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Previous research has shown that alcohol abuse may cause a deficit in frontal lobe functioning, specifically, areas of the frontal lobe that are related to executive function. Additionally, problems with executive function have been related to increased difficulty in managing cravings to addictive substances. The current study explored the relationship between alcohol use and performance on measures of executive functioning in a sample of 121 traditional college students. Students were given 5 measures of executive function designed to explore mental set shifting, updating, inhibition, sustained attention, and planning. These measures were used to examine the relationship between executive function and craving as measured by the Obsessive Compulsive Drinking Scale. Levels of alcohol use were also examined using the Alcohol Use Disorders Identification Test in relation to executive function performance and family history of alcohol abuse.
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CHAPTER 1
INTRODUCTION

College Student Alcohol Use

Nearly 17.6 million Americans suffer from an alcohol use disorder (Grant et al., 2006). A large portion of college students are included in that number, making alcohol abuse a significant problem on college campuses. Approximately 31.6 % of college students meet criteria for alcohol abuse, and 6 % meet criteria for alcohol dependence (Knight et al., 2002). Out of the students classifying for alcohol dependence, only 6.2 % seek treatment. These numbers are consistent with other reports of college student drinking.

In examining the patterns of alcohol use and abuse among the college student population, Johnsson, Leifman, and Berglund (2008) used Alcohol Use Disorders Identification Test (AUDIT) scores to determine the trajectories of alcohol use in a sample of 359 students during the first four years of college. The students were either classified as high-risk or low-risk alcohol users at the beginning of college and were followed to determine their drinking status after being in college for four years. Four trajectories for alcohol use during college were discovered. Of the students in the study, 16 % began in a risky alcohol use group and remained in this group throughout 4 years of college; 13 % increased from low-risk to high-risk alcohol use over the course of 4 years; 11 % decreased from high-risk to low-risk alcohol use over the course of 4 years; and 60 % began in a low-risk alcohol use group and remained in this group over the course of 4 years of college. These results indicate that alcohol use during college is dynamic, and while the majority of the students were classified as low-risk users at the end of college, a total of 29 % were classified as high-risk users.
While the number of college students abusing alcohol is high, and there are different patterns of alcohol use among the college student population, how do college students compare to their same-aged peers? Kypri, Cronin, and Wright (2005) compared alcohol use between college students aged 17 to 24 and their same-aged peers, who did not attend college, using scores on the AUDIT. They reported that college students’ AUDIT scores were 50 to 60% higher than their non-college peers. Additionally, the percentage of college students with AUDIT scores suggesting a pattern of hazardous drinking (score greater than 8) was twice as high as the number of non-college students. The percentage of college students with AUDIT scores indicating harmful drinking (score greater than 15) was three times as high as the number of non-college students. These results indicate that alcohol abuse among the college population is a significant problem, which requires further research.

One of the reasons for drinking reported by some individuals with alcohol problems, including college students, is craving. Alcohol craving captures the attention of some individuals and drives their desire to consume alcohol. Given the large percentage of college students, as well as members of the general population, who suffer from alcohol use disorders, alcohol craving has become an important area in the field of alcohol use research.

Research has shown that alcohol craving operates in a way similar to obsessive-compulsive disorder in that it involves both intrusive thoughts (on the use of alcohol) and compulsions (to consume alcohol) (Hommer, 1999). Research has also linked craving to areas of the brain that are responsible for executive function, specifically the prefrontal area of the neocortex, that do not fully develop until sometime after puberty when a person is in their mid 20s (Hommer, 1999; Olbrich et al., 2006; Wilson, Sayette, & Fiez, 2004). This same area of the brain is involved in the obsessions and compulsions inherent in obsessive-compulsive disorder.
(Hommer, 1999). Further, alcohol use has been shown to cause deficits in frontal lobe development. As such, explicating the relationships between executive function, alcohol use, and craving represent an important avenue to pursue for understanding the behavior of young adult drinkers (Tapert & Brown, 1999).

These areas of research were examined in the following study with the goal of determining how executive function is related to alcohol use and craving in a college student population. Specifically, the current project examined the relationship between alcohol use, craving, family history of alcohol abuse, and executive function using neurocognitive tasks designed to tap specific aspects of executive function in order to determine which components of executive function may be involved in alcohol use and craving. This research may be useful in clarifying cognitive models of craving, as well as providing evidence that problems in executive function may negatively affect the ability to adequately regulate alcohol-related cravings.

Problematic Alcohol Use

Defining Problematic Alcohol Use

Three subtypes of alcohol problems are commonly recognized: binge drinking, alcohol abuse, and alcohol dependence. Of these three subtypes, alcohol abuse and dependence are recognized by the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition – Text Revision* (American Psychiatric Association [DSM-IV-TR], 2000). Binge drinking involves excessive drinking with the purpose of maximizing the pleasurable effects of alcohol, even though there may be a prolonged period between drinking sessions. It is commonly defined based on the quantity of drinks that a person has in one sitting. Using this metric, men are considered to have binged on alcohol when they consume 5 or more drinks in a single setting, and women meet the criteria when they have 4 or more drinks in a single setting (Wechsler &
Nelson, 2001). Binge drinking is a serious problem, and is one of the more prevalent subtypes of alcohol usage among college students.

Alcohol abuse involves heavy drinking even though a person is experiencing problems related to alcohol use, or causing problems for others because of alcohol use (DSM-IV-TR, 2000). Some examples of problems that a person may have due to alcohol abuse include: losing a job, losing friends, physical injury, loss of memory during a drinking session, or getting into legal trouble. Finally, alcohol dependence subsumes the other forms of alcohol use, but also includes a physical and psychological dependence on alcohol. Some signs of alcohol dependence include the development of a tolerance for alcohol, whereby a person needs more alcohol to feel the same effects, and withdrawal. Withdrawal is a cluster of symptoms related to discontinuation of alcohol use, and involves psychological symptoms such as dysphoria, anxiety, and irritability, as well as physical symptoms such as increased heart rate, sweating, nausea, vomiting, and tremors. In more severe cases, withdrawal can include hallucinations, fever, convulsions, and loss of consciousness. When measuring problematic alcohol use, and attempting to discriminate between the various forms of such problems, several issues are important to consider.

**Measuring Alcohol Use**

Some of the more prevalent issues involved in the measurement of problematic alcohol use include: the reference period being considered, how to measure the quantity and frequency of alcohol use, whether to measure use in terms of a beverage specific or overall consumption question, whether to allow open-ended responses or use precoded responses, and how to determine drinking status (Dawson, 2003).

In deciding on a reference period for measuring alcohol use, the benefits and drawbacks of various measurement periods must be weighed (Dawson, 2003). Shorter periods enable more
exact and specific measurements of alcohol use, but minimize the ability of the measure to detect problems related to alcohol use, and could classify drinkers incorrectly. Longer periods, however, enable the examination of problems related to drinking, but may not be as exact or precise as shorter reference periods which don’t require the recall of drinking behavior in the distant past. When deciding on how to measure the quantity and frequency of alcohol use, a decision must be made between measuring exact quantities, and measuring use in regards to standardized drink size. Exact quantities provide more individualized results, whereas measuring standardized drinks enables the calculation of various drinking indices. Related to this is the issue of whether to measure beverage specific questions, such as the type of alcoholic beverage the person consumes, or to measure overall consumption without regards to the individual beverage type. Questions using beverage specific measures may be difficult for the respondent to answer due to memory lapse, while questions measuring overall consumption may not provide as much detail as to the types of alcohol consumed. The other issue of beverage measurement, whether to allow open-ended responses or precoded responses, is similar to the problem of measuring the quantity and frequency of use. Open-ended responses provide data that are more exact and cover a larger range, while precoded responses are easier for the respondent to complete and reduce the social pressure that a respondent confronts when reporting alcohol use.

Another issue related to alcohol use measurement, how to determine drinking status, is extremely important in research as it focuses on the relationship of past drinking to present behavior and mental state (Dawson, 2003). Drinking status involves whether a person is currently drinking, whether they have ever consumed alcohol, and at what periods a person has consumed alcohol. The results of an alcohol use measure are significantly different, for example,
between one person who used to drink heavily every day, but has not currently had a drink for 10 years, versus a person who currently drinks every day.

All of these measurement issues must be addressed when studying alcohol use to ensure that the methods selected provide data that relate to the type of alcohol use under consideration. Various alcohol use instruments have been created that combine these aspects of measurement in different ways. The current study focused on measurement that involves a long-term reference period, standardized drink sizes, precoded responses, overall consumption, and current versus past drinking status. This approach was taken to maximize identification of problem drinking (both past and/or present) in a large sample of young adults.

*Family History of Alcoholism*

Another important aspect of alcohol use to measure, when examining the usage patterns of individuals, is their family history of alcohol use. Family history of alcoholism has been found to be a significant biopsychosocial risk marker for an individual’s likelihood of developing an alcohol use disorder (Stoltenberg, Mudd, Blow, & Hill, 1998). Strong genetic effects have been found when examining the relationship between an individual’s family history of alcoholism and their own alcohol usage, however, this relationship is complex and is not fully understood. When examining alcohol use history, one of the strongest relationships exists for sons of male alcoholics. However, relying only on paternal alcoholism often obfuscates other biopsychosocial risk factors for alcoholism. Accordingly, most measures of family history of alcoholism examine both maternal and paternal first- and second-degree relatives.

No one method has garnered complete support by researchers as the gold standard for examining family history of alcohol abuse, however, the two most often used metrics include the examination of first-degree relatives, or a combination of first- and second-degree relatives.
(Stoltenberg et al., 1998). Using these standards, an individual is determined to be family history positive (FH+) if any one of their first- or second-degree blood relatives can be classified as a problem drinker. While using this method involves a qualitative determination of family history, other researchers have argued for a quantitative measure of family history. Using a quantitative measure of family history involves determining the total number of FH+ relatives which is then used as a continuous variable. While a quantitative metric enables more freedom in statistical analysis, it also complicates the strength of the relationship between an individual and their FH+ family members. By weighting the strength of the relationships, a quantitative measure can be made to be more representative; however, doing so may arbitrarily add more weight to a relationship than is warranted.

Another issue involved in the measurement of alcoholism family history is the type of measure used to collect information. The two most often used methods for data collection involve interviewing individual family members and the use of self-report measures (Hodgins & Shimp, 1995). Interviewing individual family members is the preferred method for determining family history as it enables an individual diagnosis of each family member and reduces the likelihood of a false positive determination of family history of alcoholism. However, interviewing individual family members is often impractical due to limited access to family members, the quantity of time involved for individual interviews, and the likelihood that family members may be deceased. Using self-report measures is often as simple as asking an individual to report their family history, however, there is an increased likelihood that an individual may misreport the drinking status of a relative. Specific issues that make self-report difficult in relationship to reporting family history of alcohol abuse include the possibility that an individual
may have had little contact with a relative, may be adopted, or may not be sure of whether someone meets criteria for problematic alcohol use.

While there are a variety of difficulties inherent in measuring alcoholism family history, the current study examined family history using a self-report measure and focused on a qualitative analysis of family history. A qualitative determination was used to improve the ability to understand the specific strength of the family history relationship. A self-report measure was used due to limited access to family members and limited resources. Finally, the current study reports both maternal and paternal family history in first- and second-degree relatives to explore the differences among various family history relationships.

Craving

Defining Craving

One of the most difficult concepts to define is that of craving (Anton, 1999). Even in the current literature examining the concept of craving, no single definition appears to have fully captured the backing of all researchers in the field. This poses a problem in that alcohol craving is viewed by some as one of the primary motivating factors that influence drinking in those who abuse alcohol. At its core, craving is a subjective state of desire that permeates the mind of the alcoholic individual causing them to focus cognitively on the use of alcohol. Despite the fact that craving is viewed as a motivating factor for the use of alcohol and other substances, reports offered by substance users indicate that it is not always the biggest factor in substance use and sometimes is not a factor at all (Toneatto, 1999). Nevertheless, it does appear that craving plays a role in the motivation to consume alcohol in certain instances, and in these instances it is important to understand the processes that contribute to alcohol use.
Several definitions for craving have been proposed via different theories and models of craving. Toneatto (1999) argues that craving is a metacognition, whereby the desire to consume alcohol causes a person to undergo a shift in thinking aimed at pacifying that desire from a cognitive perspective. This indicates that craving is, at least in part, a thought process related to the discomfort caused by the desire to consume alcohol. Sayette et al. (2000) state that craving has commonly been viewed as “a drug-acquisitive state, which motivates drug use” (p. S190). Additionally, Sayette et al. argue that craving has been defined differentially based on the focus of drug use. For example, craving may be defined in terms of the likelihood someone would use alcohol based on a certain situation such as when at a bar, or it may be defined in terms of the need to experience the effects of substances purely for their effects.

Other issues that affect the definition of craving include: whether it should be viewed as a constant or something that varies over time, whether there are different levels of craving, whether a person has to be conscious of craving for it to exist, whether craving needs to be present for drug use, or if it is even correlated to drug use. Even though these issues have not been resolved, current research evidence indicates that craving plays an important role in explaining substance use and the desire to use specific drugs. As such, several models of craving have been posited that examine the craving construct from various theoretical positions.

Models of Craving

Theoretical models of craving are numerous and span several research disciplines. The models that have been advanced by the different disciplines include: phenomenological models, conditioning theory models, cognitive models, and neurobiological models (Lowman, Hunt, Litten, & Drummond, 2000). The current research focused only on those models classified as cognitive models due to the nature of the research being conducted. These models include: the
cognitive labeling model, the outcome expectancy model, the dual affect model, the cognitive processing model, and the elaborated intrusion model.

The cognitive labeling model is based on the cognition arousal theory of emotion (Schachter & Singer, 1962). This theory holds that a person applies labels to different feeling states and uses those labels to cognitively classify their experiences (Tiffany, 1999). After several drinking episodes, a person begins to develop physiological responses to alcohol cues. Once these physiological responses and alcohol cues have been paired, a person begins to label the physiological responses that occur as the desire to consume alcohol or, craving. This model posits that the experience of craving is related to physiological arousal that is recognized or labeled as craving, and holds that the level or intensity of craving should be directly related to the level of or intensity of physiological arousal.

The outcome expectancy model of craving is based on the relationship between expectancies and motivations, as postulated by Marlatt (1985). According to this model, an alcohol cue raises the expectancy for the pleasurable effects of alcohol based on previous experiences (Tiffany, 1999). In return, a motivational component induces the desire to experience those pleasurable effects. Because of this relationship, a person experiences craving when they are cued by some form of alcohol stimulus that causes them to both recognize and desire the positive effects of alcohol. It is important to highlight that this model also postulates that the desire for the pleasurable effects of alcohol, or craving, is separate from urges or the actual intent to consume alcohol.

The dual-affect model of craving is based on the notion that positive and negative emotions are related to physiological responses to alcohol consumption, and, in-turn, these responses are associated with previous alcohol use. The pairing of responses and affect with
previous alcohol use leads to craving when similar emotional responses are present (Baker, Morse, & Sherman, 1987). According to this model, some of the causes for craving due to negative affect include: negative emotions (e.g. depression, anxiety), withdrawal, alcohol cues, and lack of availability of alcohol (Tiffany, 1999) Some of the causes for craving due to positive affect include: positive emotions, small quantities of alcohol, cues related to pleasurable events, and availability of alcohol. Positive and negative affect related cravings are mutually exclusive in this model. Additionally, it is proposed that this model includes the existence of cognitive networks related to previous experience that become activated during different affect states. Because of this, the level of craving is directly proportional to the level of activation of the cognitive network, which in turn, is related to the affect of the person.

Tiffany and Conklin (2000) argue for a model of craving in which craving represents a non-automatic process, i.e., the cognitive processing model. They argue that the use of alcohol is considered an automatic process that is based on repetition during previous drinking episodes. In this model, alcohol use occurs because a person has automatized the process of drinking similar to how tying one’s shoes becomes automatized, or easy to do with little effort after considerable practice. When presented with a scenario where one might drink, alcohol is consumed because the person is familiar with the situation, and the consumption of alcohol seems natural. For example, a person who visits a bar may drink because the drinking process has become automatized from previous drinking episodes. The consumption of alcohol, once automatized, does not require much cognitive effort and is not dependent on craving.

Contrary to the automatized consumption of alcohol, craving is viewed as a non-automatic process in the cognitive processing model (Tiffany & Conklin, 2000). Non-automatic processes are processes which are novel, and have not had sufficient repetition to become
automatized. Non-automatic processes include cognitions and behaviors required for novel tasks and tasks that involve interruptions of the completion of automatized tasks. Craving as a non-automatic process is in direct contrast to automatic processes because it requires the use of more cognitive resources. This distinction can be made by way of a comparison between automatically tying ones shoes versus calculating the solution to an algebra problem, which requires a large amount of cognitive resources.

One important aspect of the cognitive processing model is that the automatic process of drinking is not considered to be related to conditioned responses, or to the desire to consume alcohol to reduce craving, because alcohol use is viewed as something that is more complex than a stimulus-response cycle (Tiffany & Conklin, 2000). Instead of a simple response to a stimulus, alcohol use is viewed as a process that has become automatized after repetition in its own right with no need for a triggering factor. However, this model still leaves open the possibility that craving plays a role in the actual acquisition of alcohol when a person is prevented from finding a drink for some reason. As such, craving in the cognitive processing model primarily plays a role in the alcoholic individual’s “hunt” or “search” for their next drink when they encounter resistance.

The final model of craving to be discussed is the elaborated intrusion model of craving (May, Andrade, Panabokke, & Kavanagh, 2004). According to this model, cues or triggers initiate a non-conscious process whereby images are created related to the use of alcohol. The images related to alcohol use build as further associations are made with other alcohol-related images until the cognitive process eventually moves into conscious awareness. The intrusion of these thoughts is initially viewed as pleasurable, and leads to further associations with alcohol that are elaborated upon. As this elaboration continues over time, a person develops the
motivation to consume alcohol, and in instances where this is not possible, or when a person is trying not to consume alcohol, they experience a negative psychological state of craving.

The cognitive processing model and the elaborated intrusion model offer useful models of craving for the current research. The cognitive processing model is believed to be a useful model because it can account for the low correlation between alcohol use and craving that has been reported by alcoholic individuals. Similarly, the elaborated intrusion model is believed to be a useful model because it involves craving processes that operate similarly to Obsessive-Compulsive Disorder; an idea that has received some support in the craving literature (Anton, 1999). Additionally, both models postulate that a reduction in cognitive resources would result in an alcoholic individual having trouble abstaining from alcohol, which is supported by research that will be examined later.

**Measuring Craving**

As with the measurement of alcohol use, several issues are important to consider in the measurement of craving. Some of the more prevalent issues include: how to assess variables related to craving, the psychometric properties of such instruments, and the timeframe of the assessment to be considered (Drobes & Thomas, 1999).

Craving has been studied over time using a variety of means including self-report questionnaires, and more recently, measures of autonomic physiological arousal (Drobes & Thomas, 1999). Self-report questionnaires are the most frequently used type of craving measurement. However, measures of autonomic physiological arousal are becoming more prevalent. Some of the ways that physiological aspects of craving have been measured include: heart rate, blood pressure, sweat gland activity, and galvanic skin response. These same measures have been used in measuring withdrawal, though withdrawal involves more severe
physiological symptoms than craving. Additionally, since withdrawal and craving can occur at the same time, it is important to note that craving is a subjective desire for alcohol, whereas withdrawal is a physiological and psychological reaction to the lack of alcohol after the body has become dependent upon it.

New research is also being conducted based on use of advanced types of brain imaging such as functional magnetic resonance imaging (fMRI) to measure craving. Hugh et al. (2004) studied the relationship between fMRI and self-reported craving in a sample of 10 alcohol dependent individuals and 10 social drinkers. Individuals in each group were given a sip of alcohol and then exposed to a presentation of alcohol stimuli while undergoing fMRI. They found that the alcohol dependent individuals showed significantly more activation than the social drinkers in the nucleus accumbens, anterior cingulate cortex, and orbitofrontal cortex in active areas on their fMRI images when correlated with self-reports of craving. This indicates that self-report measures of craving are correlated with areas of the brain that are typically activated during craving, and that self-report measures of craving are measuring processes involved with the orbital frontal lobe; an area typically associated with executive function.

The primary issues involved in measuring aspects of craving with self-report questionnaires include, the accuracy of the measurement, as well as how the craving constructs should be operationalized. Currently, no consensus has been reached regarding the relationship between craving and alcohol use, or the desire to consume alcohol. Because of this, and the fact that there are several different models of craving, a decision had to be made to determine which measure to use in the current study, based on the constructs under consideration. Since the current research focused on cognitive aspects of craving, a self-report measure was used to capture the subjective experience involved in the cognitive experience of craving. This
subjective experience of craving involves thought processes and cognitions that cannot be directly tapped using physiological measures of craving or brain imaging.

The final issue involved in the measurement of craving involves the timeframe being considered in the measure (Drobes & Thomas, 1999). Craving measures are usually based on one of two timeframes: a state, or immediate measure of craving, or a global measure of craving that examines craving over a length of time. State measures are usually used when examining levels of craving at one time period, whereas global measures are usually used to examine the relationship between previous alcohol use and craving over time. The pros and cons of these two approaches are similar to the assessment of alcohol use.

Several measures of craving including: the Alcohol Urge Questionnaire, Obsessive-Compulsive Drinking Scale, Penn Alcohol Craving Scale, and Temptation-Restraint Inventory, were compared by Rosenberg and Mazzola (2007) to determine the relationship between the measures and also their relationship to alcohol use. Even though the measures included different items and time periods under examination, the measures had good convergent validity and did not appear to differ substantively based on the time periods examined. However, the Obsessive-Compulsive Drinking scale showed the highest correlation with number of binges and number of drinking days per week. The Obsessive-Compulsive Drinking Scale is a global measure of alcohol craving. Even though the measures did not appear to differ while measuring different time periods, the wording of the measures makes each of them appropriate for different situations that involve different periods of time under examination. The current research focused on a global measurement of craving in order to examine the phenomenon over time, as well as its relation to general alcohol use in the past.
Since cognitive models of craving focus on brain processes, it is important to determine which areas of the brain are involved in craving. One method for doing this is to examine craving using brain imaging studies, as described earlier. The theory behind this practice is that by examining the brain using imaging techniques, one should be able to determine which areas of the brain are activated when a person is placed into a cue induced craving state. Knowing which areas of the brain are active during craving can help inform cognitive models of craving.

In order to examine the areas of the brain involved in craving, Olbrich et al. (2006) used positron emission tomography to study blood flow in the brains of detoxified, alcohol dependent patients when exposed to alcoholic beverages. Areas of the brain found to have increased blood flow during craving included, the: right insula, left precentral and postcentral gyrus, left posterior cingulate gyrus, right occipital cortex, left cerebellar hemisphere and the cerebellar vermis. In addition, the left occipital cortex, right dorsolateral prefrontal cortex, and the left ventral putamen were found to have increased blood flow when craving was used as a covariate. These areas of the brain are involved in reward, memory, attention, and executive function.

Wilson, Sayette, and Fiez (2004) report that the areas of the brain most often found to be activated during craving in brain imaging studies include the: amygdala, anterior cingulate cortex, orbitofrontal cortex, and the dorsolateral prefrontal cortex. They also reported that these areas of the brain showing activation may be dependent on whether a person is in treatment, their expectation of future drug use, and on the use of possible coping mechanisms for dealing with drug craving.

In a review of studies examining brain imaging of craving, Hommer (1999) reported that the areas of the brain most often found to be involved in craving using various brain imaging
techniques such as single photon emission computed tomography, positron emission
tomography, and functional magnetic resonance imaging include: the nucleus accumbens,
caudate nucleus, thalamus, amygdala, orbital prefrontal cortex, dorsolateral prefrontal cortex,
and the anterior cingulate cortex. Hommer also suggested that the areas of the brain associated
with craving appear to be similar to areas of the brain that are involved in obsessive-compulsive
disorder, and that it is likely that craving and obsessive-compulsive disorder have similar
characteristics. Anton (1999) reported the same association between the areas of the brain
activated in craving and obsessive-compulsive disorder, and also added that these similarities
may indicate that craving operates in the same way as obsessive-compulsive disorder with
intrusive thoughts creating a desire to compulsively consume alcohol.

Lubman, Yucel, and Pantelis (2004) reported that the areas of the brain most involved in
both obsessive-compulsive disorder and alcohol craving include the anterior cingulate cortex and
the orbitofrontal cortex; however, they also stated that these areas work differently in different
situations. Specifically the anterior cingulate cortex and orbitofrontal cortex are underactive in
those who are addicted to alcohol and overactive in those with obsessive-compulsive disorder.
However, when a person is exposed to cues that solicit symptoms of craving or obsessive-
compulsive disorder both areas become overactive.

One area of the brain found by these imaging studies to be involved in both craving and
obsessive-compulsive disorder is the frontal lobe. Specifically, the prefrontal cortex, an area in
the frontal lobes that has been traditionally linked to executive function, and corresponds well
with the current research examining the cognitive components of craving. Because executive
function is largely believed to be responsible for the control of behavior, this area is believed to
be important in understanding the processes that occur during craving. Since craving appears to
operate similarly to obsessive-compulsive disorder, with both involving the frontal lobe, it was hypothesized that executive function should play a significant role in the control of craving-related thoughts and compulsions.

Executive Function

Defining Executive Function

Executive functions are defined as “general-purpose control mechanisms that modulate the operation of various cognitive subprocesses and thereby regulate the dynamics of human cognition” (Miyake et al., 2000, p. 50). According to Miyake et al., executive function is related to the central executive in Baddeley’s (1986) multicomponent model of working memory and Norman and Shallice’s (1986) supervisory attentional system. The central executive in these theories serves as the guiding force behind cognitive processes.

Five specific subprocesses, or “executive functions” have generated considerable research and are commonly regarded as component processes of executive function. These components, or executive functions, include: shifting, updating, inhibition, planning, and sustained attention. Of these executive functions, shifting involves the ability to change the focus of one’s attention to differing tasks (Miyake et al., 2000). Updating involves removing from memory information that is no longer needed while at the same time checking information to see if it is relevant for current processes. Inhibition involves the ability to stop one’s self from using prepotent responses in various situations. Planning involves the ability to determine a course of action cognitively and then put that plan into action. Finally, sustained attention involves one’s ability to focus on a task and disregard extraneous information over time. According to Miyake et al. (2000), components of executive function such as these should be examined using tasks
that are simple and specific to each component. Therefore, the current research focused on the use of tasks that were specific to these five executive functions.

*Measuring Executive Function*

As with alcohol use and craving, several issues are involved in the measurement of executive function. One of the most significant problems in measuring executive function involves the low test-retest reliability of measures of executive function (Hughes & Graham, 2002). This problem arises largely because executive function is often used to complete novel tasks. After a task has been completed, automatic processing begins to take over in future administrations, which increases a person’s performance on the same task, commonly known as practice effects. This results in low test-retest correlations in tests of specific components of executive function, which is a problem because there are limited ways to tap individual functions. Different measures can be correlated to establish construct validity for executive function; however, individual functions are more difficult to measure because of the need for a novel task. Additionally, executive function depends largely on the current processing load, so measurement of executive function can change over time.

Another issue in the measurement of executive function is the fact that executive function as a whole can be viewed as a collective process where several sub-functions are responsible for the processing of one task (Hughes & Graham, 2002). Miyake et al. (2000) conducted a study to examine the ability of executive function to be separated into component parts. Specifically they used three simple tasks to tap inhibition (antisaccade, stop-signal, Stroop), three simple tasks to tap updating (keep track, tone monitoring, letter memory), and three simple tasks to tap shifting (plus-minus, number-letter, local-global) and compared them to more global, complex, measures of executive function. The more complex measures included the Wisconsin Card Sorting Test,
Tower of Hanoi, random number generation, operation span, and dual tasking. The researchers had 137 college students perform each of the tasks and then used confirmatory factor analysis and structural equation modeling to examine the relationships among the tasks. They found that by using measures of executive function that are simple, and that tap specific aspects of executive function, the individual components of executive function could be adequately measured. It was found that the more specific tasks had enough discriminant validity to show that they were measuring separate areas of functioning, but enough convergent validity to show that they were all measuring executive function as a whole. Additionally, the separate component executive functions each accounted for performance differently on the complex tasks, such that the Wisconsin Card Sorting Test related most to shifting, the Tower of Hanoi related most to inhibition, random number generation related most to inhibition and updating, and operation span related most to updating. These results were interpreted by the authors to indicate that executive function can be measured at a more global level, where individual component functions are combined, or at a more specific level, where executive functioning is broken down into its component parts, each operating differently and accounting for different processes.

Tianyong and Deming (2005) attempted to replicate the findings of Miyake et al., and had similar results suggesting that executive function can be broken into component processes. Further, Friedman et al. (2006) conducted a study that also supported the results of Miyake et al. They compared specific components of executive function to measures of intelligence. They found that the components of executive function differentially related to intelligence such that updating was correlated with IQ, but shifting and inhibition were not.

One final issue involved in the measurement of executive function is that there may be a low correlation between executive function and specific behaviors (Hughes & Graham, 2000).
Deficits in specific aspects of executive function may result in a range of behaviors that may not seem to have underlying similarity. For example, deficits in inhibition may result in showing more overt acting-out behaviors, or it may have no real correlation to real-world behavior. However, Hughes and Graham argue that this may be understood by viewing executive function as a collection of related processes, consistent with the findings of Miyake et al. (2000), that may or may not be activated for a given situation.

Executive Function in Substance Dependent Individuals

As previously discussed, the executive functions are related to frontal lobe functioning. Therefore, one way to determine if there is a deficit in frontal lobe function in those who abuse alcohol is to examine their performance on executive tasks. For instance, in a test of performance on a number sequencing task, the P300 event related potential was used to compare alcoholic individuals with those who had frontal lobe lesions and also a control group with lesions in areas outside of the frontal lobe (George, Potts, Kothman, Martin, & Mukundan, 2004). The reasoning behind this design was that if alcoholic individuals have deficits in executive function, they will have a P300 profile similar to those with frontal lobe lesions, yet different from the control group. In fact, this was the case, as the alcohol group and the frontal lobe lesion group performed similarly on the task and had similar P300 event related potentials versus the control group. Because of the importance of executive functions in the control of behavior, these findings suggest that those who abuse alcohol may have problems controlling their behavior towards drinking. However, in order to understand such executive functioning problems more precisely, more specific aspects of executive function should be examined.

In a study examining the specific deficits of executive function in alcoholic individuals, 22 males with alcohol problems were compared against 22 matched controls on several measures
of executive function, including: the digit symbol task, the trail making test, the Stroop test, the
digit cancellation test, the Wisconsin Card Sorting Test, and a computerized reaction time task
(Ratti, Bo, Giardini, & Sorgana, 2002). Collectively these tasks measure psychomotor
performance, ability to shift attention, mental flexibility, divided attention, response inhibition,
selective attention, reaction time, cognitive set persistence, concept identification, ability to use
feedback, and hypothesis generation. The male alcoholics performed worse than the control
group on every measure but the stroop task which examines inhibition. However, the authors
reported a trend towards significance on this task, consistent with previous research showing
significance. Taken together, the results indicate that those who abuse alcohol show deficits in
both global and specific processes of executive function. While deficits in executive function
have been found using more global measures, others have argued that it is more important to
examine the sub-processes in executive function, because examining more global measures may
confound what is precisely causing the deficits (Whitney, Jameson, & Hinson, 2004).

*Craving and Executive Function in Young Adults*

One limitation of studies on executive function, alcohol use, and craving is that they are
often conducted using samples of adults who have a long history of alcohol use. This begs the
question of whether problems in executive function due to alcohol use and craving can be
replicated in younger populations, which may not have as long of a drinking history. One area of
research that indicates that young adults may suffer from similar “deficits” in executive function
involves the development of executive function.

Through magnetic resonance imaging studies, it has been found that the brain continues
to change throughout life. One specific area of the brain, the prefrontal cortex, undergoes drastic
changes starting during puberty and ending sometime during a person’s 20s (Blakemore &
Choudhury, 2006). During this period, white matter in the frontal lobe increases while grey matter decreases. It is believed that this process signifies enhanced myelination of the frontal lobe. Additionally, it is believed that this process signifies synaptic reorganization through processes such as synaptic pruning. An association has been found linking this developmental process of the prefrontal cortex with enhanced executive function abilities. Thus, it is believed that executive function is not fully developed until sometime after puberty.

Since the prefrontal cortex, and thus, executive function, do not fully come on-line until just after puberty, one would expect that the use of alcohol during adolescence and young adulthood would affect the development of these areas. Research has been done examining the use of alcohol during adolescence and its effects on brain development and neuropsychological functioning and this hypothesis has been supported.

Tapert and Brown (1999) studied the effects of alcohol use in adolescents between the ages of 13 and 19 over the course of four years. Specifically, they examined neuropsychological functioning in those who consumed alcohol heavily over the four years versus those who did not, or who stopped alcohol use at some time over the 4 years. They found that compared to those who did not drink as much, those who heavily consumed alcohol had deficits in attention. Additionally, it was found that those who suffered more periods of withdrawal had worse visuospatial functioning. That the individuals had deficits in attention, which is linked to executive function, and the frontal lobe, indicates that alcohol use during late puberty negatively affects the development of executive function.

Given that alcohol use has been shown to have negative effects on neuropsychological functioning on adolescents, one must question how prolonged alcohol use affects young adults. Specifically, how does alcohol use affect the college student population, which has high rates of
alcohol abuse and dependence (Knight et al., 2002)? Further, since problems with executive function due to alcohol use have been shown to perpetuate the craving process, which is viewed as one of the primary contributing factors to alcohol use, how are craving and executive function related in young adults and college students?

In a study using 80 college students to examine deficits in executive function it was found that students who abuse alcohol make decisions faster and have more trouble inhibiting behavioral responses than a control group (Whitney, Hinson, & Jameson, 2006). This is interesting because it indicates that those who abuse alcohol have a specific deficit in executive function that could contribute to their use of alcohol, or at least to their inability to make the decision not to drink.

Noel, Bechara, Dan, Hanak, and Verbanck (2007) further supported the notion of a behavioral response inhibition deficit, and a decision-making deficit, by comparing 30 alcoholic individuals with 30 matched-control participants on several measures of executive function. Specifically they compared the subjects” performance on the Iowa Gambling Task, the Brixton Test, the Hayling Task, and the Alpha-Span Task. Of particular note, Noel et al. found that the alcoholic individuals performed worse than the control group on the Iowa Gambling Task, a measure of response inhibition and decision-making. Additionally, they found that the alcoholic individuals made more response inhibition errors on the Hayling Task, more errors on the Brixton Test, and that the alcoholic individuals had an impaired ability to manipulate information in working memory on the Alpha-Span Task when compared to the control group. Further evidence that the same types of executive deficits found by Whitney et al. (2006), and Noel et al. (2007), exist in non-clinical college undergraduate samples was also provided via the results of a study reported by Hester and Garavan (2005).
Hester and Garavan (2005) examined the executive control of attention in a sample of undergraduate students. Specifically they examined how the load on working memory affects content specific rehearsal of information, and how this in turn affects switching and inhibition. They discovered that when subjects focused on content specific information related to alcohol it was harder for them to inhibit responses related to that information, or to switch their attention to the content of other information as the load on working memory increases. They postulated that, because of this, those who are thinking about substances due to specific substance related cues, may have trouble shifting their attention to something else, or ultimately inhibit actions related to the substance. Thus, from a cognitive perspective, it may be that some individuals get into a cycle where they ruminate about the use of a substance, such as alcohol, and ultimately have trouble stopping themselves from drinking due to limitations in executive functions perhaps brought on by the ruminative process or a preexisting problem in executive functioning.

This study provides evidence for a capacity limitation in executive function, which can lead to (or be brought on by) rumination over the use of a substance such as alcohol. One would presume that as a person begins to think about alcohol, or experiences alcohol related cues, the ruminations over the use of alcohol would lead to a person having trouble inhibiting the desire to drink, or at least from being able to switch the content of their attention to something that is not related to alcohol. Taken together, this proposed process and the related findings highlight a potential link between craving and obsessive-compulsive disorder.

Further evidence for a deficit in working memory that is related to difficulty in suppressing unwanted thoughts such as in obsessive-compulsive disorder was found by Brewin and Smart (2005). They examined 60 college students using tasks measuring working memory capacity, intrusive thoughts, negative mood, and thought suppression. Brewin and Smart found
that working memory capacity was related to intrusive thoughts suggesting that when a person is trying to suppress an intrusive thought they have more difficulty doing so with poorer working memory capacity. This further supports the hypothesis that unwanted craving-related thoughts and obsessive thoughts in obsessive-compulsive disorder are difficult to control when one has a limited capacity in areas related to executive function such as working memory.

**Executive Function and Family History of Alcoholism**

One potentially confounding factor in the relationship between executive function, alcohol use, and craving is family history of alcoholism. Several studies have examined the relationship between family history of alcoholism and executive function with mixed results. Interestingly, it is often found that family history moderates the relationship between individual alcohol use and neuropsychological dysfunction (Tapert & Brown, 2000).

Tapert and Brown (2000) examined the relationship between alcohol use, neuropsychological function, and family history of alcohol dependence in 151 adolescents aged 13 through 18. Specifically, they examined the relationship between family history of alcohol dependence and individual alcohol use on language, visuospatial abilities, verbal memory, attention, and executive function while controlling for conduct disorder and demographic variables. Using hierarchical multiple regression, the researchers discovered that family history moderated the relationship between alcohol use and the dependent variables. As such, those with a negative family history for alcohol abuse performed better on tests of language and attention than those with a positive family history. This occurred through an interaction between alcohol use and family history. The authors concluded that this indicates that family history and individual alcohol use are separate factors involved in neuropsychological dysfunction. As such,
it is important to account for family history of alcohol abuse when examining neuropsychological function in problem drinkers.

To examine the relationship between family history of alcohol abuse and executive function in healthy young adults, Lovallo et al. (2006) compared individuals with a positive family history of alcohol abuse against individuals with a negative family history of alcohol abuse on measures of neurocognitive inhibition. The individuals were also classified on their level of behavioral disinhibition. Two tasks were used to measure inhibition including the Stroop Color-Word Test and the Iowa Gambling Task. It was found that individuals with a positive family history of alcohol abuse, who were behaviorally disinhibited, showed higher levels of interference on the Stroop Color-Word Test than those with a negative family history of alcohol abuse. Additionally, males with a positive family history of alcohol abuse focused more on financial gains on the Iowa Gambling Task than females and those who were family history negative. The authors concluded that this indicates that those with a family history of alcohol abuse, who are also behaviorally disinhibited, have a deficit in working memory, and that disinhibited males focus more on the rewards of risk-taking than females. This study also suggests that there may be a problem in executive aspects of working memory for those who have a positive family history for alcoholism even when the individual does not abuse alcohol or drugs.

Also, in a study examining a broader range of executive functions in those with a positive family history for alcohol abuse, Dolan, Bechara, and Nathan (2008) compared individuals using the Wisconsin Card Sorting Test, Trail Making Test, Stroop Color-Word Test, Iowa Gambling Task, and WAIS-R Digit Span. The family history positive participants, who also qualified for an alcohol use disorder, performed worse than the family history negative individuals on the
Wisconsin Card Sorting Test which indicates an executive function deficit in set shifting ability. No other differences were found between the family history positive and negative alcohol abusers. As such, this study provides more support to the notion that family history is an important variable to account for when examining the relationship between alcohol use and measures of neurocognitive function. Additionally, these findings indicate that it is important to assess family history of alcoholism when measuring neuropsychological functioning in substance abusing individuals as well as individuals in the general healthy population.

Description of Project

*Research Question*

Taken together, the findings discussed indicate that there is a relationship between alcohol use, craving, and executive function. Specifically, alcohol use is related to “deficits” in executive function, and the use of alcohol has the ability to further decrease executive function (Tapert & Brown, 1999). Additionally, previous research has shown that deficits in executive function are related to craving in that deficits in executive function may lead to the perpetuation of craving related thoughts (Hester & Garavan, 2005). Further, brain imaging studies have shown that areas in the prefrontal cortex believed to be related to executive function are activated when a person is experiencing craving (Hommer, 1999; Olbrich et al., 2006; Wilson, Sayette, & Fiez, 2004). As reported, much research has been done on the relationship between executive function and craving, but there is a lack of research that breaks down executive function into its component processes, as suggested by Miyake et al. (2000), and examines them in relation to craving. Additionally, several studies have been done that examine the relationship between craving and executive function on adult inpatient substance abusing populations, but little research has been done examining this relationship in young adults who do not have as long or
severe of a drinking history. Since research has shown that alcohol use in young adulthood leads to deficits in neuropsychological function (Brown, Tapert, Granholm, & Delis, 2000; Tapert & Brown, 1999), a research avenue to pursue involves how these deficits in neuropsychological functioning affect craving.

The current study examined the relationship between alcohol use, craving, and executive function with the goal of determining how components of executive function were related to higher levels of craving and alcohol use. In addition, family history of alcohol problems was examined to help further understand the associations between alcohol use, craving, and executive functioning. The nature of these variable associations was studied in a college student population to enable an examination of the effects of alcohol in those with a shorter abuse history and potentially contribute to the developmental literature on substance abuse and neuropsychological function. Finally, the current research may be valuable in advancing our understanding of cognitive models of craving and potentially contribute to the current thinking on cognitive aspects of craving research.

Operational Definitions

Several variables were examined including five executive functions, craving, alcohol use, and family history of alcoholism. The five executive functions examined included: inhibition, set shifting and mental flexibility, sustained attention, mental allocation and planning, and updating of working memory. Inhibition was measured using the Stroop Color and Word Task (Stroop, 1935). Specifically, the reaction times produced by interference related to the Stroop effect were regarded as a measure of inhibition with longer reaction times indicating worse performance. Set shifting and mental flexibility was measured using a research version of the Wisconsin Card Sorting Test (Grant & Berg, 1948) with number of perseverative errors used as the measure of
shifting ability. The Continuous Performance Task – Identical Pairs Version (Cornblatt, Risch, Faris, Friedman, & Erlenmeyer-Kimling, 1988) was used as a measure of sustained attention. The value of $D'$ was used as the criterion score with lower values indicating worse performance on executive aspects of sustained attention. Mental allocation and planning was measured using the Tower of London Task (Shallice, 1982), with total moves and time to completion regarded as the criterion score. Specifically, more moves and a longer completion time are used to indicate a decrease in planning ability. Finally, updating of working memory was measured using the N-back Task. Specifically, the 2-back and 3-back conditions of the N-back task were used with total number correct used as the score under consideration, and lower scores indicating deficits in working memory updating ability.

Problematic alcohol use was measured using the total score on the Alcohol Use Disorders Identification Test (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001) with higher scores indicating more problematic alcohol use. A cut-off score of 5 for males and 4 for females was used to define those who qualify as problem drinkers. Craving was measured using the Obsessive Compulsive Drinking Scale (Anton, Moak, & Latham, 1995). This scale was used, as it is a cognitive measure of alcohol craving-related thoughts. As such, higher scores indicate a higher load of craving related thoughts. A cut-off score of 7 was used to define those who experience alcoholic levels of craving. Finally, family history was measured using the Family Tree Questionnaire (Mann, Sobell, Sobell, & Sobell, 1985). Specifically, a designation of family history positive was given for individuals with one or more relative who qualifies as a definite or possible problem drinker on either the maternal or paternal side of the family in accordance with formal scoring criteria.
Hypotheses

It was hypothesized that areas of executive function including mental set shifting, updating, planning, inhibition, and sustained attention would be related with varying degrees to alcohol use, such that higher levels of alcohol use would correspond to higher levels of executive dysfunction. It was also hypothesized that executive dysfunction would be related to craving, in that higher levels of craving would be related to higher levels of executive dysfunction. Finally, it was hypothesized that those with a positive family history would perform worse on the measures of executive function, and would be more likely to have an alcohol use disorder or experience craving.
CHAPTER 2

METHOD

Participants

An a priori power analysis was calculated to determine the number of participants required to detect a moderate effect, Cohen’s $f^2 = .15$, using multiple regression with 5 predictors and 80% power (the initially proposed analysis). The minimum sample size required was 92 participants.

Participants were recruited through the research participant pool at the University of North Texas, and also through courses whose instructor agreed to provide extra credit to students for participation. A limited number of individuals who reported a prior history of head trauma resulting in unconsciousness ($n = 3$), a diagnosis of a developmental disorder ($n = 7$), or who reported using psychoactive medications ($n = 13$), or drugs other than alcohol, caffeine, or nicotine ($n = 12$) were included in the study. Analyses were conducted using $t$-tests and no significant differences were found that would preclude their inclusion in the study or further analyses. All participants were asked to abstain from alcohol for 24 hours prior to their participation; however, due to limited resources, no objective measure was used to ensure compliance. Additionally, nontraditional students under the age of 18 or over the age of 24 were not included in the sample. After meeting this exclusion criteria, a convenience sample of 121 undergraduate students at the University of North Texas (see Table 1) were included in the study. The sample was similar in demographics to the undergraduate student body at the University of North Texas with 58.8% Caucasian, 19.3% African American, 8.4% Hispanic, 0.8% East Indian, 5.9% Asian, and 6.7% other (UNT Fact Book, n.d.). Additionally, females comprised 70.8% of the sample while males comprised the other 29.2% of the sample. The mean age of individuals in
the total sample was 19.58 ($SD = 1.596$). Finally, 34.7% of the individuals included in the sample were qualified as problem drinkers, a percentage that is similar to other college student samples (Knight et al., 2002).

Measures

*Stroop Color and Word Test*

The Stroop Color and Word Test (Stroop, 1935) that was used in the current in the current study is a computerized test of executive function measuring response inhibition. The test was administered on a computer running Windows XP. During the test, three response phases are utilized with each having 100 prompts requiring the participant to press one of three keys indicating red, green, or blue. In the first response phase, the subject is shown the randomized names of the colors red, green, and blue in black coloring and asked to respond by pressing one of the three keys before moving to the next item. In the second response phase, the subject is shown the prompt XXXX randomized in the different colors (red, green, and blue) and asked to press the key corresponding to the displayed color. In the final phase, the respondent is shown randomized prompts including the words red, green, and blue in red, green, and blue colors that are incongruent with the printed word. In this phase the subject is asked to press the key that corresponded with the printed word and not the color of the word. The test produces a reaction time measuring the difference between the third phase and the average of the first two phases, as well as a record of the number of errors. The reaction time is a measure of the interference caused by the incongruent word-color pairs and is used as a measure of inhibition. Finally, a measure of the number of errors averaged over the first two phases against the third phase is provided, which was used in this study to exclude individuals who performed at less than 90% accuracy. The Stroop Color and Word Test is a widely used measure of inhibition and has shown
good validity and reliability (Miyake et al., 2000). Specifically, it has shown split-half reliability of .72.

**Wisconsin Card Sorting Test**

A computerized research version of the Wisconsin Card Sorting Test (Grant & Berg, 1948) was used to measure mental set shifting and flexibility. The test was administered using the Psychology Experiment Building Language (PEBL) program, version 0.09, on a Windows XP computer (Mueller, 2008). During the test, subjects are presented with trials involving 80 stimulus cards that are matched to 4 target cards. The target cards, which appear fixed at the top of the computer screen, include a card with a single red circle, a card with two green stars, a card with three blue squares, and a card with four yellow plus symbols. The stimulus cards, which appear one after the other in the bottom right corner of the screen, use similar symbols and colors, which are varied to create combinations with each type of symbol, number of symbols, and color of symbols. The respondent is required to match the stimulus card with the target cards based on unknown, randomized, rules. In order to match the stimulus card with the target card, the respondent is asked to press the number key on a keyboard, which corresponds to one of the four target cards. After completing all trials the program calculates the number of perseverative errors. These scores were used as a measure of mental set shifting and flexibility with higher numbers of perseverative errors indicating poorer shifting ability. The Wisconsin Card Sorting Test is a widely used and valid measure of mental set shifting; however, it has been found to have poor test-retest and alternate-form reliability (Bowden et al., 1998).

**Continuous Performance Test – Identical Pairs Version**

The Continuous Performance Test – Identical Pairs Version (CPT-IP), (Cornblatt, Risch, Faris, Friedman, & Erlenmeyer-Kimling, 1988) is a computerized continuous performance task
that measures sustained attention. It was presented on a computer running Windows XP. The CPT-IP has 10 different configurations that can be used, however, only one of the default configurations was used for the current study. This configuration presents the subject with 150 different trials where the stimulus is displayed for 50 msec, followed by 950 msec. of a blank screen. In the configuration chosen for this study, the subject is presented with random four digit numbers. The subject is required to lift their finger off of a button on a computer mouse each time they recognize two stimuli in a row that are identical. Over the course of the presentation of the stimuli, 20% are truly identical, 20% are nearly identical but wrong, and 60% are clearly wrong. The value of $D''$, a measure of signal detection, was used to examine sustained attention, with higher numbers indicating a better performance. The CPT-IP has good reliability and validity with a test-retest coefficient of .84 (Nuechterlein et al., in press).

Tower of London

A computerized Tower of London task based on the original test by Shallice (1982) was selected as the measure of attention allocation and planning. The task was presented on a personal computer running Windows XP. On the computer monitor, subjects are presented with two panes. In the pane on the left side of the screen, or the working area, they are presented with three pegs and three balls of different colors located on the pegs. In the pane on the right side of the screen, or the goal position, they are presented with three pegs with the colored balls in an arrangement which they are to reproduce. The subject is instructed to move the balls in the working area so that they resemble the arrangement on the goal position in as few moves as possible. After completing a set with three pegs and three balls, the task changes to include four pegs and four balls, and then five pegs and five balls. The directions are the same throughout. The number of moves required is recorded for each participant with fewer moves indicating
better attention allocation and planning. Additionally the time to completion after the first move is recorded with longer times indicating worse planning ability. The Tower of London is a valid test that has been used in several studies to measure planning ability, however the reliability coefficients reported for this test have been poor ranging from .25 to .79 (Welsh & Huizinga, 2001). Additionally, very little research to date has been done on the reliability of this measure.

\textit{N-Back Task}

The computerized N-back task was chosen as a measure of updating of working memory. During the N-back task, the subject is presented with a series of numbers and must recall whether a number they are currently seeing is the same as a number they have previously seen. The position of the number the individual is tracking in the series is based on a predetermined differential or N. In the computerized N-back task chosen for this study, the 2-back and 3-back conditions were selected whereby the subject would have to determine if the currently displayed number is the same as a number displayed 2 numbers before, or 3 number before respectively. The N-back task is fully computerized and was presented on a personal computer running Windows XP. The presentation of numbers is 2 numbers per second and is a continuous data stream on the monitor. The numbers appear in a small box in the center of the computer screen. The subject is required to press a key every time they recognize a number as being the same based on the N for the specific portion of the task. The total number of correct responses for both the 2-back and 3-back conditions were calculated as a measure of working memory updating with higher numbers indicating better performance. The N-back test has been shown to have good reliability and validity when used as a measure of working memory updating (Ellis, Mehta, Wesnes, Armstrong, Nathan, 2005).
**Obsessive Compulsive Drinking Scale**

The Obsessive Compulsive Drinking Scale (Anton, Moak, & Latham, 1995) is a 14 item self-report scale measuring alcohol related thoughts (see Appendix A). This scale was designed to be used as a measure of alcohol craving, and focuses on the obsessive thoughts related to alcohol rumination. Additionally, the scale measures compulsions, as well as, the amount and frequency that a person drinks. Questions 1-6 of the Obsessive Compulsive Drinking Scale measure alcohol obsessions, while Questions 7-14 of the scale measure alcohol compulsions. A cutoff score of 7 has been shown to reliably differentiate individuals with an alcoholic level of craving, and it was reported by Anton et al. that little is gained using separate scale scores for the two portions of the measure. This scale was chosen to quantify the amount of craving an individual experiences on a global basis over a period of several weeks. This scale measures craving in a manner similar to measures of Obsessive Compulsive Disorder. It has been shown to have good reliability and validity with a test-retest coefficient of .96.

**Alcohol Use Disorders Identification Test**

The Alcohol Use Disorders Identification Test (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001) is a 10 item self-report scale designed as a screening test for alcohol disorders (See Appendix B). The test uses a likert-type scale for each question with scores ranging from 0 to 4. The highest attainable score on the Alcohol Use Disorders Identification Test is 40, and the lowest score is 0. The test measures the level of disordered drinking that a person engages in on average, and uses this information to label drinkers as potentially having an alcohol use disorder. In order to provide the most sensitive and reliable measure of alcohol use disorders, the recommended cutoff score for women is 4, and for men it is 5 (Reinert & Allen, 2007). The Alcohol Use Disorders Identification Test is a widely used measure and has good reliability and
validity with internal consistency coefficients ranging from .75 to .97. This test was used to
classify participants as having an alcohol use disorder. The cutoff score was also used for
descriptive purposes to describe the overall stratification of the sample.

*Family Tree Questionnaire*

The Family Tree Questionnaire (Mann, Sobell, Sobell, & Sobell, 1985) is a brief self-
report instrument designed to gather information about an individual’s family history of alcohol
use. Individuals are presented with a graphical portrayal of their family tree including their
parents, grandparents, brothers, and sisters. An individual is asked to rank each family member
on their history of alcohol use using one of six descriptors including: never drank, social drinker,
possible problem drinker, definite problem drinker, no relative, or don’t know or remember.
Based on the information presented by the individual, a qualitative determination can be made on
whether or not the individual should be classified as having a positive family history of alcohol
abuse or not. Using liberal criteria, an individual is determined to have a positive family history
of alcohol abuse if any of their relatives is described as a possible problem drinker or a definite
problem drinker. Using conservative criteria, individuals are determined to have a positive
family history of alcohol abuse if any of their family members is described as being a definite
problem drinker. The liberal criteria were used in the current study to provide a higher level of
sensitivity while still maintaining adequate specificity. Previous studies have indicated that the
test-retest reliability of the Family Tree Questionnaire is good with coefficients ranging from .78
to .94 (Hodgins & Shimp, 1995).

**Procedure**

Participants were initially given an informed consent form and the study was explained to
them. They then filled out a paper-and-pencil demographic survey (see Appendix) that included
questions related to previous head trauma, developmental disorders, and drug use. All participants also completed paper-and-pencil versions of the Alcohol Use Disorders Identification Test, the Family Tree Questionnaire, and the Obsessive Compulsive Drinking Scale. The participants were then asked to complete computerized versions of the Tower of London, Wisconsin Card Sorting Test, the Continuous Performance Task – Identical Pairs Version, the Stroop Color and Word Test, and the N-back Task. These tests were given in a fixed order due to the short duration of testing which was approximately 30 minutes. All computerized tests were completed on a 2.4 ghz Pentium IV computer in the Neurocognition and Personality Research Lab at the University of North Texas. After completing all of the tasks, the participants were verbally debriefed and given time to ask any questions.

To ensure the confidentiality of all participants, each subject’s participation was recorded using a numbering system that was not connected to any personally identifying information. All computer results were password protected on a computer in a locked room. Also, all documents and paper-and-pencil self-report measures were kept in a locked file cabinet in a locked room.
CHAPTER 3
RESULTS

Descriptive Statistics

Alcohol, Craving, and Family History

As reported earlier, there were 121 participants included in the study. Out of those participants 34.7% qualified as problem drinkers \( n = 42 \) based on their score on the Alcohol Use Disorders Identification Test (AUDIT), and 18.2% reported having craving levels consistent with alcohol dependence \( n = 22 \) based on their score on the Obsessive Compulsive Drinking Scale (OCDS). A breakdown of individuals by demographic group, problem drinking, and alcoholic level of craving, is reported in Table 1. The mean age that individuals reported for when they started to drink alcohol, for those who reported drinking alcohol, was 16.64 \( (SD = 2.104) \). Additionally, the mean number of drinks per week reported for the total sample was 3.00 \( (SD = 2.915) \), for males was 4.14 \( (SD = 3.468) \), and for females was 2.54 \( (SD = 2.555) \). The number of drinks reported per week by males and females fell short of significance, \( t (29) = 1.98, p = .057 \), equal variances not assumed.

To examine the properties of the Alcohol Use Disorders Identification Test and the Obsessive Compulsive Drinking scale, the mean, standard deviation, skew, kurtosis, alpha, and mean inter-item correlation for each measure were calculated for the total sample, males, and females (see Tables 3, 4, and 5). Both males and females reported similar levels of problem drinking and craving, with no significant difference in AUDIT scores, \( t (117) = 0.931, p = .354 \), or OCDS scores, \( t (116) = -0.061, p = .951 \).

Family history of alcohol use was assessed with the Family Tree Questionnaire. The breakdown of family history classification by males, females, and the total sample is provided in
Table 6. Individuals were classified as family history positive (FH+) or family history negative (FH-) using four separate metrics. Specifically, they were classified by using only the maternal side of their family (maternal), only the paternal side (paternal), by a composite of maternal and paternal relatives (MatPat), and using only their parents (parental). The mean number of relatives described as possible problem drinkers or definite problem drinkers for males was 1.09 (SD = 1.067), and for females it was 1.39 (SD = 1.255). For individuals who were classified as FH+ when examining all relatives (MatPat), the mean number of relatives described as problem drinkers for males was 1.85 (SD = .745), and for females it was 2.08 (SD = 1.007).

**Executive Function**

Descriptive statistics are provided for performance on each of the measures of executive function by total sample, males, and females in Tables 7, 8, and 9, respectively. The mean, standard deviation, skew, and kurtosis were calculated for each test. The measures included were the interference reaction time on the Stroop Color and Word Test (Stroop), total number correct on the Tower of London (TOL-TC), time before first move on the Tower of London (TOL-PT), total correct in the 2-back condition of the N-back task (N-Back 2), total correct in the 3-back condition of the N-Back task (N-Back 3), $D^*$ on the Continuous Performance Task – Identical Pairs version (CPT-IP D*), and total number of perseverative errors on the Wisconsin Card Sorting Test (WCST). No significant differences were found between males and females for each of the executive function measures. However, there was a trend toward significance with males performing slightly worse than females on the TOL-PT, $t (93) = 1.833, p = .070$, Cohen’s $d = .92$. Additionally, there was a trend towards significance in performance on the N-Back 2 with males performing slightly better than females $t (45) = 1.824, p = .075$, Cohen’s $d = .41$, equal variances not assumed.
In accordance with Miyake et al. (2000), correlation coefficients were calculated between the scores on all of the measures of executive function to ensure that they share some variance, but are measuring different aspects of executive function. This appears to be the case as all of the measures were slightly correlated (see Table 10), but none of the measures accounted for all of the variance in any of the other measures. TOL-PT showed a significant negative correlation with TOL-TC, $r(95) = -.352, p < .01$. Also, N-Back 3 showed a significant positive correlation with N-Back 2, $r(96) = .625, p < .01$, and finally, WCST showed a significant negative correlation with N-Back 3, $r(93) = -.239, p < .05$. These results were expected given that each measure is designed to measure a different aspect of executive function, but there should be some shared variance in that these are related executive processes.

Because the Stroop is a composite variable of reaction time scores, means and standard deviations are provided for males and females for each component of this measure in Table 11. Independent samples $t$-tests were calculated to determine if there were any differences between reaction time scores by gender on each component of the Stroop, and no significant differences were found.

**Inferential Statistics to Test Study Hypotheses**

**Relation Between Alcohol Use and Executive Function**

To test the hypothesis that alcohol use would be related to poor executive function, several statistics were calculated. To examine the relationship between alcohol use and executive function, Pearson correlation coefficients were calculated between AUDIT scores and each of the executive function measures for the total sample (see Table 12). None of the variables were found to be significantly correlated, thus the analyses were broken down by gender. To examine the relationship between AUDIT scores and executive function in males, Pearson correlation
coefficients were calculated, and there were no significant relationships (see Table 13).

Additionally, Pearson correlation coefficients were calculated between AUDIT scores and each of the measures of executive function using only the females. AUDIT scores were found to have a significant negative correlation with the N-Back 3 \( r (72) = -.267, p < .05 \), (one-tailed).

Additionally, a trend towards significance was found in a positive correlation between AUDIT scores and WCST scores \( r (73) = .180, p = .065 \), (one-tailed). No other relationships were found to be significant (see Table 14).

To further explore the relationship between executive function and problematic alcohol use, \( t \)-tests were calculated using the AUDIT cutoff scores to group individuals. A cutoff score of 4 was used for females and 5 was used for males in accordance with cutoffs suggested by the literature discussed earlier. As with the correlations, separate analyses were conducted for males and females. It was found that females who were classified as problem drinkers performed significantly worse than females who were classified as non-problem drinkers in the total number of correct responses on the N-Back 3, a test of working memory updating, \( t (70) = 2.58, p < .01 \) (one-tailed), Cohen’s \( d = -.61 \). No significant difference was found for females between the AUDIT groups on the N-Back 2. Additionally, it was found that females classified as problem drinkers made significantly more perseverative errors on the WCST than females classified as non-problem drinkers, \( t (71) = -1.85, p < .05 \) (one-tailed), Cohen’s \( d = .43 \). No other significant differences were found between the two groups (see Table 15).

Comparing male problem and non-problem drinkers, as classified by the AUDIT cutoff scores, it was found that males classified as problem drinkers took significantly more planning time than males classified as non problem drinkers on the Tower of London \( t (22) = -1.74, p < .05 \) (one-tailed), Cohen’s \( d = .89 \). Additionally, there was a trend toward significance on the
Stroop test with male problem drinkers showing slightly better performance than male non-problem drinkers, \( t(24.342) = 1.44, p = .081 \) (one-tailed), Cohen’s \( d = -.48 \), equal variances not assumed. No other significant differences were found (see Table 16), however, there is a possibility of a type-II error due to the low number of males used in the comparison.

Based on these results, the first hypothesis is partially confirmed in that both males and females showed significant differences in performance on various measures of executive function. Females showed significant differences in updating of working memory and set-shifting ability when comparing those classified as problem drinkers with those classified as non-problem drinkers. Additionally, males showed a significant difference in planning ability when comparing problem and non-problem drinkers.

Relation Between Craving and Executive Function

To test the second hypothesis that poor executive function would be related to higher craving scores, it was initially planned that multiple regression analyses would be used to predict craving scores using the executive function measures. However, because of the low number of males who participated in the study and the need for separate analyses by gender, this was not possible. As such, Pearson correlation coefficients were calculated to explore the relationship between craving based on OCDS scores, and each of the executive function measures. As with problem drinking, correlation coefficients were initially calculated for the total sample and showed no significant relationships (see Table 12). Pearson correlation coefficients were then calculated examining the relationship between OCDS scores and performance on the executive function measures using just the males. It was found that OCDS scores were negatively correlated with CPT-IP scores, a measure of sustained attention, \( r(32) = -.408, p < .05 \), (one-tailed). Additionally, there was a trend toward significance with a positive relationship between
OCDS scores and N-Back 3 performance, $r (24) = .302, p = .076$, (one-tailed). No other significant correlations were found for males (see Table 13). Pearson correlation coefficients were also calculated for females, and it was found that OCDS scores had a significant positive relationship with Stroop performance $r (66) = .210, p < .05$, (one-tailed). This relationship indicates worse performance on the Stroop with increasing craving. No other significant relationships were found for females.

To further explore these relationships, both males and females were divided into high and low craving groups using a cutoff score of 7. These two groups were compared using $t$-tests on their performance on each of the executive function measures. There was a trend towards significance for females on the N-back 2 with the high craving group performing better than the low craving group, $t (70) = -1.34, p = .093$ (one-tailed), Cohen’s $d = .39$. Additionally, there was a trend towards significance on the WCST with females classified in the high craving group making more perseverative errors than females classified in the low craving group, $t (15) = -1.57, p = .068$ (one-tailed), Cohen’s $d = .52$, equal variances not assumed. However, no significant differences were found between the two groups (see Table 17).

When examining males in the high and low craving groups (see Table 18) it was found that males in the high craving group performed significantly worse on the CPT-IP than males in the low craving group, $t (30) = 2.12, p = .022$ (one-tailed), Cohen’s $d = -.99$. This indicates a deficit in sustained attention. No other significant differences were found, however it is important to recognize the possibility of a type-II error due to the low number of males participating in the study.

Based on these results, the hypothesis that executive function would be related to craving was partially supported. Specifically, females showed no significant differences between high
and low craving groups on any of the executive function measures. However, there was a significant positive correlation between Stroop reaction times and OCDS scores indicating poorer performance. Males showed a significant negative correlation between OCDS scores and performance on the CPT-IP. This relationship was further confirmed when comparing group differences between males in the high and low craving groups.

Relation Between Family History, Executive Function, Craving, and Alcohol Use

To explore the final hypothesis that individuals classified FH+ would show deficits in executive function, be more likely to experience craving, and be more likely to show problematic drinking, several computations were performed. Because of the differences between the performance of males and females found earlier, all of the statistics were calculated independently between genders.

To initially explore the relationship between the alcohol, craving, executive function, and family history variables, correlation coefficients were calculated between each measure examined (see Table 19 & 20). The family history groups examined included the maternal, paternal, MatPat (combined maternal and paternal history), and parental (parents only) classifications. Correlations between each variable and the maternal and paternal classifications were calculated, however, all further analyses used only the MatPat and parental metrics to increase the number of participants included for each analysis.

To examine the differences between males classified as FH+ with males classified as FH- \( t \)-tests were performed comparing the two groups on the OCDS, AUDIT, and each of the executive function measures for the MatPat classification (see Table 21). Males who were classified as FH+ showed significantly better performance on the Stroop than males classified as
FH-, \( t \) (28) = 2.25, \( p = .017 \) (one-tailed), Cohen’s \( d = .81 \). No other significant differences were found between the two groups.

Independent samples \( t \)-tests were also performed to compare females classified as FH+ with females classified as FH- using the MatPat classification metric (see Table 22). Females classified as FH+ had significantly higher AUDIT scores than females classified as FH-, \( t \) (73) = -2.82, \( p = .003 \) (one-tailed), Cohen’s \( d = -.62 \), equal variances not assumed. Females classified as FH+ also had significantly higher OCDS scores than females classified as FH-, \( t \) (74) = -4.43, \( p < .001 \) (one-tailed), Cohen’s \( d = -.92 \), equal variances not assumed. Also, females classified as FH+ performed worse on the Stroop than females classified as FH-, \( t \) (61) = -1.73, \( p = .033 \) (one-tailed), Cohen’s \( d = -.45 \). This relationship was in the opposite direction of males’ performance.

A 2 (gender) x 2 (FH) ANOVA was attempted to show an interaction, however, it was not interpretable due to significant differences in cell sizes. Finally, females classified as FH+ also showed significantly better performance on the CPT-IP than females classified as FH-, \( t \) (68) = -1.87, \( p = .033 \) (one-tailed), Cohen’s \( d = -.45 \). No other significant differences were found between the two groups.

To further explore the relationship between family history, craving, problem drinking, and executive function, individuals were classified on family history using only their parents’ level of problem drinking and compared across groups. Independent samples \( t \)-tests were performed to compare those classified as FH+ with those classified as FH- while examining males (see Table 23) and females (see Table 24) independently. Males classified as FH+ showed significantly higher craving scores on the OCDS than males classified as FH-, \( t \) (33) = -2.07, \( p = .023 \) (one-tailed), Cohen’s \( d = -.76 \). No other results were found to be significant for males, but this pattern of results was different than those found when examining males using both first and
second generation relatives. While no significant differences were found, the effect sizes and pattern of results using only parental history were more in line with the initial hypotheses proposed for the study.

When examining females’ family history using only their parents’ alcohol use, several findings were made. Females classified as FH+ had significantly higher AUDIT scores than females classified as FH-, \( t(80) = -2.74, p = .004 \) (one-tailed), Cohen’s \( d = -.59 \), and FH+ females also had significantly higher OCDS scores, \( t(80) = -2.79, p = .004 \) (one-tailed), Cohen’s \( d = -.62 \). FH+ females also showed significantly better performance on the CPT-IP, \( t(70) = -1.86, p = .034 \) (one-tailed), Cohen’s \( d = -.45 \), and worse performance on the WCST, \( t(40) = -1.69, p = .049 \) (one-tailed), Cohen’s \( d = -.43 \), equal variances not assumed. As with males, this pattern of results was different than those found when examining family history using both first- and second-degree relatives.

Because of the possibility that family history moderates the relationship between problem drinking and executive function, or the possibility that it moderates the relationship between craving and executive function, 2 x 2 ANOVAs were attempted. However, due to significant differences in cell sizes, these analyses were not possible. However, when examining the number of individuals classified by family history in the low and high craving groups, only 1 individual was found to experience high craving who was FH- when examining all relatives. This discrepancy was significantly different than the number of individuals that were expected to fall into this group \( \chi^2(1, N = 114) = 11.39, p < .001 \). As such, only those individuals with a positive family history reported high craving in general, indicating that family history is a significant predictor of craving.
Because of the inability to test for moderation, the FH+ individuals were examined with respect to craving and problem drinking group on each of the executive function measures using t-tests. Analyses were conducted using the total sample, again, due to the high number of differences of participants in each group. Using the total sample allowed for a more even distribution among groups. No significant differences were found between the FH+ individuals in the high and low craving groups or the problem and non problem drinker groups when examining executive function using parental family history. Also, no significant differences were found between the problem and non problem drinking groups when examining executive function in FH+ individuals using total family history (MatPat). However, when examining the high versus low craving groups in FH+ individuals (MatPat), a significant difference was found between the high and low craving groups on the CPT-IP. Specifically, individuals who were FH+, and who also experienced alcoholic levels of craving, performed significantly worse ($M = 1.589; SD = .739$) than individuals who were FH+ with low craving ($M = 1.984; SD = .697$), $t(59) = 2.012, p = .049$, Cohen’s $d = .55$. This is particularly interesting given that performance on the CPT-IP was not previously found to show significant differences between groups when females were included in the analysis while not taking family history into account. Additionally, previous analyses showed that females in the FH+ groupings performed better than females in the FH- groupings without regard to drinking status, while the opposite was true for males. No other significant differences were found between the two groups.

The hypothesis that individuals who are FH+ would experience higher craving, higher levels of alcohol abuse, and worse executive function performance was partially supported. Specifically, females classified as FH+ when examining their total family history had significantly higher AUDIT and OCDS scores than those classified as FH-. Males did not show
any significant differences in AUDIT and OCDS scores when examining total family history. Similarly, females classified as FH+ using only their parents’ drinking showed significantly higher AUDIT and OCDS scores; while males, showed higher OCDS scores, but not higher AUDIT scores.

When examining executive function using total family history, FH+ males showed better performance on the Stroop while females showed worse performance compared with those who were FH-. FH+ females also showed better performance on the CPT-IP than those who were FH-. Similar results were found for females when examining only parental alcohol use; however, they also showed worse performance on the WCST. No executive function differences were found for males when only examining parental family history. Finally, CPT-IP scores were found to be significantly worse in individuals classified as FH+ who also experienced alcoholic levels of craving than those with low craving levels.
CHAPTER 4
DISCUSSION

Review of Hypotheses

The overall goal of the current research was to explore the relationship between problematic alcohol use, craving, family history of alcohol abuse, and executive function in a sample of college students. Previous research has suggested that executive function is a unitary construct of related processes, but that there are different subcomponents that may be related to different brain processes and structures (Miyake et al., 2000). Much previous research has examined executive function in relation to alcohol abuse, craving, and family history of alcoholism, but little research has been done to comprehensively determine which specific subcomponents of executive function account for overall poor executive performance in relation to alcohol use and craving. The current study attempted to do this in a sample of traditional college students, a population which is at high risk for alcohol use disorders (Knight et al., 2002). Specific measures of executive function were used to explore five of the most commonly studied subcomponents of executive function including: inhibition, sustained attention, mental set shifting, planning, and updating of working memory.

Three primary hypotheses were advanced for the current research based on findings relating the areas of executive function, problem drinking, craving, and family history of alcohol abuse. Specifically, the first a priori hypothesis was that problematic alcohol use would be related to deficits in executive function. This hypothesis was based on findings from various lines of research consistent with this relationship (Tapert & Brown, 1999; Brown, Tapert, Granholm, & Delis, 2000; George, Potts, Kothman, Martin, & Mukundan, 2004; Ratti, Bo, Giardini, & Sorgana, 2002). The primary goal of the current study, related to the first hypothesis,
was to examine the relationship between executive function and problem drinking at the subcomponent level to clarify which components of executive function are discrepant in college students when comparing problem and non problem drinkers.

The second a priori hypothesis advanced for the current study was that alcohol-related craving would be related to deficits in executive function. This hypothesis was based on previous research showing that alcohol-related craving operates in a manner similar to obsessive-compulsive disorder, with deficits in executive function being related to difficulty suppressing unwanted thoughts related to craving (Brewing & Smart, 2005; Hester & Garavan, 2005; Hommer, 1999; Anton, 1999). As with the first hypothesis, the goal was to determine which specific subcomponents of executive function may be related to difficulties with managing craving-related obsessions and compulsions.

The final a priori hypothesis for the current study was that individuals with a positive family history of alcohol abuse would show deficits in executive function and be more likely to experience problem drinking and craving. This hypothesis was based on findings implicating family history as a biopsychosocial risk marker for problematic substance use and poor neuropsychological function (Tapert & Brown, 2000; Lovallo et al., 2006; Dolan, Bechara, & Nathan, 2008). As with the first two hypotheses, the goal was to explore the relationship between executive function and family history of alcohol abuse in more detail than has been done previously.

Demographics

The participants included in the current study were similar in age, ethnicity, and gender to the overall student body at the University of North Texas (UNT Fact Book, n.d.). The participants included in the sample were also representative of other college student samples in
regards to problematic drinking with 34.7% of the sample qualifying to be classified as problem drinkers based on their scores on the Alcohol Use Disorders Identification Test (Knight, et al., 2002). A limited number of the individuals included in the sample indicated that they had a prior history of head trauma, a diagnosis of a developmental disorder, or that they were using medication or drugs other than alcohol. Analyses were conducted comparing the performance of these individuals on each of the measures included in the study and no significant differences were found. Thus, these individuals were included in the study to increase the representativeness of the overall sample. Males and females were compared with regards to their level of problem drinking, craving, and individual executive function performance, and no significant differences were found based purely on gender. The individuals also reported having similar numbers of relatives that could be classified as probable or definite problem drinkers when examining their family history of alcohol abuse. Based on the absence of differences in the study variables across gender, one would think that the sample could be collapsed across gender. However, this assumption turned out not to be an optimal means for examining the data, given that the associations between the study variables often differed as a function of gender.

Alcohol Use and Executive Function

As reported earlier, the first a priori hypothesis was that problematic alcohol use would be related to deficits in executive function. To test this hypothesis, problem drinking was correlated with executive function performance in each of the five executive function domains for the total sample. No significant relationships were found, thus the sample was analyzed separately by gender to determine if combining males and females masked any underlying relationships. No significant relationships were found when correlating problem drinking with executive function performance for males, however, females showed a significant negative
correlation between problem drinking and working memory updating as measured by the N-Back task. Females also showed a trend towards significance in a correlation between problem drinking and set shifting ability as measured by the Wisconsin Card Sorting Test. To further explore these relationships, both males and females were separated into groups based on their Alcohol Use Disorders Identification Test scores to create groups delineating problem drinkers from non problem drinkers. Doing so was consistent with previous research that has studied differences in problem drinkers, and the cut scores used in the current study were also based on conventions used in other studies (Reinert & Allen, 2007).

When comparing problem and non problem drinkers, it was found that female problem drinkers showed worse performance on working memory updating on the N-Back Task in the 3-back condition, but not in the 2-back condition. Additionally, females classified as problem drinkers performed worse in set shifting ability, as measured by the Wisconsin Card Sorting Task, than females classified as non problem drinkers. The fact that set shifting ability was found to be significantly worse in problem drinkers when comparing groups versus examining the correlation between scores is most likely due to improved power gained by comparing relatively extreme groups. The overall distribution of scores for female problem drinkers was slightly positively skewed with a lower number of individuals classifying as problem drinkers than non problem drinkers. That females showed significant differences in both set shifting and updating of working memory may be due to the higher correlation between the two tasks used to measure these subcomponents of executive function. These results support findings made by Hester and Garavan (2005) who explored the executive control of attention in a sample of undergraduate students. Specifically, Hester and Garavan found that individuals with alcohol use disorders have problems with switching the focus of their attention, especially when focusing on content
specific information related to alcohol. Both set shifting and updating of working memory are related to the control of attention with set shifting involving switching mental sets and updating involving determining if information is currently relevant in working memory. The females classified as problem drinkers in the current study showed worse performance on the 3-Back condition of the N-Back task, but not the 2-Back condition. This finding also supports the study by Hester and Garavan in that they found that as the load on working memory increases, problem drinkers have more difficulty shifting the focus of their attention. While no significant differences were found for females in the current sample on planning ability, inhibition, or sustained attention, it is possible that a larger sample size might have uncovered such differences. However, given that the sample size of females in the current study was reasonably large, it is more likely that these areas are not specifically related to problematic drinking, or at least that these differences do not show up without a longer history of substance abuse. At the same time, other studies that have found additional cognitive differences, such as that by Noel et al. (2007), employed different measures that may not be assessing exactly the same underlying subcomponents of executive function. Additionally, the analyses in the current study were done using only females, which may account for differences with studies who used both male and female problem drinkers as a single group.

As with females, male problem drinkers in the current study were also compared with regards to their performance on each of the measures of executive function by problem drinking group. Male problem drinkers were found to have significantly poorer executive planning ability than non problem drinkers as measured by the length of time taken to plan their answers on the Tower of London task. There was also a trend towards significance with male problem drinkers performing better in regards to inhibition on the Stroop Color and Word Test than non problem
drinkers. However, due to the fact that this relationship was not statistically significant, and that other researchers such as Whitney, James, and Hinson (2004) have found opposite results, it is likely that this is a statistical anomaly caused by the low number of males included in the sample. The significant results showing that male problem drinkers have more difficulty with planning is generally consistent with the finding by Whitney, James, and Hinson (2006) that college student drinkers have a decision making deficit. This current finding is also supported by research done by Noel et al. (2007) showing that problem drinkers have difficulty with decision making as found by their performance on the Iowa Gambling Task, a measure of response inhibition and decision-making. The measure of planning ability used in the current study, the Tower of London, is dependent on one’s ability to plan ahead, including the use of decision making to plan a working strategy to solve a problem. Thus, a deficit in this ability in male problem drinkers may also be related to a higher likelihood for negative consequences related to drinking such as violence, physical injury, and legal problems (Knight et al., 2002). That no other significant differences were found between male problem and non problem drinkers in the current study may be due to the low number of male participants included in the sample (Type-II error). This is particularly salient when taking into account the effect sizes of some of the non significant results.

Overall, the first hypothesis, that individuals classified as problem drinkers would show deficits in executive function, was partially supported. Specific deficits were found, but it was believed that more areas of executive function would show statistically significant results. One of the problems inherent in the pattern of results found is the lack of agreement in this area of research as to which areas of neuropsychological function are related to problem drinking. The fact that males and females showed differing results may explain the reason for disagreement.
is possible that studies conducted using both males and females, without regard to gender
differences, may find conflicting results due to not accounting for biological and psychosocial
differences which may affect development and executive function. Alternatively, it is also
possible that with a larger sample size, especially for males, additional results would have been
statistically significant, especially in light of some moderate effect sizes in comparisons that
were not significant.

Executive Function and Craving

The second hypothesis that higher craving would be related to executive function was
examined in a similar manner to the relationship between alcohol use and executive function.
The relationship between executive function and craving is a particularly important area to
examine due to the nature of craving. Specifically, craving has been defined as a cognitive
construct that drives an individual’s desire to consume alcohol (Anton, 1999). As such, any
deficit in executive function found to be related to craving would provide support for cognitive
models of craving indicating that a deficit in thought and behavioral control decreases one’s
ability to cope with craving, and thus inhibit their compulsion to drink. As such, the current
study examined craving using a measure of craving, the Obsessive Compulsive Drinking Scale,
which quantifies craving in relation to alcohol obsessions and compulsions (Anton, Moak, &
Latham, 1995).

As with problem drinking, the relationship between craving and executive function was
examined using correlations for the total sample, males, and females, separately. No significant
correlations were found between craving and the executive function measures for the total
sample. Males and females were then examined separately using correlations to explore the
relationship between craving and executive function. Males showed a significant negative
correlation between craving and sustained attention, as measured by the CPT-IP, which is believed to indicate a difficulty with maintaining the focus of attention in relation to higher craving. There was also a trend towards significance for males in a positive relationship between working memory updating on the N-Back task, in the 3-Back condition, and craving. Correlations were also calculated for females between craving scores and performance on each of the measures of executive function. A significant positive correlation was found between Stroop Color and Word Test interference reaction times, a measure of inhibition, and craving. This indicates that with increasing levels of craving, females may have more difficulty with inhibition. To further explore these relationships, both males and females were divided into groups based on high and low levels of craving and their performance on each of the executive function measures was examined.

No significant differences were found for females when comparing the high and low craving groups. However, there was a trend towards significance with females in the high craving group showing better performance in updating of working memory, as measured by the 2-back condition of the N-Back task, than low craving females. Additionally, there was a trend toward significance with females in the high craving group showing poorer set shifting ability than females in the low craving group, as measured by the Wisconsin Card Sorting Test. Little research has been done to examine this relationship; therefore, it is difficult to determine if these specific findings are consistent with the performance of other samples using females. However, the effect size for the non significant result showing poorer shifting ability in females with high levels of craving indicates a likelihood that this result would have been statistically significant with a larger sample. Such a result would be consistent with findings relating problem drinking to executive function as discussed earlier (Hester & Garavan, 2005), particularly for aspects of
executive function involving the contents of attention. Additionally, the significant correlation
for females between craving and inhibition based on Stroop performance was consistent with
research by Whitney, James, and Hinson (2004). Poorer inhibition indicates a difficulty with
controlling one’s dominant thoughts when examined from a cognitive perspective. As such, it is
possible that females have difficulty inhibiting craving related thoughts. This may also be
amplified when processing demands are increased, which is supported by the earlier finding that
females have processing difficulties when the demands on working memory are increased.

In examining males in the high craving group versus the low craving group, a significant
difference was found in performance on the CPT-IP, a measure of sustained attention, consistent
with the correlational analysis discussed earlier. Specifically, males in the high craving group
showed a significant discrepancy in sustained attention when compared with males in the low
craving group. This result is consistent with previous research indicating attention problems
related to alcohol or craving related thoughts (Hester & Garavan, 2005; Tapert & Brown, 1999).
Additionally, it is consistent with a relationship reported by Oblrich et al. (2006) between
craving and attention that was found using functional magnetic resonance imaging (fMRI).
Specifically, it was found that individuals experiencing craving showed increased blood flow to
areas of the brain involved in attention and executive function. It seems likely that craving is
related to difficulties in attention which may make it difficult for an individual to control craving
related thoughts. This relationship is consistent with that hypothesized by Anton (1999), who
argued that craving was similar to obsessive-compulsive disorder with cognitive difficulties
making it more difficult for an individual to control compulsive behavior. Again, the fact that no
other significant findings were made, may be due to the low number of males included in the
study.
Overall, the second hypothesis that craving would be related to deficits in executive function was partially supported. Females did not show any significant relationships between executive function and craving, however, males showed a deficit in selective attention. It is possible that with a bigger sample size, females may have shown a significant result, especially between set shifting ability and higher craving. Additionally, other significant findings may have been made for males with a larger sample size, especially in light of rather large effect sizes for some of the non significant results.

Executive Function, Alcohol Use, Craving, and Family History

The last hypothesis advanced for the current study was that individuals classified with a positive family history of alcoholism would show deficits in executive function, be more likely to have problems with alcohol use, and be more likely to experience high craving. In order to classify individuals as family history positive or negative two metrics were used that were consistent with previous literature (Hodgins & Shimp, 1995). Specifically, individuals were classified as family history positive if one of their first or second degree relatives were classified as someone with a definite or possible drinking problem. Additionally, a second metric was used that examined only an individual’s parents drinking. Using this metric, an individual was classified as family history positive if either of their parents could be described as a definite or possible problem drinker. Using two separate classification systems enabled for a comparison between parental and overall family influences on each of the variables under consideration.

Correlations were provided for males and females based on their individual family history of alcohol abuse in relation to all five executive function components as well as problem drinking and craving. In addition, correlations were provided to describe the relationship between these variables when examining only the maternal or paternal side of an individual’s
family. However, all of the major analyses under consideration were examined using $t$-tests that compared those classified as family history positive with those classified as family history negative. Additionally, all analyses focused on the use of the total and parental family histories to improve statistical power.

When examining males who were family history positive with those who were family history negative using their total family history, no significant differences were found between the two groups in regards to level of craving or problem drinking. This result was not consistent with previous research showing that individuals with a positive family history of alcohol abuse have a higher risk for substance abuse (Stoltenberg, Mudd, Blow, & Hill, 1998). This result was particularly surprising given that males are usually highly affected by a family history of alcohol use in regards to their own level of alcohol use. One possible explanation for the lack of differences is that when using total family history, an individual may not have as much exposure to their second-degree relative who may have been one of the only problem drinkers in their family. This would indicate that parental alcohol use has more effect on males than alcohol use by other biological relatives, an explanation that argues in favor of an individual’s environment playing a large role in their alcohol use versus purely genetic influence. Interestingly, males with a positive family history of alcohol abuse were also found to perform significantly better on the Stroop Color and Word Test, a measure of inhibition, than those who were negative for family history of alcohol abuse. This result is contradictory with findings by Lovallo et al. (2006) which showed that individuals with a positive family history of alcohol abuse had worse performance on the Stroop Color and Word Test. However, Lovallo et al. divided family history positive individuals into those with and without a behavioral inhibition component which is the most likely explanation for the discrepancy in findings. No other significant results were found.
between the family history (assessed across first- and second-degree relatives) positive and negative males. One explanation for this is that there may have been low power due to the low number of males in the study.

When examining the females who were classified as having a positive family history of alcohol abuse with those with a negative family history, the results were more consistent with previous research. Specifically, females with a positive family history for alcohol abuse were more likely to experience alcohol problems and also had higher levels of craving. Consistent with the finding by Lovallo et al. (2006), females with a positive family history of alcohol abuse performed significantly worse on the Stroop Color and Word Test than family history negative females. This finding indicates that family history positive females have more problems with inhibiting responses that may not be desirable, which further supports a similar finding for females in relation to craving. Females with a positive family history of alcohol abuse also performed significantly better on the CPT-IP indicating better sustained attention capacity. This was a novel finding and one explanation may be that, because of deficits with inhibition, females with a positive family history of alcohol abuse may have better developed abilities related to attention. This is highly speculative, but something that is worth exploring in future studies.

In order to examine the measure of family history examining only an individual’s parents, both males and females were again compared on their executive function performance, alcohol use, and level of craving. Consistent with previous research (Stoltenberg, Mudd, Blow, & Hill, 1998) males grouped according to this second method of calculating a positive parental history of alcohol abuse showed significantly higher levels of craving than those with no family (parental) history of abuse. No other measures showed significant differences between the two groups which, again, may be due to the low number of males used in the analysis. This was
particularly true for the analysis examining males with a positive parental history of alcohol abuse, because the analysis further reduced the number of males. On the other hand, it is reasonable to propose that alcohol use by college males is fairly common, regardless of family history status, and this cultural phenomenon may have influenced this set of analyses.

Females were also examined with respect to parental alcohol abuse. Those with a positive parental history of alcohol abuse had higher levels of alcohol use and craving, consistent with findings discussed earlier. Females with a positive parental history of alcohol abuse also showed better performance on the CPT-IP, which is consistent with the examination of total family history. One discrepant finding, in comparison with the findings related to total family history, was that females with a positive parental history of alcohol abuse performed significantly worse with respect to mental set shifting than those whose parents were not problem drinkers. This result was consistent with findings by Dolan, Bechara, and Nathan (2008) which showed similar deficits in set shifting ability. One explanation for this finding is that females with parents who abuse alcohol may have had a reduction in exposure to educational or every day experiences that may help to develop this ability.

Because of the high probability that family history moderates the relationship between executive function and craving, or alcohol abuse (Tapert & Brown, 2000), it was important to determine what this type of effect may have been present in the current study. Unfortunately, when grouping individuals by family history and level of craving, or alcohol abuse, the size of the groups were extremely discrepant. In fact, only one individual could be classified as having both a negative family history of alcohol abuse and a high level of craving. To work around this problem, only the family history positive individuals were examined with respect to craving or problem drinking group. The total sample was used in these analyses because of the low number
of individuals that met the criteria for inclusion in the analysis. No significant findings were made with regard to problem and non problem drinkers in relation to positive family history of alcohol abuse. However, individuals who had a positive family history of alcohol abuse, and who were classified as having a high level of craving, performed worse on the CPT-IP than individuals with positive family history and low craving. This indicates that those with a positive family history of alcohol abuse, and high craving, have a deficit in sustained attention that is significant for both males and females. This is one of the only findings made where both males and females performed similarly in the current study. As discussed earlier with respects to males, a deficit in attention is believed to underlie difficulty with managing craving related thoughts (Hester & Garavan, 2005; Tapert & Brown, 1999; Olbrich et al., 2006). It appears from the findings of this study that, while males show a deficit in sustained attention without respect to family history, females only show a deficit in sustained attention when they have a positive family history of alcohol abuse. Taken together, these results partially supported the final hypothesis that family history of alcohol abuse would be related to poorer executive function, higher levels of alcohol abuse, and higher levels of craving.

Clinical Implications

Comparing both males and females across groups, similar and contradictory findings were made. In relation to alcohol use, females showed difficulty with updating and set shifting ability, while males showed difficulty with planning ability. In relation to craving, females showed difficulty with inhibition, while males showed difficulty with sustained attention. With respect to family history, females showed difficulties with inhibition and shifting. Additionally, females showed better sustained attention in general, while those with a positive family history of alcohol abuse showed difficulties with sustained attention. Males showed better inhibition in
general, but difficulties with sustained attention in relation to family history. These results underlie the complicated relationships between alcohol use, craving, and executive function. One of the consequences of these complicated relationships is that males and females should not be classified as a singular group with respect to alcohol abuse, craving, or family history. With regards to research, including both males and females without examining the effects of gender could mask significant differences that would not be found otherwise. Clinically, it appears vital that executive functioning be assessed when determining treatment goals. It may be that determining individual deficiencies in executive functioning would allow a treatment provider to tailor a treatment plan that could both bolster deficient skills and make use of non deficient abilities to overcome issues such as alcohol craving.

Differences were found in the current study with respect to executive function in males and females classified by craving, problem drinking, and family history of alcohol abuse, and one interesting implication of these findings is that executive function deficits showed up in a study using only 18 to 24 year old participants. Further, the individuals included in the study were mostly high functioning college students, in direct contrast with other studies examining these relationships in treatment samples. Considerable research has shown that areas in the frontal lobe related to executive function do not fully develop until a person is in their early to mid 20’s (Hommer, 1999; Olbrich et al., 2006; Wilson, Sayette, & Fiez, 2004). As such, developing treatment interventions aimed at improving executive functioning while there is still a high level of plasticity may improve outcomes related to reducing substance abuse.

Related to these implications, several models have been advanced to help describe and understand the relationship between alcohol use and the processes involved in alcohol craving (Lowman, Hunt, Litten, & Drummond, 2000). Unfortunately, no consensus has been reached in
regards to which models explain alcohol use and craving the best, or even which definition of craving is the most accurate (Lowman, Hunt, Litten, & Drummond, 2000). It may be that craving operates differently in males and females. The findings of the current study provide support for the cognitive processing model of craving (Tiffany & Conklin, 2000) and the elaborated intrusion model of craving (May, Andrade, Panabokke, & Kavanagh, 2004). The cognitive processing model argues that craving is a non-automatic process that requires a high level of cognitive resources. As such, deficits in executive function should be related to higher levels of craving in that any reduction in cognitive resources would make it more difficult to manage craving related thoughts. Additionally, the elaborated intrusion model of craving argues that cues trigger a build-up of alcohol-related images that come into conscious awareness after substantial elaboration. Once these images come into conscious awareness, it is possible that a reduction in cognitive resources results in difficulty containing alcohol-related images which would drive the desire to drink.

The results of the current study, particularly that individuals with a positive family history have a deficit in sustained attention, would argue that craving is related to a process involving attention or the contents of attention. Such a relationship is supported by research showing a direct link between brain areas involving executive function and attention in relation to the experience of craving (Olbrich et al., 2006; Wilson, Sayette, & Fiez, 2004; Hommer, 1999; Lubman, Yucel, & Pantelis, 2004; George, Potts, Kothman, Martin, & Mukundan, 2004). Additionally, deficits shown in the current study by females in relation to shifting, updating, and inhibition, and males in relation to planning and inhibition would further support this. It appears likely that any model of craving needs to account for deficits in executive function that can be shown through neurocognitive performance or brain imaging. Further, it may be that the reason
that not all individuals develop craving (Toneatto, 1999), is that it is a complex process related to biopsychosocial aspects of development, that are influenced by gender, family history, the environment, and individual cognitive differences.

Limitations of the Current Study

There were several limitations to the current study. First, a small number of males participated in the study which reduced the level of power for several analyses, and increased the likelihood of a Type-II error. To account for this, effect sizes were provided for all analyses, including those that were not found to be statistically significant. Additionally, this possibility was noted in the results and discussion where appropriate. It was originally believed that analyses could be conducted in the current study which would take gender into account, but due to significant differences in cell sizes when partitioning individuals into groups, it was necessary to use \( t \)-tests for all comparisons. Second, due to computer malfunction, data was not collected for some individuals in regards to executive function performance. Third, there were a relatively low number of individuals that could be classified in the sample as experiencing high levels of craving. This is most likely representative of the population, but it may have been better to actively recruit individuals for the study that would meet this criteria. Finally, due to the need for multiple laboratory assistants, the executive function measures were not counterbalanced to reduce the possibility of fatigue affecting performance. However, the total time required to complete the executive function portion of the current study was approximately 30 minutes. Some measures of executive function can take longer to complete, so fatigue should have had a minimal effect in this study.
Future Directions for Research

Based on the results of the current study, it appears likely that developing treatment strategies for coping with alcohol craving could improve outcomes if used while the brain is still developing in the frontal lobe. As such, it is important to identify techniques which could be used to improve executive performance and examine these techniques in relation to how their use improves treatment outcomes. Additionally, it would be interesting to attempt to replicate the finding of the current study using a larger sample of males to confirm or expand on the findings. It is also important to attempt to replicate this study using the general population as there may be differences between college students and similarly aged peers.

Another area of research, tied to the current study, involves evaluation of treatment methods already in use. For example, it would be interesting to see the effects of participation in support groups on executive function. Alternatively, it would be interesting to see if spirituality, an important component of some treatment strategies, has an effect on executive function. Specifically, it may be possible that being in a support group, or increasing spirituality, helps to expand executive performance or reduce the effect of executive deficits through alternate means. Answering questions such as these would greatly expand the number and type of treatment options that are available. Additionally, due to the differences found in the current study related to gender and family history, it may be that treatments need to be tailored to individuals while taking gender into account.

Finally, the current study focused largely on laboratory measures of executive function. As such, it is important to examine the relationships found in the current study using ecological measures of psychological performance to determine the real-world significance of the current findings, or to determine if there are any other factors that need to be accounted for.
Table 1

**Demographics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency (%)</th>
<th>Problem Drinkers (%)</th>
<th>High Craving (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>35 (29.2)</td>
<td>8 (22.9)</td>
<td>6 (17.1)</td>
</tr>
<tr>
<td>Female</td>
<td>85 (70.8)</td>
<td>34 (40.0)</td>
<td>15 (17.6)</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>79 (58.8)</td>
<td>18 (22.8)</td>
<td>12 (15.2)</td>
</tr>
<tr>
<td>Black/African American</td>
<td>23 (19.3)</td>
<td>1 (4.3)</td>
<td>2 (8.7)</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>10 (8.4)</td>
<td>1 (10.0)</td>
<td>3 (30.0)</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>7 (5.9)</td>
<td>2 (28.6)</td>
<td>2 (28.6)</td>
</tr>
<tr>
<td>Asian Indian/East Indian</td>
<td>1 (0.8)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Other</td>
<td>8 (6.7)</td>
<td>4 (50.0)</td>
<td>3 (37.5)</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>118 (98.3)</td>
<td>26 (22.0)</td>
<td>21 (17.8)</td>
</tr>
<tr>
<td>Married</td>
<td>2 (1.7)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td><strong>Religious Affiliation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evangelical Christian</td>
<td>23 (19.2)</td>
<td>3 (13.0)</td>
<td>2 (8.7)</td>
</tr>
<tr>
<td>Protestant</td>
<td>22 (18.3)</td>
<td>5 (22.7)</td>
<td>4 (18.2)</td>
</tr>
<tr>
<td>Roman Catholic</td>
<td>18 (15.0)</td>
<td>1 (5.6)</td>
<td>2 (11.1)</td>
</tr>
<tr>
<td>Muslim</td>
<td>4 (3.3)</td>
<td>1 (25.0)</td>
<td>1 (25.0)</td>
</tr>
<tr>
<td>Buddhist</td>
<td>1 (0.8)</td>
<td>1 (100.0)</td>
<td>1 (100.0)</td>
</tr>
<tr>
<td>Other</td>
<td>52 (43.3)</td>
<td>15 (28.8)</td>
<td>11 (21.2)</td>
</tr>
</tbody>
</table>
Table 2

*Descriptive Statistics*

<table>
<thead>
<tr>
<th>Question</th>
<th>Frequency (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever knocked unconscious</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3 (2.5)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>117 (97.5)</td>
<td></td>
</tr>
<tr>
<td>Do you drink alcohol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>75 (62.5)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>45 (37.5)</td>
<td></td>
</tr>
<tr>
<td>Do you smoke cigarettes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>14 (11.7)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>106 (88.3)</td>
<td></td>
</tr>
<tr>
<td>Use of psychoactive medications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>13 (10.8)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>107 (89.2)</td>
<td></td>
</tr>
<tr>
<td>Other drug use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>12 (10.0)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>108 (90.0)</td>
<td></td>
</tr>
<tr>
<td>Developmental disorder diagnosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>7 (5.8)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>113 (94.2)</td>
<td></td>
</tr>
</tbody>
</table>
Table 3

*Measures of Alcohol Use – Total Sample*

<table>
<thead>
<tr>
<th>Measure</th>
<th>$M$</th>
<th>$SD$</th>
<th>Skew</th>
<th>Kurtosis</th>
<th>$\alpha$</th>
<th>MIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCDS*</td>
<td>3.44</td>
<td>3.708</td>
<td>1.259</td>
<td>1.727</td>
<td>.800</td>
<td>.302</td>
</tr>
<tr>
<td>AUDIT*</td>
<td>4.20</td>
<td>4.346</td>
<td>1.338</td>
<td>2.043</td>
<td>.779</td>
<td>.301</td>
</tr>
</tbody>
</table>

*Note. OCDS = Obsessive Compulsive Drinking Scale; AUDIT = Alcohol Use Disorders Identification Test.  *$^a$n = 118 , $^b$n = 119.*
Table 4

*Measures of Alcohol Use – Males*

<table>
<thead>
<tr>
<th>Measure</th>
<th>$M$</th>
<th>$SD$</th>
<th>Skew</th>
<th>Kurtosis</th>
<th>$\alpha$</th>
<th>MIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCDS$^a$</td>
<td>3.40</td>
<td>3.397</td>
<td>0.652</td>
<td>-0.459</td>
<td>0.679</td>
<td>0.154</td>
</tr>
<tr>
<td>AUDIT$^b$</td>
<td>4.86</td>
<td>5.292</td>
<td>1.585</td>
<td>2.515</td>
<td>0.819</td>
<td>0.369</td>
</tr>
</tbody>
</table>

*Note. OCDS = Obsessive Compulsive Drinking Scale; AUDIT = Alcohol Use Disorders Identification Test. $^a$n = 35, $^b$n = 32.*
Table 5

*Measures of Alcohol Use – Females*

<table>
<thead>
<tr>
<th>Measure</th>
<th>M</th>
<th>SD</th>
<th>Skew</th>
<th>Kurtosis</th>
<th>α</th>
<th>MIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCDSa</td>
<td>3.45</td>
<td>3.852</td>
<td>1.434</td>
<td>2.254</td>
<td>0.831</td>
<td>0.347</td>
</tr>
<tr>
<td>AUDITb</td>
<td>3.93</td>
<td>3.889</td>
<td>0.916</td>
<td>0.133</td>
<td>0.758</td>
<td>0.283</td>
</tr>
</tbody>
</table>

*Note. OCDS = Obsessive Compulsive Drinking Scale; AUDIT = Alcohol Use Disorders Identification Test. a[n = 83, b[n = 83.*
Table 6

_Breakdown of Alcoholism Family History by Male and Female – Family Tree Questionnaire_

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th></th>
<th>Female</th>
<th></th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FH+</td>
<td>FH-</td>
<td>FH+</td>
<td>FH-</td>
<td>FH+</td>
<td>FH-</td>
</tr>
<tr>
<td>Maternal</td>
<td>13</td>
<td>20</td>
<td>29</td>
<td>51</td>
<td>42</td>
<td>71</td>
</tr>
<tr>
<td>Paternal</td>
<td>14</td>
<td>20</td>
<td>42</td>
<td>36</td>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>MatPat</td>
<td>20</td>
<td>14</td>
<td>52</td>
<td>28</td>
<td>72</td>
<td>42</td>
</tr>
<tr>
<td>Parental</td>
<td>10</td>
<td>25</td>
<td>33</td>
<td>49</td>
<td>43</td>
<td>74</td>
</tr>
</tbody>
</table>

*Note.* FH+ = Positive family history of alcoholism; FH- = Negative family history of alcoholism; Maternal = Maternal family history; Paternal = Paternal family history; MatPat = Composite of maternal and paternal history; Parental = Family history of alcoholism using composite of parental alcoholism only (i.e. no grandparents). All groups are based on liberal Family Tree Questionnaire criteria.
Table 7

*Executive Function – Total Sample*

<table>
<thead>
<tr>
<th>Measure</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>Skew</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroop</td>
<td>92</td>
<td>0.156</td>
<td>0.145</td>
<td>1.014</td>
<td>1.312</td>
</tr>
<tr>
<td>TOL – TC</td>
<td>95</td>
<td>88.28</td>
<td>8.185</td>
<td>0.768</td>
<td>-0.014</td>
</tr>
<tr>
<td>TOL – PT</td>
<td>95</td>
<td>2.049</td>
<td>0.637</td>
<td>0.963</td>
<td>0.848</td>
</tr>
<tr>
<td>N-Back 2</td>
<td>96</td>
<td>19.43</td>
<td>7.724</td>
<td>-0.342</td>
<td>-1.098</td>
</tr>
<tr>
<td>N-Back 3</td>
<td>96</td>
<td>15.69</td>
<td>6.484</td>
<td>-0.288</td>
<td>-0.347</td>
</tr>
<tr>
<td>CPT-IP D’’</td>
<td>104</td>
<td>1.783</td>
<td>0.746</td>
<td>0.254</td>
<td>0.057</td>
</tr>
<tr>
<td>WCST</td>
<td>103</td>
<td>19.63</td>
<td>9.020</td>
<td>1.449</td>
<td>2.440</td>
</tr>
</tbody>
</table>

Table 8

*Executive Function – Males*

<table>
<thead>
<tr>
<th>Measure</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>Skew</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroop</td>
<td>31</td>
<td>0.166</td>
<td>0.166</td>
<td>0.789</td>
<td>-0.438</td>
</tr>
<tr>
<td>TOL – TC</td>
<td>24</td>
<td>88.75</td>
<td>6.816</td>
<td>0.164</td>
<td>-0.801</td>
</tr>
<tr>
<td>TOL – PT</td>
<td>24</td>
<td>2.254</td>
<td>0.548</td>
<td>1.374</td>
<td>3.009</td>
</tr>
<tr>
<td>N-Back 2</td>
<td>24</td>
<td>21.71</td>
<td>6.773</td>
<td>-0.931</td>
<td>-0.548</td>
</tr>
<tr>
<td>N-Back 3</td>
<td>24</td>
<td>16.21</td>
<td>6.297</td>
<td>0.125</td>
<td>-1.392</td>
</tr>
<tr>
<td>CPT-IP D’”</td>
<td>32</td>
<td>1.856</td>
<td>0.807</td>
<td>-0.149</td>
<td>-0.068</td>
</tr>
<tr>
<td>WCST</td>
<td>30</td>
<td>18.60</td>
<td>8.645</td>
<td>2.215</td>
<td>6.984</td>
</tr>
</tbody>
</table>

Table 9

*Executive Function – Females*

<table>
<thead>
<tr>
<th>Measure</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>Skew</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroop</td>
<td>61</td>
<td>0.151</td>
<td>0.134</td>
<td>1.179</td>
<td>3.153</td>
</tr>
<tr>
<td>TOL – TC</td>
<td>71</td>
<td>88.13</td>
<td>8.637</td>
<td>0.881</td>
<td>0.056</td>
</tr>
<tr>
<td>TOL – PT</td>
<td>71</td>
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<td>0.792</td>
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<td>18.67</td>
<td>7.913</td>
<td>-0.173</td>
<td>-1.116</td>
</tr>
<tr>
<td>N-Back 3</td>
<td>72</td>
<td>15.51</td>
<td>6.580</td>
<td>-0.397</td>
<td>-0.123</td>
</tr>
<tr>
<td>CPT-IP D”</td>
<td>72</td>
<td>1.751</td>
<td>0.721</td>
<td>0.467</td>
<td>0.326</td>
</tr>
<tr>
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<td>73</td>
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<td>9.194</td>
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</table>

Table 10

Summary of Correlations for Measures of Executive Function

<table>
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<th>Measure</th>
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<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<td>1. Stroop</td>
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<tr>
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<td>-.352**</td>
<td>-</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. TOL-PT</td>
<td>.046</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. N-Back 2</td>
<td>- .064</td>
<td>-.080</td>
<td>-.044</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. N-Back 3</td>
<td>.091</td>
<td>-.037</td>
<td>.025</td>
<td>.625**</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. CPT-IP D'</td>
<td>.084</td>
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<td>.165</td>
<td>-.005</td>
<td>-.020</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>7. WCST</td>
<td>.009</td>
<td>.148</td>
<td>-.011</td>
<td>-.141</td>
<td>-.239*</td>
<td>-.005</td>
<td>-</td>
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</table>

Table 11

*Summary of Means and Standard Deviations for Stroop Test Reaction Times by Gender*

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
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<tr>
<td>Interference</td>
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<td>.166</td>
</tr>
<tr>
<td>Monotone</td>
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<td>.218</td>
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<tr>
<td>Color Word</td>
<td>.669</td>
<td>.123</td>
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<td>Incongruent</td>
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</table>
Table 12

*Summary of Correlations Between Alcohol Measures and Executive Function – Total Sample*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Stroop</th>
<th>TOL-TC</th>
<th>TOL-PT</th>
<th>N-Back 2</th>
<th>N-Back 3</th>
<th>CPT-IP D”</th>
<th>WCST</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCDS</td>
<td>.138</td>
<td>.059</td>
<td>-.029</td>
<td>.125</td>
<td>.069</td>
<td>-.089</td>
<td>.055</td>
</tr>
<tr>
<td>AUDIT</td>
<td>.028</td>
<td>.024</td>
<td>-.001</td>
<td>.011</td>
<td>-.120</td>
<td>.017</td>
<td>.092</td>
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</table>

Table 13

Summary of Correlations Between Alcohol Measures and Executive Function – Males

<table>
<thead>
<tr>
<th>Measure</th>
<th>Stroop</th>
<th>TOL-TC</th>
<th>TOL-PT</th>
<th>N-Back 2</th>
<th>N-Back 3</th>
<th>CPT-IP D’</th>
<th>WCST</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCDS</td>
<td>-.019</td>
<td>.036</td>
<td>-.073</td>
<td>.099</td>
<td><strong>.302</strong></td>
<td>-.408**</td>
<td>-.225</td>
</tr>
<tr>
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<td>-.097</td>
<td>.127</td>
<td>.236</td>
<td>.067</td>
<td>.250</td>
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<td>-.143</td>
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</table>

### Table 14

**Summary of Correlations Between Alcohol Measures and Executive Function – Females**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Stroop</th>
<th>TOL-TC</th>
<th>TOL-PT</th>
<th>N-Back 2</th>
<th>N-Back 3</th>
<th>CPT-IP D”</th>
<th>WCST</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCDS</td>
<td>.210**</td>
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<td>.141</td>
<td>.015</td>
<td>.045</td>
<td>.139</td>
</tr>
<tr>
<td>AUDIT</td>
<td>.100</td>
<td>-.011</td>
<td>-.099</td>
<td>-.026</td>
<td>-.267**</td>
<td>.121</td>
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</table>

Table 15

*Contrast of Problem and Non-Problem Drinkers on Craving and Executive Function Measures - Females.*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Non Problem</th>
<th>Problem</th>
<th>95% CI</th>
<th>Cohen’s d</th>
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</thead>
<tbody>
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<td>$M$</td>
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<td>$M$</td>
<td>$SD$</td>
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<tr>
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<td>1.64</td>
<td>2.464</td>
<td>6.18</td>
<td>3.988</td>
</tr>
<tr>
<td>Stroop</td>
<td>.146</td>
<td>.128</td>
<td>.164</td>
<td>.167</td>
</tr>
<tr>
<td>TOL-TC</td>
<td>88.59</td>
<td>9.744</td>
<td>87.50</td>
<td>6.957</td>
</tr>
<tr>
<td>TOL-PT</td>
<td>2.04</td>
<td>.715</td>
<td>1.90</td>
<td>.562</td>
</tr>
<tr>
<td>N-Back 2</td>
<td>18.64</td>
<td>7.877</td>
<td>18.70</td>
<td>8.099</td>
</tr>
<tr>
<td>N-Back 3</td>
<td>17.14</td>
<td>5.800</td>
<td>13.23</td>
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<tr>
<td>CPT-IP D”</td>
<td>1.676</td>
<td>.703</td>
<td>1.855</td>
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<tr>
<td>WCST</td>
<td>18.42</td>
<td>8.048</td>
<td>22.40</td>
<td>10.314</td>
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</table>

Table 16

Contrast of Problem and Non-Problem Drinkers on Craving and Executive Function Measures - Males.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Non Problem</th>
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<th>Cohen’s d</th>
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</thead>
<tbody>
<tr>
<td>OCDS</td>
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<td>.006</td>
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<tr>
<td>Stroop</td>
<td>.179</td>
<td>.114</td>
<td>1.44</td>
<td>.081</td>
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<td>TOL-TC</td>
<td>88.37</td>
<td>90.20</td>
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<td>.302</td>
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<td>TOL-PT</td>
<td><strong>2.158</strong></td>
<td><strong>2.617</strong></td>
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<td>.380</td>
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<td>1.874</td>
<td>1.778</td>
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Table 17

*Contrast of High and Low Craving Groups on Alcohol and Executive Function Measures - Females.*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low Craving</th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>t</td>
<td>p</td>
<td>LL</td>
<td>UL</td>
</tr>
<tr>
<td>AUDIT</td>
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<td>3.164</td>
<td>8.53</td>
<td>3.502</td>
<td>-6.18</td>
<td>&lt;.001</td>
<td>-7.51</td>
<td>-3.85</td>
</tr>
<tr>
<td>Stroop</td>
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<td>.116</td>
<td>.212</td>
<td>.217</td>
<td>-1.23</td>
<td>.119</td>
<td>-.202</td>
<td>.054</td>
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<tr>
<td>TOL-TC</td>
<td>87.88</td>
<td>8.678</td>
<td>89.23</td>
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<td>.307</td>
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<tr>
<td>TOL-PT</td>
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<td>.691</td>
<td>1.88</td>
<td>.462</td>
<td>.79</td>
<td>.217</td>
<td>-.198</td>
<td>.447</td>
</tr>
<tr>
<td>N-Back 2</td>
<td>18.08</td>
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<td>.093</td>
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<td>N-Back 3</td>
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</tr>
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<td>.457</td>
<td>-.407</td>
<td>.454</td>
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<td>8.097</td>
<td>24.43</td>
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Table 18

**Contrast of High and Low Craving Groups on Alcohol and Executive Function Measures - Males.**

<table>
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<tr>
<th>Variable</th>
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<th>High Craving</th>
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<tbody>
<tr>
<td></td>
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<td>M</td>
<td>SD</td>
</tr>
<tr>
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<td>6.401</td>
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<tr>
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<td>.177</td>
<td>.164</td>
<td>.106</td>
</tr>
<tr>
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<td>7.201</td>
<td>89.67</td>
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<td>6.322</td>
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<td>1.979</td>
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Table 19

_Correlations Between Family History, Alcohol, and Executive Function Measures – Males_

<table>
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<th>Paternal</th>
<th>MatPat</th>
<th>Parental</th>
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</thead>
<tbody>
<tr>
<td>OCDS</td>
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<td>.103</td>
<td>.109</td>
<td>.340*</td>
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<td>.108</td>
<td>-.031</td>
<td>.196</td>
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<tr>
<td>Stroop</td>
<td>-.404*</td>
<td>-.081</td>
<td>-.391*</td>
<td>-.215</td>
</tr>
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<td>.037</td>
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<td>.026</td>
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<td>.047</td>
<td>.004</td>
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</tr>
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<td>-.230</td>
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</table>

*Note. OCDS = Obsessive Compulsive Drinking Scale. AUDIT = Alcohol Use Disorders Identification Test. Stroop = Stroop Color Word Test; TOL-TC = Tower of London – Total Correct; TOL-PT = Tower of London – Planning Time; N-Back 2 = N-Back 2-Back Condition; N-Back 3 = N-Back 3-Back Condition; CPT-IP D’ = Continuous Performance Test- Identical Pairs D-prime; WCST = Wisconsin Card Sorting Task Perseverative Errors. Maternal = Maternal family history; Paternal = Paternal family history; MatPat = Composite of maternal and paternal history; Parental = Family history of alcoholism using composite of parental alcoholism only (i.e. no grandparents). *p < .05, one-tailed.*
Table 20

Correlations Between Family History, Alcohol, and Executive Function Measures – Females

<table>
<thead>
<tr>
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<th>Maternal</th>
<th>Paternal</th>
<th>MatPat</th>
<th>Parental</th>
</tr>
</thead>
<tbody>
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<td>OCDS</td>
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<td>.150</td>
<td>.274**</td>
<td>.292**</td>
</tr>
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<td>.142</td>
<td>.216*</td>
<td>.097</td>
</tr>
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<td>-.086</td>
<td>-.061</td>
<td>-.062</td>
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<tr>
<td>TOL-PT</td>
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<td>.076</td>
<td>-.029</td>
<td>.237</td>
</tr>
<tr>
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<td>.059</td>
<td>.078</td>
<td>-.049</td>
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<td>-.004</td>
<td>.029</td>
<td>-.174</td>
</tr>
<tr>
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<td>.145</td>
<td>.221*</td>
<td>.216*</td>
</tr>
<tr>
<td>WCST</td>
<td>.089</td>
<td>.030</td>
<td>.117</td>
<td>.218*</td>
</tr>
</tbody>
</table>

Note. OCDS = Obsessive Compulsive Drinking Scale. AUDIT = Alcohol Use Disorders Identification Test. Stroop = Stroop Color Word Test; TOL-TC = Tower of London – Total Correct; TOL-PT = Tower of London – Planning Time; N-Back 2 = N-Back 2-Back Condition; N-Back 3 = N-Back 3-Back Condition; CPT-IP D’’’ = Continuous Performance Test- Identical Pairs D-prime; WCST = Wisconsin Card Sorting Task Perseverative Errors. Maternal = Maternal family history; Paternal = Paternal family history; MatPat = Composite of maternal and paternal history; Parental = Family history of alcoholism using composite of parental alcoholism only (i.e. no grandparents). *p < .05, **p < .01, one-tailed.
Table 21

Contrast of Family History Classification on Alcohol and Executive Function Measures - Males.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$FH-$</th>
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<th>$FH+$</th>
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<th>t</th>
<th>p</th>
<th>LL</th>
<th>UL</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>$SD$</td>
<td>$M$</td>
<td>$SD$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>4.848</td>
<td>.18</td>
<td>.431</td>
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<td>3.692</td>
<td>.06</td>
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<td>.270</td>
<td>-3.214</td>
<td>1.714</td>
<td>-.22</td>
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<td>Stroop</td>
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<td>.114</td>
<td>.137</td>
<td>2.25</td>
<td>.017</td>
<td>.011</td>
<td>.248</td>
<td>.81</td>
</tr>
<tr>
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<td>87.75</td>
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<td>.26</td>
</tr>
<tr>
<td>TOL-PT</td>
<td>2.281</td>
<td>.646</td>
<td>2.138</td>
<td>.355</td>
<td>.67</td>
<td>.257</td>
<td>-.304</td>
<td>.589</td>
<td>.27</td>
</tr>
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<td>N-Back 2</td>
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<td>21.83</td>
<td>7.259</td>
<td>.33</td>
<td>.372</td>
<td>-4.731</td>
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<td>-.02</td>
<td>.494</td>
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<td>5.547</td>
<td>.01</td>
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Table 22

Contrast of Family History Classification on Alcohol and Executive Function Measures - Females.

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<th>FH- M</th>
<th>FH- SD</th>
<th>FH+ M</th>
<th>FH+ SD</th>
<th>t</th>
<th>p</th>
<th>LL</th>
<th>UL</th>
<th>Cohen’s d</th>
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</thead>
<tbody>
<tr>
<td>AUDIT</td>
<td>2.54</td>
<td>2.835</td>
<td>4.77</td>
<td>4.199</td>
<td>-2.82</td>
<td>.003</td>
<td>-3.810</td>
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<td>-.62</td>
</tr>
<tr>
<td>OCDS</td>
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<td>1.815</td>
<td>4.58</td>
<td>4.295</td>
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<td>&lt;.001</td>
<td>-4.410</td>
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</tr>
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<td>.117</td>
<td>.099</td>
<td>.181</td>
<td>.167</td>
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<td>.045</td>
<td>-.139</td>
<td>.010</td>
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<td>87.81</td>
<td>7.306</td>
<td>.46</td>
<td>.232</td>
<td>-3.613</td>
<td>5.772</td>
<td>.12</td>
</tr>
<tr>
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<td>1.992</td>
<td>.798</td>
<td>1.954</td>
<td>.549</td>
<td>.24</td>
<td>.408</td>
<td>-.285</td>
<td>.326</td>
<td>.05</td>
</tr>
<tr>
<td>N-Back 2</td>
<td>17.81</td>
<td>8.186</td>
<td>19.07</td>
<td>7.847</td>
<td>-.64</td>
<td>.263</td>
<td>-5.186</td>
<td>2.673</td>
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<td>7.158</td>
<td>-.25</td>
<td>.404</td>
<td>-3.550</td>
<td>2.773</td>
<td>-.05</td>
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<td>1.896</td>
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<td>.033</td>
<td>-.662</td>
<td>.022</td>
<td>-.45</td>
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<td>9.811</td>
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<td>.167</td>
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</table>

Table 23

Contrast of Parental History Classification on Alcohol and Executive Function Measures - Males.

<table>
<thead>
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<th>Variable</th>
<th>FH- M</th>
<th>SD</th>
<th>FH+ M</th>
<th>SD</th>
<th>t</th>
<th>p</th>
<th>95% CI</th>
<th>Cohen’s d</th>
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<td>4.512</td>
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<td>5.633</td>
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<td>3.172</td>
<td>5.20</td>
<td>3.425</td>
<td>-2.07</td>
<td>.023</td>
<td>-4.989</td>
<td>-.051</td>
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<td>.115</td>
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<td>.122</td>
<td>-0.054</td>
<td>.0205</td>
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<td>TOL-TC</td>
<td>88.63</td>
<td>7.999</td>
<td>89.00</td>
<td>3.928</td>
<td>-.15</td>
<td>.439</td>
<td>-5.424</td>
<td>4.674</td>
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<td>.602</td>
<td>2.112</td>
<td>.417</td>
<td>0.89</td>
<td>.192</td>
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<td>5.760</td>
<td>17.38</td>
<td>7.539</td>
<td>-.63</td>
<td>.267</td>
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<td>.103</td>
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<td>19.00</td>
<td>7.331</td>
<td>-.16</td>
<td>.436</td>
<td>-7.748</td>
<td>6.605</td>
</tr>
</tbody>
</table>

Note. FH+ = Positive family history of alcoholism; FH- = Negative family history of alcoholism; AUDIT = Alcohol Use Disorders Identification Test; OCDS = Obsessive Compulsive Drinking Scale; Stroop = Stroop Color Word Test; TOL-TC = Tower of London – Total Correct; TOL-PT = Tower of London – Planning Time; N-Back 2 = N-Back 2-Back Condition; N-Back 3 = N-Back 3-Back Condition; CPT-IP D” = Continuous Performance Test- Identical Pairs D-prime; WCST = Wisconsin Card Sorting Task Perseverative Errors. Family History is based on Liberal Criteria Using a Composite of Parental Alcohol Use on the Family Tree Questionnaire. One-tailed.
Table 24

*Contrast of Parental History Classification on Alcohol and Executive Function Measures - Females.*

<table>
<thead>
<tr>
<th>Variable</th>
<th>FH- M</th>
<th>FH- SD</th>
<th>FH+ M</th>
<th>FH+ SD</th>
<th>t</th>
<th>p</th>
<th>95% CI LL</th>
<th>95% CI UL</th>
<th>Cohen’s d</th>
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<td>AUDIT</td>
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<td>5.30</td>
<td>4.348</td>
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</tr>
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<td>4.88</td>
<td>3.935</td>
<td>-2.79</td>
<td>.004</td>
<td>-3.988</td>
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<td>.140</td>
<td>.169</td>
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<td>.77</td>
<td>.222</td>
<td>-.101</td>
<td>.045</td>
<td>-.19</td>
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<td>.238</td>
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</tr>
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<td>13.96</td>
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<td>1.47</td>
<td>.074</td>
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<td>5.595</td>
<td>.36</td>
</tr>
<tr>
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<td>1.627</td>
<td>.752</td>
<td>1.945</td>
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<td>.034</td>
<td>-.660</td>
<td>.024</td>
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<tr>
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<td>.049</td>
<td>-9.039</td>
<td>.787</td>
<td>-.43</td>
</tr>
</tbody>
</table>

*Note.* FH+ = Positive family history of alcoholism; FH- = Negative family history of alcoholism; AUDIT = Alcohol Use Disorders Identification Test; OCDS = Obsessive Compulsive Drinking Scale; Stroop = Stroop Color Word Test; TOL-TC = Tower of London – Total Correct; TOL-PT = Tower of London – Planning Time; N-Back 2 = N-Back 2-Back Condition; N-Back 3 = N-Back 3-Back Condition; CPT-IP D’ = Continuous Performance Test- Identical Pairs D-prime; WCST = Wisconsin Card Sorting Task Perseverative Errors. **Family History is based on Liberal Criteria Using a Composite of Parental Alcohol Use on the Family Tree Questionnaire.** One-tailed.
APPENDIX

DEMOGRAPHICS QUESTIONNAIRE
How old are you ________________

Circle the Race/Ethnicity that best describes you.
White/Caucasian          Black/African American          Asian          Hispanic          Native American          Other

Have you ever been in an accident where you hit your head and were unconscious for more than 2 minutes?
Yes           No

Have you ever been told that you have a developmental disorder such as: Autism, Mental Retardation, Rett’s Disorder, Childhood Disintegrative Disorder, or Asperger’s Disorder?
Yes           No

Do you drink alcohol?           Yes           No

Do you use drugs other than alcohol?           Yes           No

Are you currently taking any psychoactive medications such anti-anxiety medications, anti-depressants, seizure disorder medication, or anti-psychotics?
Yes           No

If you drink, at what age did you begin drinking? ________________

How many alcoholic beverages do you consume during a typical week? ________________

If you have recently stopped drinking, how long has it been since your last drink? ________________
REFERENCES


