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# Binge Drinking: Subtypes and Associations in Young Adults

## **Cover Page Footnote**

First, I would like to thank Dr. Peter Finn for his guidance throughout this process and sponsorship of my thesis. Additionally, I want to thank the other members of my thesis committee, Dr. Brian O'Donnell and Dr. Richard Viken, for taking the time to consider my research and provide feedback. I would also like to express my sincere appreciation to Kyle Gerst, Rachel Gunn, and Allison Lake for their feedback throughout my preparations with the overall research design. Furthermore, I would like to thank Dr. Tayla Lee for her assistance with the cluster analyses and final statistical analyses. Lastly, I am especially grateful to Dr. Dale Sengelaub for all his advice throughout this process. A special thanks to my family and friends for their undying support and words of encouragement, without which, this thesis would not have been possible. This research was supported by NIAAA, R01AA13650 awarded to Dr. Peter R. Finn at Indiana University Bloomington.

## **BINGE DRINKING: SUBTYPES AND ASSOCIATIONS IN YOUNG ADULTS**

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### **Abstract**

Binge drinking has been common practice and a rite of passage for many young adults in the college population. The practice of binge drinking has continued even as bingeing is associated with several cognitive deficits. One unanswered question still remains: namely, at what levels of binge drinking do these cognitive deficits associate? To investigate this question, three different groups of binge drinkers (low, moderate, and heavy) were compared on two measures of cognition: intelligence (IQ) and executive working memory (EWM) capacity. The binge groups were also compared to non-bingers and abstainers to further investigate how they differed in EWM capacity and IQ. Lastly, correlations were made between binge density and the cognitive measures. Based on the previous literature, the following hypotheses were made: (1) low, moderate, and heavy binge clusters would emerge from the cluster analyses, (2) the heavy and moderate cluster would exhibit decreased performance in the two cognitive domains in comparison to the low cluster, (3) the binge density measure would be negatively correlated with the cognitive measures, and (4) the low, moderate, and heavy clusters would exhibit lower EWM capacity and IQ scores in comparison with non-bingers and abstainers. Some of the obtained data support that different binge subtypes are indeed differentially associated with both EWM capacity and IQ in young adults who binge. However, the mixed findings illustrate that additional longitudinal research is merited.

### **Introduction**

The use of alcohol is common practice among young adults. This is often manifested in the form of binge drinking, with the 18-30 age population exhibiting the highest rates of alcohol bingeing (Kessler *et al.*, 2005). A binge drinking episode is defined by the NIAAA as 4 drinks for women (5 for men) in two hours (NIAAA; Wechsler & Nelson, 2008). Due to its ubiquitous

(Wechsler *et al.*, 1995) and seemingly innocuous nature, binge drinking is habitually viewed as harmless among young adults. Psychological and neurological study has suggested more malevolent consequences: namely, decreased inhibition in decision making (Fridberg, Gerst, & Finn, 2013; Mazas *et al.*, 2000), increased risk of self-harm (Klonsky, 2011), decreased academic performance (Singleton & Wolfson, 2009), among others. Public health consequences such as an increased rate of incidence of car accidents (Norman & Conner, 2006), sexual assault (Abbey, 2002), and property damage (Wechsler *et al.*, 1995) are also commonly associated with binge drinking. Most importantly, as binge drinking has led to 88,000 deaths from 2006-2010 and about 1 in 10 deaths in working age adults, its continued study is essential (Stahre *et al.*, 2014).

Several binge drinking studies have previously found associations between bingeing and cognitive performance. Parada *et al.* (2011) studied a cohort of Spanish individuals who bingeed and their performance on declarative memory tasks. It was found that the individuals who bingeed remembered fewer words on this memory task as well as performed worse in comparison to a control group on a Logical Memory Task (Parada *et al.*, 2011). This study utilized the Alcohol Use Disorders Identification Task (AUDIT; WHO, 1982) and the Semi-Structured Assessment for the Genetics of Alcoholism (SSAGA; Bucholz *et al.*, 1994) to classify students. The researchers suggested further study was necessary to further substantiate and develop these findings, especially with a sample of young, North American adults. The second study, Sanhueza *et al.* (2011), used the California Learning Verbal Test (CLVT) as well as the Tower of Hanoi task to examine cognition in relation to binge drinking. These data illustrate that the binge drinking group exhibited lower performance in terms of immediate recall as well as delayed recall (Sanhueza *et al.*, 2011). The third study, Thoma *et al.* (2011), tested a cognitive battery of tests on 48 alcohol using adolescents. It was found that these subjects exhibited an inverse relationship between the intensity of drinking and the reduction of executive functioning abilities and attention (Thoma *et al.*, 2011). One finding from the work of Thoma *et al.* (2011) that will be sought to be confirmed in these data is a negative correlation between alcohol use and tests of the neuropsychological battery. This study will seek to build on the work of these three studies by comparing binge drinking subtypes with cognitive performance.

One method to gain a greater understanding of the problems individuals who binge experience could be to consider different bingeing subtypes. Often

within the broad umbrella of certain clinical populations, different subtypes or groupings of individuals are present. Though several studies have considered typologies of alcohol abuse (Cable & Sacker, 2008; Morey *et al.*, 1984), few have considered solely binge subtypes in young adults. A longitudinal study by Goudriaan *et al.* (2007) suggests several binge drinking trajectories over time: low, stable moderate, increasing, and stable high. Other studies have confirmed a similar finding of generally three main groups (i.e., low, moderate, and heavy) (Tucker *et al.*, 2003; Muthén & Shedden, 1999). Formation of groups based upon the natural trends in these data may provide insights as to typical young adult binge drinking and the potential differences in cognitive performance among these groups.

Individuals who binge, individuals who drink, but do not binge (non-bingers), and abstainers could elicit differences when considering their respective cognitive performance. Previous research has considered differences in terms of alcohol related problems among individuals who binge, non-bingers, and abstainers, but there is a paucity of research in terms of cognitive comparisons among these groups (Wechsler, Lee, Kuo, & Lee, 2000). In individuals who binge specifically, two cognitive areas have been observed to be associated with binge drinking: executive working memory capacity (EWM capacity) and IQ.

In several studies considering the cognitive effects of alcohol use, researchers have used both EWM capacity (Finn *et al.*, 2009; Finn & Hall, 2004; Squeglia, Schweinsburg, Pulido, & Tapert, 2011) and IQ assessments (Finn & Hall, 2004; Moss *et al.*, 1994; Tapert *et al.*, 2004; Sanhueza *et al.*, 2011) as measures of neuropsychological performance. Baddeley's (2002) definition of working memory is as follows: a system that allows humans to actively interpret their environments, engage in attention shifting, and solve problems in face of other competing information. Research supports the conclusion that executive functioning is highly contingent on certain levels of EWM capacity (Finn, 2002). Thus, based on these previous findings, IQ is used as a broad measure of general intelligence, whereas EWM capacity serves as a much more specific measure of cognition in this study.

Based on this research, this study seeks to investigate several questions. Through the use of both Ward's method and a k-means cluster analysis, clusters of individuals who binge will be formed in two separate samples. These clusters will then be compared to the abstainer group and non-binger group on measures of cognition: IQ and EWM capacity. Finally, correlations between the cognitive measures and binge density will also be made. This study therefore makes four predictions: (1) from the cluster analysis, three

groups will emerge: low, moderate, and heavy clusters, (2) the moderate and heavy clusters will exhibit decreased performance in the two cognitive domains in comparison to the low cluster, (3) the binge density measure will be negatively correlated with the cognitive measures, and (4) low, moderate, and heavy clusters will exhibit lower cognitive performance in comparison to the non-bingers and abstainers.

## Methods

### PARTICIPANTS

**Recruitment.** Data for this study was taken from two previous studies conducted from 2002-2004 (Sample 1) and 2010-2012 (Sample 2). Both of these samples utilized similar methods in recruiting participants. These studies sought individuals from the community who demonstrated a variety of levels in externalizing behaviors and disinhibited personality traits. Participants were recruited from the Bloomington, IN community and Indiana University using Widom's method (1977). Recruitment flyers were placed around campus and around the community. Flyers contained phrases such as the following: "Are you a heavy drinker?", "Are you a more reserved and introverted type of person?", "WANTED: Subjects interested in psychological research", "Are you impulsive?", "WANTED: Males/Females, 18-25 yrs old, who only drink modest amounts of alcohol and who do not take drugs.", "Do you think you have a drinking problem?", "Are you adventurous (daring, etc)?"

**Telephone screen.** Participants called the lab to conduct a ten minute phone screen to see if they met study selection criteria. The phone screen first consisted of the screener giving a short description of the study. The participant was then asked questions that addressed several different conditions of externalizing psychopathology: alcohol and drug abuse, childhood conduct disorder, antisocial personality disorder, and attention-deficit hyperactivity disorder. If the participant met the study criteria, he or she would be given more information regarding the tasks that would be completed during the study. They were instructed that the study would take about three sessions, reaching a total of about nine hours, and would be required to take a breath-alcohol test. In addition, participants were instructed to refrain from using alcohol and recreational drugs for 12 hours prior to their session, sleep 6 hours the night before, and eat something

within 3 hours of testing. Participants were paid for their participation in the studies.

**Exclusion criteria.** Exclusion criteria included being not being 18-30 years of age, inadequate English proficiency (i.e., ability to read and speak effectively and efficiently), not having obtained a 6th grade education or higher, never having consumed alcohol, a history of head trauma or cognitive impairment, taking prescriptions that severely affect behavior (e.g., antipsychotics), or a history of non-externalizing, psychological disorder. At the start of each session, the participant was asked about their drug and alcohol use over the past 12 hours and given a breath alcohol test using an Alco Sensor IV (Intoximeters Inc., St. Louis, MO). If the participant demonstrated any blood-alcohol concentration over .000%, any drug use over the past 12 hours, feeling hung over or sleepy, or unable to answer the screening questions, they were unable to participate that day and rescheduled.

## SAMPLE CHARACTERISTICS

**Sample 1.** 468 participants (256 males and 212 females) were recruited in Sample 1. **Table 1** lists the sample demographics and binge drinking patterns. Additionally, the Semi-Structured Assessment for the Genetics of Alcoholism (SSAGA; Bucholz *et al.*, 1994) was used to gain an understanding of other problems that are present in these individuals. The number of participants with diagnoses of alcohol, drug, and marijuana dependence are also listed in **Table 1**. 29 abstainers were excluded due to past diagnoses of alcohol dependence.

**Sample 2.** 823 participants (447 males and 376 females) were recruited in Sample 2. **Table 1** details sample demographics and binge drinking patterns. In addition, as in Sample 1, the Semi Structured Assessment for the Genetics of Alcoholism was used to depict and identify other problems observed in these participants (see **Table 1**). The number of participants with alcohol, drug, and marijuana dependence are also listed in **Table 1**. 39 abstainers were excluded because of past alcohol dependence diagnoses.

## MEASURES

**Binge drinking.** Binge frequency and binge density were used to measure binge drinking. Binge frequency indicated the average number of days per week an individual would typically binge. Contrastingly, binge density indicated the average number of drinks per binge occasion over the past

Category	Sample 1	Sample 2
Age (years)	21.91±2.835	21.20±2.413
Years education	13.74±2.079	14.090±1.705
Binge frequency, past 6 months	2.180±2.052	2.056±1.707
Binge density, past 6 months	8.459±3.945	8.384±3.727
Maximum # of drinks ever consumed	21.70±17.980	19.864±17.049
Maximum # of drinks consumed in past 6 months	13.20±12.643	13.479±8.908
# of individuals with alcohol dependence diagnosis	255	317
# of individuals with marijuana dependence diagnosis	167	253
# of individuals with other drug dependence diagnosis	102	114

**Table 1.** Descriptive statistics of Sample 1 and Sample 2.

several months (i.e., 6 months in Sample 1, 3 months in Sample 2). The binge density variable was calculated simply by dividing the total drinks consumed across all binge occasions by the number of binge episodes per week. These variables were calculated using data from an alcohol use history measure which measured the typical drinking patterns over the past several months on each day of the week (again, past 6 months in Sample 1, past 3 months in Sample 2). Following the logic of Stahre *et al.* (2006), it is thought this form of the frequency-quantity measure would provide for an accurate measure of an individual's binge drinking. Both of these factors are also important as frequency is thought to be heavily influenced by social factors, whereas quantity is influenced by personal control (Vogel-Sprott, 1974).

**Executive working memory capacity (EWM).** EWM capacity was assessed using two separate dual span measures: a modified version of the Auditory Consonant Trigram task (ACT; Brown, 1958) and the Operation Word Span Task (OWS; Conway & Engle, 1994). Numerous studies are indicative of the reliability and validity of these measures in measuring EWM capacity (Engle *et al.*, 1999; Unsworth & Engle, 2008).

The ACT consists of being given a nonsense sequence of letters. The participant was then instructed to count backwards by multiples of 3 for



either 18 or 36 seconds (undisclosed to the participant). The participant recalled the original given sequence of letters following this delay. Performance was measured by the correct number of letters recalled. The working memory load on this version of the ACT was higher than the original task (Brown, 1958) as a previous study illustrated that a greater working memory load gives greater group differences (Finn *et al.*, 2009).

On the OWS, the participant is again instructed to focus upon past information in the face of competing information. Here, the subject is given a packet of flashcards. Each flashcard consists of a mathematical equation and a word. The subject is instructed to say whether or not the equation is a valid mathematical expression and to remember the word (e.g.,  $22/2 + 1 = 15$ ? Fish). A series of these flashcards were completed (trials range from 2-6 cards). After each series participants were instructed to recall the words in the order they were presented. Performance was measured by the correct number of words recalled.

**IQ.** For Sample 1, the Shipley Institute of Living Scale (Zachary, 1986) was used to assess IQ. The Shipley measures IQ through tests on both vocabulary and abstract reasoning and has been shown to be an accurate approximation of IQ (Goodman, Streiner, & Woodward, 1974). In Sample 2, the Wechsler Abbreviated Scale of Intelligence (WASI) was used. The WASI has four sections testing different components of a participant's cognition: vocabulary, block design, similarities, and matrix reasoning. The WASI has been shown to have excellent reliability in predicting IQ ( $r_s = .97$ ) (Wechsler, 1999) and has been frequently used to quickly predict an individual's IQ (Moss *et al.*, 1994; Sanhueza *et al.*, 2011).

## DATA ANALYSIS

**Group formation.** The participants were clustered based on the binge density measure. Hierarchical clustering using Ward's method and squared Euclidean distance as the distance measure was first completed to analyze how many different binge clusters emerged in the sample (i.e., through use of the dendrogram and agglomeration schedule). Subsequently, a k means cluster analysis was then completed for group formation based upon the binge density measure. K means analysis was completed as it has been demonstrated to be a more rigorous method of assigning cases to clusters than agglomerative methodologies such as Ward's method (Aldenderfer & Blashfield, 1984). In addition to these three clusters, an abstainer group and

a non-binger group were also formed separately of the cluster analyses for comparative purposes on the cognitive tasks.

**Analysis of variance and group comparisons.** ANOVA's with the factors of group (i.e., abstainer, non-binger, low, moderate, and heavy), sex, working memory, and IQ were all conducted. Post hoc analyses using Tukey's HSD and Cohen's *d* to examine effect size were also used in making comparisons among the groups.

In summary, the same analyses were run on each of the two samples. Analyses were run separately as Sample 1 and Sample 2 because the two samples differed slightly on a number of measures as previously mentioned. Three participants were excluded from Sample 1 because their binge drinking values were extreme outliers, more than 3 standard deviations above the mean. Five outlier participants also were excluded from Sample 2 using the same criteria.

## Results

### SAMPLE 1

Ward's method indicated that three clusters fit these data best. This solution was reached in consideration of the dendrogram of cluster distance and the agglomeration schedule, which indicated an increase in error variance at the 216th step relative to the previous steps. The *k* means cluster analysis was thereafter run to assign participants to a three cluster solution. From examination of the cluster solutions emerged three types of binge drinkers: low, moderate, and heavy individuals who binge. Sample 1 contained 181 low individuals who binge, 103 moderate individuals who binge, and 31 heavy individuals who binge (**Table 2**).

**Group differences.** The obtained data on the cognitive tasks is summarized in Table 3. The ANOVA indicated a significant main effect of drinker group on the OWS,  $F(4,431) = 3.847, p < .005$  and the Shipley,  $F(4,437) = 7.180, p < .005$ . There were not any significant main effects on the ACT,  $F(4,429) = 2.137$ . Post hoc tests indicated that the heavy individuals who binge had significantly lower scores on the OWS compared to both the non-bingers ( $d1 = -.61, p < .05$ ) and the low individuals who binge ( $d2 = -.62, p < .05$ ). Comparisons on the Shipley showed that heavy individuals who binge scored significantly less than non-bingers ( $d1 = -.77, p < .005$ ), low individuals who binge ( $d2 = -.68, p < .005$ ), and moderate individuals who binge ( $d3 = -.56, p <$

.005). Post-hoc comparisons are summarized in **Table 4**. There was not a significant main effect of sex, nor were there any significant Cluster by Sex interactions. Finally, negative correlations between binge density and the three cognitive measures were significant (-OWS:  $-.242, p < .01$ ; ACT:  $-.212, p < .05$ ; Shipley:  $-.321, p < .01$ ).

## SAMPLE 2

Results of the agglomerative cluster analysis of participants' binge density using Ward's method gave that three clusters fit these data best. This solution was reached in consideration of the dendrogram of cluster distance and the agglomeration schedule, which indicated an increase in error variance at the 454th step relative to the previous steps. The k means cluster analysis was thus run to assign participants to a three cluster solution. From examination of the cluster solutions emerged three subtypes of individuals who binge: low ( $n = 366$ ), moderate ( $n = 192$ ), and heavy ( $n = 18$ ) (**Table 2**).

**Group differences.** **Table 3** summarizes the cognitive performance across all groups. ANOVA revealed a significant main effect of group on the WASI,  $F(4, 800) = 4.156, p < .005$ . There was not a significant main effect of drinker group on OWS,  $F(4, 813) = 2.260, p = .061$ , or ACT,  $F(4, 813) = 1.675, p = .154$ . Post-hoc comparisons indicated on the WASI that low individuals who binge scored significantly less than abstainers ( $d1 = -.29, p < .05$ ) and non-bingers ( $d2 = -.33, p < .05$ ). A summary of the post-hoc analyses is in **Table 4**. There was not a significant main effect of sex, nor were there any significant Group by Sex interactions. Finally, there were not any significant correlations between the binge density and the cognitive measures (OWS:  $-.015$ ; ACT:  $-.033$ ; WASI:  $-.014$ ).

## Discussion

Binge drinking is associated with several cognitive deficits. Numerous studies have shown effects in populations with individuals suffering clinical diagnoses of alcohol dependence, but few have considered these associations in populations of adults who binge ages 18-30. The studies which have investigated these domains have found that individuals who binge remember fewer words on declarative memory tasks and perform worse on a Logical Memory Task (Parada *et al.*, 2011), exhibit decreases in immediate and delayed recall abilities in comparison to control groups (Sanhueza *et al.*, 2011), and show a positive correlation between the intensity of drinking and dysfunction in executive functioning (Thoma *et al.*, 2011).

Sample 1	Cluster A Low (n=181)	Cluster B Moderate (n=103)	Cluster C Heavy (n=31)
Binge density	5.815±1.926	10.433±1.355	17.331±3.114
Binge frequency	2.558±1.340	4.049±1.611	4.516±1.503
Sample 2	Cluster A Low (n=366)	Cluster B Moderate (n=192)	Cluster C Heavy (n=18)
Binge density	6.172±1.396	11.431±1.973	20.839±3.154
Binge frequency	2.631±1.134	3.422±1.120	4.000±1.879

**Table 2.** Cluster analysis results from Sample 1 and Sample 2.

Sample 1 Measure	Cluster A (Low) (n=181)		Cluster B (Moderate) (n=103)		Cluster C (Heavy) (n=31)		(Abstainers) (n=36)		(Non-Bingers) (n=117)		<i>F</i> (4,429)
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
	OWS	42.54	10.988	39.21	10.958	34.72	14.749	40.28	13.333	43.04	
ACT	28.98	10.534	26.94	11.133	24.54	11.523	27.81	14.036	30.43	11.423	2.137 <sup>n.s.</sup>
IQ	106.27	8.491	104.61	8.359	97.04	17.130	103.30	13.589	107.33	8.244	7.180**

Sample 2 Measure	Cluster A (Low) (n=366)		Cluster B (Moderate) (n=192)		Cluster C (Heavy) (n=18)		(Abstainers) (n=115)		(Non-Bingers) (n=132)		<i>F</i> (4,800)
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
	OWS	39.07	11.095	40.91	10.095	36.89	11.926	41.16	12.617	41.58	
ACT	30.24	10.049	31.51	9.376	27.39	10.416	28.87	10.410	30.58	10.657	1.675 <sup>n.s.</sup>
IQ	110.64	9.897	111.05	8.976	108.94	8.011	113.96	12.530	113.97	10.107	4.156**

**Table 3.** Cognitive performance in Sample 1 and Sample 2.

Note: \* =  $p < .05$

\*\* =  $p < .005$

n.s. = not significant

Degrees of freedom differed slightly from task to task due to missing data in each sample. For example, Sample 1, OWS,  $F(4,431)$ , ACT  $F(4,429)$ , Shipley  $F(4,437)$ ; Sample 2, OWS  $F(4,812)$ , ACT  $F(4,812)$ , WASI  $F(4,800)$

Sample 1		Tukey's HSD	HB vs. NB	HB vs. LB	HB vs. MB
<i>F</i> (4,429)			<i>d</i> <sub>1</sub>	<i>d</i> <sub>2</sub>	<i>d</i> <sub>3</sub>
OWS	3.847**	HB<NB, LB	-.61	-.60	—
ACT	2.137 <sup>n.s.</sup>	—	—	—	—
IQ	7.180**	HB<NB, LB, MB	-.77	-.68	-.56
Sample 2		Tukey's HSD	HB vs. NB	HB vs. LB	
<i>F</i> (4,800)			<i>d</i> <sub>1</sub>	<i>d</i> <sub>2</sub>	
OWS	2.260 <sup>n.s.</sup>	HB<NB, LB	-.61	-.60	—
ACT	1.675 <sup>n.s.</sup>	—	—	—	—
IQ	7.180**	HB<NB, LB, MB	-.77	-.68	-.56

**Table 4.** Post-hoc comparisons and effect sizes among groups.

Note: \*\* =  $p < .005$

n.s. = not significant

Abstainer (AB), non-bingers (NB), low individuals who binge (LB), moderate individuals who binge (MB), and heavy individuals who binge (HB).

To complement and further develop the work these researchers have already completed, this study sought to investigate how an individual's binge drinking in the recent past was associated with their cognitive performance. Four hypotheses concerning these associations were originally made: (1) low, moderate, and heavy bingeing subtypes will emerge from cluster analyses in both Sample 1 and Sample 2, (2) the moderate and heavy bingeing clusters will exhibit decreased performance on the cognitive measures in comparison to the low cluster, (3) the binge density measure will be negatively correlated with the cognitive measures, and the (4) low, moderate, and heavy bingeing clusters will exhibit lower cognitive performance in comparison to the non-bingeing and abstainer groups.

To summarize, the analyses brought conflicting results to the proposed hypotheses. The use of Ward's method followed by a k-means analysis did indeed yield the three predicted clusters in each clustering method. The Sample 1 analyses gave significant main effects on the OWS and the Shipley tasks, with no significant findings on the ACT. Contrastingly, Sample 2's analyses found significant main effects solely on the WASI. Sample 1's post-

hoc comparisons illustrated that individuals who binge heavily scored significantly lower than all groups besides abstainers (Shipley) and that individuals who binge heavily scored significantly lower than individuals who binge at low levels and abstainers (OWS). Thus, Hypothesis 2 was partly supported in Sample 1. Hypothesis 3, the prediction of a significant negative correlation between the binge density measure and cognitive performance, was supported in Sample 1, but not supported in Sample 2. Finally, Hypothesis 4 was significant in Sample 1 as individuals who binge heavily significantly differed from non-bingers, individuals who binge at low levels, and individuals who binge at moderate levels (Shipley), and by individuals who binge heavily also significantly differing from non-bingers and individuals who binge at low levels (OWS). Hypothesis 4 was also supported in Sample 2 as individuals who binge at low levels significantly differed from non-bingers and abstainers (WASI).

As predicted, Hypothesis 1 was supported as three clusters emerged from each sample. This confirms the findings of previous studies indicating three overall binge drinking groups (Goudriaan *et al.*, 2007; Tucker *et al.*, 2003; Muthén & Shedden, 1999). Furthermore, each respective cluster was observed to have similar binge frequencies and densities as well as similar ratios of participants in each cluster (e.g., both low clusters gave similar binge frequencies and densities; similar proportions of the sample in each cluster). Though these clustering methods were a useful tool in classifying these data and efforts were made to ensure for more valid clustering (i.e., the use of the two separate methods), it is difficult to determine their external validity. Continued research using similar clustering methodologies in samples with a wider demographic and longer term measures of binge drinking would be of merit.

One of the primary aims of this study was to consider the association of cognitive deficits with young adult binge drinking behavior. Hypothesis 2, addressing if the moderate and heavy clusters significantly differed from the low cluster, was supported in Sample 1, but not in Sample 2. There are several possible conclusions that could be reached from this result. One possible conclusion is that Sample 1's significant findings are indicative of binge drinking's effects on cognitive ability. As previously mentioned, extensive research exists considering the effects of chronic alcohol use upon cognition in numerous alcohol induced disorders such as Korsakoff's syndrome and Wernicke encephalopathy (Marshall, Guerrini, & Thomson, 2009). Hermens *et al.* (2013) noted, however, there has been a deficit on the

research concerning the early phases of neurological damage and cognitive deficits, especially in young adults.

The results in this study suggest recent binge levels associate with the cognitive deficits at the heavier end of the spectrum of bingeing. Something to consider, however, is that this level of bingeing may not be the early stage Hermens *et al.* (2013) specifies: the level of bingeing present in this heavy subtype (**Table 2**) would likely go beyond casual “social bingeing” and manifest more so a DSM V diagnosis of dependence. Contrastingly, a separate conclusion could be drawn based on Sample 2’s lack of significance: namely, decreases in cognitive ability in relation to young adult binge drinking are not evident at these levels and in this age group. The discrepancy between these two conclusions may be attributable to differences in the sampled populations.

While these samples have similar binge drinking patterns, they may differ in how long they had been bingeing at these levels. While the length of time the subjects had been bingeing for is not available, it is very possible that Sample 1 had individuals who had been bingers for longer periods of time (i.e., had started bingeing earlier in adolescence), which could have impacted their cognitive performance and led to the significant findings. This result, however, is indicative of why longitudinal research into individuals who binge over time would be invaluable in comparison to two separate archival data samples. Despite this, the presented averages of binge densities and frequencies may prove to be a useful starting point for future studies.

Hypothesis 3 was supported as a significant negative correlation between the binge density and cognitive measures was observed in Sample 1, but not in Sample 2. The significant effect in Sample 1 supports the results of other studies of the possible deleterious effects of heavy alcohol use (Ferrett *et al.*, 2010; Squeglia *et al.*, 2009; Goudriann *et al.*, 2007; Courtney & Polich, 2009; Courtney & Polich, 2010; Parada *et al.*, 2011). Specifically, this study supported similar correlations made by Tapert *et al.* (2004) on IQ tasks. This finding is logical as alcohol use over the course of many years is commonly associated with cognitive ability, especially EWM capacity (Finn & Hall, 2004; Finn *et al.*, 2009). However, the directionality between these two variables and the variety of other factors that may moderate this relationship still requires additional research. However, the analyses in Sample 2 were not significant for Hypothesis 3. A conclusion that could be made based on this result is that the negative correlation expected between these variables would not be seen until an individual engages in higher levels of drinking over the course of a greater time span (i.e., not in this young population). In

addition, this result is again likely due to population differences (i.e., length of time an individual had been a binge drinker, different levels of cognitive performance). Regardless, the directionality between these two variables and the variety of other factors that may moderate this relationship still requires additional research.

Hypothesis 4 was designed to investigate differences between not only individuals who binge, but also among different types of drinkers as well (i.e., abstainers, non-bingers). Several noteworthy points to consider include the following: heavy individuals who binge scored significantly less than non-bingers, low individuals who binge, and moderate individuals who binge in Sample 1 on the Shipley and that low individuals who binge scored significantly lower than abstainers and non-bingers on the WASI in Sample 2. The first finding, heavy individuals who binge scoring significantly lower, supports the aforementioned research that suggests higher levels of bingeing are associated with differences in cognitive performance. The finding that low individuals who binge scored significantly lower than abstainers and non-bingers is of particular interest in the context of the research questions posed. However, the argument made regarding this finding is that while it is a statistically significant finding, it is not of clinical significance. This conclusion has been made as the difference in IQ scores between non-bingers/abstainers and low individuals who binge is about 3 points (less than half a standard deviation). In addition, Cohen's  $d$  only gives a small effect ( $d = -.29$ ). Both of these findings suggest that though this finding is of interest in relation to the proposed questions, it is likely not of clinical significance.

Although this study elicited novel findings regarding associations between binge drinking and cognitive capacity, it comes with the caveat of several limitations. Most notably, this study used two archival data sets which were designed to analyze different questions than the ones proposed in this study. In an ideal setting, based upon the recommendations of Goudriann *et al* (2007), participants' drinking patterns would be assessed in 6 month increments and over the course of several years. This design would provide for more accurate estimates of participants' binge drinking. However, although the ideal measure of alcohol use was not used in this study, it seems that the available data does provide a useful method of considering the average college student's binge drinking.

In addition, the participants who were sought for these samples often had high rates of externalizing pathology. A recent meta-analysis (Ruiz, Pincus, & Schinka, 2008) and a separate study (Finn, Gunn, & Gerst, 2014) suggest that those who suffer from externalizing pathology (most commonly



in these two samples: antisocial personality disorder, conduct disorder, and borderline personality disorder) will typically engage in more alcohol and drug abuse, resulting in higher levels of substance use disorder diagnosis. Lastly, the obtained heavy bingeing cluster was significantly smaller than its moderate and low counterparts. This cluster was kept separate as it was seen that these individuals exhibited unique binge drinking patterns in comparison to the other two clusters.

### Conclusions

As the pervasiveness of binge drinking continues across the United States in the young adult population, continued research into its effects on multiple cognitive domains remains essential. Acute, intense alcohol use greatly associates with neuropsychological performance especially in EWM capacity and IQ. As the drug of choice in both college populations as well as the general population, further longitudinal research concerning the biological and cognitive effects of binge drinking will allow young adults to make wiser decisions in their behaviors. The mixed findings observed in this study between Sample 1 and Sample 2 demonstrate the necessity of such longitudinal study, which could potentially comprehensively answer this question. In conclusion, though mixed results were obtained, some of the analyses in this study suggest that different levels of binge drinking are associated with cognitive effects in the young adult population.

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