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## Initiating Moderate to Heavy Alcohol Use Predicts Changes in Neuropsychological Functioning for Adolescent Girls and Boys

L. M. Squeglia<sup>1,2</sup>, A. D. Spadoni<sup>1,2</sup>, M. A. Infante<sup>2</sup>, M. G. Myers<sup>2,3</sup>, and S. F. Tapert<sup>2,3,\*</sup>

<sup>1</sup>SDSU/UCSD Joint Doctoral Program in Clinical Psychology

<sup>2</sup>VA San Diego Healthcare System

<sup>3</sup>University of California San Diego, Department of Psychiatry

### Abstract

This study prospectively examines the influence of alcohol on neuropsychological functioning in a sample of boys and girls who were characterized prior to initiating drinking ( $N=76$ , ages 12–14). Adolescents who transitioned into heavy ( $n=25$ ; 11 female, 14 male) or moderate ( $n=11$ ; 2 female, 9 male) drinking were compared to demographically-matched controls who remained non-users throughout the approximately 3-year follow-up period ( $n=40$ ; 16 female, 24 male). For girls, more drinking days in the past year predicted a greater reduction in performance on visuospatial tasks from baseline to follow-up, above and beyond performance on equivalent measures at baseline ( $R^2\Delta = 10\%$ ,  $p < .05$ ), particularly on tests of visuospatial memory ( $R^2\Delta = 8\%$ ,  $p < .05$ ). For boys, a tendency was seen for more hangover symptoms in the year before follow-up testing to predict a relative worsening of sustained attention ( $R^2\Delta = 7\%$ ,  $p < .05$ ). These preliminary longitudinal findings suggest that initiating moderately heavy alcohol use and incurring hangover during adolescence may adversely influence neurocognitive functioning. Neurocognitive deficits linked to heavy drinking during this critical developmental period may lead to direct and indirect changes in neuromaturational course, with effects that would extend into adulthood.

### Keywords

Adolescence; alcohol; hangover; neuropsychological assessment; neurocognitive functioning; visuospatial functioning; attention

### INTRODUCTION

Adolescence marks a time of significant increases in alcohol use, with 31% of boys and 22% of girls in the 12<sup>th</sup> grade endorsing heavy episodic drinking in the past two weeks (Johnston, O'Malley, Bachman, & Schulenberg, 2008). These high rates are concerning in regards to potential deleterious effects of alcohol on adolescent brain development (Brown et al., 2008; Squeglia, Jacobus, & Tapert, 2009 for reviews). The adolescent brain incurs rapid anatomical and neurochemical changes (Giedd, 2004; Sowell et al., 2004), including cortical remodeling

\*Corresponding author: S. F. Tapert, Ph.D., 3350 La Jolla Village Drive (151B), San Diego, CA 92161, US; telephone: 858 552 8585, stapert@ucsd.edu.

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and hormonal alterations (Crews, He, & Hodge, 2007), with females undergoing these changes 1–2 years before males on average (Giedd et al., 2006). These changes may heighten adolescents' vulnerability to the neural effects of alcohol (Clark & Tapert, 2008; Dahl, 2004), impeding key processes of cognitive development (Chanraud et al., 2007).

As most studies have been cross-sectional, the effects of adolescent alcohol use on neurocognitive development remain inconclusive. Cross-sectional studies have found disadvantaged neurocognition among adolescents with alcohol use disorders (AUD), including poorer retrieval (Brown, Tapert, Granholm, & Delis, 2000), attention and information processing (Tapert & Brown, 2000; Tarter, Mezzich, Hsieh, & Parks, 1995), visuospatial (Sher, Martin, Wood, & Rutledge, 1997; Tapert & Brown, 1999), and language (Moss, Kirisci, Gordon, & Tarter, 1994) functioning than non-drinkers. Executive functioning deficits have been found in female substance-using teens (Giancola, Shoal, & Mezzich, 2001; Moss et al., 1994). Longitudinal studies found deteriorations in visuospatial functioning and attention in treated teens who continued heavy drinking and reported hangover or withdrawal (Tapert & Brown, 1999; Tapert, Granholm, Leedy, & Brown, 2002).

Post-drinking symptoms (e.g., hangover and withdrawal) indicate relatively intense alcohol use levels, have been linked to brain changes (Glenn, Parsons, Sinha, & Stevens, 1988; Parsons & Stevens, 1986), and are not dependent on quantity, which is difficult to compare across genders. In humans, poorer visuospatial performance, attention (Brown et al., 2000; Tapert et al., 2002), and memory (Tapert et al., 2001), and greater abnormalities in brain response (Tapert et al., 2004) have been seen in adolescents who endorsed more alcohol withdrawal symptoms. Thus, the effects of alcohol withdrawal on adolescent cognition may be more detrimental than the actual quantity of alcohol consumed, or may more accurately mark the extent of a heavy drinking episode than recollections of alcohol quantity. While severe withdrawal is uncommon in adolescents (Martin, Chung, Kirisci, & Langenbucher, 2006), hangover symptoms may index post-drinking effects that could influence neurocognition. Hangovers have been described along a continuum of post-drinking effects that range from withdrawal to mild symptoms (Swift & Davidson, 1998; Wiese, Shlipak, & Browner, 2000). Males tend to report hangover symptoms more commonly than females (Deshmukh et al., 2003), but occurrence in females is more strongly related to heavy drinking (Piasecki, Sher, Slutske, & Jackson, 2005). The long-term effects associated with this milder form of withdrawal have not been examined longitudinally in adolescents first assessed prior to the initiation of substance use.

This study prospectively examined neurocognition in adolescents first assessed prior to the onset of any heavy drinking, some of who transitioned into moderately heavy alcohol use during the follow-up. Based on prior work (Brown et al., 2000; Tapert & Brown, 1999, 2000; Tapert et al., 2002), greater alcohol use and hangover over the follow-up were hypothesized to predict worsening scores on tests requiring visuospatial processing, sustained attention, learning and memory, working memory, and planning. Due to the differential influence of alcohol on cognition by sex (Nixon, 1994; Pfefferbaum, Adalsteinsson, & Sullivan, 2006; Sullivan, Fama, Rosenbloom, & Pfefferbaum, 2002), females and males were evaluated separately. It was hypothesized that female drinkers would show worsened visuospatial performance (Tapert et al., 2001) and working memory (Flannery et al., 2007; Sullivan et al., 2002), while male drinkers would show relative decline on sustained attention and planning tasks (Fama, Pfefferbaum, & Sullivan, 2004).

## METHODS

### Participants

Participants were recruited as part of an ongoing longitudinal neuroimaging study. Flyers were mailed to households of local middle schools describing the project, major inclusion criteria,

and compensation. Exclusionary criteria were prenatal alcohol (>2 drinks in a week) or any tobacco or illicit drug use; history of chronic medical illness, any neurological or DSM-IV (APA, 1994) Axis I disorder other than conduct disorder, loss of consciousness (>2 minutes), or learning disabilities; parental history of bipolar, psychotic, or antisocial personality disorder; sensory problems; and left handedness. In all, 13% of respondents met eligibility criteria. Extensive screening and background data were obtained from each participant, one biological parent, and one other parent or close relative. At baseline, this study included 76 participants, ages 12–14 years, who had minimal substance use ( $\leq 6$  total lifetime drinks with  $\leq 3$  drinks on any occasion;  $\leq 3$  lifetime uses of marijuana ( $>0$  for  $n=5$ ) and none in the past three months;  $\leq 10$  lifetime cigarette uses ( $>0$  for  $n=5$ ); and no history of other intoxicant use). The current study included adolescents who transitioned into heavy ( $n=25$ ; 11 females) or moderate ( $n=11$ ; 2 females) drinking, and those who remained non-users through follow-up ( $n=40$ ; 16 females; see Table 1). Because this study is ongoing, different follow-up time points were examined, ranging from one to five years (mean=3.6).

## Measures

**Substance use**—The Customary Drinking and Drug Use Record (CDDR; Brown et al., 1998) was administered at baseline for self-reported lifetime alcohol, tobacco, and other drug use, and withdrawal/hangover symptoms. The version at annual follow-ups assessed past year and past 3-month use. Breathalyzer and urine screens and parent reports on youth use verified self-report data. The Hangover Symptoms Scale (HSS; Slutske, Thomas M. Piasecki, & Hunt-Carter, 2003) given at each follow-up provided past-year severity ratings on 13 hangover symptoms. HSS scores ranged from 13–36, from a possible range of 13–65, and were internally consistent (Cronbach's  $\alpha=.90$ ). Alcohol related blackouts were not examined because of low endorsement (8%).

**Neuropsychological (NP) battery**—The baseline NP battery lasted ~3 hours and included domains found compromised in prior studies of adolescent alcohol use (Brown et al., 2000; Tapert & Brown, 1999, 2000; Tapert et al., 2002). Measures of visuospatial processing were Complex Figure copy and 30-minute delay accuracy (Rey & Osterrieth, 1993); and Wechsler Abbreviated Scale of Intelligence (WASI) Block Design (Wechsler, 1999). Measures of sustained attention, speeded information processing, and working memory included the Digit Vigilance Test (DVT; Lewis, 1995); Delis Kaplan Executive Function System (D-KEFS) Trail Making (Delis, Kaplan, & Kramer, 2001); and Wechsler Intelligence Scale for Children-III (WISC-III) Digit Span and Coding (Wechsler, 1991). Learning and memory scores were obtained from the California Verbal Learning Test—Children's Version (CVLT-C; Delis, Kramer, Kaplan, & Ober, 1994); and executive functioning/planning were D-KEFS Color-Word Interference and Towers (Delis et al., 2001). Premorbid functioning and intellectual capacity were estimated from WASI Vocabulary and Similarities and Wide Range Achievement Test-3 Reading scores (WRAT-3; Wilkinson, 1993). The Taylor scoring system (Taylor, 1998) was used for Complex Figures, each independently scored by two trained, reliable raters (intraclass correlation coefficient=.94), then reviewed in consensus meetings. At each follow-up, the DVT target number was alternated, and the Rey-Osterrieth Complex Figure was replaced by a novel figure (Loring & Meador, 2003; Meador et al., 1993; Taylor, 1969) to minimize practice effects. At the 4-year follow-up, WISC-III subtests were replaced with corresponding Wechsler Adult Intelligence Scale-III (Wechsler, 1997) subtests, and the CVLT-II (Delis, Kramer, Kaplan, & Ober, 2000) replaced the CVLT-C.

**Covariates**—The Family History Assessment Module (FHAM; Rice et al., 1995), administered to youth and parent, ascertained familial density of AUD by adding 0.5 per biological parent and 0.25 per biological grandparent (Zucker, Ellis, & Fitzgerald, 1994) endorsed by either youth or parent. This measure has been shown to be valid and more sensitive

than classifications (Stoltenberg, Mudd, Blow, & Hill, 1998). The Conduct Disorder Questionnaire (CDQ; Brown, Gleghorn, Schuckit, Myers, & Mott, 1996), administered to the youth and parent, provided a continuous measure of CD behaviors based on DSM-IV criteria (APA, 1994), with one point added for each item endorsed by either youth or parent (possible range: 0–27; Myers, Stewart, & Brown, 1998). Family socioeconomic status (SES) considered the educational attainment and occupation of each parent (Hollingshead, 1965).

## Procedures

At baseline, screening interviews were administered to youth and parents by trained lab assistants to assess eligibility. Eligible youth and parents independently completed interviews, and participants were administered the standardized NP battery by a trained psychometrist. Participants were followed annually using rigorous follow-up procedures (Twitchell, Hertzog, Klein, & Schuckit, 1992), and contacted by phone to complete questionnaires on current substance use. Those who fit criteria at follow-up (see Figure 1) for heavy or moderate drinking were invited to return and complete assessments, then were matched on gender, familial AUD category (negative, mild, positive), baseline age, and age at follow-up to continuous non-users. Adolescents who were non-drinkers but initiated other drug use were excluded from analyses. Follow-up rates are >95% at each time point. Consent and assent were obtained each year. Study protocol was executed in accordance with standards approved by the University of California, San Diego Human Research Protections Program.

## Data Analyses

All substance involvement variables were positively skewed, so logarithmic transformations were applied (Tabachnick & Fidell, 2007). All NP measures were normally distributed and free from outliers. Z-scores for each NP measure at each time point were computed based on scores (raw, unless otherwise noted) of all participants tested at that time point. Change scores were created by subtracting each subject's baseline z-score from their most recent follow-up z-score for the corresponding NP measure. To reduce the number of dependent variables, composite scores were computed using established cognitive domain groupings, based on tasks' purported underlying brain systems (Lezak, Howieson, Loring, Hannay, & Fischer, 2004; Medina et al., 2007): (1) Visuospatial Functioning, (2) Attention and Working Memory, (3) Learning and Memory, and (4) Executive Functioning/Planning. Composite scores were computed by averaging change scores across tests within a domain (see Table 2). Age, SES, and familial AUD density, CDQ scores (range: 0–9), and practice effects (Bates, Voelbel, Buckman, Labouvie, & Barry, 2005; Matarazzo & Herman, 1984; White, Campbell, Echeverria, Knox, & Janulewicz, 2009) were used as covariates if they correlated ( $p < .05$ ) with NP composite change scores. For females, none of these variables correlated with NP measures. For males, SES correlated with Learning and Memory. For females and males, baseline NP scores correlated with their corresponding change scores; to mitigate regression to the mean, baseline scores for each corresponding measure were used as covariates. Females and males were examined separately, as it was hypothesized that alcohol use would have a differential influence by gender. Hierarchical regressions used the four NP composite change scores as dependent variables, entered covariates on Block 1, and transformed past year drinking days on Block 2 ( $\alpha < .05$ ). Follow-up regressions were run for each significant composite score to determine which NP tasks were predicted by alcohol use, and to see if lifetime drinking, average past 3-month drinking, and HSS scores predicted cognitive change. Exploratory analyses were conducted to examine task specific results, because little is known about associations between neuropsychological performance and alcohol use in adolescents based on prospective data.

## RESULTS

Regression analyses used past year drinking days to predict composite NP change scores. For females ( $n=29$ ), more drinking days in the year prior to follow-up predicted greater reduction in performance in Visuospatial Functioning from baseline to follow-up, above and beyond baseline Visuospatial Functioning scores ( $F(2,24)=11.42, p<.001; R^2\Delta=10\%, p<.05; \beta=-.33$ ; see Table 3 and Figure 2). For males, follow-up drinking did not predict NP domain change scores.

Exploratory hierarchical regressions used task-specific NP change scores as dependent variables (i.e., the 12 non-premorbid functioning measures in Table 2), the corresponding baseline NP score and any covariates on Block 1, and substance involvement variables on Block 2. Variables that correlated ( $p<.05$ ) with outcome change scores were used as covariates in analyses. For females, age was used as a covariate for Coding, Block Design, and CVLT Long Delay Free Recall change scores. For males, age was a covariate for Coding and Color Word Interference Inhibition/Switching; CDQ total for Complex Figure copy; family history density for Coding and Block Design; and SES for CVLT Long Delay Free Recall change scores. For females, past year drinking days predicted Complex Figure change scores, similar as above ( $F(2,20)=19.04, p<.001; R^2\Delta=8\%, p<.05; \beta=-.32$ ). For males, higher follow-up HSS scores predicted slowed DVT completion times from baseline to follow-up, above and beyond baseline DVT time ( $F(3,39)=8.65, p<.001; R^2\Delta=7\%, p<.05; \beta=.27$ ). DVT omission and commission errors were not significantly related to HSS scores, suggesting that the decrements in time completion were due to processing speed rather than accuracy.

Follow-up regressions using lifetime drinking, average past 3-month drinking, and HSS scores were used to predict individual NP test change scores within the Visuospatial Functioning domain for females. More past 3-month drinking predicted greater reduction in Complex Figure delay performance from baseline to follow-up, above and beyond baseline Complex Figure delay scores ( $F(2,20)=19.17, p<.001; R^2\Delta=8\%, p<.05; \beta=-.32$ ; see Figure 3). Lifetime drinking days and HSS scores did not predict reductions on Block Design or Complex Figure copy.

Results above remained unchanged when using non-transformed alcohol involvement variables. After controlling for alcohol consumption, lifetime and past month tobacco and marijuana use reported at follow-up did not significantly predict any follow-up NP change score. Recency of drinking did not predict follow-up NP change measures, and results above remained unchanged when controlling for days since last alcohol use.

## DISCUSSION

This study prospectively examined the effects of alcohol use on neurocognition in adolescent girls and boys. For girls, more drinking days in the year before the follow-up NP assessment predicted a relative worsening in visuospatial functioning. For boys, greater hangover symptoms in the year before the follow-up was linked to relative worsening in sustained attention. This is consistent with past research reporting visuospatial (Brown et al., 2000; Sher et al., 1997; Tapert et al., 2001; Tapert & Brown, 1999) and attentional (Tapert & Brown, 1999; Tarter et al., 1995) decrements in adolescent substance users. Contrary to hypotheses, planning scores did not relate to drinking. Our findings are part of a longitudinal study in which subjects had little to no substance exposure at baseline, reducing the likelihood that decrements are attributable to premorbid traits.

As females and males drank at similar rates in this sample, the different manifestations of cognitive decrements could relate to divergent neurodevelopmental trajectories, physiological responses to alcohol, and social factors influencing drinking onset. Generally, females

outperform males on tasks of psychomotor speed and accuracy, while males perform better on visuospatial tests (Lezak et al., 2004). Areas of relative weakness may be vulnerable to effects of alcohol and hangover. For girls, decrements seen in complex non-verbal productive memory, but not visual reproduction or verbal memory, are consistent with findings in adult female alcoholics (Sullivan et al., 2002), and may suggest affected frontoparietal circuitry (Selemon & Goldman-Rakic, 1988; Tapert et al., 2001). Girls consuming  $\geq 12$  drinks per month at follow-up showed a relative decline in visuospatial memory (see Figure 3), while females consuming  $< 12$  drinks per month did not. For males, decrements were found on DVT completion time but not other tasks of processing speed (i.e., Trails or Digit Symbol), suggesting reduced maturation in sustained attention and not simply processing speed, consistent with findings in adult alcoholics (Tedstone & Coyle, 2004). These results are concerning, as the severity of alcohol use is relatively low (mean drinks per month = 7.4) and most drinking is subclinical (only 4 of the 76 subjects met criteria for an AUD at follow-up).

While only some behavioral disadvantages may be apparent yet, it is possible that underlying neural structures may be compromised. White matter coherence may drive the spatial decrements found in females, as subclinical adolescent drinking has been linked to reduced white matter integrity (McQueeney et al., in press), and coherence positively relates to visuospatial skills (Fryer et al., 2008). fMRI studies have detected abnormalities in brain response to spatial working memory tasks despite intact performance in youth with short drinking histories (Tapert et al., 2004), but young adult females with longer drinking courses showed decreased frontal and parietal activation and attenuated performance (Tapert et al., 2001).

Limitations of this study include the relatively low drinking level and sample size. We used different follow-up durations across participants; ideally, each individual would be examined after the same follow-up duration. As the z-scores represent a ranking of scores at each time point, the results are relative to those assessed at a given assessment period. However, with the nature of longitudinal pediatric cognitive data, raw scores cannot be used because of differences between child and adult versions and alternate forms of tests at follow-ups. Future studies are needed to replicate the above findings, given the exploratory nature of some analyses.

The current findings present important clinical and public health implications. Visuospatial deficits could negatively impact females' capacity to recall previously encoded spatial information, which could potentially have consequences for success in driving and figural reasoning. Deficits in males' sustained attention adversely influence academic achievement and behavioral functioning. While the effects sizes reported in this study are relatively modest, negative NP consequences from drinking could affect large numbers of youth who engage in moderate to heavy levels of alcohol consumption.

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Portions of this study were presented at the 2008 meeting of the Research Society on Alcoholism. This work represents the master's thesis of the first author.

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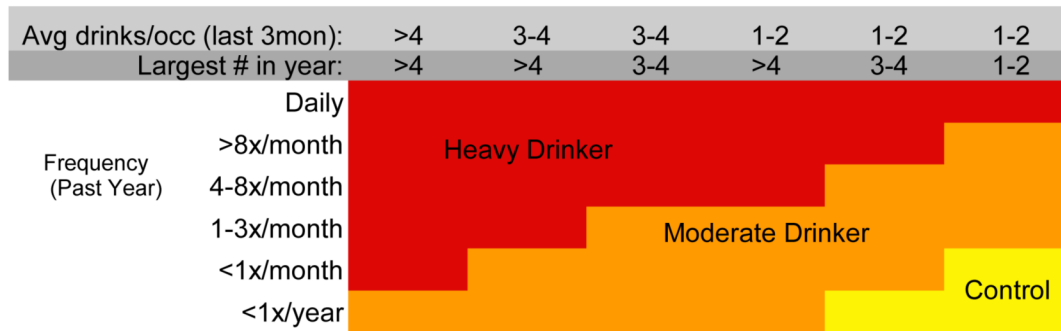
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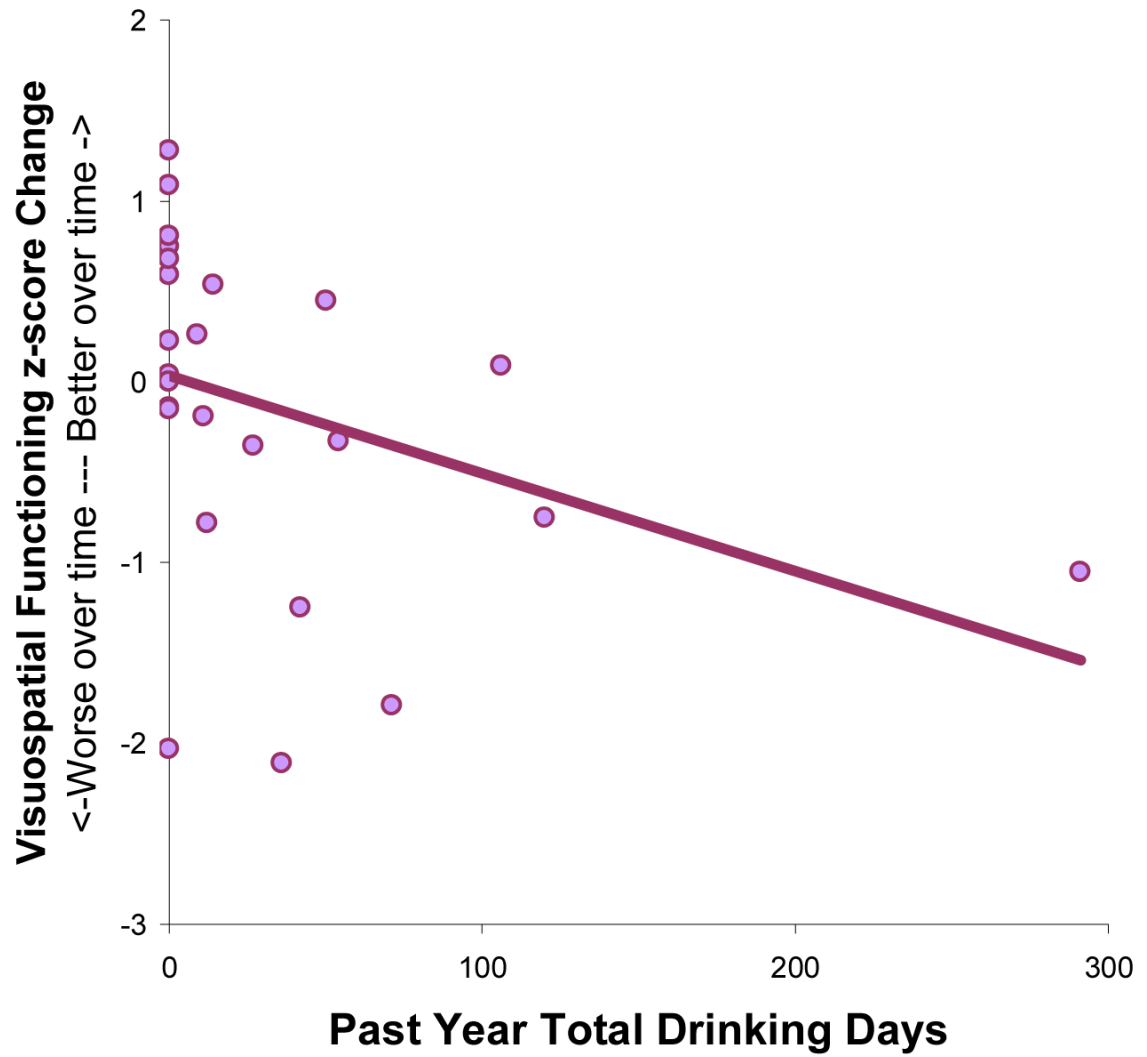


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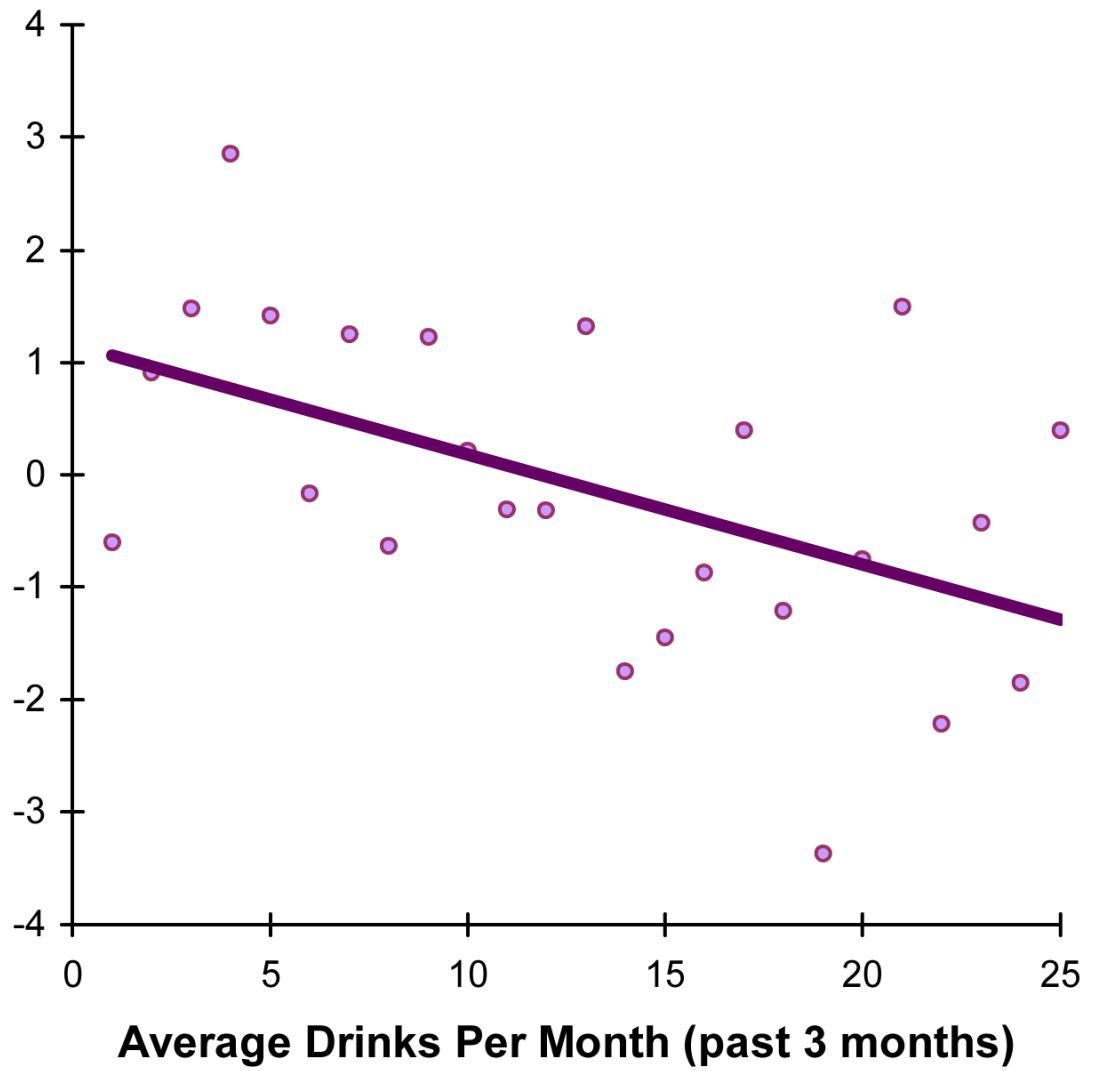
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**Figure 1.** Outcome drinking classification, based on Cahalan et al., 1969 and modified based on the distribution of drinking characteristics of adolescent males and females observed in the first two years of this project (Schweinsburg et al., 2005; Tapert et al., 2004).



**Figure 2.** For female adolescents, more past year drinking days predicted a greater reduction in performance on the Visuospatial Functioning composite score ( $R^2\Delta = 10\%$ ,  $\beta = -.33$ ,  $p < .05$ ).



**Figure 3.** For female adolescents, more drinks per month predicted a greater reduction in performance on complex figure delay ( $R^2\Delta = 8\%$ ,  $\beta = -.32$ ,  $p < .05$ ).

**Table 1**

Descriptive characteristics of adolescents who transitioned into moderate or heavy drinking versus those who did not, at baseline and follow-up

	Females (n=29) M (SD)		Males (n=47) M (SD)	
	Controls n=16	Drinkers n=13	Controls n=24	Drinkers n=23
Age at baseline (range: 12-14)	13.44 (0.66)	13.88 (0.76)	13.52 (0.82)	13.76 (0.76)
Caucasian (%) <sup>*</sup>	75%	85%	58%	91%
Hollingshead socioeconomic status	20.38 (11.70)	22.15 (9.66)	25.96 (15.75)	21.83 (11.98)
Wide Range Achievement Test-3 Reading standard score	108.75 (9.50)	108.85 (9.92)	108.99 (11.61)	108.09 (8.56)
Family history density of alcohol use disorder (range 0 – 1.5) <sup>a e</sup>	0.11 (0.22)	0.46 (0.51)	0.18 (0.31)	0.33 (0.35)
Conduct Disorder Questionnaire total score <sup>a b c d e</sup>	0.56 (0.89)	2.15 (2.30)	1.88 (1.60)	3.35 (2.35)
Conduct disorder diagnosis (%) <sup>a d</sup>	0%	15%	0%	39%
Lifetime drinking days <sup>a d e</sup>	0.00 (0.00)	1.15 (2.12)	0.00 (0.00)	0.83 (1.47)
Lifetime marijuana use days <sup>a d</sup>	0.00 (0.00)	0.08 (0.28)	0.00 (0.00)	0.39 (0.94)
Years until follow-up <sup>d</sup>	2.69 (1.08)	3.54 (1.27)	2.42 (1.35)	3.57 (1.08)
Number of follow-up assessments <sup>a</sup>	1.50 (0.97)	2.31 (1.18)	1.54 (0.93)	1.96 (0.98)
Lifetime drinking days <sup>a d e</sup>	0.00 (0.00)	87.92 (87.68)	1.42 (3.36)	50.57 (52.22)
Average drinks per month, past 3 months <sup>a d e</sup>	0.00 (0.00)	9.85 (10.16)	0.54 (1.91)	6.09 (10.38)
Past month total drinks <sup>a d e</sup>	0.00 (0.00)	4.46 (7.66)	0.00 (0.00)	11.57 (16.92)
Lifetime marijuana use days <sup>a d</sup>	0.00 (0.00)	77.69 (184.51)	1.00 (2.72)	65.26 (134.42)
Lifetime other drug use days <sup>d</sup>	0.00 (0.00)	12.92 (45.40)	0.00 (0.00)	2.09 (4.66)
Past month cigarette use <sup>a</sup>	0.00 (0.00)	3.31 (7.15)	0.08 (0.41)	3.39 (8.63)

Note: Among drinkers, moderate to heavy drinking was initiated 2.3 years (SD=1.3) after baseline, on average. Drinkers had consumed alcohol at moderate or heavy levels for an average of 2.8 years since initiation (SD=1.3).

<sup>a</sup> Drinkers ≠ Controls,  $p < .05$

<sup>b</sup> Males ≠ Females,  $p < .05$

<sup>c</sup> Male Controls ≠ Female Controls,  $p < .05$

<sup>d</sup> Male Drinkers ≠ Male Controls,  $p < .05$

<sup>e</sup> Female Drinkers ≠ Female Controls,  $p < .05$

\* For the full sample, ethnicity was: 15% Hispanic or Latino and 85% Not Hispanic or Latino; race was: 73% Caucasian, 15% multiracial, 5% Asian, and 7% other.

**Table 2**

Neuropsychological change (outcome - baseline) z-scores of adolescents who transitioned into moderate or heavy drinking versus those who did not

	Females <i>n</i> =29 <i>M</i> ( <i>SD</i> )		Males <i>n</i> =47 <i>M</i> ( <i>SD</i> )	
	Controls <i>n</i> =16	Drinkers <i>n</i> =13	Controls <i>n</i> =24	Drinkers <i>n</i> =23
Visuospatial Functioning				
Complex Figure copy accuracy*	0.01 (1.43)	-1.00 (1.61)	0.12 (0.99)	0.18 (1.45)
Complex Figure delay accuracy <sup>a b*</sup>	0.36 (1.26)	-0.84 (1.42)	0.29 (1.01)	-0.10 (0.96)
WASI Block Design*	0.02 (0.61)	-0.31 (0.45)	0.22 (0.72)	0.01 (0.67)
Attention and Working Memory				
Digit Vigilance Test Time <sup>†</sup>	-0.25 (0.83)	0.0 (0.70)	-0.21 (0.71)	-0.00 (0.96)
D-KEFS Trails Condition 4 Time <sup>†</sup>	-0.25 (0.92)	0.14 (0.72)	-0.12 (0.82)	-0.04 (0.92)
Digits Forward*	0.27 (1.01)	-0.14 (1.47)	0.20 (0.81)	-0.13 (0.93)
Digits Backward*	-0.49 (0.75)	0.10 (0.94)	-0.10 (0.71)	0.09 (1.39)
Coding*	-0.12 (0.88)	-0.07 (1.27)	0.13 (0.84)	-0.09 (0.61)
Learning and Memory				
CVLT List 1-5 Total*	0.08 (0.99)	0.22 (1.38)	0.09 (0.90)	0.30 (1.03)
CVLT Long Delay Free Recall*	0.40 (0.96)	0.17 (1.22)	-0.13 (0.89)	0.11 (0.96)
Executive Functioning/Planning				
D-KEFS Color-Word Interference Inhibition/Switching (Completion Time / Combined Naming and Reading Contrast)*	-0.07 (0.83)	0.14 (0.83)	-0.03 (1.29)	0.21 (1.13)
D-KEFS Towers (Total Achievement Score)*	-0.08 (1.61)	0.09 (0.82)	0.12 (1.17)	-0.03 (1.52)
Premorbid Functioning, raw scores at baseline				
WASI Vocabulary*	53.06 (4.22)	50.69 (6.21)	51.63 (8.48)	52.30 (5.46)
WASI Similarities*	34.31 (5.53)	34.08 (3.50)	33.92 (5.83)	33.22 (5.27)
WRAT-3 Reading*	43.63 (4.57)	44.08 (3.77)	44.04 (4.71)	43.78 (3.88)

Note: D-KEFS=Delis-Kaplan Executive Function System; WASI=Wechsler Abbreviated Scale of Intelligence; CVLT=California Verbal Learning Test; WRAT-3=Wide Range Achievement Test, 3<sup>rd</sup> edition. Range of correlations among measures within each NP domain were: Visuospatial functioning (.26-.43); Attention and Working Memory (.01-.31); Learning and Memory (.56); Executive Functioning (.05). Composite scores were based on established cognitive domain groupings (Lezak et al., 2004; Medina et al., 2007).

<sup>a</sup>Drinkers ≠ Controls, *p* < .05

<sup>b</sup>Female Drinkers ≠ Female Controls, *p* < .05



\* Higher scores indicate improved performance

† Higher scores indicate worsened performance

**Table 3**

Standardized betas showing extent to which adolescent drinking days in the past year predicted change in neuropsychological performances

<i>Dependent variable:</i>	<b>Females</b>	<b>Males</b>
Visuospatial Functioning	-.33*	n.s.
Attention and Memory	n.s.	n.s.
Learning and Memory	n.s.	n.s.
Executive Functioning/Planning	n.s.	n.s.

Note: All analyses controlled for baseline neuropsychological functioning

\*  $p < .05$