suvisaari, & Lönnqvist, 2008; Heinrichs & Zakzanis, 1998; Millis et al., 2001; Quraishi & Frangou, 2002; Reichenberg et al., 2009; Seidman, 2006). Eating disorders were excluded to protect against the chance that participants modify their beer intake due to anxieties over calorie intake. Last, participants were excluded if they met criteria for lifetime alcohol dependence according to the DSM-IV-TR (American Psychiatric Association, 2000). In addition, participants were asked to report on their lifetime illicit drug use. Specifically, if participants indicated that they had used any illicit drugs (excluding marijuana) more than 50 times in their lifetime, they were excluded from participating. Women who indicated being pregnant or breastfeeding were also excluded.

Last, the experimental protocol required the consumption of beer. Participants were excluded if they indicated that they are not beer drinkers. Beer drinking status was assessed by asking the potential participant to think of all the times he/she engaged in drinking and to estimate what percentage of this time he/she drank liquor, wine, and beer. If the potential participant endorsed drinking beer less than 25% of the time when drinking, they were excluded from participation.

## Materials

### Telephone Screen 1

In this initial screening, participants were asked questions regarding alcohol intake (e.g., how many alcoholic drinks they consumed over the past month, what percentage of the alcohol they consume is liquor, beer, or wine, etc.), medical history (e.g., current medications, any medical condition that might be exacerbated by the consumption of alcohol, etc.), psychiatric history, and personal characteristics (e.g., height, weight, etc.). See appendix A for Telephone Screen 1.

**Telephone Screen 2**

The second phase of the phone screening process consisted of confirming eligibility criteria (e.g., binge drinking and/or heavy drinking status, no significant medications/medical conditions/psychiatric conditions, no pregnancy or breastfeeding, etc.). In addition, participants were administered the alcohol use disorders section of the Structured Clinical Interview for DSM-IV-TR Axis I disorders (SCID-I; First, Spitzer, Gibbon, & Williams, 2007) to screen for lifetime alcohol dependence. See Appendix B for Telephone Screen 2.

**Demographics**

General demographic information was collected such as age, sex, height, weight, ethnicity, and vision status (i.e., if they require corrective visual aids and if they currently wear these aids). Participants were asked about their vision status to protect against difficulty reading or completing the cognitive tasks or the computer task. See Appendix C for the demographics questionnaire.

**Alcohol Use Questionnaire**

Alcohol use history was assessed by asking participants to respond to alcohol related questions (e.g., number of times engaged in binge drinking over the past year, etc.; see Appendix D).

**Rutgers Alcohol Problem Index**

Alcohol-related problems over the past month were measured using the Rutgers Alcohol Problem Index (RAPI; White & Labouvie, 1989). This 23-item questionnaire assesses alcohol-related consequences for young adults (see Appendix E). Items in this questionnaire are reflective of problems and consequences related to alcohol use (e.g., “Got into fights with other people,” “Wanted to stop drinking but couldn’t,” etc.). On a 5-point ordinal scale, with responses ranging from 0 (*Never*) to 4 (*More than 10 times*), participants indicated how many times each of these problems or consequences occurred during the previous month. This measure has demonstrated adequate internal consistency ($\alpha = 0.75$) and convergent validity (Martens et al., 2006).

**Minnesota Nicotine Withdrawal Scale**

The Minnesota Nicotine Withdrawal Scale (MNWS; Hughes & Hatsukami, 1986) is a 9-item self-report measure of nicotine withdrawal symptoms. On a 4-point ordinal scale, with responses ranging from 0 (*Not At All*) to 4 (*Extreme*), participants rated urge to smoke, depressed mood, irritability, frustration, anxiety, difficulty concentrating, restlessness, increased appetite, difficulty going to sleep, and difficulty staying asleep. Scores can range from 0 to 36, with higher scores indicating more intense experiences of nicotine withdrawal. High internal consistencies have been reported for the Minnesota Nicotine Withdrawal Scale ($\alpha$ 's = 0.80–0.85; Cappelleri et al., 2005; Etter and Hughes, 2006). This measure was included to examine the potential effect of nicotine withdrawal on outcome data.

**Fagerstrom Test of Nicotine Dependence**

The Fagerstrom Test of Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991) is a 6-item self-report measure of nicotine dependence that assesses smoking pattern (e.g., “Do you find it difficult to refrain from smoking in places where it is forbidden, e.g., in church, at the library, in cinema, etc.?”; “How many cigarettes per day do you smoke?") and morning smoking (e.g., "Which cigarette would you hate most to give up?"; "Do you smoke more frequently during the first hours after waking than during the rest of the day?"). In scoring the FTND, yes/no items are scored from 0 to 1 and multiple-choice items are scored from 0 to 3. The items are summed to yield a total score of 0-10. The higher the total score, the more intense is the participant's nicotine dependence. Internal consistencies for the FTND range from 0.56–0.67 (Etter, 2005; Haddock et al., 1999; Heatherton et al., 1991; Payne et al., 1994; Pomerleau et al., 1994). This measure was included to examine the potential effect of nicotine dependence on outcome data.

**International Positive and Negative Affect Schedule – Short Form**

The Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) was developed to measure two mood states: Positive Affect (PA) and Negative Affect (NA). PA measures states such as feeling enthusiastic, alert, and active. High PA tends to reflect high energy, concentration, and engagement while low positive affect reflects sadness and lethargy. Negative affect (NA) measures subjective distress and unpleasurable engagement. Low NA tends to reflect feelings of being calm and composed. In this study, the International Positive and Negative Affect Schedule – Short Form (I-PANAS-SF) was used, as it is a briefer tool for assessing PA and NA (Thompson, 2007). Participants were asked to rate on a 5-point ordinal scale, with responses ranging from 1 (*Very slightly or not at all*) to 5 (*Extremely*), the extent to which they were currently experiencing each positive mood state (i.e., inspired, determined, alert, attentive, active) and negative mood state (i.e., upset, hostile, ashamed, nervous, afraid). The measure has demonstrated adequate internal consistencies ($\alpha$ = .78

for the PA scale, and .76 for the NA scale; Thompson, 2007). Additionally, the I-PANAS-SF PA and NA subscales had test-retest reliabilities similar to the original PANAS, suggesting this shortened form compares well to the original form.

**Wisconsin Card Sorting Task**

The Wisconsin Card Sorting Task (WCST; Grant & Berg, 1948) is a task designed to assess ECF by requiring participants to utilize such abilities as abstract reasoning, conception formation, behavioral inhibition, problem-solving, cognitive flexibility, and response strategies to change (Nyhus, & Barceló, 2009; Tchanturia, et al., 2012). In this protocol, the WCST was completed on the computer. During the WCST, participants were provided four key cards with geometric figures on them. Participants were then asked to match new cards to one of the four key cards; however, participants were not told the rules for classification. Classification rules changed several times throughout the task and could be based on a number of different card characteristics (i.e., color, form, number of geometric figures). The participant was required to figure out classification rules via trial and error and feedback from the computer program. The task is not timed and lasts as long as it takes for participants to sort all the provided cards (usually 12-20 minutes). Scores were calculated by standardizing and summating the WCST raw scores for Total Failure to Maintain Set, Total Incorrect, and Total Perseverative Error. The result was a standardized Executive Functioning Error Score for participants.

**2-Back**

For subjects who experienced working memory depletion, a 2-back was used to deplete working memory resources. The 2-back is one of several testing options based on the N-back (Gevins & Cutillo, 1993). The N-back is a continuous performance task commonly used to assess working memory. During this task, the participant was instructed to monitor a series of stimuli on the computer. He/she was then instructed to respond, by clicking the mouse, whenever a stimulus was presented that was the same as the one presented n-trials previously. The n usually varies from 1 to 3; however, participants' ability to successfully complete the task when n=3 tends to decrease, which raises concerns about the validity of results in those settings (Callicott et al., 1999). In this protocol, a 2-back was used, which is a standard procedure in much of the research on working memory (Owen, McMillan, Laird, & Bullmore, 2005). For example, the participant was shown a string of integers (e.g., 1, 5, 2, 5, 6, 4, 1, 3, 1, etc). They were asked to respond every time the newest integer was the same as the integer shown 2 trials previously. In the provided example, the participant would have to respond by clicking the mouse when the underlined 5 and 1 are shown, because for both of those stimuli the identical stimulus was shown 2 trials previously. This task required the constant monitoring, manipulation, and updating of incoming stimuli and inhibition against responding incorrectly, and therefore placed great demands on working memory (Owen et al., 2005). The N-back presented stimuli for the participant to respond to for approximately 10 minutes.

Currently, there is no research demonstrating the depletion of working memory resources through participation in an N-back test; however, the N-back is one of the most popular tests in functional neuroimaging studies of working memory (Owen et al., 2005). As previously mentioned, working memory performance has been found to decrease following demanding cognitive tasks (Anguera et al., 2012; Jha et al., 2010; Schmeichel, 2007). The N-back was chosen for its difficulty and intensity and it required the constant use of working memory for approximately 10 minutes; therefore, it was reasonable to infer its ability to deplete working memory resources.

**0-Back**

For subjects who did not experience working memory depletion, a 0-back was used. This task was also a continuous performance task, but the component of the n-back that requires utilization of working memory resources was removed. The 0-back required participants to respond whenever a prespecified stimulus was presented, and therefore did not require the manipulation or maintenance of information within working memory (Owen et al., 2005). For example, the participant was asked to respond, by clicking the mouse, whenever a 3 appears. The 0-back lasted for approximately 10 minutes.

**Taste-Rating Task**

Alcohol intake is often unobtrusively measured in lab settings through the use of a Taste-rating Task (TRT; Marlatt, Demming, & Reid, 1973). During this task, subjects were asked to sip different alcoholic beverages and rate their taste characteristics (e.g., bitter, strong, sweet, etc.; See Appendix F). Immediately after completion of either the depletion or control task, participants were given glasses of chilled Budweiser beer (5% alcohol by weight), Newcastle Brown Ale (4.7% alcohol by weight) and Keystone beer (4.2% alcohol by weight). The participants were not made aware of the types of beers being used during the taste test. Each glass contained 12oz (355mL) of beer (i.e., a standard drink). The participant was instructed to sip as much or as little of the beers as needed to rate the degree to which the three beers possess different taste characteristics. In order to make sure subjects did not modify their drinking for the task, they were not made aware of either the amount of time they were given for the taste test (i.e., 10 minutes) nor the length of the test (i.e., 35 ratings).

The TRT was computerized and completed by the participant via iPad. Each page of the survey contained one taste characteristic for the participant to rate the three beers on, and these taste ratings were made on a 7-point Likert scale from 0 (*Not at all)* to 7 (*extremely*). The TRT was terminated after 10 minutes by the experimenter, regardless of the participant's completion status on the survey. The TRT used in this procedure was a modification of methods used by Muraven, Collins, and Nienhaus (2002) to investigate alcohol consumption following a self-control depletion task and by Houben, Nederkoorn, Weirs, and Jansen (2011) to investigate the effect of training response inhibition on reduction of drinking behaviors.

**Procedure**

Interested participants underwent two phone-screening processes where eligibility criteria were established. Trained undergraduate research assistants conducted the first phone screen. Information regarding drinking history, medical history, psychiatric history, personal characteristics, and alcohol preference was collected. Participants were told that they would receive a call back if eligibility criteria were met. This author conducted the second phone screen. During the second phone screen, any participants who meet criteria for lifetime alcohol dependence, according to the SCID-I (DSM-IV), were informed that they could not participate, but were given information regarding alcohol treatment programs and treatment options in the area (e.g., Alcoholics Anonymous, Psychological Services Center, Altru Health System). During the second phone screen, once all eligibility criteria were confirmed, subjects were scheduled for participation and also given information pertinent to their upcoming session. Participants were scheduled no earlier than 4:00pm for participation, as earlier times in the day might impact drinking behavior. Participants also received a cover story that the purpose of the study was to examine how different types of mental stimulation (e.g., visual, auditory, verbal) impacted taste discrimination abilities. This deception was used to protect the validity of the experiment. In addition, participants were told that they may not drive home from the their session due to the consumption of alcohol. Further, participants were told they could not drive a motor vehicle for at least two hours after participation. The participant was asked to refrain from consuming alcohol or illicit substances, such as marijuana, for the 24 hours prior to their participation, from consuming cigarettes or caffeine for 8 hours prior to their participation, and from eating food for 3 hours prior to their participation. Female participants were told that they must take a pregnancy test in the lab in order to participate in the study. Only after these facts were shared with the participant and he/she agreed to these terms, was he/she scheduled for participation.

Upon arrival, participants were provided the informed consent document. They were instructed to read it thoroughly and ask any questions. It was required that the participants bring a valid license so that the experimenter could confirm they were least 21 years of age. Participants were provided with a copy of the informed consent for their personal records. After the informed consent process, female participants underwent a pregnancy test due to the risks that even small amounts of alcohol pose during pregnancy. They were informed that they may decline a pregnancy test, but doing so would disallow them from participating. The participant provided a urine sample and the experimenter conducted the pregnancy test to ensure that the participant was not pregnant. All participants completed an initial BAL assessment. In the current study, BAL was measured using an AlcoHawk PT500 Breathalyzer. If this initial BAL measurement read anything other than 0.00g/dL, the participant was rescheduled to later date. All participants were asked to complete a field sobriety test as another measure of acute intoxication. The field sobriety test used in this protocol was the One Leg Stand Test, which screens for acute intoxication other than just alcohol intoxication (e.g., marijuana; Papafotiou, Carter, & Stough, 2005). Participants were instructed to stand on one leg with the other leg stretched out in front of them, while counting aloud for 30 seconds starting from one thousand. During this time, the experimenter observed the following behaviors: swaying while attempting to balance; using arms to help maintain balance; hopping to help maintain balance; and placing one's outstretched foot back on the ground before the 30 seconds is complete. If two or more of these behaviors were observed, if the participant put down his/her foot 3 or more times, or if the participant failed to complete the test, the participant was judged to be impaired and was rescheduled for a later date. Participants were also told that they must remain in the lab following the consumption of alcohol for 20 minutes in order to accurately measure their BAL, as this time limit allows for alcohol to be sufficiently metabolized into one's body. Participants were told that if they chose to leave after the consumption of alcohol but before the 20-minute mark, they would forfeit their compensation and, as a safety measure since the experimenter could not accurately assess BAL, campus police would be alerted.

After the completion of the informed consent process, pregnancy test (for females), the initial BAL, and the one leg stand, participants completed the Wisconsin Card Sorting Task (WCST). Completion of the WCST required participants to utilize many executive processes and abilities (e.g,. rule learning, inhibition, cognitive flexibility, abstract reasoning, problem solving, set-switching, etc.) Executive cognitive functioning is typically assessed by examining cognitive flexibility, working memory, verbal and spatial memory, inhibition, psychomotor abilities, attention, set-shifting, planning, and verbal fluency (Rasmussen, 2005; Welsh, Pennington, & Grossier 1991). However, not all of these cognitive facilities need to be measured to assess one's ECF. Nevertheless, the WCST assessed many of these abilities and it is argued by the author that it was sufficient to make a judgment on participants' baseline ECF. In addition, the use of a single task that assessed multiple ECF constructs was used to measure baseline ECF in this protocol because of the difficulty of combining ECF tasks aimed at measuring different abilities (McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010).

Once participants completed the WCST, they filled out a demographics questionnaire, the alcohol use questionnaire, and the RAPI. All participants were given a 10-minute break between the cognitive and executive functioning tasks and the working memory depletion or control task. Although the WCST used to assess baseline ECF was chosen carefully as to avoid the depletion of cognitive resources (i.e., by not targeting any specific ECF area too heavily and by not being too time intensive), it was hoped that this 10-minute break would offer relief to any general cognitive fatigue so that participants would approach the experimental or placebo task with appropriate effort. After this 10-minute time span, participants were randomly assigned to one of two conditions: Working Memory Depletion Task or Control Task. Participants in the Working Memory Depletion Task underwent the 2-back test, designed to deplete working memory, while participants in the Control Task underwent a control task, the 0-back, which did not include a working memory depletion component.

Immediately following either the Depletion or Control Task, participants were asked to complete a Taste-Rating Task (TRT). For this task, participants were asked to sip three different common beers (i.e., Budweiser, Keystone, and Newcastle) and rate their taste characteristics (e.g., bitter, sweet, gassy, strong, watery, etc.) on a 7-point Likert scale. Beers were provided, chilled, in glasses labeled with a number. Each glass contained 12oz of beer. Participants were instructed to sip as much or as little of the beers as needed to accurately rate them on different characteristics. During the TRT, the participant was monitored through a one-way mirror to ensure the participant was following TRT protocol (i.e., he/she was making an effort at comparing the three beers on different aspects and did not appear to just be drinking the beer). The number of sips taken by the participant during the 10-minute TRT was tallied. Sips were defined as the discrete touch of the glass to the lips (Muraven et al., 2002). After 10 minutes of the TRT, the experimenter reentered the room regardless of the participant's status on the computerized TRT. The drinks were removed and total amount consumed was assessed by measuring the amount of beer left and subtracting it from the original amount. The participant's BAL was assessed 20 minutes following the TRT. This time limit allowed for an accurate recording of BAL, as alcohol needs sufficient time to be metabolized (Muraven et al., 2002). At that time, the participant was asked do the One Leg Stand Test again as a safety precaution to make sure that he/she could safely move around (e.g., go to the restroom, get water, etc.) During the 20-minute break, participants completed a manipulation check, were debriefed to the true nature of this study, and were invited to use the internet to pass the time. At the time of BAL measurement (i.e., 20 minutes after the TRT), if the participant's BAL was above a safe level (0.030 g/dL), he/she was asked to remain in the lab until it falls to that level. BAL was checked every 10 minutes after this measurement until it fell to a safe level. If detoxification was required, participants were offered water, snacks, and the continued use of internet to pass the time. After detoxification (if needed), participants were compensated twenty dollars, thanked for their participation, and escorted from the lab.

## Data Analytic Plan

Descriptive statistics and frequencies for all experimental variables were examined to ensure normal distribution. To assess the study hypotheses, multivariate analyses of covariance (MANCOVAs) were conducted with Condition (experimental/control) as one independent variable (IV), and the Executive Functioning Error Score (a continuous variable) as the second IV. Consequences related to drinking, as measured by the RAPI, and negative affect, as measured by the PANAS, were examined as covariates. Originally, nicotine withdrawal and nicotine dependence were also to be included as covariates. Given the limited use of cigarettes and the denial withdrawal/dependence symptoms across the sample, these covariates were excluded from analyses. The three dependent variables (DV) being measured were mL consumed, Sips Taken, and Breath Alcohol Level (BAL). MANCOVAs were used in this study as this statistical test allows for the examination of both main effects and interactions with regard to group differences related to several DVs. G*Power estimated a sample size of 87 participants is needed to achieve adequate power. This estimate was made with the following statistical parameters: (a) a medium $f^2$ effect size of 0.25; (b) an alpha level of

0.05; (c) a power level set at 0.80; (d) two groups; (e) three predictors; and (f) three response variables.

A MANCOVA was used over an ANCOVA due to its ability to take into consideration multiple dependent variables and because of MANCOVA's increased ability to detect an effect. Running multiple ANCOVAs would increase the chance of incorrectly rejecting the null hypothesis while running one MANCOVA on all response variables simultaneously keeps the family error rate equal to an alpha level of 0.05. A MANCOVA was over other statistical tests, such as regression analyses due to regression analyses limited abilities to elaborate on the direction of the relationship between two variables.

# CHAPTER III

# RESULTS

## Descriptive Statistics

Missing data analyses were conducted and there were no missing data. Within the experimental condition, men made up 66.67% of the group and the average age was 23.25 (*SD* = 2.56) years. Reported college attendance was 100%. All individuals reported their ethnicity as White except for one participant who reported being bi-racial (i.e., Latino/White). The average weight (lbs) of the participants in this condition was 174.74 (*SD* = 33.60). All individuals in this group reported their last alcoholic drink being within one week of study participation, and all reported having a drink containing alcohol at least weekly within the past year. In the past year, the average amount consumed during a drinking period for the experimental group ranged from 2-11 drinks, with 66.67% of the group reporting consuming at least 5-6 drinks during drinking periods in the last year. Within the experimental condition, all participants reported engaging in a binge-drinking episode 2-3 times per month in the last year.

Within the control condition, men made up 66.67% of the group and the average age was 22.67 (*SD* = 2.15) years. Reported college attendance was 83.33%. Reported ethnicity was 100% White. The average weight (lbs) of the sample was 173.50 (*SD* = 28.79). Within this group, 83.33% reported their last alcoholic drink being within one week of study participation, with 83.33% reporting having a drink containing alcohol at least weekly within the past year. In the past year, the average amount consumed during a drinking period for the control group ranged from 2-11 drinks, with 58.33% of the group reporting consuming at least 5-6 drinks during drinking periods in the last year. Within the control condition, 83.33% of the group reported engaging in a binge-drinking episode 2-3 times per month in the last year.

Independent samples *t*-tests were conducted to compare differences in alcohol related problems, nicotine withdrawal, nicotine dependence, positive and negative affect, weight, age, and Executive Functioning Error Scores between the working memory depletion group and the control group. There were no significant group differences. Variable means, *t*-test statistics, and *p* values are displayed in Table 1.

Chi-square tests of independence were performed for ethnicity, college attendance, and self-reported drinking behaviors. There was no relationship found between ethnicity and group membership, $X^2$ (1, N=24) = 1.04, $p = 0.31$, or between college attendance and group membership; $X^2$ (1, N=24) = 2.18, $p = 0.14$. In terms of drinking behavior, there were no relationships between last drink consumed ($X^2$ = (2, N=24) = 4.92, $p = 0.08$), past-year drinking prevalence ($X^2$ = (4, N=24) = 3.15, $p = 0.53$), past-year average amount consumed ($X^2$ = (4, N=24) = 0.53, $p = 0.97$), or past-year binge drinking prevalence ($X^2$ = (5, N=24) = 2.48, $p = 0.78$) and group membership. Due to small cell sizes, Fisher's Exact Test was performed to examine the potential group differences for sex. There was no significant difference between groups for reported sex ($p = .67$).

Table 1. Sample Descriptives Using *t*-test for Equality of Means Across Conditions.

| | Variable | Working Memory Depletion M (SD) | Control M (SD) | *t*-test value | *p* value |
|---|---|---|---|---|---|
| 1 | RAPI | 0.24 (.20) | 0.28 (0.22) | -0.50 | 0.63 |
| 2 | MNWS | 0.25 (0.46) | 0.38 (0.76) | -0.51 | 0.62 |
| 3 | FTND | 0.67 (1.50) | 0.50 (1.17) | 0.30 | 0.76 |
| 4 | PANAS – Positive | 2.97 (0.74) | 2.67 (0.82) | 0.94 | 0.36 |
| 5 | PANAS – Negative | 1.23 (0.24) | 1.47 (0.49) | -1.48 | 0.15 |
| 6 | Weight (lbs) | 174.74 (37.60) | 173.50 (28.79) | 0.09 | 0.93 |
| 7 | Age (years) | 23.25 (2.56) | 22.67 (2.15) | 0.61 | 0.55 |
| 8 | Executive Functioning Error Score | 151.40 (17.32) | 148.59 (20.66) | 0.36 | 0.72 |

*Note*.
*M* = Mean, *SD* = Standard Deviation. Measure means represent the average answer across the scale.
RAPI = Rutger's Alcohol Problem Index,
MNWS = Minnesota Nicotine Withdrawal Scale,
FTND = Fagerstrom Test of Nicotine Dependence
PANAS – Positive = Positive and Negative Affect Schedule – Positive
PANAS – Negative = Positive and Negative Affect Schedule – Negative

Table 2 displays the correlations between the study variables. Negative affect and nicotine withdrawal were significantly correlated ($p < 0.01$) as well as nicotine withdrawal and nicotine dependence ($p < 0.01$). In terms of outcome variables, Sips Taken and mL consumed was significantly correlated ($p < 0.01$) as well as mL consumed and BAL ($p < 0.01$).

latrix of Predictor and Outcome Variables.

| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| /e | .13 | -.16 | .23 | -.04 | .14 | -.23 | -.12 | -.14 |
| ive | -- | .53** | .33 | .19 | .22 | -.03 | .05 | .22 |
| | | -- | .32 | .72** | -.02 | -.01 | .17 | .26 |
| | | | -- | .32 | .31 | -.07 | -.10 | .03 |
| | | | | -- | .08 | -.12 | .18 | .23 |
| oning Error Score | | | | | -- | .25 | .24 | .05 |
| | | | | | | -- | .64** | .34 |
| | | | | | | | -- | .68** |
| evel | | | | | | | | -- |

s significant at $p \leq .01$ (2-tailed) **
is significant at $p \leq .05$ (2-tailed) *
Positive = Positive and Negative Affect Scale – Positive,
Negative = Positive and Negative Affect Scale – Negative,
Minnesota Nicotine Withdrawal Scale,
itger's Alcohol Problem Index,
agerstrom Test of Nicotine Dependence

## Main Analyses

Hypothesis 1 predicted individuals in the experimental condition would consume more during the TRT (as measured by Sips Taken, Alcohol Consumed, and Breath Alcohol Level) than individuals in the control condition. Hypothesis 2 predicted participants with poorer executive functioning would drink more than participants with greater executive functioning, regardless of condition.

Assumptions for a MANCOVA were examined. Correlation analyses demonstrate the Pearson *r*s for the dependent variables were within acceptable limits for conducting a MANOVA (<.80; Field, 2013). Box's *M* was 18.31, which was significant ($p$ = .02). However, Box's *M* may be disregarded when cell sizes are equal, as Pillai's Trace is robust to violations of assumptions (Field, 2013). The cell sizes were equal in these data.

There was significant main effect of Condition ($F_{(3,20)} = 3.07$, $\eta_p^2 = 0.32$, $p = 0.05$). Executive Functioning Score was not significant ($F_{(3,20)} = 0.69$, $\eta_p^2 = 0.09$, $p = 0.57$). Examination of the covariates showed neither covariate significantly influenced the combined DV (RAPI; $F_{(3,16)} = 0.15$, $\eta_p^2 = 0.03$, $p = 0.93$) ,PANAS - Negative; $F_{(3,16)} = 0.18$, $\eta_p^2 = 0.03$, $p = 0.91$. Examination of follow-up ANOVAs determined where significant mean differences occurred in Condition and in the interaction between Condition and Executive Functioning Error Score.

Univariate ANOVA results displayed a significant difference in mL Consumed between the experimental condition ($M = 296.67$, $SD = 182.20$) and control condition ($M = 257.08$, $SD = 135.40$); $F_{(1,18)} = 6.33$, $\eta_p^2 = 0.26$, $p = .02$. There was no significant difference for Sips Taken between the experimental condition ($M = 24.58$, $SD = 14.20$) and the control condition ($M = 22.67$, $SD = 5.51$); $F_{(1,18)} = 3.71$, $\eta_p^2 = 0.17$, $p = 0.07$. There was no significant difference in BAL measurements between the experimental condition ($M = 0.01$, $SD = 0.01$) and the control condition ($M = 0.02$, $SD = 0.01$); $F_{(1,18)} = 0.67$, $\eta_p^2 = 0.04$, $p = 0.43$). These analyses support Hypothesis 1, that individuals who experience working memory depletion would drink more than individuals who do not. As there was no significant main effect of ECF, the hypothesis that individuals with poorer executive functioning would drink more than individuals with greater executive functioning was not supported.

Hypothesis 3 predicted an interaction between condition and ECF, such that participants who experienced depleted working memory and who had poorer baseline abilities would consume the most alcohol during the TRT. This hypothesis was supported as results indicated a significant interaction effect ($F_{(3,16)} = 4.03$, $\eta_p^2 = 0.43$, $p = 0.03$). Examination of the univariate effects displayed a significant interaction between condition and executive functioning error score for mL Consumed ($F_{(1,18)} = 6.78$, $\eta_p^2 = 0.27$, $p = 0.02$). Executive Functioning Error Score significantly moderated the effect of Condition on mL Consumed, such that greater number of errors predicted increased mL consumed while executive functioning errors had no influence on mL consumed in the control group. Figure 1 illustrates the interaction of Executive Functioning Errors and Condition on mL Consumed. There was no significant interaction for Sips Taken ($F_{(1,18)} = 3.86$, $\eta_p^2 = 0.18$, $p = 0.07$) or BAL ($F_{(1,18)} = 0.45$, $\eta_p^2 = 0.02$, $p = 0.51$).

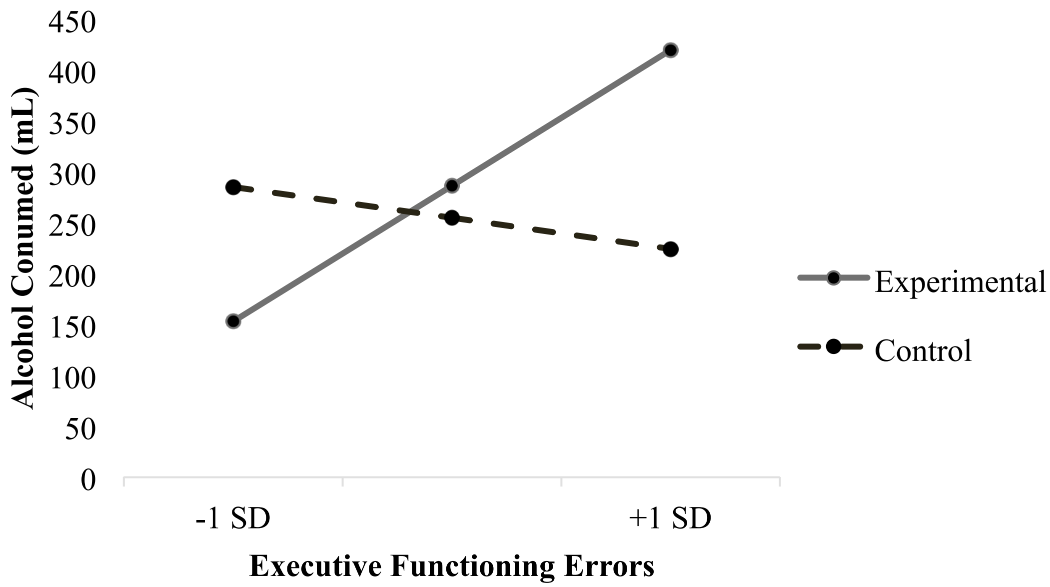


*Figure 1*. Interaction Reflecting the Executive Functioning Moderation of Condition on mL Consumed

# CHAPTER IV

# DISCUSSION

Hypothesis 1 predicted participants in the experimental condition would consume more alcohol (as measured by Sips Taken, mL consumed, and BAL) than individuals in the control condition. This hypothesis was designed to examine the effect taxing working memory has on alcohol consumption. As highlighted previously, working memory is a cognitive process strongly linked to drinking behaviors. Proficient working memory allows drinkers to more effectively inhibit behavior motivated by automatic processes (Grenard et al., 2008), better utilize goal-directed behavior in the face of distracting alcohol-related stimuli (Sharbanee et al., 2013), and make more reasoned drinking decisions (Thush et al., 2008). Working memory research has shown evidence to support that working memory can be depleted or taxed in such a way as to cause deterioration in working memory performance, but has not yet shown the potential deleterious effect on drinking behaviors. Given the role working memory plays when it comes to consuming alcohol, this study, in its first hypothesis, was designed to explore the potential consequences of taxing working memory on alcohol consumption.

Hypothesis 1 was supported. Individuals in the experimental condition consumed significantly more mL of beer than did individuals in the control condition. There was no significant difference in Sips Taken or BAL between conditions. Sips Taken was likely not significant as individuals did not consume enough alcohol to have significantly different numbers of sips. Given the current methodology, differences in consumption appeared to be best measured by volume (mL) consumed, as this outcome variable was sensitive to small difference. BAL may not have been a useful outcome measure for a similar reason as Sips Taken. Given the limited amount of alcohol consumed across study conditions, the study's average amount of beer consumed was 78% of a standard 12oz serving. As a result, BAL measurements were relatively low across condition ($M = 0.012$ g/dL). With regard to the link between BAL and impairment, divided-attention and information processing abilities begin to show observable impairment at 0.015 g/dL (Moskowitz, Burns, & Williams, 1985). At 0.012 g/dL, participants were relatively sober across conditions, suggesting BAL might be a more appropriate outcome variable if the current methodology allowed for longer periods of time over which to consume more alcohol.

Hypothesis 2 predicted participants with poorer executive functioning, as measured by standardized WCST error score, would drink more than participants with greater executive functioning. Executive functioning, which includes working memory abilities, is the management system responsible for regulating cognitive processes. This hypothesis was designed to examine the risk that poorer ECF poses for problematic drinkers. Hypothesis 2 was not supported. There were no significant differences in Sips Taken, mL consumed, or BAL across executive functioning performance. The absence of a significant difference is likely due to low sample size and lower power to detect the effect. Additionally, a significant portion of the sample (n = 22; 91.67%) was composed of individuals who were currently or had previously attended college. The fact that study participants had executive functioning skills that allowed them to apply, get accepted, and attend a two or four-year college suggests these individuals were likely functioning at an average to above average level. At average to above average executive functioning levels, it is expected individuals have the resources and facilities to be relatively able to exert cognitive and behavioral control when it comes to consuming alcohol. As it stands, the individuals in this study were likely too well functioning for the effects of poorer executive functioning on drinking behavior to be examined. In this study, on its own, executive functioning appears to not be related to drinking behaviors; however, even in this sample of relatively well functioning individuals, executive functioning predicted drinking behaviors when participants underwent a strenuous mental task.

Hypothesis 3 predicted an interaction effect, such that individuals with poorer executive functioning in the experimental condition would consume more alcohol than individuals in the same condition with greater executive functioning. This hypothesis was designed to examine the compounding effect working memory loads and poorer functioning has on behavior. Hypothesis 3 was supported. Individuals in the experimental condition, scores that suggested poorer baseline functioning, predicted greater alcohol consumption. In the control condition, executive functioning had largely no impact on drinking behaviors. These results should be interpreted with caution, as sample sizes were small; however, these data pose questions about drinking outcomes for individuals functioning at a less than optimal level and who also experience heavy cognitive loads during periods of alcohol consumption. As highlighted previously, there are numerous ways individuals can experience heavy cognitive loads prior to or during alcohol consumption. One of the examples discussed was participation in drinking games, where players often engage in complex and intentionally tricky verbal memory games. There is evidence to suggest drinking games pose severe risks to drinkers, as Newman, Crawford, and Nellis (1991) found that players drank twice as much alcohol as non-players over a 15-minute observation period. In addition, 89% of a sample of students surveyed reported witnessing or experiencing a loss of consciousness during or as a result of game play (Polizzotto, Saw, Tjhung, Chua, & Stockwell, 2007). When it comes to binge drinkers, these individuals are 4-12 times more likely than non-binge drinkers to report participation in drinking games (Borsari, Bergen-Cico, & Carey, 2003). In this study, it was not the intention of the participants to become inebriated and they were not in a fun social situation, yet their drinking was influenced by cognitive load. The results from this study raise serious concerns for individuals who engage in intensive cognitive tasks with the intention of becoming drunk, as just a brief, intensive working memory task has been shown to lead to significantly increased alcohol consumption.

The current study also examined other variables that were possibly predictive of the outcomes (mL consumed, sips taken, BAL) under study, as drinking behaviors are often predicted by multiple factors. Nicotine withdrawal and dependence were not endorsed within the study sample, suggesting that these variables did not contribute to drinking behaviors in the study. Negative affect was found to not significantly contribute to drinking behaviors and endorsement of negative affect was low across both conditions. Last, a greater number of problems related to drinking was found to not significantly contribute to drinking behaviors. As with negative affect, endorsement of alcohol related problems/consequences was low across conditions. While these results rule out the impact of these extraneous variables and strengthen the argument that group differences were due to the experimental manipulation, there must be concern for the potential impact of these variables, and others like them, in a real-world situations (i.e., where individuals often drink to cope with negative emotion or with individuals who are experiencing serious and persistent consequences related to use).

## Study Limitations and Strengths

One limitation in the current study was its restricted sample size. The sample size (*N* = 24) likely resulted in decreased power to detect the effect for Executive Functioning Error Score. The effect size of Executive Functioning Error Score was 0.09 (a small effect size). Observed power for this effect was 0.17, suggesting a larger sample is needed to detect this potential effect and that, currently, there is not enough statistical power to rule out the presence or absence of the effect of Executive Functioning Error Score.

While there was variability among executive functioning scores, a greater sample size would have resulted in a stronger ability to compare and draw conclusions regarding the differences between individuals with greater and poorer abilities. Another limitation to the current study is its lack of generalizability to individuals who are not Caucasian young adults who have received some level of higher education.

In future studies there should be an increased effort to recruit participants with a greater variability of executive functioning abilities, as the greatest concern for the effect of executive functioning on drinking behaviors lies with individuals who experience considerable deficits.

Other ways of examining and measuring executive functioning may be considered in future studies, as this study defined executive functioning as a standardized error score derived from the WCST. There may be a more accurate and encompassing measure of executive functioning available, which would allow one to make stronger assertions about the relationship executive functioning and drinking behaviors.

Last, a final limitation of this study was its inability to sort out competing mechanisms for why taxation of working memory led to increased alcohol consumption. This study succeeded in demonstrating taxing working memory leads to observable changes in drinking behavior; however, there is more that needs to be uncovered. Future research must address the mechanism more directly. For example, did individuals in the experimental condition drink more alcohol because the ability to keep focused attention during the TRT was diminished, or was it because judgment making regarding beer flavors was slowed and, therefore, more difficult, or was it because these individuals experienced decreased ability to inhibit behavior, which lead to drinking greater amounts than was required to rate beer flavors? Perhaps it was a combination of all of the above. The inability to disentangle these competing mechanisms of action is a limitation that must be addressed.

The study's greatest strength was its implementation of an experimental design, which allowed for causal assumptions to be made regarding working memory and drinking behaviors. Most research in this area relies on correlational data, and therefore is often not suited to untangle the multifaceted relationship between executive functioning and alcohol use. Additionally, this study was the first to experimentally manipulate working memory in order to bring about a change in drinking behavior. Other working memory manipulation research has shown changes in similar areas of working memory performance, but had not applied the same methodology to behavioral performances which involve one's use of working memory (e.g., the TRT used in this study) but which are not single measures of working memory (e.g., a card rotation tasks, a word span task).

Another strength lies in the sample recruited for participation, which was made up predominately of college students. Within the general population, college students are most likely to engage in binge drinking behaviors, making this research question most applicable to them.

**Future Directions**

As mentioned previously, individuals, on average, consumed less than a beer during the experimental protocol. Replications of this study may benefit from modifying the current methodology to allow for a longer drinking time and for more alcohol to be made available to the participant. A longer drinking time may allow for clearer conclusions to be drawn regarding the clinical significance of these factors on drinking. The mean difference in alcohol consumed between conditions was 1.34oz. This finding was statistically significant; however, it is unclear at this time if this finding can allow one to make predictions regarding clinical significance, as 1.34oz beer is relatively little alcohol. In the future, a longer drinking time and more available alcohol may allow researchers to make statements on clinical significance (e.g., the likelihood of a binge episode, increased impairment, or increased negative consequences) related to working memory depletion and poor executive functioning. Additionally, a longer drinking time and more available alcohol may render BAL a more valuable outcome measure. As the current methodology stands, little was gleaned from BAL measurements.

Last, as there is now preliminary evidence to suggest taxed working memory combined with poorer executive functioning can lead to increased drinking, future research should apply this finding to situations more applicable to real life. Outside of the lab, individuals are not participating in n-backs designed to deplete working memory.

Individuals are watching T.V., playing videogames, and/or visiting with friends, etc. These tasks draw upon working memory resources, but it is unknown whether they produce a measurable effect on drinking behaviors. Additionally, future research should investigate whether the effect observed in this study is only immediate in nature or if there is also a delayed effect. Individuals completed the TRT several minutes after undergoing the n-back and demonstrated immediate increases in drinking behavior, but it is unknown if this effect would continue to be seen after even a brief delay. In the workforce, many occupations require full workdays of heavy cognitive demands, which may impact evening drinking. Future research may want to look toward whether these individuals are at increased risk of alcohol misuse upon clocking out. Last, future research should examine whether this effect is replicable with other substances (e.g., marijuana).

The implications of this research extend into the realm of intervention. As it was found that individuals with poorer ECF consumed significantly more alcohol when faced with a working memory task than those with greater ECF who faced the same working memory task, premise working memory capacity significantly impacts one's ability to regulate one's drinking behavior was supported. Currently, there are few interventions that take into account the role ECF plays in initiating and maintaining problematic drinking behaviors, as most interventions focus exclusively on psychosocial variables that increase one's risk. It is hoped that results from this study have provided support for future research that examines the use of working memory interventions for problem drinkers who suffer from ECF deficits, as these individuals would likely benefit from interventions that seek to increase working memory capacity so greater cognitive control can be exerted.

## Conclusion

Overall, this study revealed several important findings. First, it was demonstrated that heavy loads on working memory have an effect on alcohol consumption. Previous research has shown that taxing working memory can result in diminished performance in specific working memory tasks (e.g., word span tasks, card rotation tasks) and in more general skill areas (e.g., ability to fight distraction). While working memory's role in initiating and maintaining problematic alcohol use behaviors has been studied, these results give a more nuanced understanding of the function working memory serves in in-the-moment drinking behaviors, and raises concerns regarding environmental factors, many of which were mentioned earlier, that may place heavy loads on working memory (e.g., participating in drinking games, managing simultaneous tasks, fighting distraction, resisting impulses). Second, this study demonstrated that not only does greater working memory load result in increased alcohol consumption, but that this increase in consumption is even greater for individuals with poorer executive functioning abilities. This finding suggests that, for a subset of individuals with problematic drinking behaviors, there are multiple, intertwined factors contributing to increased risk. These factors and their relationship to each other must be taken into consideration when developing intervention and prevention treatments. Overall, these individuals have fewer resources at their disposal to aid in regulating drinking behavior. The resources they do have may be expended at a faster rate or may be less able, in general, to assist in meeting cognitive and environmental demands. Either way, it is apparent interventions should consider approaching problematic alcohol use, for a certain group of individuals, with the goal of strengthening areas of cognitive abilities, namely working memory.

There is preliminary data that supports the use of working memory training to intervene in cases of problematic alcohol use. Houben, Wiers, and Jansen (2011) demonstrated, through an online study, working memory training has the potential to be an effective strategy for reducing alcohol use, with the theorized mechanism of action being increased control over automatic impulses to drink alcohol. Their results suggested working memory training might be a particularly helpful supplementary intervention for individuals who experience a greater than average deterioration in inhibitory abilities, as inhibitory abilities have been shown to be strongly related to working memory capabilities (Bull & Scerif, 2001; Carlson, Moses, & Breton, 2002; Conway, Cowan, & Bunting, 2001). Houben, Wiers, and Jansen's (2011) findings should be extended via replication with an in-person study, preferably, a randomized controlled trial. There are several difficulties with this proposed study, as the working memory intervention consisted of 25 training sessions over a minimum of 25 days and required participants to want to change drinking behaviors; however, the current study's results are clear in that heavy loads on working memory predicted greater alcohol consumption, with individuals who displayed overall poorer functioning experiencing the greatest effect. These individuals would likely benefit from efforts designed to strengthen working memory so greater cognitive control can be achieved.

Overall, the results from this study have illustrated how working memory depletion can lead to increased alcohol consumption, especially among those with poorer ECF. As it stands, it appears interventions aimed at strengthening working memory capabilities might be one of the more efficacious interventions for this population.

# APPENDICES

**Appendix A**
**Telephone Screen 1**

Name: ______________________________________

Gender: Man or Woman (circle one)

Age: ___________________

Height: _____________ Weight: _____________

For Females:

Are you pregnant? YES or NO

Is there a chance you could be pregnant? YES or NO

Are you breastfeeding? YES or NO

**Medical History**

Do you have any current medical diagnoses? YES or NO (circle one)

If yes, what are your current medical diagnoses:

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
________________________

Has a physician ever asked you to refrain from drinking for any reason: YES or NO (circle one)

If yes, why?

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
________________________

Are you currently on any medications? YES or NO (circle one)

If yes, please list your current medications:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________

## Psychiatric History

Has a health professional (e.g., a clinical psychologist, a psychiatrist, family doctor etc.) ever diagnosed you with a mental disorder? YES or NO (circle one)

If yes, what disorder(s) were you been diagnosed with and what year were you diagnosed?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________

## Alcohol Use

**All participants:**

Do you have a barley allergy? YES or NO (circle one)

Please think of all the times that you drink. The three most common types of alcohol are beer, wine, and hard liquor. Please indicate the percentage of alcoholic drinks you consume that are beer, wine, and hard liquor. For example, when John Doe goes out, 50% of the drinks he chooses are liquor, 45% of the drinks he chooses are beers, and 5% of the drinks he chooses are wines. What do you think your percentages for these three drink types are?

Wine ________

Liquor ________

Beer ________

**For Males:**

Have you consumed five or more alcoholic drinks in one sitting twice during the last month? YES or NO (circle one)

Have you consumed 15+ drinks in a week twice in the last month? YES or NO (circle one)

**For females:**

Have you consumed four or more drinks in one sitting twice in the last month? YES or NO (circle one)

Have you consumed 8+ drinks in a week twice in the last month? YES or NO (circle one)

**Other Substance Use**

Have you ever used any illicit drugs (e.g., marijuana, cocaine, ecstasy, etc.)? YES or NO (circle one)

If yes, what drugs have you used and approximately how many times?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
__________________________

Thank you for your interest in participating in our lab's research. You receive a call back from us if you are eligible to participate.

## Appendix B
## Telephone Screen 2

Thank you for your interest in participating in our lab's research. From your first telephone screen, it appears that you may be eligible to participate in one of our studies. I need to ask some additional questions to confirm your eligibility.

Name: ________________________________________

Gender:  Man or Woman (circle one)

Age: ____________________

Height: ______________ Weight: ______________

For Females:

Are you pregnant? YES or NO

Is there a chance you could be pregnant? YES or NO

Are you breastfeeding? YES or NO

**For Males:**

Have you consumed five or more alcoholic drinks in one sitting twice during the last month? YES or NO (circle one)

Have you consumed 15+ drinks in a week twice in the last month? YES or NO (circle one)

**For females:**

Have you consumed four or more drinks in one sitting twice in the last month? YES or NO (circle one)

Have you consumed 8+ drinks in a week twice in the last month? YES or NO (circle one)

### Medical Information

Has there been any significant change with your medical history since we spoke to you last (e.g., have you had surgery, been in an accident, received a new diagnosis, etc.)? YES or NO (circle one)

If yes, what is this change?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
__________________________

Have you started any new medications since we spoke last? YES or NO (circle one)

If yes, what new medications did you start?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
__________________________

**Psychiatric Information**

Have you received a psychiatric diagnosis (e.g., major depressive disorder, bipolar disorder, etc.) from a health care professional (e.g., a clinical psychologist, a psychiatric, your family doctor, etc.) since we spoke last? YES or NO (circle one)

If yes, what diagnosis did you receive and when?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
__________________________

I am now going to ask you some more in-depth questions about your alcohol use.

[Administer alcohol use portion of the SCID-I]

**Appendix C**
**Demographics**

1. What is your age? __________

2. Gender (circle one) Man Woman

3. Do you attend, or have you ever attended, a 2 or 4-year college? (circle one)

   Yes No

4. What is your height (in feet and inches)? __________

5. What is your weight (in pounds)? __________

6. What is your race or ethnic group?
   a. White/Caucasian
   b. Hispanic/Latino
   c. Black/African American
   d. American Indian/Alaskan Native
   e. Asian/Pacific Islander
   f. Other: ____________________

7. Is English your native language?
   a. Yes
   b. No

8. Regarding your vision:
   a. It is normal without glasses/contacts
   b. It is normal with glasses/contacts that I have and am wearing
   c. I require glasses/contacts, but I don't have them with me

## Appendix D
## Alcohol Use Questionnaire

1. When was the last time you had a drink that contained alcohol?
    a. Within the last 30 minutes
    b. Within the last hour
    c. Within the last 2-4 hours
    d. Within the last 5-6 hours
    e. Within the last 7-12 hours
    f. Within the last 24 hours
    g. Within the last 2 days
    h. Within the last 3-7 days
    i. Over 1 week ago

2. During the past **year**, how often did you usually have any kind of drink containing alcohol?
    a. Every day
    b. 5 to 6 times a week
    c. 3 to 4 times a week
    d. Twice a week
    e. Once a week
    f. 2 to 3 times a month
    g. Once a month
    h. 3 to 11 times in the past year
    i. 1 or 2 times in the past year

3. During the past **year**, how many alcoholic drinks did you have on a typical day when you drank alcohol?
    a. 25 drinks or more
    b. 19 to 24 drinks
    c. 16 to 18 drinks
    d. 12 to 15 drinks
    e. 9 to 11 drinks
    f. 7 to 8 drinks
    g. 5 to 6 drinks
    h. 3 to 4 drinks
    i. 2 drinks
    j. 1 drink

4. MALES, During the past **year** how often did you have five or more drinks containing any kind of alcohol in one sitting? [That would be the equivalent of at least five 12 oz cans or bottles of beer, five 5 oz glasses of wine, or five drinks each containing one shot (1 oz) of hard liquor].
    a. Every day
    b. 5 to 6 days a week
    c. 3 to 4 days a week
    d. 2 days a week
    e. 1 day a week
    f. 2 to 3 days a month
    g. 1 day a month
    h. 3 to 11 days in the past year
    i. 1 or 2 days in the past year

5. FEMALES, During the past **year** how often did you have four or more drinks containing any kind of alcohol in one sitting? [That would be the equivalent of at least five 12 oz cans or bottles of beer, five 5 oz glasses of wine, or five drinks each containing one shot (1 oz) of hard liquor].
    a. Every day
    b. 5 to 6 days a week
    c. 3 to 4 days a week
    d. 2 days a week
    e. 1 day a week
    f. 2 to 3 days a month
    g. 1 day a month
    h. 3 to 11 days in the past year
    i. 1 or 2 days in the past year

**Appendix E**
**Rutgers Alcohol Problem Index**

Different things happen to people when they are drinking alcohol, or as a result of their alcohol use. Some of these things are listed below. Please indicate how many times each has happened to you during the past **month** while you were drinking alcohol or as the result of your alcohol use.

| How many times did the following things happen to you while you were drinking alcohol or because of your alcohol use during the past **month**? | ***Never*** | ***1-2 times*** | ***3-5 times*** | ***6-10 times*** | ***More than 10 times*** |
|---|---|---|---|---|---|
| 1. Not able to do your homework or study for a test. | 0 | 1 | 2 | 3 | 4 |
| 2. Got into fights with other people (friends, relatives, and strangers). | 0 | 1 | 2 | 3 | 4 |
| 3. Missed out on other things because you spent too much money on alcohol. | 0 | 1 | 2 | 3 | 4 |
| 4. Went to work or school high or drunk. | 0 | 1 | 2 | 3 | 4 |
| 5. Caused shame or embarrassment to someone. | 0 | 1 | 2 | 3 | 4 |
| 6. Neglected your responsibilities. | 0 | 1 | 2 | 3 | 4 |
| 7. Relatives avoided you. | 0 | 1 | 2 | 3 | 4 |
| 8. Felt that you needed more alcohol than you used to in order to get the same effect. | 0 | 1 | 2 | 3 | 4 |
| 9. Tried to control your drinking (tried to drink only at certain times of the day or in certain parts; that is, tried to change your pattern of drinking). | 0 | 1 | 2 | 3 | 4 |
| 10. Had withdrawal symptoms; that is, felt sick because you stopped or cut down on drinking. | 0 | 1 | 2 | 3 | 4 |
| 11. Noticed a change in your personality. | 0 | 1 | 2 | 3 | 4 |
| 12. Felt that you had a problem with alcohol. | 0 | 1 | 2 | 3 | 4 |

| | | | | | |
|---|---|---|---|---|---|
| 13. Missed a day (or part of a day) of school or work. | 0 | 1 | 2 | 3 | 4 |
| 14. Wanted to stop drinking but couldn’t. | 0 | 1 | 2 | 3 | 4 |
| 15. Suddenly found yourself in a place that you could not remember getting to. | 0 | 1 | 2 | 3 | 4 |
| 16. Passed out or fainted suddenly. | 0 | 1 | 2 | 3 | 4 |
| 17. Had a fight, argument, or bad feeling with a friend. | 0 | 1 | 2 | 3 | 4 |
| 18. Had a fight, argument, or bad feeling with a family member. | 0 | 1 | 2 | 3 | 4 |
| 19. Kept drinking when you promised yourself not to. | 0 | 1 | 2 | 3 | 4 |
| 20. Felt you were going crazy. | 0 | 1 | 2 | 3 | 4 |
| 21. Had a bad time. | 0 | 1 | 2 | 3 | 4 |
| 22. Felt physically or psychologically dependent on alcohol. | 0 | 1 | 2 | 3 | 4 |
| 23. Was told by a friend or neighbor to stop or cut down drinking. | 0 | 1 | 2 | 3 | 4 |

**Appendix F**
**The Minnesota Nicotine Withdrawal Scale**

For each of the following, rate yourself on how you have been feeling over the past **8 hours**.

Mark the number that applies to you.

| | Not at all | Slight | Moderate | Quite a bit | Extreme |
|---|---|---|---|---|---|
| 1. Urge to smoke | 0 | 1 | 2 | 3 | 4 |
| 2. Depressed mood | 0 | 1 | 2 | 3 | 4 |
| 3. Irritability, frustration, or anger | 0 | 1 | 2 | 3 | 4 |
| 4. Anxiety | 0 | 1 | 2 | 3 | 4 |
| 5. Difficulty concentrating | 0 | 1 | 2 | 3 | 4 |
| 6. Restlessness | 0 | 1 | 2 | 3 | 4 |
| 7. Increased appetite | 0 | 1 | 2 | 3 | 4 |
| 8. Difficulty going to sleep | 0 | 1 | 2 | 3 | 4 |
| 9. Difficulty staying asleep | 0 | 1 | 2 | 3 | 4 |

**Appendix G**
**Fagerstrom Test of Nicotine Dependence**

Please mark with an “X” the box next to the option that best corresponds to your answer.

1. How soon after you wake up do you smoke your first cigarette?

- ☐ Within 5 minutes
- ☐ 5-30 minutes
- ☐ 31-60 minutes
- ☐ After 60 minutes

2. Do you find it difficult to refrain from smoking in places where it is forbidden, e.g., in church, at the library, in cinema, etc.?

☐ Yes ☐ No

3. Which cigarette would you hate most to give up?

- ☐ The first one in the morning
- ☐ All others

4. How many cigarettes/day do you smoke?

- ☐ 10 or less
- ☐ 11-20
- ☐ 21-30
- ☐ 31 or more

5. Do you smoke more frequently during the first hours after waking than the rest of the day?

☐ Yes ☐ No

6. Do you smoke if you are so ill that you are in bed most of the day?

☐ Yes ☐ No

## Appendix H
## Positive and Negative Affect Schedule

Indicate to what extent you feel this way right now:

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Very Slightly or Not at all | A Little | Moderately | Quite a Bit | Extremely |

| | | |
|---|---|---|
| _______ 1. Interested | _______ 10. Hungry | _______ 20. Distressed |
| _______ 2. Excited | _______ 11. Hostile | _______ 21. Starved |
| _______ 3. Thirsty | _______ 12. Proud | _______ 22. Inspired |
| _______ 4. Strong | _______ 13. Quenched | _______ 23. Nervous |
| _______ 5. Full | _______ 14. Upset | _______ 24. Parched |
| _______ 6. Guilty | _______ 15. Alert | _______ 25. Determined |
| _______ 7. Over-nourished | _______ 16. Ashamed | _______ 26. Ravenous |
| _______ 8. Faint | _______ 17. Dehydrated | _______ 27. Enthusiastic |
| _______ 9. Active | _______ 18. Afraid | _______ 28. Attentive |

## Appendix I
## Taste-Rating Test

Before you are three different common beers, each labeled with a number. For this task, please drink as much or as little as you need in order to rate the drinks on different characteristics. If you are unsure of what a characteristic pertains to, answer to the best of your ability. Please make your ratings after careful consideration of the beers.

To make your ratings, simply touch the number shown the screen on the iPad that corresponds with your rating of that specific beer.

Example:

On a scale of 1 (Not acidic at all) to 7 (very acidic), how **acidic** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not flat at all) to 7 (completely flat), how **flat** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not malty at all) to 7 (very malty), how **malty** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not sweet at all) to 7 (extremely sweet), how **sweet** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not bitter at all) to 7 (extremely bitter), how **bitter** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not creamy at all) to 7 (extremely creamy), how **creamy** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not rich at all) to 7 (extremely rich), how **rich** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not fruity at all) to 7 (extremely fruity), how **fruity** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not hoppy at all) to 7 (extremely hoppy), how **hoppy** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not watered-down at all) to 7 (extremely watered-down), how **watered-down** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not dry at all) to 7 (extremely dry), how **dry** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not coffee-ish at all) to 7 (extremely coffee-ish), how **coffee-ish** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not smokey at all) to 7 (extremely smokey), how **smokey** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not velvety at all) to 7 (extremely velvety), how **velvety** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not citrusy at all) to 7 (extremely citrusy), how **citrusy** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not burnt at all) to 7 (extremely burnt), how **burnt** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not chalky at all) to 7 (extremely chalky), how **chalky** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not chocolaty at all) to 7 (extremely chocolaty), how **chocolaty** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not gassy at all) to 7 (extremely gassy), how **gassy** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not hot at all) to 7 (extremely hot), how **hot** (overly alcoholic) are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not oaky at all) to 7 (extremely oaky), how **oaky** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not smooth at all) to 7 (extremely smooth), how **smooth** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not tart at all) to 7 (extremely tart), how **tart** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not stale at all) to 7 (extremely stale), how **stale** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not viscous at all) to 7 (extremely viscous), how **viscous** (thick in a fluid nature) are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not robust at all) to 7 (extremely robust), how **robust** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not nutty at all) to 7 (extremely nutty), how **nutty** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not crisp at all) to 7 (extremely crisp), how **crisp** (pleasant bitterness) are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (Not caramel at all) to 7 (extremely caramel), how **caramel** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (no aftertaste at all) to 7 (extremely strong aftertaste), how **intense is the aftertaste** in the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (not thirst-quenching at all) to 7 (extremely thirst-quenching), how **thirst-quenching** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (not metallic at all) to 7 (extremely metallic), how **metallic** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (not mellow at all) to 7 (extremely mellow), how **mellow** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (not salty at all) to 7 (extremely salty), how **salty** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

On a scale of 1 (not sour at all) to 7 (extremely sour), how **sour** are the three beers?

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|---|
| *Beer 1* | | | | | | | |
| *Beer 2* | | | | | | | |
| *Beer 3* | | | | | | | |

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