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Does Self-Reported or Behavioral Impulsivity Predict Subjective Response to Low-Dose Alcohol?

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Abstract

Aims: Subjective response to alcohol and impulsivity are both independent predictors of alcohol use and may be related risk factors for alcohol use disorders (AUDs). Recent findings suggest that more impulsive individuals may experience higher risk subjective response patterns at moderate-to-high doses of alcohol. However, whether these relationships are observable early in a drinking occasion remains an open question. This study examined multiple measures of impulsivity in relation to subjective response following low-dose alcohol.

Method: Eighty-seven non-treatment-seeking heavy drinkers were enrolled in a placebo-controlled alcohol administration study testing the effects of NMDA receptor antagonist, Memantine. Baseline impulsivity assessments included the Cued Go/No-Go Task, Experiential Discounting Task, and Barratt Impulsiveness Scale, Version 11 (BIS-11). Following consumption of low-dose alcohol aimed to increase blood alcohol concentration (BAC) to 0.03%, subjective stimulation and sedation were measured using the Biphasic Alcohol Effects Scale. Models were tested to relate impulsivity measures to subjective response with a *post hoc* exploratory model exploring boredom as an alternate predictor.

Results: Increases in stimulation and sedation were observed following low-dose alcohol, but were not predicted significantly by impulsivity measures. Although greater impulsivity on the BIS-11 was a trend-level predictor of increased sedation, *post hoc* analyses suggested these results were an artifact of boredom.

Conclusion: Although impulsivity did not predict subjective response to low-dose alcohol, the results suggest that small amounts of alcohol can produce a range of subjective effects, even among heavy drinkers. Future studies would benefit by examining subjective response across a range of BACs among both light and heavy drinkers.

INTRODUCTION

Heavy drinking is a public health problem with a considerable societal impact, costing the U.S. \$249 billion in 2010 (Sacks *et al.*, 2015). Further, the National Epidemiologic Survey on Alcohol and

Related Conditions (NESARC-III) reported past-year and lifetime rates of alcohol use disorder (AUD) are 13.9% and 29.1%, respectively (Grant *et al.*, 2015). Thus, to inform future interventions aimed at reducing heavy drinking and minimizing alcohol-related

problems, it is vital to continue to examine correlates and predictors of AUD.

Impulsivity is a well-established risk factor for AUD, which broadly refers to a tendency toward immediate action with diminished regard for future consequences (Moeller *et al.*, 2001; Brewer and Potenza, 2008). Moreover, impulsivity is a heterogeneous construct encompassing several unique aspects of cognition and behavior, some assessed by paper and pencil measures and others with computer-based tasks (Caswell *et al.*, 2015). Previously, impulsivity has been linked to alcohol-related problems (Lejuez *et al.*, 2010) and heavy drinking in animal and human models (Sanchez-Roige *et al.*, 2014). Impulsivity also shares common genetic links with AUD (Slutske *et al.*, 2002). Further, while impulsivity increases alcohol consumption, repetitive alcohol consumption can also increase impulsive behavior (Dick *et al.*, 2010).

Similarly, subjective response to alcohol (SR) has been identified as a risk factor for AUD (e.g. Newlin and Thomson, 1990; Schuckit, 1994; King *et al.*, 2002), which reflects differential sensitivity to pharmacologic alcohol effects (Morean and Corbin, 2010). Several studies have found that heightened sensitivity to hedonic, stimulant effects and dampened sensitivity to impairing, sedative effects are related to AUD risk (Newlin and Thomson, 1990; King *et al.*, 2011; 2014; 2016). Conversely, other studies have found that an attenuated response to primarily negative, sedating subjective effects are indicative of AUD risk (Schuckit, 1994).

Previous studies have identified heavy drinking and a family history of alcohol problems as factors associated with high-risk SR patterns (see Morean and Corbin, 2010, for a review). For instance, one recent study found that participants with a positive family history experienced greater stimulation during intravenous alcohol administration and administered more alcohol at a subsequent session relative to those without a family history (Hendershot *et al.*, 2016). Heavy drinking is also related to specific higher risk SR patterns (Quinn and Fromme, 2011). Greater sensitization to the positive, stimulating effects of alcohol has been supported empirically as a determinant of AUD risk (King *et al.*, 2011, 2014, 2016).

While studies relating impulsivity to AUD risk are extensive (see Lejuez *et al.*, 2010, for a review), less is known regarding mechanisms underlying these relationships (Dalley *et al.*, 2011). Although SR and impulsivity have been established independently as risk factors for AUD, these constructs have been infrequently studied as common links to AUD. Impulsivity may be linked to higher risk SR patterns. Conversely, higher risk SR patterns may help elucidate why impulsivity predicts AUD. More impulsive people focus on reward inordinately and discount or neglect indicators of punishment (Patterson and Newman, 1993). It is necessary to know if this tendency also applies to alcohol consumption, specifically. The presence of both impulsivity and high-risk SR could make drinkers especially susceptible to adverse outcomes. In this circumstance, SR would be a proximal factor linking impulsivity to risk of AUD and possibly a more appropriate target for intervention than impulsivity directly. These issues are clinically relevant because intervention is particularly challenging for more impulsive individuals (Helstrom *et al.*, 2007).

Previous studies linking impulsivity to SR yielded equivocal results (e.g. Shannon *et al.*, 2011), however recent results suggest that more impulsive individuals experience heightened stimulation and/or dampened sedation from alcohol (Leeman *et al.*, 2014; Bery *et al.*, 2017; Westman *et al.*, 2017). However, because all prior studies utilized alcohol administration to higher blood alcohol concentrations (BACs), it is unclear to what extent relationships between impulsivity and subjective responses manifest early in a drinking

session or whether heavier alcohol consumption is required. Interestingly, a study examining SR among individuals with alcohol dependence found that low doses of alcohol (0.02 g/kg) produced notable subjective effects, specifically stimulation, which led to greater subsequent within-session alcohol administration (Boyd *et al.*, 2016). While Boyd *et al.* (2016) did not consider impulsivity in their analyses, their results suggest that greater sensitivity to hedonic alcohol effects following low-dose alcohol relates to heavier subsequent alcohol consumption, which is a risk factor for problem drinking. Accordingly, SR to initial alcohol use may contribute to sustained heavy drinking (Quinn and Fromme, 2011).

Prior studies have consistently found that moderate doses of alcohol (i.e. ≥ 0.4 g/kg) targeting peak BACs between 0.045% and 0.065% impair inhibitory control (Fillmore *et al.*, 2008), increase subsequent alcohol consumption (Weafer and Fillmore, 2008) and increase craving and specific subjective effects (e.g. relaxation; Fernie *et al.*, 2012). In contrast, a limited number of studies have evaluated the effects of low-to-moderate doses of alcohol on SR, although results do suggest that small and moderate amounts of alcohol can produce measurable subjective, and primarily positive, effects (e.g. Rose and Grunsell, 2008; Fernie *et al.*, 2012; Boyd *et al.*, 2016). If initial alcohol consumption increases hedonic subjective effects, then these effects may relate to other risk factors related to problem drinking, including subsequent drinking and impulsivity (Rose and Duka, 2007). Thus, determining whether more impulsive individuals experience higher risk SR patterns early within a drinking session may offer valuable insight regarding the relation between impulsivity and alcohol use, including inherent AUD risk.

This study aimed to replicate and extend prior findings assessing relationships between impulsivity and SR using behavioral and self-report data in a sample following the consumption of low-dose alcohol (Krishnan-Sarin *et al.*, 2015). With one known exception (Shannon *et al.*, 2011), studies tend not to relate both objective and self-report measures of impulsivity to SR. Thus, we aim to address a gap in the literature by examining multiple facets of impulsivity in relation to SR and whether more impulsive individuals experienced heightened stimulation and dampened sedation early after the initiation of drinking, at lower BACs. We hypothesized that more impulsive individuals would report heightened stimulation and dampened sedation following low-dose alcohol. Though Westman *et al.* (2017) found the hypothesized relationship between a measure of impulsivity and elevated stimulation, in contrast to prediction, they found a positive relationship between impulsivity and sedation in both alcohol and placebo conditions. Given that elevated sedation was reported in both conditions, it is likely that more impulsive participants' attributions of sedation related to a factor other than alcohol's pharmacologic effects. Considering the prior literature among impulsive individuals, these participants may have misattributed boredom as sedation. High levels of boredom are common in impulsive individuals (Watt and Vodanovich, 1992) and prior investigators have reasoned that boredom may have influenced ratings of subjective response to alcohol (Davidson *et al.*, 1997). Thus, on an exploratory, *post hoc* basis, we explored boredom as a possible alternate predictor of sedative response.

METHOD

Participants

Data for this study were from a human laboratory study examining effects of the NMDA receptor antagonist, memantine on alcohol

self-administration and craving in non-treatment seeking heavy drinkers. Eligible participants must have reported drinking alcohol at least 4 days per week, 25–70 drinks/week for men and 20–65 drinks for women. These inclusion criteria increased the likelihood of variability in alcohol self-administration while excluding individuals whose drinking has reached a level of severity indicating they should be in immediate treatment. At the intake appointment, participants completed self-reports (including impulsivity) and were classified as Family History Positive or Negative based on criteria defined by the Family History Assessment Module (Rice *et al.*, 1995). Participants ($n = 111$) were randomly assigned between-subjects to one of three medication conditions (placebo [$n = 34$], 20 [$n = 37$], or 40 [$n = 40$] mg/day) and received study medication daily, for seven days. Participants were admitted to the Yale-New Haven Hospital Research Unit on Day 7. Behavioral task measures were administered prior to consuming alcohol. The present study focuses on responses to low-dose alcohol, which aimed to increase participants' blood alcohol concentration (BAC) to 0.03% (for a full review of participants and study procedures, see Krishnan-Sarin *et al.*, 2015). The number of drinks consumed between participants during the self-administration period varied considerably, thus, we utilized only the initial low-dose of alcohol, as all participants consumed this beverage. Further, results linking self-reported impulsivity to alcohol self-administration were reported in Krishnan-Sarin *et al.* (2015). In total, 87 participants (placebo [$n = 29$], 20 [$n = 31$] and 40 [$n = 27$] mg/day) provided data for the final analyses due to missing data on at least one of the measures utilized in these analyses. The Yale School of Medicine Human Investigation Committee approved all procedures and informed consent was obtained.

Measures completed during intake

Demographic variables included sex and family history status of alcohol problems.

Family history status

This structured diagnostic instrument assesses several psychiatric disorders among a participant's relatives and consists of a screener, self-report battery, and an individual assessment module (Rice *et al.*, 1995). Specifically, participants are asked 'have any of your relatives ever had any family, job, school, police, or health problems because of drinking?' This question is asked for each first-degree relative. Participants with two or more first-degree relatives with an AUD diagnosis were classified as having a positive family history.

Alcohol consumption

A questionnaire developed by the National Institute on Alcohol Abuse and Alcoholism assessed participants' frequency and quantity of alcohol use in their lifetime and in the past 12-months (e.g. During the last 12 months, how many alcoholic drinks did you have on a typical day when you drank alcohol) (NIAAA, 2004). This study utilized the drinks per drinking day in the past year item. This question uses 10 response options with anchors at '1 drink' and '25 or more drinks'.

Self-reported impulsivity (Barratt Impulsiveness Scale; BIS-11)

Self-reported impulsivity was assessed using the 30-item Barratt Impulsiveness Scale, Version 11 (BIS-11; Patton *et al.*, 1995). Participants rate items on a four-point scale ranging from *rarely/never* to *almost always/always* such as 'I act on impulse' and 'I do

things without thinking'. Higher scores indicate more impulsive behavior. The total score was utilized, as research has called into question the psychometric properties of the BIS-11 subscales (Morean *et al.*, 2014). This measure evinced good reliability ($\alpha = 0.81$).

Measures completed at the alcohol drinking session

Choice impulsivity (experiential discounting task; EDT)

This computerized discounting task exposes participants to choice consequences during test administration and involves multiple latencies (i.e. 0, 15, 30, 60 seconds) (Reynolds *et al.*, 2006). Participants choose between an immediately delivered smaller sooner amount or an uncertain larger later amount. Results from the 0 second delay were utilized as a baseline measure that was subtracted from the other three latencies (i.e. 15, 30, 60 seconds), which were converted to area under the curve (AUC) values, then summed to create a total score. Higher scores on this task indicate greater discounting (i.e. more impulsive behavior) and this measure evinced good reliability across the three AUC values on Day 0 ($\alpha = 0.80$) and Day 7 ($\alpha = 0.79$).

Response impulsivity (cued go/no go task; GNG)

This computerized task measures inhibitory control as the ability to inhibit instigated, 'prepotent' responses (Marczinski and Fillmore, 2003). This task manipulates response prepotency by presenting a preliminary go or no-go cue before the actual target. However, the preliminary cue correctly signals the actual target only 80% of the time. Participants must either press, or refrain from pressing, a key depending on the color of the target shape. Inhibition errors (i.e. pressing a 'go' key when the 'no go' stimuli is presented) were the main variable of interest and the total number of inhibition errors were examined. More inhibition errors equate to more impulsive behavior, and this measure evinced good reliability between Day 0 and Day 7 iterations ($r = 0.728$, $P < 0.01$).

Subjective response to alcohol (BAES)

Subjective response to alcohol was measured using the 14-item Biphasic Alcohol Effects Scale (Martin *et al.*, 1993). This self-report, unipolar adjective rating scale asks individuals to rate current feelings of stimulating (e.g. talkative) and sedating (e.g. sluggish) effects of alcohol. Each subscale (stimulation & sedation) contains 7 items. Summed scores for stimulation and sedation were examined. The BAES was administered at 20 minutes following low-dose alcohol and each subscale evinced excellent reliability (stimulation subscale; $\alpha = 0.86$, sedation subscale; $\alpha = 0.95$).

Mood state

Mood state was measured using the brief Profile of Mood States (POMS; Shahid *et al.*, 2012) and administered 20 minutes following low-dose alcohol. This 30-item adjective checklist is rated on a 5-point scale from 'not at all' to 'extremely'. This measure contains six factors (i.e. Tension-Anxiety, Depression-Dejection, Anger-Hostility, Fatigue-Inertia, Vigor-Activity, and Confusion-Bewilderment). Five items (i.e. *worn out*, *fatigued*, *exhausted*, *sluggish*, and *weary*) were utilized to create a sum score of the Fatigue-Inertia factor, which evinced good reliability ($\alpha = 0.93$).

Data analytic plan

All continuous variables were examined for normality and transformed (e.g. logarithmic) when necessary to reduce skew. Continuous predictor variables were centered. Bivariate correlations were examined for possible multicollinearity in the regression models. Because participants were randomized to receive study medication in three doses (i.e. placebo, 20, 40 mg/day), the study condition variable was dummy coded with placebo as the reference value. Multiple linear regression models were tested using SPSS version 23.0 for Windows (SPSS Inc, 2013). Initially, two sets of models were tested to predict SR (BAES stimulation and Sedation) at 20 minutes following beverage consumption. A third model was tested *post hoc* to predict self-reported sedation that also included boredom (POMS Fatigue-Inertia subscale) as an independent variable. Accordingly, the POMS fatigue scale was utilized as specific items in this subscale (e.g. *weary*) relate closely to boredom. It was hypothesized, *post hoc*, that boredom would be significantly related to self-reported sedation.

The first set of models aimed to predict stimulation and sedation using hierarchical entry of six variable groupings (study condition, demographics, Intake [BIS-11] and Day 7 [EDT; GNG] impulsivity variables, drinks per drinking day, interactions between study condition and each impulsivity measure and interactions between drinks per drinking day and each measure of impulsivity). Because almost 80% of the current sample consumed alcohol at least five times per week, drinks per drinking day was included in regression models to represent baseline drinking. No interactions between study variables were statistically significant, thus they were not included in the final versions of the models reported here but are available upon request from the authors. To account for a potential influence of memantine on behavioral impulsivity, models utilizing Day 0 scores for the EDT and GNG instead of Day 7 scores were tested but did not differ from models using Day 7 scores, thus the Day 0 administrations were not included in the final versions of the models reported here. Results of these alternate models are available upon request from the authors. To address further potential memantine effects on impulsivity, we tested, *post hoc*, models predicting stimulation and sedation among participants in the placebo condition only using hierarchical entry of five variable groupings (demographics,

forementioned impulsivity variables, drinks per drinking day, interactions between impulsivity measures and drinks per drinking day).

A second set of models to predict stimulation and sedation consisted of only study condition, demographics, BIS-11 total score, drinks per drinking day, and interaction terms between the BIS-11 total score and study condition and between BIS-11 total score and drinks per drinking day. Because the BIS-11 has been previously shown to be a predictor of SR, it was the only impulsivity measure utilized in the second set of models (Leeman *et al.*, 2014; Berey *et al.*, 2017).

A third *post hoc* model aimed to predict sedation statistically using hierarchical entry of four variable groupings (study condition, demographics, BIS-11 total score, and POMS Fatigue-Inertia subscale). Given prior work linking fatigue to boredom (Desmond and Hancock, 2001), items in the POMS Fatigue-Inertia subscale correspond closely to boredom and are face-valid indicators of boredom, which we hypothesized *post hoc* to be positively related to sedation beyond effects of generalized impulsivity. The drinks per drinking day variable and interaction terms were omitted from this model due to null results in aforementioned models.

RESULTS

Sample characteristics

Descriptive data ($N = 87$) are reported in Table 1. The sample was largely male and reported drinking on average 5–6 drinks per drinking occasion. Almost two thirds reported a negative family history of alcohol problems. Mean self-report scores on the BIS-11 approximated normative adult scores (Stanford *et al.*, 2009). Further, participants reported experiencing a considerable range of stimulation and sedation 20 minutes post beverage administration.

To normalize skewed data, the drinks per drinking day variable was log-10 transformed, which brought skew to an acceptable level. Several participants were missing data on at least one of three latency variables for the EDT. In these cases, a new third latency variable was created by averaging the two available latency scores. This third latency variable was then added to the two available

Table 1. Demographic, alcohol, impulsivity and subjective response characteristics

$N = 87$	M	SD	Range	%
Study group (Memantine 20 or 40 mg/day)				69.4
Race (Caucasian)				68.5
Gender (Female)				29.1
Family history status (positive)				33.7
Age (years)	30.56	8.44	21–50	
Past-year drinks per drinking day (1–10) ^a	4.23	1.15	2–9	
Barratt Impulsiveness Scale 11 (BIS-11): Total Score ^b	68.13	10.7	42–89	
Cued go/no go task (GNG): inhibitory errors ^c	14.05	7.47	2–37	
Experiential Discounting Task (EDT): Total Score ^c	0.61	0.21	0.01–0.83	
BAES sedation ^d	11.68	15.4	0–54	
BAES stimulation ^e	10.93	10.44	0–34	
POMS fatigue ^f	2.64	2.80	0–12	

^aDrinks per drinking day M score equivalent to 5–6 drinks, full possible range is 1–10.

^bFull possible range of BIS-11 is 30–120.

^cDescriptives for GNG & EDT are based on $N = 71$.

^dFull possible range of BAES Sedation subscale is 0–70; measured at 20-minutes post beverage administration.

^eFull possible range of BAES Stimulation Subscale is 0–70; measured at 20-minutes post beverage administration.

^fFull possible range of POMS Fatigue Subscale is 0–20; Descriptives for POMS fatigue are based on $N = 81$.

Table 2. Bivariate correlations among study condition, demographics, impulsivity and subjective response measures

	1	2	3	4	5	6	7	8	9	10	11
1. Study condition (20 mg/day memantine)											
2. Study condition (40/mg day memantine)											
3. Sex	0.000	0.001									
4. FHP ^a	−0.013	0.041	−0.161								
5. BIS-11 ^b	−0.112	−0.011	−0.039	0.121							
6. Cued Go No/Go	−0.155	0.141	0.159	−0.063	−0.033						
7. EDT ^c	−0.117	0.079	0.225*	−0.126	0.240*	0.046					
8. Drinks per drinking day	−0.011	−0.03	0.121	0.078	0.161	−0.063	0.019				
9. BAES sedating ^d	−0.017	0.128	0.044	−0.089	0.194	0.045	0.111	0.014			
10. BAES stimulating ^e	0.01	−0.17	0.224*	0.093	0.009	−0.038	−0.005	0.038	0.260*		
11. POMS Fatigue ^f	−0.06	0.038	−0.012	−0.127	0.322**	−0.032	0.159	0.021	0.71**	0.15	

* $P < 0.05$; ** $P < 0.01$.

^aFHP = Positive Family History of Alcohol Problems.

^bBIS-11 = Barratt Impulsiveness Scale, Version 11.

^cEDT = Experiential Discounting Task.

^dBAES Sedating = Biphasic Alcohol Effects Scale Sedation Subscale at 20 minutes post beverage administration.

^eBAES Stimulating = Biphasic Alcohol Effects Scale Stimulation Subscale at 20 minutes post beverage administration.

^fPOMS Fatigue = Profile of Mood States Fatigue Subscale at 20 minutes post beverage administration.

latency scores to create a new EDT sum score. Table 2 provides bivariate correlations among study variables.

Multiple regression models with measures of impulsivity predicting subjective response

When behavioral and self-report measures of impulsivity were included in the model, none were statistically significant predictors of stimulation or sedation. There was no main effect of study condition on either stimulation or sedation. Moreover, interactions between impulsivity measures and study condition and between impulsivity measures and drinks per drinking day contained no statistically significant results. Male sex ($P = 0.083$) was a trend-level predictor of increased stimulation following low-dose alcohol (Table 3).

Although underpowered ($n = 24$), when behavioral and self-report measures of impulsivity were included in the model among participants in the placebo condition only, there was a statistically significant interaction between BIS-11 and drinks per drinking day, such that more impulsive individuals who consumed more drinks per drinking day experienced heightened sedation following low-dose alcohol ($P = 0.04$) (Supplementary Table 1).

Multiple regression models with BIS-11 predicting subjective response

When BIS-11 was the only impulsivity measure included in the model, it was still not a statistically significant predictor of stimulation; however, counter to original hypotheses, higher BIS-11 scores were a trend-level predictor of heightened sedation ($P = 0.065$). There was no main effect of study condition on stimulation or sedation. The interaction between BIS-11 and study condition did not yield significant results. Male sex ($P = 0.03$) predicted heightened stimulation, but not sedation, following low-dose alcohol (Table 4).

Exploratory hierarchical regression model with BIS-11 and boredom predicting sedative response

This model was tested on a *post hoc* basis as results regarding BIS-11 and sedative response ran counter to original hypotheses. Thus,

we hypothesized *post hoc* that findings may have been due to participants experiencing greater boredom rather than sedative response due to alcohol. Further, BIS-11 and the POMS fatigue scale were positively correlated ($r = 0.32$, $P < 0.01$). This model used a hierarchical entry of four variable groupings (study condition, sex, BIS-11 total score, POMS fatigue subscale). At first entry into the model, BIS-11 was a statistically significant predictor of sedative response. However, the POMS Fatigue variable was statistically significant when included in the final entry of the model, and BIS-11 went from being a statistically significant predictor of sedation to non-significant ($P = 0.46$) (Table 5). There was no main effect of study condition on either stimulation or sedation.

DISCUSSION

As AUD remains prevalent, examining constructs related to heavy drinking and AUD risk has theoretical, clinical and public health relevance. While impulsivity has been linked consistently to AUD risk (Verdejo-García *et al.*, 2008), questions remain regarding how and why impulsivity confers risk (Dalley *et al.*, 2011). Recent studies examining relationships between impulsivity and SR suggest that more impulsive individuals experience high-risk SR patterns at higher doses (Leeman *et al.*, 2014; Berey *et al.*, 2017; Westman *et al.*, 2017). However, to our knowledge, this is the first study to examine these constructs as related risk factors following low-dose alcohol administration. The current study suggests that among heavy drinkers, low doses of alcohol may produce a range of subjective effects. Extensive research strongly suggests that hedonic, rewarding alcohol effects prospectively predict heavy drinking and alcohol-related problems (King *et al.*, 2011; 2014; 2016). However, among this sample, self-report and behavioral impulsivity measures were not statistically significant predictors of high-risk SR patterns.

Regardless, determining whether more impulsive individuals experience specific subjective effects (i.e. elevated stimulation and/or dampened sedation) shortly after drinking is initiated has clinical implications and is relevant to our understanding of why impulsivity confers problem drinking risk. While participants experienced a range of subjective alcohol effects following low-dose alcohol, clear relationships between impulsivity and high-risk SR patterns may

Table 3. Multiple regression model of behavioral, self-reported and choice impulsivity predicting subjective response to alcohol

	BAES sedation				BAES stimulation			
	B	SE B	β	P	B	SE B	β	P
Study condition: 20 mg/day dummy coded	0.135	0.219	0.088	0.541	-0.186	0.154	-0.171	0.231
Study condition: 40 mg/day dummy coded	0.067	0.118	0.081	0.574	-0.135	0.083	-0.233	0.107
Sex	3.111	4.14	0.099	0.455	5.134	2.91	0.23	0.083
BIS-11	0.321	0.189	0.213	0.095	-0.04	0.133	-0.038	0.764
Cued go no/go	-0.152	0.243	-0.078	0.535	0.001	0.171	0.000	0.997
EDT	4.838	9.638	0.066	0.618	0.26	6.775	0.005	0.970
Drinks/drinking day	-0.479	1.676	-0.037	0.776	0.042	1.178	0.005	0.972

Note: Interactions between impulsivity variables and study condition and interactions involving drinks per drinking day were tested but were not significant predictors of subjective response. Thus, these interactions were dropped from the model.

Study condition reference = 0 mg/day Memantine.

Sex: 1 = male; 0 = female; B = unstandardized coefficient; SE B = standard error of unstandardized coefficient; β = standardized coefficient.

BAES Sedation $r^2 = 0.077$; BAES stimulation $r^2 = 0.088$.

BIS-11 = Barratt Impulsiveness Scale, Version 11.

EDT = experiential discounting task.

Table 4. Multiple regression model of BIS-11 predicting subjective response to alcohol

	BAES sedation				BAES stimulation			
	B	SE B	β	P	B	SE B	β	P
Study condition: 20 mg/day dummy code	0.13	0.193	0.084	0.504	-0.106	0.129	-0.100	0.417
Study condition: 40 mg/day dummy coded	0.143	0.101	0.177	0.162	-0.129	0.067	-0.236	0.059
Sex	0.709	3.553	0.022	0.842	5.227	2.371	0.237	0.03
BIS-11	0.297	0.159	0.206	0.065	-0.028	0.106	-0.029	0.791
Drinks/drinking day	-0.15	1.444	-0.011	0.918	-0.032	0.966	-0.004	0.974

Note: Family history status was included in the model but did not significantly predict subjective response.

Interactions between BIS-11 and study condition were tested but were not significant predictors of subjective response.

Thus, they were dropped from the model.

Sex: 1 = male; 0 = female; B = unstandardized coefficient; SE B = standard error of unstandardized coefficient; β = standardized coefficient.

BAES sedation $r^2 = 0.062$; BAES stimulation $r^2 = 0.092$.

Table 5. Hierarchical regression model of BIS-11 and POMS fatigue subscale predicting BAES sedation

	BAES sedation							
	First entry				Final model			
	B	SE B	β	P	B	SE B	β	P
Study condition: 20 mg/day dummy code	0.047	0.194	0.031	0.808	0.066	0.142	0.044	0.643
Study condition: 40 mg/day dummy coded	0.165	0.100	0.211	0.104	0.126	0.073	0.161	0.091
Sex	-0.311	3.441	-0.01	0.928	0.351	2.517	0.012	0.889
BIS-11	0.365	0.154	0.269	0.02	0.087	0.118	0.064	0.46
POMS fatigue					3.501	0.441	0.684	0.000

Note: Interactions between BIS-11 and study condition were tested but were not significant predictors of subjective response.

Thus, they were dropped from the model.

Sex: 1 = male; 0 = female; B = unstandardized coefficient; SE B = standard error of unstandardized coefficient; β = standardized coefficient.

First entry $r^2 = 0.104$; final entry $r^2 = 0.528$.

manifest only at higher BACs. Clinically, this may indicate that harm reduction is a reasonable goal even for more impulsive heavy drinkers as they may not experience a strong rewarding effect until they have a higher number of alcoholic drinks. However, to limit drinking to this extent in an impulsive heavy drinker will likely require an intervention with strong evidence of efficacy.

Counter to original hypotheses, when behavioral and choice measures of impulsivity were excluded from the model, higher self-reported impulsivity was a trend-level predictor of heightened alcohol sedation. Given prior findings relating impulsivity and alcohol consumption, we hypothesized that the current sample of heavy drinkers was experiencing boredom, which could have been

misinterpreted as sedative alcohol effects. This supposition was confirmed in a *post hoc* hierarchical regression analysis. While the BAES has consistently been used as a valid measure of subjective effects related specifically to acute alcohol administration (for a review, see [Boyd et al., 2017](#)), future studies should account for mood states, such as boredom, as they may affect subjective alcohol effects or participants may misconstrue these mood states as effects stemming directly from alcohol ([Davidson et al., 1997](#)).

Based on the present findings, impulsivity does not appear to be related to subjective effects resulting from low-dose alcohol in heavy drinkers. These findings diverge from predictions based on the tendency for impulsive individuals to focus inordinately on reward ([Patterson and Newman, 1993](#)) and the possibility that this tendency also applies to alcohol consumption. Because no placebo condition was utilized in the parent study, it is possible that these results were influenced by alcohol expectancies, although some individuals experienced considerable subjective effects from relatively small doses of alcohol. Perhaps larger doses of alcohol are required for relationships between impulsivity and SR to manifest among heavy drinkers.

This study is not without limitations. The primary aim of the original study examined the efficacy of the NMDA receptor antagonist, memantine, on alcohol craving and self-administration in non-treatment seeking heavy drinkers. Thus, the parent study did not utilize a placebo beverage condition. Thus, subjective responses reported by participants in this study may have been partially influenced by alcohol expectancies. Although participants' self-reports indicated a range of stimulation and sedation from low-dose alcohol, scores tended toward the lower end of the scale. The current study assessed SR using the standard version of the BAES, which does not permit baseline assessment of stimulation and sedation. Participants are asked to rate the extent to which alcohol explicitly has produced a range of subjective effects at that time. Thus, we cannot determine whether alcohol influenced these ratings beyond any stimulation or sedation participants experienced prior to alcohol administration. The current study consisted primarily of males, who are more likely than females to engage in heavy drinking ([Kanny et al., 2013](#)). However, results of this study may not be representative of heavy drinkers at large, as heavy drinking among females has become more prevalent ([Gruzca et al., 2008](#)). True of all laboratory studies, there was a departure from ecological validity, as participants drank alone and in a hospital setting.

Nonetheless, these results add to the theoretical understanding of the associations between impulsivity and SR. Relationships between measures of impulsivity and SR may be observable at low-to-moderate doses among lighter drinkers only ([Leeman et al., 2014](#)). Among heavier drinkers, larger doses of alcohol may be needed to observe relationships between measures of impulsivity and SR ([Westman et al., 2017](#)). Relationships between impulsivity and SR at lower BACs have been studied infrequently, but can offer insight into initial alcohol responses that may be linked to greater within-session drinking. Replication of studies similar to this is important, and more research is necessary to understand the causal nature of the relationships between impulsivity and SR.

SUPPLEMENTARY MATERIAL

Supplementary data are available at *Alcohol And Alcoholism* online.

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CONFLICT OF INTEREST STATEMENT

None declared.

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