DISSERTATION

AN EVALUATION OF EXECUTIVE FUNCTIONS, COGNITIVE CONTROL AND A NEUROCOGNITIVE PROFILE OF COLLEGE BINGE DRINKERS

Submitted by

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ABSTRACT

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Introduction: Binge drinking is a detrimental behavior which presents with consumption of large amounts of alcohol however, does not present with symptoms of dependence. The college population is a unique group to investigate due to the neuroplasticity and development those in this cohort are undergoing. Specifically, this age group is experiencing a natural period of neural immaturity specific to the prefrontal cortex. In addition to being identified by the personal, physical, and academic detriments caused by binge drinking, it was hypothesized this population of binge drinkers could be categorized with a neurocognitive profile which varies from their non-drinking peers.

Participants: One hundred and ninety seven Colorado State University students were recruited and categorized in to different levels of binge alcohol consumption on non-drinkers based on two self-report measures.

Method: Alcohol consumption was evaluated through a sex based questionnaire and the Alcohol Use Disorder Identification Test. Neurocognitive performance was assessed through six tasks: Wisconsin Card Sorting Test, Delay Discounting Task, One Touch Stockings of Cambridge, Trail Making Task (A and B), the Behavioral Rating Inventory of Executive Function, and the Dysexecutive Questionnaire.

Results: An initial MANOVA was used to assess differences between non-drinkers and binge drinkers, showing no significance, F (12, 19) = 1.96, p = 0.09. A secondary MANOVA was used to evaluate differences across different categories of binge drinkers and non-drinkers,

where significance was noted, F (36, 92.32) = 1.56, p = 0.045. The post hoc tests suggest the significance of this relationship was due to poorer performance on the WCST by binge drinkers, F (3, 42) = 3.27; p = 0.03.

Conclusions: Though the deficits were not as vast as hypothesized, the inability for binge drinkers to complete an equal number of categories in the WCST as their non-drinking peers holds interesting conclusions. Those which are discussed relate to binge drinkers' inefficient self-reporting of executive functioning performance, as well as allowing us to possibly understand why we see differences in binge drinkers' perception of alcohol outcomes and their personal self-efficacy with alcohol consumption.

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DEDICATION

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INTRODUCTION

Alcohol consumption is a behavior which spans a large portion of the lifetime and varies within individuals, from light or social drinking to heavy or dependent drinking. Alcohol dependence has been an area of interest due to the abuse, dependence, and blatant consequences evident through diminished personal life, relationships, and health. Research regarding college binge drinking has only been of interest for the past twenty years, roughly. While some rename binge drinking as "weekend alcoholism" (Sanhueza, Garcia-Moreno, & Exposito, 2011), binge drinkers lack some of the defining factors of alcohol dependence. Specifically, alcohol dependence is associated with craving and withdrawal, which are atypical of college binge drinkers. However, based on other new criteria set by the Diagnostic and Statistical Manual of Mental Disorders - 5, binge drinkers may be misdiagnosed with mild alcohol abuse disorder due to characteristics such as missing important activities (e.g., class), or drinking more than intended.

Though some individuals begin drinking in high school, there is an influx of those engaging in binge drinking during the first year of college (Weitzman, Toben, & Wechsler, 2003). This college aged population is of interest in the current study due to the pattern of drinking, vast consequences, and unique neuroanatomical and neurocognitive developments and deficits associated with this group. Binge drinking is an epidemic within college aged individuals in the United States and abroad. This behavior that has been termed "coming of age behavior" by Schulenberg and colleagues (1996) seems innocuous to those consuming, however effects range from poor academic performance and disturbing others to accidental death, and does not appear to be simply due to autonomy from parents (Chassin, Pitts, & Prost, 2002). Binge drinking is unique for a number of reasons, but the single most identifying feature is the pattern of

consumption. Formally defined in 2004 by the National Institute on Alcohol and Alcoholism, binge drinking brings the blood alcohol content (BAC) to a minimum of 0.08 gram-percent. Specifically, four or more drinks for a female or five or more drinks for a male must be consumed in a two hour period (Wechsler & Isaac, 1992; NIAAA, 2004). Though binge drinking is a behavior which is also found within older populations, in younger populations they appear to be transitioning to an environment which solicits and sanctions drinking, suggesting a possibly different pathway for college aged drinkers. College areas tend to host bars which discount alcohol, and in general have higher densities of places to buy alcohol, enveloping students in alcohol stimuli. Additionally, an increase in availability within a two mile radius of a college campus has been shown to link to an increase in college drinking, and therefore negative consequences of alcohol. (Weitzman, Folkman, Folkman, & Wechsler, 2003).

While the college population is the impetus for the current study, it should be noted that binge drinking is not solely present within college students or even this college-age demographic. In fact, 34.1% of 26-34 year olds, 24.2% of 35-54 year olds, and 10.2% of those over 55 report binge drinking. In terms of young adults, including both college attending and non-attending, rates are higher at 51.3% for all 18-20 year olds and 48.6% of 21-25 year olds. (Naimi, et al, 2003). When one looks at differences in gender, males in the college age range binge drink more than females; 61.1% of 18-20 year old males, 61.9% of 21-25 year old males and 37.7% of all 18-20 year old females and 32% of 21-25 year old females (Naimi, et al, 2003).

Though these data support the ideology of college binge drinking being a predominantly developmental disorder (Chassin, Pitts, & Prost, 2002), there are clearly factors that are associated with college-attending students' binge drinking that may not be as robust in their non-college attending peers. Based on data from two national drug and/or alcohol use surveys

(Monitoring the Future and National Household Survey on Drug Abuse), alcohol use is higher in college students than those same aged peers that do not attend college. Additionally, some college binge drinkers use other substances, the most frequent being cigarettes, followed by marijuana, and rarely cocaine. These substances are also used by those that do not attend university, and unlike binge drinking, the rates of substance use in the *non-college* population appear to be higher than college attending peers. These results suggest that there is something unique about alcohol use, specifically, for college attending students (O'Malley & Johnston, 2002).

Consequences of Binge Drinking

Given the high prevalence of binge drinking in college, there may be an impression of this type of behavior being a fairly regular part of college life. Binge drinking, however, is not just a coming of age behavior that results in innocent, harmless mistakes. Annually, college students report damage to self and others related to alcohol consumption. Some of these negative consequences are seemingly more minor, such as academic performance declines, and others can be as severe as death. Poor grades have been reported by 26% of drinkers most likely associated with 33% of drinkers reporting missing class due to alcohol or drug use (Presley, Meilman, & Cashin, 1996). Another consequence, which is typically viewed as minor or not negative by drinkers, is blacking out. Experienced by 27% of college drinkers (Wechsler, et al, 1998), blackouts are alcohol-induced, temporary memory loss periods which the individual cannot recall any information associated with the events which occurred during this time.

Sexual activity is another behavior which can be altered once intoxicated, roughly 23% of drinkers engaged in unplanned sex, 11% of which did not use protection when surveyed, increasing the risk of pregnancy and sexually transmitted infections (Wechsler, et al, 1998).

Interestingly, while sober, students were asked their likelihood of using protection while intoxicated, 70% of which reported they were less likely to use a condom (Poulson, et al, 1998). Unfortunately, unplanned sexual activity due to alcohol intoxication does not remain between consensual partners. Presley and colleagues (1996) report 14% of college females and 13% of college males have received unwanted sexual advances, 55% of these acts were committed while the victim had been drinking and 60% of the attackers had been drinking. Harvard School of Public Health College Alcohol Study (2000) has reported, nationally, 1.5% of college students or roughly 70,000 individuals were victims of alcohol related date rape or sexual assault. Interestingly, 12% of males and 4% of females have admitted to sexually assaulting another individual while intoxicated (Presley, Meilman, & Cashin, 1996).

Attacks and personal harm to others are clearly evident, but personal injury due to alcohol intoxication is also prevalent *within* drinkers, with roughly 15% of individuals who abuse alcohol reporting that they have been the victims of personal injury. An alarming 630,000 college students report being hit or assaulted while either party was intoxicated and roughly 1,400 college deaths occurring due to unintentional injury (Hingson, et al, 2002). With 56% of male heavy drinkers and 43% of female heavy drinkers reporting driving while intoxicated (Engs, Diebold, & Hanson, 1996) it is not surprising 1,100 of 1,400 deaths were related to traffic incidents (Hingson, et al, 2002). Finally, 6.1% of college drinkers have reported suicidal thoughts and 1.9% of which have unsuccessfully attempted suicide (Presley, Meilman, & Cashin, 1996).

Young Adult Binge Drinkers and Neurocognitive Consequences

While these negative consequences may provide enough rationale to study binge drinking in college aged students, this specific population has fostered interest among researchers and

policy makers for several additional reasons. While most of these individuals seem to mature out of this type of heavy drinking, this population is also at a higher risk to develop future alcohol use disorders (AUDs) (Jessor, Donovan, & Costa, 1991). Even without the development of a future AUD, the act of binge drinking poses negative consequences for various brain regions, the resulting executive and cognitive functions, and behaviors. High levels of alcohol consumption and blood alcohol levels in alcoholics result in widespread grey and white matter deficits (Crews & Nixon, 2008). A rat binge model has shown marked neurodegeneration within the frontal lobes and limbic system (Crews, Braun, Hoplight, Switzer III, & Knapp, 2000). Additionally, deficits in neuroregeneration and proliferation are evident with high alcohol consumption, which has been suggested may result in decreased learning ability (Crews, et al, 2003).

Specifically, within early adolescent drinkers, multiple studies have noted differences between those who do and do not consume. Adolescent binge drinkers showed decreased white matter integrity in the superior corona radiata, inferior longitudinal fasciculus, inferior frontal-occipital fasciculus, and the superior longitudinal fasciculus through diffuse tensor imaging (Jacobus, et al, 2009). Medina and colleagues (2008) have found the prefrontal cortex (PFC), which is of particular interest of the current study, to be smaller in heavy drinking adolescents. Smaller PFC volume in heavy drinking females compared to non-drinking females was most significant (p = .003). These gender difference data support other recent data which suggests differences in neurodegeneration based on gender (Nagel, et al, 2006). While these differences may not be as widespread as with adult chronic alcohol abusers these significant patterns within adolescent drinkers suggests there may be similar effects to cognitive processes and executive functions.

While the current investigation's focus remains on these differences, it is important to note what may be an underlying driver or contributor to PFC differences. GABA and its receptors have been utilized in finding an appropriate medication for alcohol dependence. Alcohol intoxication is known to increase the release of GABA (Ward, Lalleman, & de Witte, 2009), while $GABA_A$ receptor has been linked to excessive alcohol drinking (Yu, et al, 2006), and reduction in $GABA_A$ activity leads to a decrease in the signs of intoxication (Crews, He, & Hodge, 2007). GABA, a well-studied inhibitory neurotransmitter, holds importance due to its high prevalence in the adolescent brain, higher than that of the adult brain. GABA has also been accredited to cortical remodeling, making it essential during the developmental stages, specifically when it is flooding the PFC region in monkeys during adolescence (Crews, He, & Hodge, 2007). While GABA will not directly be assessed in the current study, the possible contribution to the neurocognitive profile will be addressed.

Binge Drinking & Executive Functioning

The discussed neurophysiological deficits in heavy drinking adolescents, specifically those within the PFC, suggest executive functions may be affected. Several of these executive functions have been evaluated in past literature. Two studies have shown significant differences in binge drinkers compared to non-drinkers in spatial working memory (Townsend & Duka 2005; Weissenborn & Duka, 2003). Additionally, Townsend and Duka (2005) found that binge drinking females had the most difficulty inhibiting prepotent responses. Hartley (2004) found marked deficits in decision making within binge drinkers compared to non-drinkers using a traditional measure of planning, the Tower of London.

The use of neurocognitive measures to evaluate possible differences between populations has been effective in past literature. Youths who participate in "weekend alcoholism" were noted

to have executive functioning patterns more similar to those with cognitive deficits due to aging than their same aged peers (Sanhueza, Garcia-Moreno, & Exposito, 2011). Evaluating differences between neurocognitive task performance of binge drinkers and the performance of their peers will inform researchers whether deficits appear to be uniform and parallel (a lower level of performance is seen across a variety of executive functioning tasks, suggesting a generalized cognitive deficit) or deficits are uneven across the board, possibly including select intact resources for certain items (Harris, 1985). Neurocognitive profiles have been used extensively in populations who have abused substances (Rogers & Robbins, 2001; Fox, et al, 2002; Kalechstein, et al, 2007) in addition to those who have been exposed to substances prenatally (Korkman, Kettunen, & Autti-Rämö, 2003; Kodituwakku, 2009) in an attempt to better understand differences in the brain associated with early exposure to alcohol versus later exposure to alcohol, and in an attempt to delineate which differences in the neurocognitive profile appear to result from exposure to various substances versus those that seem to predispose individuals to substance abuse. For example, in the past, researchers such as Kodituwakku (2009) have evaluated neurocognitive performance of individuals exposed to alcohol prenatally. Specifically, individuals who have been diagnosed with fetal alcohol syndrome disorders (FASD) have been assessed across a variety of similar, yet distinct measures in order to delineate a neurocognitive profile. In the case of FASD, the neurocognitive profile suggests a general cognitive deficit within children exposed to alcohol associated with integration and processing of information. While the brains of FASD and college binge drinking are exposed to alcohol during imperative developmental stages, one key difference is the method of exposure. Those affected by FASD do not choose this exposure while college binge drinkers consciously make the

decision to drink to intoxication. Seemingly, they continue to choose to drink even after they or others have experienced the negative consequences previously discussed.

Addressing neurocognitive profiles, specifically in terms of executive function deficits between binge drinkers and non-drinkers, is an interesting and necessary avenue to understanding this population. Specifically, given that the population of interest likely has developmental issues associated with immature prefrontal cortices paired with possible higher level cognitive dysfunction, a broader understanding of the specific neurocognitive profile associated with binge drinking versus underdevelopment of the frontal lobes would be helpful to identify and treat binge drinking. College binge drinkers are a unique population, which in more recent years has become a popular interest. They and their peers are engaged in similar activities, living situations, stress, and environmental factors, however, this sect of students choose to drink while others do not. Overall, the literature pool is growing, however, there is not enough evidence to determine if the neurocognitive differences are purely a result of drinking, are the cause of drinking, or possibly both. While the current study does not intend to answer this question, providing further evidence of neurocognitive deficits in this population may help us better understand the cognitive factors associated with binge drinking.

The measures chosen for this neurocognitive profile offer a unique perspective of this population and were chosen based on what is perceived as the associated neurophysiology of binge drinking. While some of these assessments have been used with similar populations, the combination of measures which evaluate executive functioning on a micro and macro level had not previously been used (Brown, Tapert, Granholm, & Delis, 2000; Tapert, Granholm, Leedy, & Brown, 2001; Weissenborn & Duka, 2003; Stephens & Duka, 2008; Crego, et al, 2009). The current investigation provides a comprehensive profile of college-aged binge drinkers by

including executive functioning measures that include more isolated types of higher level processing, such as the One Touch Stockings of Cambridge, and more day to day, behavioral executive function measures such as the Dysexecutive Questionnaire. Developing a more thorough neurocognitive profile will allow us to predict alcohol and drug use and associate findings with those of other special populations.

Since binge drinking was defined, researchers have been investigating a multitude of facets thought to be associated with binge drinking or those which may differ between binge drinkers and non-drinkers. The goals of each were to develop a better understanding of this population through many variables from individual behavioral patterns, cohort identification, other drug use, parental drug use/abuse, to electrophysiological and neuroimaging techniques. Though past literature associated with this population has used similar measures as proposed in the current study, they have primarily focused on identifying a specific executive function and mapping to a specific neural correlate (e.g. Stephens & Duka, 2008; Scaife & Duka, 2009; Parada, et al, 2012). A goal of the current study was to develop a more comprehensive neurocognitive phenotype to assess possible predisposition and attributes of college-aged individuals who binge drink. Past work suggests binge drinkers may indulge in this unique behavior for a variety of reasons, such as impulsivity, poor planning, discounting of rewards or negative effects, cognitive flexibility, and decision making. The assessments that have been chosen evaluate this array of executive functions. The chosen tasks will allow for the needed assessment of both specific executive functions and the more every day, behavioral representations of executive functions. An assessment through the measures proposed will allow us to evaluate not only possible differences between college binge drinkers and their non-drinking peers but allow us to compare within college binge drinkers as well.

Executive functions have consistently been an area of interest within the literature associated with binge drinking. These important cognitive facets, decision making, planning, and being able to understand future consequences, are all believed to be associated with drinking in excess (Oei & Morawski, 2004). Within this sect of adolescents identified as binge drinkers, an increased value is placed on the more immediate, favorable effects of alcohol consumption than the later occurring, delirious effects of this type of alcohol abuse (Oei & Morawski, 2004), suggesting an important difference in executive functioning between those that choose to binge and those that do not choose to binge drink. College binge drinkers tend to have low alcohol expectancies, meaning, while they may focus on more positive effects, the power of alcohol's influence is low. These alcohol expectancies are the cognitive openings which allow environmental factors and social pressures to be effective (Christiansen, Goldman, & Inn, 1982). Additionally, college binge drinkers have high drinking refusal self-efficacy, they can refuse drinks easily but once they begin, they are unable to cease (Oei & Morawki, 2004). While these facets are understood the underlying drivers of these facets have yet to be investigated thoroughly.

The series of tasks which have been chosen, Wisconsin Card Sorting Test (WCST), Trail Making Task (TMT), One Touch Stockings of Cambridge (OTS), Delay Discounting Test (DDT), Behavioral Ratings Inventory of Executive Function (BRIEF), and Dysexecutive Questionnaire (DEX), evaluate these important cognitive facets. This series of six tasks examined together will provide a unique perspective on college binge drinkers. Each measure was chosen based on the facets of executive functioning it evaluates and the supporting literature suggesting possible differences between binge drinkers and non-drinking controls, which will be discussed.

The Wisconsin Card Sorting Test is a well-known measure which asks participants to categorize a set of cards based on four cue cards. The rules for categorization, however, are unknown to the participant and change periodically throughout the task. Sensitive to frontal lobe dysfunction, scores from this task allow administrators to better understand if abstract thinking has been compromised, as well as executive functions. Specifically, this task measures planning, goal achievement, organized searching, use of available feedback, and impulsivity. The WCST is reliably used to evaluate set shifting, an inability to do so would lead to the repetition of a specific response even if notified it was incorrect; perseveration. (Heaton et al., 1993; Strauss et al., 2006) Though typically used within clinical patients, the WCST has repeatedly been used in experimental work. (Heaton, et al, 1993) This measure has been used with similar populations as the current population of interest, however, resulting data has been conflicting; DSM-III-R diagnosed alcohol abusing or dependent adolescent females have been noted as performing worse on this measure with abusing adolescent males performing better than control males (Moss, Kirisci, Gordon, & Tarter, 1994), while others have reported no difference between binge drinking students and those students who do not engage in binge drinking (Parada, et al, 2011). The WCST was chosen because it is associated with demand on the dorsolateral prefrontal cortex, an area which is seemingly affected within binge drinking adolescents as seen through previous studies involving the Spatial Working Memory task (Scaife & Duka, 2009). Additionally, decreased amplitude in P100/N100 components provide further neurophysiological support for deficits in attention switching (Maurage, et al, 2012).

Trail Making Task is a simple, paper and pencil task which an individual is asked to connect dots in ascending order. Version A includes just numbers and version B requires the taker to switch between numbers and letters (i.e. 1-A-2-B and so on). The TMT has previously

been reported to evaluate multiple cognitive facets, including cognitive flexibility and working memory. Additionally, the two versions evaluate different aspects of executive functioning. Version A is thought to assess visual perceptual skills, visual search abilities, and motor speed. Differences in performance within version B have been associated with cognitive control, specifically task switching, mental flexibility, abilities to maintain two sequences, working memory, and attention (Crowe, 1998; Arbuthnott & Frank, 2000). No performance differences are seen based on intelligence between those with average to above average IQ. While not previously used to evaluate adolescent drinkers, this measure has been used within "healthy" abstinent alcoholics. When compared to controls, these "healthy" abstinent alcoholics performed worse on both the simpler TMT version A and the more tasking version B (Davies, et al, 2005). As is the WCST, the TMT is associated with the dorsolateral prefrontal cortex (DLPFC) as well as the medial PFC and areas within the parietal lobe (Moll, de Oliveira-Souza, Moll, Bramati, & Andreioulo, 2002). Additional neurophysiological evidence is suggested by Maurage, et al (2012), drinkers presented with decreased P100/N100 amplitudes compared to controls, which led those authors to suggest deficits in basic visual processing and early processing of visual stimuli. Perceptual effects may be expected due to remodeling and plasticity which is still occurring during adolescence within the visual cortex (Crews, et al, 2007).

Another measure which taxes the DLPFC is the One Touch Stockings of Cambridge (OTS). In addition to evaluating executive planning and working memory, the OTS also assesses spatial planning specifically (Chamberlain, et al, 2011; Grant, Chamberlain, Schreiber, Odlaug, 2012). The OTS task is thought to be a more cognitively taxing version of the Stockings of Cambridge (SOC). In both of these tasks, takers are asked to arrange a set of billiard balls in as few moves as possible to reflect the given example. While SOC allows the individual to touch

and move the balls on a screen, while attending to a set of rules, the OTS asks the individual to imagine the moves necessary, count the number of moves, and report this value. While OTS has yet to be evaluated with a binge drinking adolescent population, the SOC test has been evaluated with binge drinkers. Hartley and colleagues (2004) found that binge drinkers performed significantly slower than their non-drinking peers. While SOC has been used, it lacks the difficulty and heightened working memory, spatial planning, visual attention, and decision making components which make OTS unique and likely more challenging for our non-clinical college population.

The Delay Discounting Task (DDT) was selected as it measures the types of behaviors one might expect to be problematic in binge drinkers regarding impulse control. The DDT has frequently been utilized by behavioral economists, and social and clinical psychologists as it is thought to evaluate impulse control behavior through assessing an individual's discounting of a reward as the delay to the reward increases. The test is thought to allow the examiner to have a more realistic view of impulse control and future goal attainment than other more experimental measures that have more abstract rewards (Kirby & Marakovic, 1996). The DDT assesses probabilistic risk as part of the process of decision making about future rewards as well as a discount function, the rate at which future reward is discounted. This value is part of a hyperbolic discounting measure, through the varying large delay rewards and time to reward we are able to see if the devaluation of the reward is proportional to the delay (Steinberg, et al., 2009). In other words, as the delay involved in gratifying one's needs becomes longer, the reward associated with that delay becomes less appealing to the individual compared to the smaller, more immediate rewards. Impulse control and restraint are defining factors not only of binge drinkers but also of adolescents. Binge drinkers, in particular, seem to place more value on the immediate

"positive" effects of alcohol consumption and over consumption than the later, negative consequences (Oei & Morawski, 2004). Additionally, this behavior continues to reinforce the "positive effects" and immediate gratification of being intoxicated while overlooking the multiple negative interactions with the effects of intoxication (Murphy, Correia, & Barnett, 2007). Though Kirk and de Wit (1998) evaluated individual's desires for alcohol or money based on intoxication, they suggest there may be a discounting effect within a heavy drinking, nondependent population for other scenarios without an actual monetary reinforcement. A similar trend, placing greater value on immediate rewards and less value on more substantial, later rewards, has been seen within individuals addicted to alcohol, cocaine, or heroine (Kirby & Petry, 2004).

These four measures evaluate executive functions through tasks which engage the facets of interest (planning, reward delay, etc.). The final two tasks which will be assessed evaluate executive dysfunction via self-report. Due to the global effect alcohol has on the brain, and therefore cognition and behavior, the BRIEF and DEX ought to be sensitive to deficits, as long as the participants recognize their own difficulties and are able to articulate specific areas of dysfunction. While neither of these measures have been used within this population, it is believed there will be deficits seen comparing binge drinkers to non-drinkers based on the unique subcategories each measure breaks down to in order to evaluate different aspects of executive functioning and cognitive control.

While developed and typically used within clinical populations, the use of the BRIEF within a non-clinical population holds merit. While typical executive function tests are designed to evaluate multiple executive functions, the BRIEF allows administrators to parse out specific behavioral examples of executive function deficits. There are multiple scales within the BRIEF.

An overall Global Executive Composite (GEC) is composed of the Behavioral Regulation Index (BRI) and the Metacognition Index (MI). These two indexes can be broken down to clinical scales; BRI to Emotional Control, Self-Monitor, Shift, and Inhibit, and the MI in to Organization of Materials, Plan/Organize, Working Memory, Initiate, and Task Monitor. Scores for each evaluation can be reported by clinical items, index, and/or a summary composite. (Roth, Isquith, Gioia, 2005; Malloy & Grace, 2005). Due to the more observational methodology of the BRIEF, greater sensitivity has been seen within frontal lobe patients that perform standard executive functioning tasks without any marked deficits, which is how a non-clinical population would perform (Roth, Isquith, & Gioia, 2005).

DEX is known to be sensitive to goal directed behavior, an affected facet within binge drinkers (Sheeran, et al, 2005). Like the BRIEF, each item of DEX evaluates a different behavior associated with dysexecutive syndrome, each of which may be parsed out depending on researcher goal and interest (Burgess, 1996). While a general grand score is informative, numerous studies have used this measure and manipulated the four broad areas in to different factor structure models. While many of these studies have specifically been interested in the rater or independent version of DEX, the self-report version, solely, will be utilized. While some studies have developed models specifically for this version, there are still various models available. While seemingly analogous, there are differentiations between each, however, this current study focused on the traditional three factors as defined by the developers of the measure; behavior, cognition, and emotion (Burgess, 1996; Burgess, et al., 1998). Finally, Bodenburg and Dopslaff (2008) concluded DEX may be used as not only a qualitative measure but also a quantitative measure.

While each of these measures adds to the small pool of knowledge associated with binge drinkers, the grouping of these evaluations would allow for a global perspective and neurocognitive profile. The current study aimed to develop a profile which would begin to fill the gaps in our current knowledge of binge drinkers and understanding what may lead to or be a result of this detrimental behavior. The inclusion of these specific measures allowed for the evaluation of any possible interactions between separate drivers, cognitive/executive functioning and behavioral/psychological factors. These interactions were thought to be evident due to differences in self-other interactions and other binge drinking risk factors associated with the deficits in interpersonal awareness, constructs which are related to various cognitive components and the PFC (Decety & Sommerville, 2003). The increase in knowledge and understanding of these factors will help to identify and develop prevention programs for those at risk, which is critical for treatment, though was not a focus of the current investigation.

METHOD

Participants

One hundred ninety seven (75 males) participants were recruited from Introduction to Psychology courses at Colorado State University. Individuals received extra credit or class credit for attending the study in order to fill course research requirements. Of this group, those that were over the age of 25 or did not report an age were excluded from further analyses (17 total). In accordance with standard protocol, those individuals with a history of neurological (50) or psychological (37) diagnoses were not included in data analyses. Additionally, in order to control for confounds due to familial drug or alcohol addiction or abuse, those with this history were excluded (24 total).

Procedure

Each participant was asked to read and complete an approved consent form. Each participant completed a demographics form which also included questions regarding gender specific binge alcohol consumption (e.g. "If you are a male, please answer the following: Have you consumed 5 or more drinks on at least one occasion during the 2 weeks before survey? If so, how many drinks in one sitting?").

Alcohol Use Disorder Identification Test

The Alcohol Use Disorder Identification Test (AUDIT) was developed by the World Health Organization for practitioners to evaluate severity of patient alcohol use. In addition to being used in the United States, it has been tested in five other countries (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001). The AUDIT allowed for a more detailed view of the drinking and consequential behavior of these individuals. In order to ensure individuals with possible alcohol

abuse were excluded from the current analyses, individuals who scored and eight or above on the AUDIT were excluded from any analyses.

The demographic form, AUDIT, and the following tasks were administered in a counterbalanced order across participants.

Executive Function Measures

Wisconsin Card Sorting Test (WCST)

The Wisconsin Card Sorting Test, a computerized card sorting task during which participants sort cards based on three categories: color, form, or number. Four stimulus cards allow individuals to see representations of the categories as one red circle, two green stars, three blue squares, and four yellow crosses. Participants are told that they will be informed whether their categorization is "correct" or "wrong", however, no direction is given as to which category is correct; the correct category changes after ten trials. (Strauss, Sherman, & Spreen, 2006).

Trail Making Task (TMT)

The Trail Making Task is a paper and pencil neuropsychological measure which participants connect dots in a sequential manner. Two versions are administered to each participant; version A asks participants to connect dots labeled 1-25, version B requires connecting in an alphanumeric manner, A-1 through L-13. The ratio calculated from the time to successfully complete trials A and B were used with this population; greater impairment is reflected through larger ratios. (Reitan, 1958).

One Touch Stockings of Cambridge (OTS)

The OTS, a subtest of the Cambridge Neuropsychological Test Automated Battery (CANTAB), is a more complex variation of the Stockings of Cambridge (SOC) subtest. Individuals use a computer tablet to complete the task. Individuals are asked to report how many

moves it will take to arrange a given set of billiard balls in stockings to mirror an example. Unlike SOC, one does not get the opportunity to move the billiard balls, items are rearranged mentally. (Hodges, 2007) The two outcome measures used in this investigation were mean latency to correct choice and mean choices to correct choice.

Delay-Discounting Task (DDT)

The DDT was developed by Kirby & Marakovic (1996) to assess individual choices. Over 27 items, participants are asked to choose if they would like to receive a smaller, immediate reward (SIR) or a larger, delayed reward (LDR). The LDRs are divided in to three categories; S: $25-35, M: $50-60, L: $75-85. 2.3.6 *Behavioral Ratings Inventory of Executive Function - Adult Version (BRIEF-A):* Comprised of 75 items, this paper and pencil measure has been effective at evaluating the everyday aspects of executive function (Strauss, Sherman, & Spreen, 2006).

Dysexecutive Questionnaire (DEX)

The DEX is a 20-item, paper and pencil questionnaire that is not formally part of the Behavioural Assessment of Dysexecutive Syndrome (BADS) but is usually administered in conjunction with the battery. The four broad areas these items are classified in are behavior, cognition, motivation, and emotion and personality; cognitive regulation (Wilson, Alderman, Burgess, Emslie, & Evans, 1996). Each item is scored on a 5 point Likert scale, 0-4 for "Never" to "Very Often", higher scores implying greater dysexecutive function.

RESULTS

A multivariate analysis of variance (MANOVA) was utilized to assess possible correlations between variables to decipher if a differing neurocognitive and executive functioning profile of college binge drinkers (BD) compared to non-drinkers (ND) exists. This initial analyses was composed of 32 participants; 14 (3 males) were considered binge drinkers, and 18 (10 males) considered non-drinkers (ND). In addition to the initial demographic exclusion factors, those individuals who may be considered alcohol abusing based on the AUDIT (a score of eight or higher) were also removed from this initial analyses. Results from the initial MANOVA showed no significance, F (12, 19) = 1.96, p = 0.09, Wilk's $\Lambda = 0.45$, partial $\eta^2 = 0.55$ between BD and ND.

A secondary analyses sought to find any differences between population quartiles, non-drinkers (14 total; ND), low binge drinkers (9 total; LBD), high binge drinkers (9 total; HBD) and binge drinkers which may have problematic behaviors (14 total; PBD). Groups met the following criteria: non-drinkers (no binge drinking reported through 4/5 questionnaire and zero scores on AUDIT, same non-drinker group as the initial MANOVA), low binge drinkers (binge drinking reported through 4/5 questionnaire and AUDIT scores between one and four), high binge drinkers (binge drinking reported through 4/5 questionnaire and AUDIT scores between five and seven), and binge drinkers with possible alcohol abuse tendencies (those binge drinkers which also scored an eight or above on the AUDIT with binge drinking reported through the 4/5 demographic question). This analysis was significant, F (36, 92.32) = 1.56, $p = 0.045$, Wilk's $\Lambda = 0.25$, partial $\eta^2 = 0.37$ across a variety of measures.

Demographic information for groups included in either analyses can be found in Table 1.

From here, the univariate main effects from these analyses will be discussed by each task, nonsignificant main effects are noted below each task and may be found in Tables 2 and 3.

Due to the strict nature of the exclusion factors, a concern was the overall generalizability of the two initial analyses. Thus, the individuals which were included in the initial two analyses were included in a third analysis in order to greater answer the initial question whether there is a pattern of differences between non-drinkers and binge drinkers. In order for these groups which were initially excluded to be reintroduced to the data set, within group comparisons between the excluded set and the included set were used to ensure no significant differences. No significant differences were found between any excluded and included groups. Therefore, two additional MANOVAs were run to investigate the original question between 28 non-drinkers (5 males) and 32 binge drinkers (14 males), and one addressing possible sex differences between groups. For these analyses the only exclusion factors were scores above "8" on the AUDIT in order to ensure alcohol abusing diagnoses were not confounding, as well as those aged over 25 years. Neither analyses was significant; between ND and BD, $F(12, 47) = 1.54$, $p = 0.14$, Wilk's $\Lambda = 0.72$, partial $\eta^2 = 0.28$; between male ND, female ND, male BD, and female BD, $F(36, 141) = 1.18$, $p = 0.24$, Wilk's $\Lambda = 1.19$, partial $\eta^2 = 0.24$. From here, the univariate main effects from these analyses will be discussed by each task, nonsignificant main effects are noted below each task and may be found in Tables 4 and 5.

Wisconsin Card Sorting Task

For both analyses, the categories completed variables were reported for the WCST. No significant relationship was found for the initial comparison between ND and BD.

A significant effect between the non-drinker, low binge drinker, high binge drinker, and problem binge drinker groups was found for categories completed during the task, $F(3, 42) =$

3.27; $p = 0.03$; partial $\eta^2 = 0.19$. Post hoc comparisons using the Tukey HSD test show a significant relationship between ND and LBD ($p = 0.03$) and a moderate relationship between the LBD and HBD ($p = 0.09$).

Interestingly, with the increased participants when exclusions were reduced, this trend still held; between ND and BD, $F(1,58) = 5.22$; $p = .03$; partial $\eta^2 = .08$; and between male ND, female ND, male BD, and female BD, $F(3,56) = 5.28$; $p = .08$; partial $\eta^2 = .11$.

Trail Making Task (TMT)

Congruent with previous literature examining differences within categories of college participants, the ratio between times from TMT trial B and trial A were utilized (Arbuthnott & Frank, 2000). No significant differences were found for any analyses.

One Touch Stockings of Cambridge (OTS)

The mean number of choices to correct answer and the mean latency to correct answer were used to analyze the OTS. No significant differences were found between groups in across all analyses performed.

Delay Discounting Task (DDT)

Three values were derived from the DDT for analyses, the hyperbolic discount parameters for the larger, delayed reward (LDR), medium, delayed reward (MDR), and the small, delayed reward (SDR). Significant differences were not found for any of the three parameters for either of the analyses with the strict exclusion factors.

While there was no significant differences between groups for the ND vs BD comparison using the larger population, a trend towards significance was found between groups for the comparison including sex for the small, delayed reward; $F(3,56) = .64$; $p = .08$; partial $\eta^2 = .11$. However, post hoc analyses showed no significance between groups.

Behavioral Ratings of Executive Function - Adult Version (BRIEF)

The Global Executive Composite (GEC), the Metacognitive Index (MI), and the Behavioral Regulation Index (BRI) were used as variables for the BRIEF. These three variables were not significant in any of the analyses.

Dysexecutive Questionnaire

The original three categories as designed by Burgess (1996) behavior, cognition, and emotion were used to assess possible differences between these groups. Again, no significant differences were found between any groups for any variables in any of the analyses.

DISCUSSION

The purpose of the current study was to investigate the role of different executive functions in college students who meet criteria for binge drinking compared to those who do not drink through a variety of differing tasks to try to add to the understanding of risk factors associated with binge drinking behavior. The tasks selected for the current study were chosen to allow for a global perspective of executive functioning through evaluating decision making, impulsivity, abilities to adapt self-perception of emotional and executive functioning processes, planning faculties and those associated with adapting to environmental cues and goal changes through neuropsychological tasks as well as self-report measures. The use of self-report and clinical measures allowed the current investigation to question not only if performance related to these executive functions vary but also assess whether those who participate in this detrimental behavior report different self-perceptions. The two self-report measures used, DEX and BRIEF, have been suggested to be sensitive for both non-clinical and clinical populations, especially in situations in which other behavioral measures do not detect deficits. It has been suggested that social or binge drinking populations may fall within this gray area where behavioral measures may not be sensitive (Bijl, et al., 2005). Though the binge drinking population varied in their abilities to complete categories in the WCST, there was not a statistically significant difference between the self-report measures which evaluate executive functioning of the various binge and non-binge drinking groups. As described earlier, there may be a level of sensitivity within other non-clinical groups and self-report measures such as DEX or BRIEF. However, this discrepancy between binge drinkers' ability to report their perceived behavioral executive functioning and their actual performance on executive functioning tasks, suggests that self-report measures may not be as effective within the binge drinking population as earlier proposed. More importantly,

the implications of this population's inability to reconcile their actual abilities with their perceived abilities may prove to be detrimental.

One of the justifications for the tasks included in this study was the numerous links to the frontal lobes and prefrontal cortical areas across the measures. While even acute alcohol consumption is known to have potentially global effects on the brain, some of the most significant adverse effects have been tied to the PFC. Moreover, the vast neurodevelopment occurring within the PFC during this age added further support for the study to focus heavily on tasks which evaluate function in this region. An interesting finding regarding the current study's results was that the only significant variation between groups were the number of completed categories on the WCST. The pattern of performance suggests that one of the key differences between groups may be functioning in the anterior cingulate cortex (ACC), a region which has been associated with error correction and detection (Bush, Luu, & Posner, 2000). Previously the ACC has been shown to be impaired during alcohol intoxication, specifically related to the detection of errors (Ridderinkhof, et al., 2002). Bijl, et al., (2005) investigated event-related potential patterns and WCST outcomes in various drinking groups, in those aged 30-65. Trends found were associated with the N1, an ERP component thought to be related to orienting attention. Specifically, results suggested reduced N1 which may reflect activity in the ACC. The relationship between decreased N1 amplitudes in response to feedback within the task and an increase in alcohol consumption may be associated with the ACC due to this region's connections with those outer cortical regions associated cognitive control (Steinberg, 2007). While not specific to the current population of interest, data from schizophrenia patients also suggests a correlation between the WCST and the ACC (Ohrmann, et al., 2008). By suggesting the neurophysiological resources for the WCST are not solely allocated from frontal lobe regions

we open the door for understanding why we see differences in performance on this well used neuropsychological task. Inclusion of the ACC in the ideology surrounding binge drinking etiology allows us to move from solely contemplating PFC and FL differences or deficits among binge drinkers. This new consideration suggests we need to investigate neural regions which contribute to executive processes and project to the PFC, especially those related to impulsivity. Additionally, taken together it may suggest varying approaches between groups in order to "successfully" complete the task. Those individuals who exhibit more binge drinking behaviors may in fact be more likely to attempt to achieve goals through a reactionary trial and error process rather than contemplating the feedback.

While many of the tasks used to evaluate different facets of executive functioning in this study hold ecological validity, the inability to complete categories with the same efficacy as their collegiate peers holds interesting implications. If binge drinkers are completing this task in the suggested trial and error method, rather than an evaluatory, planned manner, then we may conclude this population would have difficulty planning their behaviors as well as adjusting to changes in their environment, social setting, or even physiological and psychological changes due to alcohol consumption. However, if this group proceeds through situations which are disparate to beliefs in a manner which eludes intention or planning it may result in risky behavior choices (e.g. binge drinking).

The relationship with the Theory of Planned Behavior (TPB) helps us understand and discuss the variations that are seen between binge drinkers and non-drinkers and their alcohol expectancies and drinking refusal self-efficacy. These components are based on the same cognitive facets which TPB helps model and explain. In the case of binge drinkers we see their alcohol expectancies are low, they not only view this substance's influence to be low but they

place greater value on the immediate positive effects, and less value on the later, negative effects. This group also presents with interesting self-efficacy specific to drinking, they can easily refuse drinks however, once they begin, they cannot stop consuming. (Oei & Morawska, 2004). Therefore, it may be possible to postulate a connection between these detrimental alcohol expectancies and drinking refusal self-efficacy, and their poor inhibitory, planning skills associated with their poor performance on the WCST, and the disparity in their performance and inability to report their executive functioning through the DEX. This last component may more specifically be tied to a deficit in the binge drinkers' ability to relate their expectations with the actual expectations of alcohol consumption.

Finally, it is prudent to discuss the possible limitations of the current study. The variety of tasks included, and specifically those which have been thought to be more sensitive to deficits within a population that shows no deficit on the standard neuropsychological tasks, were thought to be adequate to evaluate variations between groups. Results suggest that this may not have been the case. While the self-report measures, DEX and BRIEF, may be more sensitive than traditional neuropsychological measures within other populations, they require the taker to be able to accurately report their behaviors and performance, something which has specifically been addressed as being faulty within binge drinkers. Therefore, it is not yet appropriate to assume that college binge drinkers do not have deficits associated with those executive functions which these tasks evaluate; it is possible that they were not sensitive enough or binge drinkers have developed mechanisms which may help performance or mask deficits within these tasks. These cognitive compensation techniques may be similar to those seen in an aging population as well as those with frontal lobe injuries. These demographics develop skills which may allow them to

access parts of the brain that are intact to mask poor performance on tasks that tap in to less optimally functioning areas of their brain, similar to what we have seen with binge drinkers.

Additionally, the current sample population itself may have certain limitations. Specifically, we see the various exclusion factors within the study dramatically reduced the number of participants who could be analyzed. By using these exclusion factors, we also reduced the number of participants to a degree to which sex based analyses were not plausible, even though the ratio of females to males is similar for both non-drinking and binge drinking college students. Though the use of a secondary round of analyses allowed for the included evaluation of these originally excluded groups, the increased variance within tasks may be cause for reevaluation. Though these exclusion factors were an amalgamation of those used throughout the associated previous literature, an evaluation was used to see if any effects hold if the defining variable between groups was purely the sex specific binge drinking question, therefore, those individuals that replied "no" to the binge drinking question may have a greater than zero score on the AUDIT. A similar trend between these two groups still held, $F(12, 106) = 1.69$, $p = .08$, Wilk's $\Lambda = 0.84$, partial $\eta^2 = 0.16$, interestingly, in addition to seeing the same differences within categories completed for WCST, $F(1,117) = 6.24$, $p = .01$, partial $\eta^2 = 0.05$, a difference had been noted between groups with the ration between time to complete version B and version A of the TMT, $F(1,117) = 5.23$, $p = .03$, partial $\eta^2 = 0.04$. These comparison trends suggest a reevaluation of how the field, in general, chooses to exclude individuals, specifically, there ought to be greater homogeneity in how exclusion factors are chosen. While there are continuing issues which ought to be addressed in future studies, the current investigation suggests there may be neurocognitive differences between binge drinkers and their non-drinking peers. Though the data may seem simple, the poorer performance seen in this battery may help in future understanding

of the underlying processes related to alcohol consumption, as well as the ideologies this population has in regard to alcohol outcomes. Importantly, these differences may impact the way binge drinkers proceed through decision making situations, whether or not they be related to alcohol consumption.

Table 1. Demographic Information of Groups from both MANOVAs.

Group	Total(males)	Age(SD)	AUDIT(SD)
ND	14(3)	19.21(1.12)	0(0)
BD	18(10)	20.11(1.64)	4.83(1.25)
LBD	9(5)	20.33(2.00)	4.78(0.44)
HBD	9(5)	19.89(1.27)	6.89(0.78)
PBD	14(8)	19.29(0.72)	12.50(2.79)

Table 2. Between-Subjects Effects from MANOVA Analysis Between Non Drinkers and Binge Drinkers

	Non Drinkers		Binge Drinkers				
Measures	**Mean (SD)**	**SE**	**Mean(SD)**	**SE**	**Mean Square**	**F**	**p**
WCST Categories completed	4.43(0.65)	0.16	3.83(1.1)	0.15	2.79	3.23	0.08
TMT Ratio	2.41(0.55)	0.20	2.97(1.46)	0.18	2.53	1.89	0.18
One Touch Stockings							
Latency to correct (s)	17932.76 (6566.02)	1129.88	19050.08 (5223.04)	1056.90	9831031.90	0.29	0.60
Choices to correct	1.32(0.18)	0.05	1.46 (0.36)	0.05	0.15	1.68	0.20
Delay Discounting task							
Large, delayed reward	0.02(0.07)	0.01	0.02(0.03)	0.01	2.20E-06	0.00	0.98
Medium, delayed reward	0.03(0.06)	0.01	0.04(0.05)	0.05	0.00	0.53	0.47
Small, delayed reward	0.04(0.07)	0.01	0.06(0.05)	0.01	0.00	0.52	0.47
Behavioral Rating Inventory of Executive Function							
Global executive composite	102.07(15.09)	4.63	99.78 (26.13)	4.33	41.43	0.09	0.77
Metacognition index	56.43(9.10)	2.83	57.72 (15.87)	2.65	13.18	0.07	0.79
Behavioral rating index	45.64(8.49)	2.04	42.06 (10.97)	1.90	101.34	1.02	0.32
Dysexecutive Questionnaire							
Emotion	2.5 (1.61)	0.35	3.5(1.72)	0.33	7.87	2.81	0.10
Behavior	4.93 (3.95)	0.86	5.94(4.67)	0.80	8.13	0.42	0.52
Cognition	3.50 (2.47)	0.61	3.94(3.3)	0.57	1.56	0.18	0.68

Table 3. Between-Subjects Effects from MANOVA Analysis Between ND, LBD, HBD, and PBD

	ND		LBD		HBD		PBD				
Measures	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean Square**	**F**	**p**
WCST Categories completed	**4.43**	**0.65**	**3.33**	**1.22**	**4.33**	**0.71**	**3.93**	**0.92**	**2.52**	**3.27**	***0.03**
TMT Ratio	2.41	0.55	2.76	0.81	3.19	1.94	2.68	1.21	1.13	0.81	0.49
One Touch Stockings											
Latency to correct (s)	17932.76	6566.02	20027.75	5476.46	18072.40	5082.13	20785.99	8157.89	25079998.00	0.56	0.64
Choices to correct	1.32	0.18	1.56	0.36	1.36	0.36	1.32	0.23	0.13	1.66	0.19
Delay Discounting task											
Large, delayed reward	0.02	0.07	0.04	0.04	0.01	0.01	0.01	0.01	0.00	0.80	0.50
Medium, delayed reward	0.03	0.06	0.06	0.05	0.03	0.04	0.01	0.01	0.00	1.63	0.20
Small, delayed reward	0.04	0.07	0.07	0.06	0.04	0.05	0.03	0.04	0.00	0.76	0.52
Behavioral Rating Inventory of Executive Function											
Global executive composite	102.07	15.09	104.44	25.3	95.11	27.61	115.64	21.72	861.50	1.78	0.17
Metacognition index	56.43	9.10	59.78	14.55	55.67	17.73	66.00	13.43	192.25	2.00	0.13
Behavioral rating index	45.64	8.49	44.67	11.16	39.44	10.67	49.64	9.62	283.65	1.56	0.21
Dysexecutive Questionnaire											
Emotion	2.50	1.61	3.67	2.06	3.33	1.41	3.43	1.40	3.23	1.24	0.31
Behavior	4.93	3.95	5.78	5.72	6.11	3.69	8.36	4.03	29.38	1.57	0.21
Cognition	3.50	2.47	2.89	2.20	5.00	3.97	4.71	2.73	10.22	1.26	0.30

* Denotes $p < .05$

Table 4. MANOVA comparison between ND and BD, original exclusion factors removed.

	Non Drinkers		Binge Drinkers				
Measures	**Mean (SD)**	**SE**	**Mean(SD)**	**SE**	**Mean Square**	**F**	**p**
WCST Categories completed	**4.32(0.61)**	**0.16**	**3.81(1.03)**	**0.15**	**3.87**	**5.22**	***0.03**
TMT Ratio	2.49(0.58)	0.19	2.78(1.29)	0.18	1.19	1.12	0.29
One Touch Stockings							
Latency to correct (s)	18825.89 (6394.52)	1129.88	20157.39 (5591.53)	1056.91	26475205.73	0.74	0.39
Choices to correct	1.35(0.23)	0.05	1.39(0.29)	0.05	0.04	0.54	0.47
Delay Discounting task							
Large, delayed reward	0.02(0.05)	0.01	0.02(0.03)	0.01	0.00	0.05	0.82
Medium, delayed reward	0.03(0.06)	0.01	0.03(0.04)	0.01	0.00	0.12	0.73
Small, delayed reward	0.03(0.06)	0.01	0.05(0.05)	0.01	0.00	0.89	0.35
Behavioral Rating Inventory of Executive Function							
Global executive composite	107.86(16.22)	4.63	105.91(29.88)	4.33	56.84	0.09	0.76
Metacognition index	61.18(11.18)	2.83	61.88(17.60)	2.64	7.24	0.03	0.86
Behavioral rating index	46.68(7.48)	2.04	44.03(13.00)	1.91	104.66	0.90	0.35
Dysexecutive Questionnaire							
Emotion	3.04(1.89)	0.35	3.31(1.80)	0.33	1.14	0.34	0.56
Behavior	6.46(4.07)	0.86	6.44(4.91)	0.80	0.01	0.00	0.98
Cognition	4.21(2.99)	0.61	4.38(3.41)	0.57	0.39	0.04	0.85

*Denotes $p<.05$

Table 5. MANOVA comparison between mND, fND, mBD, and fBD, original exclusion factors removed.

	MND		FND		MBD		FBD				
Measures	**Mean(SD)**	**SE**	**Mean(SD)**	**SE**	**Mean(SD)**	**SE**	**Mean(SD)**	**SE**	**Mean Square**	**F**	**p**
WCST Categories completed	4.80(0.45)	0.39	4.22(0.60)	0.18	3.79(1.05)	0.23	3.83(1.04)	0.20	1.76	2.37	0.08
TMT Ratio	2.56(0.70)	0.46	2.48(0.57)	0.21	2.45(0.57)	0.27	3.03(1.64)	0.24	1.27	1.21	0.32
One Touch Stockings											
Latency to correct (s)	16426.02 (2869.81)	2697.99	19347.61 (6862.37)	1257.95	20126.58 (5348.93)	1612.36	20181.36 (5927.29)	1421.97	2E+07	0.56	0.64
Choices to correct	1.40(0.26)	0.12	1.33(0.23)	0.06	1.35(0.28)	0.07	1.43(0.31)	0.06	0.03	0.46	0.71
Delay Discounting task											
Large, delayed reward	0.02(0.03)	0.02	0.02(0.05)	0.01	0.03(0.03)	0.01	0.01(0.02)	0.01	0.00	0.64	0.59
Medium, delayed reward	0.04(0.07)	0.02	0.03(0.06)	0.01	0.04(0.04)	0.01	0.03(0.05)	0.01	0.00	0.13	0.94
Small, delayed reward	0.07(0.09)	0.02	0.03(0.05)	0.01	0.07(0.06)	0.01	0.03(0.04)	0.01	0.01	2.41	0.08
Behavioral Rating Inventory of Executive Function											
Global executive composite	106.40 (23.26)	11.14	108.17 (14.97)	5.19	104.79 (31.13)	6.66	106.78 (29.76)	5.87	33.67	0.05	0.98
Metacognition index	58.00(14.21)	6.79	61.87(10.67)	3.17	61.64(18.99)	4.06	62.06(17.01)	3.58	23.36	0.10	0.96
Behavioral rating index	48.40(9.92)	4.90	46.30(7.07)	2.28	43.14(13.13)	2.93	44.72(13.24)	2.58	47.45	0.40	0.76
Dysexecutive Questionnaire											
Emotion	3.40(2.07)	0.82	2.96(1.89)	0.38	3.93(1.94)	0.49	2.83(1.58)	0.43	3.80	1.13	0.34
Behavior	5.60(5.98)	2.06	6.65(3.69)	0.96	6.50(5.33)	1.23	6.39(4.71)	1.09	1.55	0.07	0.97
Cognition	2.80(2.28)	1.45	4.52(3.07)	0.68	4.36(4.07)	0.87	4.39(2.91)	0.76	4.19	0.40	0.75

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APPENDIX

Additional Tables from Supplemental Analyses

1. Table 6. MANOVA comparison between ND and BD with least stringent exclusions, 4/5 ratio classification.
2. Table 7. MANOVA comparison between mND, fND, mBD, and fBD with least stringent exclusions, 4/5 ratio classification.
3. Table 8. Mann-Whitney U comparisons between ND and BD with most stringent exclusion factors.
4. Table 9. Mann-Whitney U comparisons between ND and BD with only exclusion being age.

Table 6. MANOVA comparisons between ND and BD with least strict exclusions, 4/5 ratio classification.

	Non Drinkers		Binge Drinkers				
Measures	**Mean (SD)**	**SE**	**Mean(SD)**	**SE**	**Mean Square**	**F**	**p**
WCST Categories completed	**4.19(0.88)**	**0.11**	**3.69(1.17)**	**0.16**	**6.24**	**6.60**	****0.01**
TMT Ratio	**2.49(0.66)**	**0.12**	**2.97(1.74)**	**0.18**	**5.93**	**4.92**	***0.03**
One Touch Stockings							
Latency to correct (s)	19336.13 (7451.74)	760.82	19985.94 (5523.68)	1155.24	10602323.00	0.22	0.64
Choices to correct	1.4(0.32)	0.03	1.42(0.30)	0.05	0.00	0.03	0.86
Delay Discounting task							
Large, delayed reward	0.02(0.04)	0.00	0.02(0.03)	0.01	0.00	0.06	0.81
Medium, delayed reward	0.03(0.06)	0.01	0.03(0.04)	0.01	0.00	0.01	0.93
Small, delayed reward	0.03(0.06)	0.01	0.04(0.05)	0.01	0.00	0.72	0.40
Behavioral Rating Inventory of Executive Function							
Global executive composite	105.66(20.06)	2.52	106.31(28.58)	3.82	10.38	0.02	0.89
Metacognition index	60.71(12.37)	1.54	62.39(17.18)	2.33	70.70	0.36	0.55
Behavioral rating index	44.95(9.82)	1.17	43.92(12.33)	1.77	26.90	0.24	0.63
Dysexecutive Questionnaire							
Emotion	3.11(2.08)	0.22	3.39(1.82)	0.33	1.97	0.49	0.48
Behavior	6.83(4.70)	0.52	6.19(4.68)	0.78	10.18	0.46	0.50
Cognition	4.12(2.91)	0.34	4.47(3.43)	0.51	3.11	0.33	0.57

**denotes p < .01; *denotes p<.05

Table 7. MANOVA comparisons between mND,fND, mBD, and fBD with least strict exclusions, 4/5 ratio classification

	MND		FND		MBD		FBD				
Measures	**Mean(SD)**	**SE**	**Mean(SD)**	**SE**	**Mean(SD)**	**SE**	**Mean(SD)**	**SE**	**Mean Square**	**F**	**p**
WCST Categories completed	4.26(0.96)	0.20	4.17(0.85)	0.13	3.73(1.03)	0.25	3.67(1.28)	0.21	2.14	2.23	0.09
TMT Ratio	**2.56(0.59)**	**0.22**	**2.46(0.68)**	**0.14**	**2.39(0.59)**	**0.28**	**3.39(2.14)**	**0.23**	**4.93**	**4.29**	****0.01**
One Touch Stockings											
Latency to correct (s)	19333.16 (9578.83)	1457.28	19337.27 (6554.52)	902.26	19586.63 (5562.42)	1804.52	20271.15 (5615.23)	1525.10	4900862.42	0.10	0.96
Choices to correct	1.37(0.370)	0.07	1.42(0.29)	0.04	1.34(0.28)	0.08	1.47(0.31)	0.07	0.07	0.67	0.57
Delay Discounting task											
Large, delayed reward	0.02(0.04)	0.01	0.02(0.05)	0.01	0.03(0.03)	0.01	0.01(0.01)	0.01	0.00	0.65	0.59
Medium, delayed reward	0.03(0.04)	0.01	0.03(0.06)	0.01	0.04(0.04)	0.01	0.03(0.04)	0.01	0.00	0.13	0.94
Small, delayed reward	0.05(0.07)	0.01	0.03(0.05)	0.01	0.06(0.06)	0.01	0.03(0.04)	0.01	0.01	2.29	0.08
Behavioral Rating Inventory of Executive Function											
Global executive composite	105.96 (15.88)	4.82	105.55 (21.57)	2.98	103.53 (30.38)	5.97	108.29 (27.82)	5.04	70.25	0.13	0.94
Metacognition index	63.00(10.37)	2.93	59.83(13.03)	1.81	60.80(18.59)	3.62	63.52(16.46)	3.06	100.78	0.51	0.67
Behavioral rating index	42.96(7.46)	2.22	45.72(10.54)	1.38	42.73(12.75)	2.75	44.76(12.26)	2.33	63.19	0.56	0.64
Dysexecutive Questionnaire											
Emotion	3.74(2.24)	0.41	2.87(1.98)	0.26	3.80(1.93)	0.51	3.10(1.73)	0.43	6.32	1.60	0.19
Behavior	7.70(5.07)	0.98	6.50(4.56)	0.61	6.27(5.22)	1.22	6.14(4.39)	1.03	11.36	0.51	0.68
Cognition	4.13(2.99)	0.65	4.12(2.90)	0.40	4.07(4.08)	0.79	4.76(2.96)	0.68	2.45	0.26	0.86

**Denotes $p < .01$

Table 8. Mann-Whitney Comparisons between BD and ND with only exclusion being age.

	Non-Drinkers		Binge Drinkers			
Measures	**Mean**	**SD**	**Mean**	**SD**	**U**	**p**
WCST Categories completed	4.43	0.65	3.83	1.10	86.00	0.10
TMT Ratio	2.41	0.55	2.97	1.46	86.00	0.13
One Touch Stockings						
Latency to correct (s)	17,932.76	6,566.02	19,050.08	5,223.04	103.00	0.38
Choices to correct	1.32	0.18	1.46	0.36	105.00	0.42
Delay Discounting task						
Large, delayed reward	0.02	0.07	0.02	0.03	76.00	0.06
Medium, delayed reward	0.03	0.06	0.04	0.05	83.00	0.09
Small, delayed reward	0.04	0.07	0.06	0.05	80.50	0.08
Behavioral Rating Inventory of Executive Function						
Global executive composite	102.07	15.09	99.78	26.13	123.00	0.91
Metacognition index	56.43	9.10	57.72	15.87	118.50	0.78
Behavioral rating index	45.64	8.49	42.06	10.92	99.50	0.31
Dysexecutive Questionnaire						
Emotion	2.50	1.61	3.50	1.72	86.50	0.12
Behavior	4.93	3.95	5.94	4.67	114.00	0.65
Cognition	3.50	2.47	3.94	3.30	121.50	0.86

Table 9. Mann-Whitney U Comparisons between ND and BD original exclusion factors removed.

	Non Drinkers		Binge Drinkers			
Measures	**Mean**	**SD**	**Mean**	**SD**	**U**	**p**
WCST Categories completed	**4.32**	**0.61**	**3.81**	**1.03**	**364.00**	***0.05**
TMT Ratio	2.49	0.58	2.78	1.29	531.00	0.76
One Touch Stockings						
Latency to correct (s)	18825.89	6394.52	20157.39	5591.53	426.00	0.19
Choices to correct	1.35	0.23	1.39	0.29	522.50	0.97
Delay Discounting task						
Large, delayed reward	**0.02**	**0.05**	**0.02**	**0.03**	**388.00**	***0.03**
Medium, delayed reward	0.03	0.06	0.03	0.04	407.50	0.06
Small, delayed reward	0.03	0.06	0.05	0.05	366.50	0.02
Behavioral Rating Inventory of Executive Function						
Global executive composite	107.86	16.22	105.91	29.88	528.50	0.92
Metacognition index	61.18	11.18	61.88	17.60	485.00	0.51
Behavioral rating index	46.68	7.48	44.03	13.00	463.50	0.35
Dysexecutive Questionnaire						
Emotion	3.04	1.89	3.31	1.80	464.00	0.24
Behavior	6.46	4.07	6.44	4.91	547.50	0.92
Cognition	4.21	2.99	4.38	3.41	499.50	0.48

*Denotes p .05