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Effects of Heavy Drinking on Executive Cognitive Functioning in a Community Sample

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Abstract

Background—Deficits in several aspects of executive cognitive functioning (ECF) have been consistently associated with alcohol use disorders. Most of this research, however, has been conducted in alcohol dependent patient samples. A handful of recent studies, primarily in college students, has also reported similar deficits, but little is known about the effects of heavy drinking in adult, non-patient men and women.

Methods—A community sample (N=560) of men and women completed a brief battery of ECF measures including measures of attentional control, cognitive flexibility, working memory and response inhibition. Quantity/frequency of alcohol and illicit drug use in the past year were also assessed.

Results—Regression analyses indicated that men and women with higher levels of alcohol consumption exhibited greater impairment on several ECF measures, primarily those pertaining to cognitive flexibility and response inhibition. These results remained after controlling for demographic factors such as age, gender, education, and illicit drug use.

Conclusions—These findings support and extend prior work documenting the deleterious effects of heavy alcohol consumption on ECF in a community sample and specifically indicate robust effects on cognitive flexibility, psychomotor speed, and response inhibition.

Keywords

Executive Functioning; Alcohol; Inhibition; Heavy Drinking

1.1 Introduction

Executive cognitive functioning (ECF) is a complex construct involving several neurocognitive domains such as response inhibition, cognitive flexibility, and working

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memory (Anderson et al., 2008). Individuals with alcohol use disorders (AUDs) demonstrate ECF impairments (see Uekermann & Daum, 2007 for review) as well as damage to the frontal brain (Oscar-Berman & Marinkovic, 2007; Sullivan et al., 2010). Most studies of ECF and AUD have focused on alcohol patient/treatment samples for which impairments are pronounced and related to the history of alcohol consumption (Du et al., 2002). Accordingly, the value of gaining a better understanding of neurocognitive deficits with regard to AUD treatment implementation (Blume et al., 2009), prognosis (Schrimsher & Parker, 2008) and non-treatment factors such as quality of life and interpersonal relationships (Sherman et al., 2006; Vohs et al., 2009) has been repeatedly demonstrated.

Evidence suggests that subclinical levels of heavy/binge drinking also result in ECF deficits that have a significant impact on daily life. Alcohol consumption/problems can result in ECF impairment in planning, working memory, and cognitive flexibility (Blume et al., 2000; Giancola et al., 1996; Sher et al., 1997). Studies comparing binge/heavy drinkers to light drinkers or abstainers report similar effects (Hartley et al., 2004; Meyerhoff et al., 2004). These findings provide evidence of alcohol-related ECF deficits in actively drinking, non-clinical samples, but are primarily limited to college students whose drinking patterns may be atypical compared to later adulthood. Given the potential for recovery of functioning (De Sousa Uva et al., 2010; Mann et al 1999) when heavy drinking stops (e.g., after college; Schulenberg et al., 1996; Tucker et al., 2003), it would be informative to examine the effects of binge drinking in an older, non-clinical sample.

The current study was designed to examine ECF in relation to alcohol consumption in a community sample of adults. We hypothesized that heavy drinkers would exhibit greater ECF deficits than those consuming less alcohol. We also explored whether demographic factors such as gender, age, education, and recent illicit drug use might affect the ECF-drinking relation. For example, given evidence suggesting women are more vulnerable to alcohol’s neurotoxic effects (Hashimoto & Wiren, 2008; Mann et al., 2005), we examined whether women exhibit greater ECF impairment than men at the same average daily alcohol volume.

2.1 Material and Methods

2.1.1 Participants

A community sample of couples, 280 men (M age = 36.9 years, *SD* = 5.8) and 280 women (M age = 35.4 years, *SD* = 5.9), was recruited via mailed survey (21,000 surveys mailed; 26% response rate; see Testa et al, 2012 for detail). The majority were White (91% each), fairly well-educated (58% of men and 67 % of women completed college), and employed at least part-time (91% of men and 80% of women). Participants were demographically similar to the current population of couples in the county who are either married or living together as married (U.S. Census Bureau, 2011). Couples were excluded if either partner reported a current medical condition or past head injury that might influence ECF. Eligible couples attended a session that included ECF tasks, questionnaires assessing alcohol and drug use, relationship functioning, partner aggression, and a marital conflict interview. Because the larger study examined varying patterns of drinking in couples, we oversampled for couples in which one or both of the members were heavy drinkers (HD) resulting in recruitment of

159 HD men, 120 HD women, 121 control men and 160 control women. HD was defined as consuming 5 or more drinks at one time (4 drinks for women) or becoming intoxicated at least weekly. Given the oversampling approach, all analyses were conducted using sampling weights, in essence providing a more precise estimate of the effects of HD. All participants provided informed consent and the study protocol was approved by the affiliated Institutional Review Board.

2.1.2 Procedures

Participants completed the following measures:

Alcohol Use—Beverage-specific questions on frequency of consumption in the past year and quantity of alcohol consumed in a typical drinking event (Cahalan et al, 1969) were used to compute a measure of average daily alcohol consumption (drinks/day).

Drug Use in the Past Year—Because illicit drug use has been shown to affect ECF (Fernández-Serrano et al., 2010), participants were asked to rate drug use in the past year (Not at all, Once, A few times, About once a month, 1–2 times a month, or Once a week or more) for six non-prescription drug categories (sedatives, stimulants, hallucinogens, marijuana, cocaine, heroin/methadone). One-hundred twenty-three participants (48 women) reported using illicit drugs in the past year.

Dysexecutive Functioning Questionnaire (DEX; Wilson et al., 1996)—Respondents rated how often they observe 20 executive problems on a Likert scale resulting in a total score. Higher scores reflect greater ECF impairment.

Stroop Color-Word Task (Stroop, 1935)—Participants read words (Word) or named the ink color (Color, Color-Word) for as many stimuli as they could in 45 seconds. A Color-Word interference score was calculated according to Golden and Freshwater (2002). Lower scores indicate poorer attentional control.

WAIS-III Digit Span (The Psychological Corporation, 1999)—A sequence of digits (one per second) was read to the participant. For the Backward condition (working memory), the participant was asked to repeat the sequence in the reverse order. The number of digits increased with successful trials. Number of successful trials was summed for total scores. The Backward score was subjected to a square root transformation.

Trail Making Test (Reitan, 1958)—The TMT is a measure of cognitive flexibility, visual attention and motor speed (Lezak et al., 2004). In TMT-A, the participant must draw a line connecting a series of numbers in sequential order. TMT-B requires the participant to draw a line connecting a series of letters and numbers alternating between sequential and alphabetical order. Completion time scores were subjected to logarithmic transformations.

Wisconsin Card Sorting Test—The WCST (Heaton et al., 1993) is a measure of cognitive flexibility and perseverative responding in which the participant is presented with one card printed with 1 of 4 symbols in one of four colors. The participant was asked to match each card to one of the four stimulus cards according to a principle that s/he must

deduce from the pattern of the examiner's response to each placement. Scores derived include perseverative errors (inverse transformation), non-perseverative errors (logarithmic transformation), conceptual level of response (square root transformation), number of categories completed (inverse transformation), and failure to maintain set (inverse transformation).

GoStop Task (Dougherty et al., 2005)—Number stimuli were displayed on a computer screen for 500 ms. Half of the stimuli were target trials (matching stimuli requiring a response) and half were filler trials (non-matching stimuli). Half of the target trials were “stop” trials in which participants were signaled to withhold a response 50 to 350 ms after the stimulus appears. The GoStop Ratio, calculated as the number of response inhibition failures (i.e., responses to *stop* trials) relative to the number of responses to *go* trials was the primary dependent variable. Ratios for 150 and 250 ms stop trials provide the best group discrimination (e.g., Marsh et al., 2002). Number of commission errors (responses to fillers) was also recorded as a measure of impulsive responding.

3.1 Results

3.1.1 Preliminary Analyses

Due to the disproportionate sampling method, all analyses were conducted using sample weights. Men (M = 1.24, SD = 1.71) consumed significantly more alcohol than women (M = 0.47, SD = 0.87), $t(544) = 6.66$, $p < .001$). Alcohol consumption was positively correlated with age, $r(546) = .10$, $p = .025$, and negatively correlated with education, $r(546) = -.16$, $p < .001$. Those who used non-prescription drugs (M = 2.08, SD = 2.10) consumed more alcohol than those who did not (M = 0.69, SD = 1.20), $t(544) = -7.84$, $p < .001$. Table 1 depicts descriptive statistics and intercorrelations of ECF measures. Variables from different tasks were very weakly correlated within couples (rs <.14), and were not strongly correlated with each other (rs < .30), thus we examined each ECF measure separately in the following analyses.

3.1.2 Alcohol Consumption and Executive Cognitive Functioning

To examine the association between average daily alcohol consumption and ECF, we conducted a series of simultaneous regression analyses. The demographic covariates (dummy-coded main effects of gender and non-prescription drug use and the centered main effects of age and education) were entered with the centered main effect of alcohol use (average drinks/day). Even after controlling for demographic covariates, greater alcohol use was associated with significantly poorer ECF on the DEX, TMT, Go/Stop and WCST errors (Table 2).

3.1.3 Moderation

We examined each demographic covariate as a possible moderator of the influence of alcohol use on ECF because each of these variables has been shown to influence ECF. Specifically, we entered the two-way Alcohol Use X Demographic Covariate interactions into the third block of our regression analyses. No consistent interactions emerged to indicate demographic moderation.[1]

4.1 Discussion

This study examined ECF in a community sample of men and women with minimal recent drug use. Heavier drinking was associated with poorer performance in multiple ECF domains. Individuals with greater levels of alcohol consumption exhibited impairment in cognitive flexibility, psychomotor speed, perseverative responding, and response inhibition while controlling for demographic factors. Overall, these findings are consistent with prior literature on the association between alcohol consumption and ECF and extend these findings to a community sample of adults.

These results offer interesting points of interpretation regarding the effects of HD. Participants who consumed more alcohol, on average, performed poorly on both TMT-A and TMT-B. The TMT-B is a widely used measure of cognitive flexibility and our finding is consistent with prior studies. In contrast, the TMT-A is not often used as a measure of ECF. The effect of HD on TMT-A performance may be attributable to psychomotor slowing. Psychomotor speed is important in many neuropsychological tasks as well as both portions of the TMT and recent research has demonstrated that moderate drinking is associated with slowed psychomotor speed in a battery of non-ECF tests (Green, et al. 2010). However, it is important to note that other ECF findings in the current study, such as perseverative responding, did not include a speeded component.

Although previous research had suggested that the relation between alcohol and ECF might be moderated by other variables, the results of the present study generally support a consistent pattern across age, gender, education, and non-prescription drug use. Neuropsychological evidence for differential gender effects of chronic drinking on cognitive performance has historically been mixed, particularly with regard to ECF. It is unclear, however, which factors may contribute to past inconsistent findings. It has been suggested that such effects, when observed, may be related to gender differences in AUD severity such that women may exhibit neurocognitive impairments at lower levels of alcoholism severity as compared to men (Nolen-Hoeksema, 2004; Sullivan & Pfefferbaum, 2005). However, these studies were often limited to AUD patient samples. As noted, the sample in this study is unique in that it is a community sample and women comprised half of the sample. The mean age (mid-30's) for this sample is also slightly younger than most studies of ECF in alcohol dependent patients possibly indicating less lifetime alcohol consumption and therefore, less severe cognitive consequences. It is possible that in the current study these factors, along with the gender adjusted recruitment for heavy drinkers (5+ drinks for men; 4+ drinks for women), may have contributed to the null effects of gender and age. In order to comprehensively assess these effects, future work should employ a longitudinal design to determine the extent of alcohol consumption and problem drinking severity on ECF over time. However, the sample does represent individuals who have moved beyond the variable drinking pattern that often characterizes emerging adulthood, particularly for college students. Thus, the drinking pattern is likely more stable and adds to our understanding of the effects of HD beyond emerging adulthood, which has been the focus of most studies on

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[1]Moderation analyses resulted in two significant interactions out of a total possible 56 effects. Education and drug use each moderated the effect of alcohol on only one (different) variable. Details are available from the first author upon request.

binge drinking. The participants in this sample were not restricted from drinking, which is not the case for most studies using AUD patient samples. Thus participants were unlikely to be suffering withdrawal symptoms, which can have adverse effects on cognition.

In terms of limitations, our analyses did not specifically examine other factors that have been associated with ECF deficits such as family history of alcoholism, prescription drug use (e.g., opiates) or duration of substance use. We also used a fairly brief battery of ECF tests. Because ECF encompasses a broad domain of cognitive functions, future research on heavy drinking should include a more comprehensive test battery to better delineate specific aspects of ECF that are influenced by a pattern of heavy alcohol consumption. Despite these limitations, the current study supports prior research demonstrating ECF deficits related to alcohol consumption and extends these findings to a community sample of HD adult men and women.

As noted, compromised ECF, presumably as a result of HD, can influence course of treatment and quality of life (Blume et al., 2005, 2009; Schrimser & Parker, 2008, Sherman et al., 2006). Future neuropsychological work in this area should continue to better quantify effects of specific levels of drinking in relatively high functioning individuals (i.e., community samples) as well as apply more specificity in ECF assessment. This, coupled with neuroimaging techniques, should allow for a better understanding of the specific brain regions and functions that are most affected by HD, and thus may influence the development of intervention and treatment approaches. Other potential influences should also be taken into account including family history, licit and illicit drug use, and duration of use.

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Highlights

- Men and women with higher levels of alcohol consumption exhibited greater impairment on several ECF measures, primarily those pertaining to cognitive flexibility, psychomotor speed, and response inhibition.
- These results remained after controlling for demographic factors such as age, gender, education, and illicit drug use.
- These findings in a community sample of adults extend evidence of ECF impairments associated with heavy/binge drinking beyond college age samples.

Table 1

Descriptive statistics for and bivariate correlations between the executive cognitive functioning measures.

	M (SD)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Dysexecutive Functioning Questionnaire														
1. DEX Total Score	35.67 (9.39)													
Stroop Color-Word Test														
2. Interference Score	1.16 (9.55)	.06												
WAIS-III Digit Span														
3. Digits Forward Total	10.95 (2.33)	−.02	$.21^{***}$											
4. Digits Backward Total	7.58 (2.45)	$−.09^{*}$	$.15^{***}$	$.44^{***}$										
Trail Making Test														
5. Version A (seconds)	21.81 (5.78)	.04	$−.29^{***}$	$−.10^{*}$	−.05									
6. Version B (seconds)	51.23 (16.99)	−.02	$−.22^{***}$	$−.27^{***}$	$−.22^{***}$	$.48^{***}$								
GoStop Task														
7. 150 ms Stop Ratio	0.55 (0.20)	.02	−.02	−.01	$−.10^{*}$	−.04	.01							
8. 250 ms Stop Ratio	0.49 (0.21)	.00	−.06	.01	−.04	.02	−.02	$.67^{***}$						
9. Total Commission Errors	1.09 (1.56)	$.11^{**}$	$−.11^{**}$	$−.07^{+}$	$−.12^{**}$	$.08^{+}$	$.13^{**}$	$.44^{***}$	$.50^{***}$					
Wiscons in Card Sorting Test														
10. Perseverative Errors	9.34 (7.43)	−.05	−.01	$−.09^{*}$	$−.17^{***}$	$.11^{**}$	$.18^{***}$	.06	$.08^{+}$	$.12^{**}$				
11. Non-Perseverative Errors	8.51 (6.77)	.02	−.04	−.05	$−.14^{***}$	.06	$.18^{***}$	.03	.04	$.09^{*}$	$.80^{***}$			
12. Trials to Complete First Category	15.29 (10.08)	.02	−.03	−.03	$−.08^{+}$	.07	$.14^{***}$	−.02	.04	.03	$.56^{***}$	$.61^{***}$		
13. Failure to Maintain Set	0.51 (0.76)	−.01	−.02	$−.09^{+}$	−.04	.04	.06	−.03	.01	−.01	$.40^{***}$	$.41^{***}$	$.40^{***}$	
14. WCST: Learning to Learn	0.40 (3.03)	$−.10^{*}$	−.05	$.08^{+}$	.04	$.09^{*}$	.06	.02	.06	.06	$−.21^{***}$	$−.15^{***}$	$.44^{***}$	−.03

Note. M = mean; SD = standard deviation.

$^{+}p < .10$,

$^{*}p < .05$,

** $p < .01$,

*** $p < .001$

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Table 2

Results of the regression analyses examining the association between average daily alcohol consumption and executive cognitive functioning.

	Average Daily Alcohol Use				
				95% CI	
	b	***t***	***df***	***Low***	***High***
Dysexecutive Functioning	0.60	1.97**	540	0.002	1.19
Stroop Interference	0.18	0.56	521	−0.45	0.82
Digit Span					
Forward	0.03	0.44	537	−0.12	0.19
Backward	−0.01	−0.17	537	−0.17	0.15
Trail Making Test					
Version A (seconds)	0.79	4.16***	537	0.42	1.16
Version B (seconds)	1.80	3.32***	536	0.73	2.87
Go/Stop Task					
150ms Ratio	0.02	2.61**	537	0.004	0.03
250ms Ratio	0.01	1.83+	537	−0.001	0.03
Commission Errors	0.11	2.08**	541	0.006	0.21
Wisconsin Card Sorting Task					
Perseverative Errors	0.38	1.61+	530	−0.08	0.84
Non-Perseverative Errors	0.79	3.66***	530	0.37	1.22
Trials to Complete First Category	0.14	0.43	530	−0.51	0.79
Failure to Maintain Set	−0.02	−0.88	530	−0.07	0.03
Learning to Learn	−0.08	−0.76	507	−0.29	0.13

Note. Results are from simultaneous regression analyses, controlling for demographic covariates, run using sampling weights. Dependent variables are located in the left column. *b* = unstandardized regression coefficient; *t* = *t*-score; *df* = degrees of freedom; 95% CI = 95% confidence interval for the unstandardized regression coefficient.

+ $p < .10$,

* $p < .05$,

** $p < .01$,

*** $p < .001$