

Research

Acquired substance-dependent compulsivity but not general compulsivity predicts increased substance use

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Abstract

Background Substance misuse among college students is a growing area of concern. Approximately 2 in 5 college students suffer from binge drinking disorder, the consequences of which include sexual misconduct, low grade point average (GPA), injury, and even death. Compulsivity is thought to play a key role in the initiation and maintenance of substance use disorder. We aim to clarify the role of compulsivity by evaluating several key components of this construct including rumination and “letting go.”

Methods 443 undergraduate students participated in an online survey which included measures for substance misuse as well as general measures for compulsivity and a new, adapted measure for substance-dependent compulsivity.

Results Our findings support our hypothesis that substance-dependent compulsivity, as defined as the drive to consume drugs and/or alcohol specifically, can be used as a behavioral marker to predict substance misuse.

Conclusions Substance-dependent compulsivity plays a significant role in an unhealthy relationship with substances, including alcohol, above and beyond predisposition for obsessive–compulsive spectrum behavior. Given the age of our study population, it seems then likely that compulsive use of mind-altering substances emerges early in the pathogenesis of substance use disorder.

Keywords Compulsivity · Letting go · Rumination · Substance use disorder

1 Introduction

In 2021, the U.S. Department of Health and Human Services reported that an estimated 46.3 million people aged 12 and over (16.5% of the population) met the Diagnostic and Statistical Manual (5th ed.; DSM-V) criteria for substance use disorder (SUD). Only approximately 6% of those received treatment [38]. The excessive use of alcohol and the misuse of other drugs is a growing public health concern in the United States, particularly among college students, who reportedly drink more than age-matched, non-college attending controls [34, 48]. Approximately 2 in every 5 American college students qualify as binge drinkers [34]; one study found that almost half of 936 college students fit the criteria for an SUD diagnosis for at least one substance [48]. Among the risks associated with increased alcohol use are lower grade point averages (GPA, which is a summary numerical measure of academic achievement compiled over all available classes

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over a semester or a college career), failure to graduate, unemployment following graduation, death, sexual assault, and physical injury [10, 48].

There are indications that the psychological mechanisms behind SUD might change over the course of an individual's history with substances [15, 28, 29, 31, 50]. Specifically, people who use substances and ultimately develop SUDs are often initially driven by the impulse to increase pleasure. This initially impulse-driven use can progress to compulsive use, where the aim becomes the removal of negative internal states as opposed to the achievement of positive internal states. This progression is likely linked to neurological changes, such as the observed strengthened dopaminergic connection from the orbitofrontal cortex to the dorsomedial striatum and weakened projections from the medial prefrontal cortex to the ventrolateral striatum in those who suffer from SUDs when compared to healthy controls. The former projection is most closely associated with habit-driven behavior while the latter is considered to be involved in motivated or goal-driven behavior, implying that as pathological substance use progresses, habit formation overtakes purpose-driven behavior [28, 31]. Importantly, dysregulation of the same neurocircuitry is associated with obsessive–compulsive disorder (OCD) and other obsessive–compulsive (OC) spectrum disorders [5, 15].

In the light of these findings, the present study further examines the compulsive component of substance use. We expand on the existing literature in two ways. First, we examine whether the compulsivity component of SUD is specific to substance use or whether it is related to more generalized, pathological compulsive tendencies. Second, we cast a relatively wide net of variables assumed to be related to compulsive tendencies or the ability to break them, specifically rumination, the ability to let go, and mindfulness. We discuss both extensions in turn below.

First, the role of compulsion is still debated. Heather [21] formulated two competing understandings of compulsion within the context of addiction: “weak” versus “strong” compulsion. Weak compulsion (i.e., the compulsion to seek and consume drugs) arises from a disordered sense of motivational attribution—the substance user falls prey to “overwhelming” or “irresistible” urges [21]. This view has deep cultural and literary roots. Susan Zeiger (2008, p. 1–3) describes the early Victorian belief that addiction was a “disease of the will.” This belief persists, in one form or another, into the twenty-first century for instance in claims that individuals who misuse substances could overcome what is often labeled as a “disease” with more willpower or greater resolve [51].

Conversely, the strong compulsion view is based on aberrant learning theories and the idea of automaticity. Under this view, the individual experiences a transition from occasional, recreational, and intentional substance use to habitual use terminating in automatic use which is no longer under intentional control [21]. Key neurobiological changes include initial positive reinforcement through activation of reward pathways and the dopaminergic neurotransmitter system which is followed by a loss of top-down control as efferent projections from the prefrontal cortex begin to weaken [31]. Eventually positive reinforcement is replaced by negative reinforcement as the person dependent on substances begins attempting to escape the sober state which is now perceived as aversive. As drug seeking and taking becomes more automatic, the person dependent on substances loses awareness of the gravity or intensity of their consumption. This constitutes compulsive use because it is perceived to occur against the user's will or conscious consent.

It is still unclear to what extent the role of compulsivity in the initiation and maintenance of SUD is due to a general propensity for compulsive behaviors or specific to compulsive consumption of substances, that is, whether compulsion as an individual-differences variable correlates with substance use and SUD (as could be expected under the weak view), or whether a more specific measure related to compulsion around drinking and substance-use behavior is necessary to capture this relationship adequately (as under the strong view; e.g., Cuzen et al. [11, 21]). One hint that the latter might be the case comes from a meta-analysis comparing task-related brain activation in individuals with SUD and individuals with OCD, showing both overlap and marked differences in activated regions [27]. Therefore, in the present study, we designed a new brief survey to tap specifically into substance-use-related compulsion.

A second contribution concerns the inclusion of several variables that are assumed to be related to compulsive tendencies or the ability to break them; specifically, rumination, the ability to let go, and mindfulness. It has been suggested that, while the correlation between mood and anxiety disorders (particularly Major Depressive Disorder) and increased rates of substance use has been well documented in the literature (see Hunt et al. [24] for systematic review and meta-analysis; [4]), rumination may act as a potential third variable underlying the proposed relationship [7, 8, 49]. Similar to the obsessive thinking associated with classic OCD and OC spectrum disorders, rumination can be defined as an intrusive, repetitive pattern of thought that centers around one's negative circumstances and how they came to exist [10, 23]. Rumination, as opposed to negative affect, often prolongs negative internal states. Users of alcohol and other drugs may attempt to alleviate this prolonged negative internal environment by increasing substance use [23]. We note that the relationship between rumination and substance use might not be straightforward. Different types of

rumination have been identified. Reflectiveness, for instance, is characterized by more active attention towards problem solving while brooding is defined as a passive fixation on one's current situation and the idealized better situation [23, 42].

Additionally, the degree to which intrusive thought is self-sustaining versus easy to let go of may moderate the relationship between rumination and substance use. Specifically, Caswell et al. [9] point out that the ability to let go may be a key characteristic differentiating those who engage in positive and adaptive reflection (e.g., mindfulness) and those who engage in deleterious rumination. It is for this reason that we examine this lesser researched facet of rumination of "letting go" in the context of substance use disorder.

Finally, we included mindfulness as a covariate because this variable has often been found to be negatively associated with rumination, likely in a causal way (see Mao et al. [32], for a meta-analysis), as well as with substance use [3, 25]. We operationalized this construct as the mindfulness manifold of reflective awareness, controlled sense-of-self in the moment, self-preoccupation, self-compassion, and self-transcendence [44], after the common-denominator model of mindfulness proposed by Vago and Silbersweig [43] that distinguishes self-awareness, self-regulation, and self-transcendence as different modes of mindfulness. Reflective awareness and controlled sense-of-self in the moment are both aspects of self-awareness, with the former indexing the more active, deliberate, probing aspect of mindfulness and the latter the more passive, equanimous, non-judgmental aspect of mindfulness. Self-preoccupation and self-compassion are aspects of self-regulation. Self-transcendence concerns decentering and a stronger awareness of interdependence between self and others. More details on how to measure these aspects can be found in the Methods section.

Summarized, the present study aims to clarify the role of behavioral compulsivity in substance use in a college population. Specifically, we are interested in understanding (a) whether compulsivity plays a role in maintenance of substance misuse above and beyond the established relationship between pathological compulsion in OC spectrum disorders and increased substance consumption, (b) whether measures for compulsivity specific to drug use could be used to predict actual drug use behaviors over and beyond general, pathological compulsivity, and (c) elucidating the relationship between rumination and substance misuse by evaluating measures for "letting go" (a newly defined aspect of rumination) and mindfulness.

2 Methods

2.1 Subjects

The sample consists of 381 students at the Georgia Institute of Technology who participated in return for course credit (see Table 1 for demographic information). This sample was part of a larger sample of 443; 49 participants were excluded from analysis because of incomplete surveys. A survey was considered to be incomplete if the Qualtrix survey software identified less than 100% completion. Fifteen additional participants were filtered out because they took less than ten minutes to answer all questions. Subjects were compensated with one hour of credit of research participation through Sona, a software that connects volunteers with faculty and students in need of participants for psychological studies.

2.1.1 Inclusion and exclusion criteria

All participants were required to be current students at the Georgia Institute of Technology. Participants were excluded if they were under the age of 18. Participants were to be fluent in English. Participants were also excluded if they were located in an EU country.

2.2 Measures

2.2.1 Personality

In addition to the measures mentioned in the Introduction, the International Personality Item Pool (IPIP; Extraversion Cronbach's = 0.82, Agreeableness Cronbach's = 0.75, Conscientiousness Cronbach's = 0.68, Neuroticism Cronbach's = 0.69, Intelligence and Imagination Cronbach's = 0.71) was included to control for personality (i.e., the Big Five) [13, 18]. (Note that all Cronbach's alpha values reported throughout the Measures section are calculated from the current sample.) We anticipate that personality traits might act as a potential third variable, partially explaining some of the relationships

Table 1 Demographics of study sample

Factor	Number of responses	Percentage of responses
Gender		
n	381	
Cis-gendered male	183	48.0
Cis-gendered female	187	49.1
Non-binary	4	1.0
Prefer not to answer	7	1.8
Ethnicity		
Native American/Alaska Native	0	0.0
Asian	160	42.0
Black or African American	29	7.6
Native Hawaiian/Pacific Islander	0	0.0
Hispanic, Latinx, Spanish Origin	26	6.8
White	120	31.5
Prefer not to say or other	11	2.8
2 or more racial identities	35	9.3
Year in school		
1st year	149	39.1
2nd year	94	24.7
3rd year	74	19.4
4th year	55	14.4
5th year or more	6	1.6
Master's program	2	0.5
Doctoral (PhD) program	1	0.3

between our constructs of interest. For instance, one study characterized alcohol use disorder (AUD) and cannabis use disorder (CUD) in terms of high neuroticism, low agreeableness, and low conscientiousness [12].

2.2.2 Compulsivity

Propensity for pathological compulsive behavior not related to substance consumption (from here on referred to as “general compulsivity”) was measured using the five-item compulsion subscale of the Y-BOCS (Cronbach’s = 0.70) [19]. We then adapted three of those five compulsion items from the Y-BOCS to specify compulsivity in the context of substance consumption; we labeled this version the Y-BOCS-SU (Cronbach’s = 0.80). These items were: “How would you feel if prevented from drinking or consuming drugs? How anxious would you become?”, “How much of an effort do you make to resist the urge to drink or consume drugs when the urge arises?”, and “How strong is the drive to drink or consume drugs? How much control do you have over your urges to consume drugs?”. The other two Y-BOCS items relating to time spent performing compulsive behaviors and interference due to compulsive behaviors were not adapted for the Y-BOCS-SU. The first was excluded because it was deemed confounding; substance use does take up time (particularly if in a social context) and the timing may not relate to the compulsive aspect. The second question was excluded as substance use by virtue impairs the person who is using the substance and precludes social and work functioning. This component of SUDs was captured elsewhere in the survey.

2.2.3 Rumination and reflection

Rumination was measured using the Rumination-Reflection Questionnaire (RRQ; Cronbach’s = 0.65) [41]. Reflection and Insight were also measured using the self-reflection and insight scale (SRIS; Reflection Cronbach’s = 0.90, Insight Cronbach’s = 0.87) [20].

2.2.4 Letting go

The ability to let go was measured using an adaptation of the University of British Columbia Cognition Inventory Letting Go scale (UBC-LG; Cronbach's = 0.96) [17]. The original 32-item questionnaire was revised to allow for participants to estimate how long (in seconds, minutes, hours, and so on) to let go of a troubling thought.

2.2.5 Mindfulness

Mindfulness was measured as the five-part mindfulness manifold as derived after a set of exploratory and confirmatory factor analyses as reported in Verhaeghen [44]. *Reflective awareness* was measured as the unit-weighted z-score composite of three questionnaires: (a) the Observing subscale of the Five Facets Mindfulness Questionnaire (FFMQ; 8 items; Cronbach's = 0.76) [1]; (b) the Reflectiveness subscale of the Broad Rumination Scale (BRS; 4 items; Cronbach's = 0.82) [40]; and (c) Search for Insight/Wisdom of the Aspects of Spirituality scale (ASP; 7 items; Cronbach's = 0.83) [6]. *Controlled sense-of-self in the moment* was measured as the unit-weighted z-score composite of three questionnaires: (a) the Acting with Awareness subscale from the FFMQ (8 items; Cronbach's = 0.86); (b) the Sense-of-self Scale (SOSS; 12 items; Cronbach's = 0.82) [14]; and (c) the Nonjudging of inner experience subscale of the FFMQ (8 items; Cronbach's = 0.88). *Self-transcendence* was measured as the unit-weighted z-score composite of the Joy (6 items; Cronbach's = 0.87) and Love (6 items; Cronbach's = 0.83) subscales of the Dispositional Positive Emotion Scale (DPES) [37], and the Meaningfulness (7 items; Cronbach's = 0.84) subscale from the Resilience Scale (RS) [30].

2.2.6 Substance use

Substance use was measured using the Rutgers Collegiate Substance Abuse Screening Test (RCSAST) [2]. The RCSAST was designed to screen for substance misuse in college students and was chosen because of its relevance to our study population when compared with other traditional screening measures like the alcohol use disorder identification test (AUDIT) or the Drug Use Disorder Identification Test (DUDIT).

2.2.7 Data analysis

Data analysis was performed using Jamovi (version 2.3) software, which is a user-friendly overlay for the R statistical computing package (version 4.1) [16, 35, 36, 39]. First, the RCSAST questions were input into an exploratory factor analysis (EFA). The purpose of this EFA was to determine whether there is some previously unidentified underlying structure within this questionnaire. Factors were determined using minimum residuals extraction method and Oblimin rotation. Factors with eigenvalues exceeding 1 were used in analysis. Details are below in the Results section. A series of two hierarchical regressions were performed to predict responses to each of the RCSAST factors discovered in the EFA. Predictor variables included in block 1 were Gender, IPIP scales, RRQ, mindfulness manifold, reflection score, and insight score; block 2 included the Y-BOCS average, and the University of British Columbia Cognition Inventory Letting Go scale; and block 3 the Y-BOCS-SU average. Note that the scores on all scales were averaged to control for missed responses.

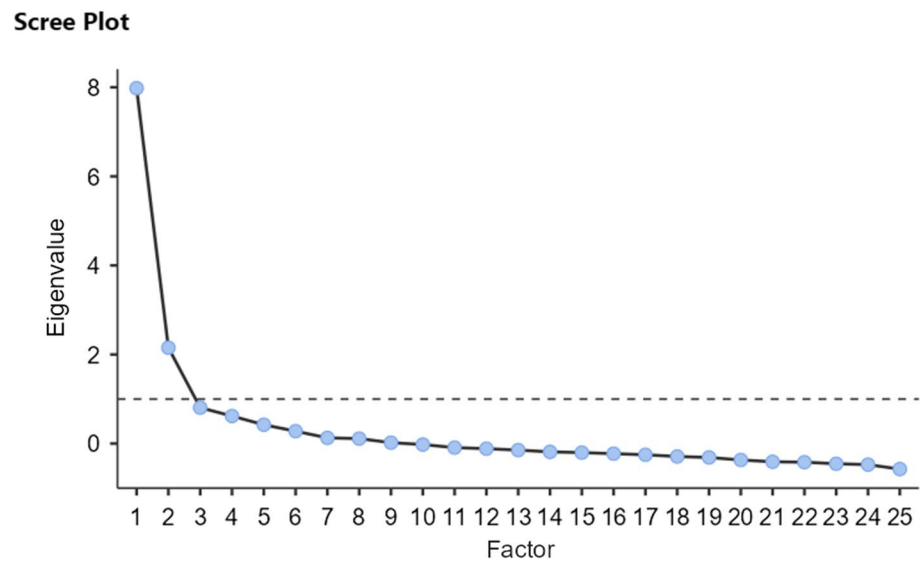
3 Results

3.1 Exploratory factor analysis

Figure 1 shows line plot depicting eigenvalues of factors in the exploratory factor analysis. The dotted line indicates that the bend of the scree plot occurs in between 2 and 3 factors, meaning that 2 factors should be generated from the analysis.

Results from the factor analysis are reported in Table 2. Taken together, the eigenvalues and scree plot (Fig. 1) suggest the presence of two factors, which account for 41.7% of the variance. Factor 1 consisted of 15 items with factor loadings larger than 0.3 (indicated Table 2 using bolded font), including two cross-loading items. This factor contained items that measure intra- and interpersonal negative consequences of drug or alcohol use, as well as the propensity to use substances as a means of escape. We will refer to this factor as Personal and Interpersonal Repercussions. Internal consistency was high (Cronbach's = 0.88; this includes the cross-loaded items). Factor 2 consisted of 12 items with factor

Fig. 1 Scree plot for exploratory factor analysis of RCSAST



loadings larger than 0.3 (indicated in Table 2 using bolded font), including 2 cross-loading items. This factor contained items that measure more serious negative consequences of sustained drug and alcohol abuse. This factor was labeled Inability to Fulfill Responsibilities. This factor, too, had a high internal consistency (Cronbach's = 0.89; this includes the cross-loaded items). The two factors were interrelated, $r=0.41$.

3.2 Regression analyses

Table 3 shows the results from the hierarchical multiple linear regressions performed in order to predict results on the RCSAST factors; Table 4a presents the correlation matrix. No variable resulted in a tolerance below 0.25 (lowest 0.39) nor a VIF above 4.0 (largest 2.59) and it was therefore deemed that variables used failed the tests of multicollinearity. 33.6% of the variance in the RCSAST Personal and Interpersonal Repercussions factor was explained by our independent variables. Our measures for the substance-use-dependent letting go construct and the substance-dependent compulsivity construct were statistically significant. Also statistically significant in all three steps was the IPIP measure for extraversion and the measure for self-transcendence, which appears to be protective in nature. For the RCSAST Inability to fulfill responsibilities factor, only 7.9% of the variance in responses could be explained by our independent variables. Extraversion was again significant in all three steps. The Y-BOCS was also significant in the final step.

4 Discussion

The main research question for the present study was whether a substance-use-specific measure of compulsivity would explain increased substance use (as measured by the RCSAST) over and beyond the effects of general compulsivity; we also included a number of other potential covariates (i.e., SRIS, gender, the Big Five, rumination, and select aspects of mindfulness). We conclude that the answer to this question is largely affirmative but acknowledge that our results require further interpretation due to the nuance of the constructs evaluated. For one of our two measures of substance misuse (viz., the Personal and Interpersonal Repercussions factor of the RCSAST), our measure for substance-dependent compulsivity explained additional variance beyond all other variables. This was not the case for the second measure of substance misuse (viz., the Inability to Fulfill Responsibilities factor of the RCSAST). These findings are discussed in detail below.

4.1 Exploratory factor analysis of RCSAST

Factor analysis revealed that the RCSAST (at least in this sample) was not a unitary scale, but contained two factors, one associated with personal and interpersonal repercussions (e.g., memory loss, conflicts with friends due to use) and the other with the inability to fulfill responsibilities (e.g., ever being treated by a physician for drinking/using drugs, losing a job because of substance use). Even though these two factors are highly interrelated, with a correlation of 0.41, they

Table 2 Pattern factor loadings and communalities for exploratory factor analysis of the RCSAST questionnaire

Item no	Items	Factor 1	Factor 2	Communalities
8	Do you lose time due to drinking or using drugs?	0.77	- 0.55	0.57
20	Have you ever had complete or partial loss of memory as a result of using drugs or drinking?	0.69	- 0.09	0.43
9	Has drinking alcohol or using drugs ever interfered with your exam prep?	0.69	0.01	0.48
16	Have you ever felt remorse after drinking or using other drugs?	0.68	- 0.11	0.41
13	Do you drink or use drugs to build self-confidence?	0.65	0.02	0.43
23	Do you seek out drinking or drug use companions/environments?	0.64	0.06	0.44
11	Do you drink alcohol or other drugs to escape from worries or troubles?	0.61	0.05	0.40
10	Has your efficiency decreased since drinking or using drugs?	0.57	0.10	0.38
3	Do you use alcohol or other drugs because you're shy with other people?	0.52	- 0.02	0.26
5	Has drinking alcohol or using other drugs ever caused conflicts with close friends of the same sex?	0.50	0.14	0.33
4	Has drinking alcohol or using other drugs ever caused conflicts with close friends of the opposite sex?	0.49	0.07	0.28
6	Has drinking alcohol or using other drugs ever damaged other friendships?	0.42	0.19	0.28
17	Do you drink or use drugs alone?	0.32	0.18	0.18
24	Has your physician ever treated you for drinking/using drugs?	- 0.16	0.95	0.81
7	Has drinking alcohol or using drugs ever been behind your losing a job?	- 0.02	0.76	0.57
22	Does your drinking make you care less of your family's welfare?	0.02	0.73	0.55
25	Have you ever been to a hospital or institution on account of drinking or using drugs?	0.00	0.71	0.50
18	Do you crave a drink or other drug at a definite time daily?	0.12	0.70	0.58
19	Do you want a drink or other drug the morning after drinking or using?	0.12	0.56	0.38
21	Is drinking or using other drugs affecting your reputation?	0.25	0.53	0.46
15	Does drinking or using other drugs cause you to have difficulty sleeping?	0.19	0.51	0.38
14	Has your ambition decreased since drinking or using other drugs?	0.29	0.45	0.40
2	Is alcohol or other drug use making your college life unhappy?	0.20	0.41	0.28
12	Is your drinking or using drugs jeopardizing academic performance?*	0.35	0.35	0.38
1	Have you ever gotten into financial difficulties as a result of drinking or using other drugs?*	0.34	0.34	0.32
Eigenvalues		7.98	2.15	
% of variance		21.8	19.9	

N=381

*Cross-loading items

Bold numbers refer to factor loadings greater than or equal to 0.3

Table 3 Hierarchical multiple linear regressions predicting RCSAST Factor 1 and RCSAST Factor 2

	RCSAST personal and inter			RCSAST inability		
	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3
Gender	−0.07	−0.13	−0.14	−0.21	−0.22	−0.22
IPIP extraversion	0.28***	0.30***	0.19**	0.16*	0.18*	0.17*
IPIP agreeableness	0.08	0.09	0.08	−0.08	−0.07	−0.07
IPIP conscientiousness	0.03	0.05	0.07	−0.02	−0.01	−0.01
IPIP neuroticism	0.00	−0.06	−0.01	0.03	0.01	0.01
IPIP intellect and imagination	0.01	−0.01	0.02	0.00	0.00	−0.01
Insight score	−0.03	0.00	0.02	−0.02	0.00	0.00
Reflection score	−0.03	−0.01	−0.02	0.08	0.07	0.07
RRQ average	0.05	0.05	0.03	0.04	0.03	0.03
UWCSOSIM	−0.09	−0.01	−0.03	−0.10	−0.04	−0.04
Uwselftransc	−0.33***	−0.25**	−0.17*	0.01	0.02	0.03
UWreflectaware	0.15	0.14	0.10	−0.07	−0.06	−0.06
R-squared	0.135***			0.050		
Y-BOCS		0.07	0.09		0.18**	0.18**
LGQ-adapted		0.25**	0.15*		0.04	0.04
R-squared		0.174***			0.079	
R-squared change		0.039**			0.029*	
Y-BOCS-SU			0.43***			0.01
R-squared			0.336***			0.079
R-squared change			0.162***			0.000

N = 241. Standard estimates reported

IPIP international personality item pool, *RRQ* rumination-reflection questionnaire, *Y-BOCS* Yale-Brown obsessive compulsive scale, *Y-BOCS-SU* Yale-Brown obsessive compulsive scale adapted for use with substances. *RCSAST Personal and Inter* Rutgers collegiate substance abuse screening test personal and interpersonal repercussions, *RCSAST inability* RCSAST inability to fulfill responsibilities, *LGQ* letting go questionnaire

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

appear to have different antecedents and consequences. We suggest that the second factor, the inability to fulfill responsibilities, may represent treatment-related outcomes. Specifically, two questions (“Has your physician ever treated you for drinking/using drugs?” and “Have you ever been to a hospital or institution on account of drinking or using drugs?”) pertain explicitly to treatments. We argue, therefore, that this measure lacks validity in identifying active substance misuse. Instead, we propose that this factor may more accurately capture historical substance misuse. This is particularly true of questions pertaining to therapeutic interventions (i.e. have you ever been treated for or hospitalized for substance use). This is discussed further below.

4.2 Multiple linear regression

4.2.1 RCSAST personal and interpersonal repercussions

In the first hierarchical multiple linear regression (Table 3), the IPIP Extraversion measure was the only Big Five factor that was a consistent, statistically significant predictor of the RCSAST personal and interpersonal repercussions score. This finding is a departure from what has historically been associated with SUD in general and with AUD in particular. Typically, high neuroticism and low conscientiousness are associated with AUD [12]. In fact, other SUDs are usually associated with low extraversion in addition to neuroticism and low conscientiousness [12]. We speculate that our finding is due to two potentially interrelated factors. First, as mentioned above, this sample is composed of emerging

Table 4a Correlation matrix for the variables included in the linear regression analyses

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
1. Gender	—																
2. IPIP extraversion	0.078	—															
3. IPIP agreeableness	0.171***	0.32***	—														
4. IPIP conscientiousness	0.052	0.051	0.088	—													
5. IPIP neuroticism	0.275***	-0.07	0.126*	-0.171***	—												
6. IPIP Intelligim	-0.039	0.159**	0.195***	-0.051	-0.183***	—											
7. SRIS Insight	-0.074	0.103*	0.01	0.13*	-0.347***	0.206***	—										
8. SRIS Reflection	0.057	0.166**	0.352***	0.075	0.105*	0.263***	0.015	—									
9. RRQ Average	0.095	-0.091	0.143**	-0.129*	0.388**	-0.043	-0.36***	0.211***	—								
10. UWCSOSIM	-0.106*	0.183***	-0.048	0.374***	-0.486***	0.113*	0.576***	-0.005	-0.577***	—							
11. UWselftransc	0.084	0.415***	0.444***	0.291***	-0.279***	0.19***	0.141**	0.327***	-0.044	0.278***	—						
12. UWreflect-ware	0.058	0.163**	0.359***	0.131*	0.004	0.352***	0.015	0.659***	0.219***	-0.033	0.477***	—					
13. LGQ-ObsAVG	0.177***	-0.225***	-0.092	-0.296***	0.483***	-0.086	-0.375***	-0.078	0.322***	-0.54***	-0.461***	-0.095	—				
14. YBOCSavg	0.021	-0.13*	-0.055	-0.145*	0.213***	-0.077	-0.262***	0.021	0.21***	-0.367***	-0.152*	-0.032	0.284***	—			
15. Y-BOCS_SU-AVG	0.011	0.138**	-0.004	-0.116*	0.068	-0.003	-0.095	0.006	0.054	-0.102*	-0.085	0.023	0.179***	0.006	—		
16. Score Factor 10.003	0.162**	0.053	-0.027	-0.055	0.119*	0.037	-0.116*	0.053	0.122*	-0.161**	-0.105*	0.085	0.241***	0.127*	0.518***	—	
17. Score Factor 2-0.073	0.091	-0.027	-0.074	-0.074	0.049	-0.001	-0.069	0.03	0.063	-0.092	-0.027	-0.013	0.072	0.19**	0.075	0.443***	—

IPIP international personality item pool, SRIS self reflection and insight scale, RRQ rumination-reflection questionnaire, LGQ-ObsAVG adapted UBC letting go questionnaire, Y-BOCS Yale-Brown obsessive compulsive scale, Y-BOCS-SU Yale-Brown obsessive compulsive scale adapted for use with substances. Score factor 1 Rutgers collegiate substance abuse screening test personal and interpersonal repercussions, Score factor 2 Rutgers collegiate substance abuse screening test inability to fulfill responsibilities, LGQ compulsion letting go questionnaire, compulsion subscale

* p < 0.05

** p < 0.01

*** p < 0.001

adults. It's possible that personality traits influence substance use behaviors differently in this age demographic than in older groups. Second, for college students, alcohol and other drugs of abuse are most frequently available at social gatherings—most prominently being large parties. This is especially true for underage students, the largest demographic in our study. Extraversion is, by definition, correlated with outgoingness.

In addition to extraversion, self-transcendence was protective against increased substance use as measured by the RCSAST personal and interpersonal repercussions factor in all three steps. In our previous work on mindfulness, self-transcendence has proven to be a key variable, being associated with beneficial outcomes as diverse as well-being [44]; lower levels of prejudice [47]; the virtues of inquisitiveness, caring, and self-control [46]; an individualizing moral stance [33, 47]; empathy [33]; and wisdom [45]. What a lot of these outcomes have in common, as perhaps expected from the self-transcendence construct, is a more open orientation toward others and away from narrow self-interest. It could then also be protective against problematic substance use by allowing users to take the broader view. Heggeness et al. [22] further point out that PWSFA may rely on substances, and alcohol in particular, to more easily manipulate self-relevant thought. The theory is that those who misuse substances also have higher self-attribution biases (i.e. tendency to inflate the degree to which they are responsible for a negative event or circumstance). The substance, then, acts as a coping mechanism or tool for self-medication [22]. Self-transcendence may mechanistically protect against this self-attribution style by allowing for the possibility that one person is not entirely at fault for all negative circumstances in their life at any given moment. Note that the spiritual side of self-transcendence is considered to be one of the components necessary for success in treatments such as AA and NA. Importantly, this idea has faced some scrutiny as some researchers consider spirituality to be a key factor in successful abstinence/use reduction while others consider spirituality to be completely extraneous to the core program [26].

Finally, the measures for letting go and substance-dependent compulsivity were significant predictors of personal and interpersonal repercussions. The letting go factor represents an emerging construct in the study of rumination. Crucially, none of the other measures for rumination (i.e., SRIS reflection and insight and the RRQ) were statistically significant predictors of substance use as measured by the RCSAST factor, suggesting that this particular facet of being able to release potentially compulsive thoughts is uniquely associated with problematic substance use.

4.2.2 RCSAST inability to fulfill responsibilities

Extraversion was a significant predictor of RCSAST Inability to Fulfill Responsibilities score, but to a lesser extent than was the case for personal and interpersonal consequences. The only other significant predictor of this aspect of substance use was the Y-BOCS. It is important to note that none of our regression models for prediction of this score were statistically significant. We do, however, propose that the influence of the Y-BOCS on this score may indicate that the treatments or the “rock bottom” experiences referenced in this factor may lead to some effective uncoupling of the compulsion to drink with consumption habits. It is possible that this compulsion is replaced by other, more traditional OC spectrum behaviors.

5 Conclusions

Based on the existing literature as well as our findings, we conclude that compulsion to use drugs is a predictor of substance use above and beyond the general propensity for compulsive behaviors. This finding may point to a potential site of therapeutic intervention for PWSFA wherein patients could uncouple the compulsive drive to consume substances from the actual consumption and instead replace this behavior with an adaptive coping mechanism. This is supported by our finding that the standard Y-BOCS was the only significant predictor of the “Inability to Fulfill Responsibilities” factor of the RCSAST, which included items related to treatment of SUDs, indicating the possibility that subjects replace compulsive substance use with more classic OC behaviors following treatment.

Importantly, we also found evidence to support the emerging literature that rumination is an important predictor of increased levels of substance use. Specifically, we have identified a facet of rumination, known as “letting go,” that inversely predicts score on RCSAST above and beyond measures for general rumination. Finally, we posit that self-transcendence may protect against substance misuse. Our explanation for this finding is twofold: We suggest that self-transcendence may reduce the self-attribution bias (described in more detail in Heggeness et al. [22]) as well as ability to

disengage from ruminative thinking, evidenced by the highly significant negative correlation (i.e. $r = -0.46$; see Table 4a.) between our measure for inability to let go and self-transcendence.

6 Limitations and future directions

In light of our findings, we suggest more research is needed on understanding the role of internalized thought on substance use behaviors. Rumination has consistently been implicated in SUDs, but with varying proposed mechanisms [10, 23, 42]. Here, we identified “letting go” as a potential explanatory component of rumination which would help clarify the role of rumination in SUDs. Similarly, we see that one component of the mindfulness manifold (self-transcendence) appears to be protective against substance misuse. We therefore propose that more research be conducted to elucidate the qualitative and characteristic differences between mindfulness and the more deleterious form of self-directed thought: Rumination.

Finally, the data suggest that behavioral therapies aimed at curbing compulsion and/or raising awareness of compulsions could be particularly effective in the treatment of SUDs. It would also be beneficial to assess whether this compulsive aspect of drug consumption is universally applicable to all drug classes or whether drug class (stimulants versus depressants, for instance) alters compulsive tendencies. Furthermore, we suggest that additional research be conducted into the pathogenesis of substance use disorder. It would be prudent to understand whether compulsive drug use develops over time due to a combination of substance induced neurobiological changes and psychological conditioning or if this substance-associated compulsivity is a precursor/risk factor for substance misuse.

Limitations do exist in this study. The RCSAST focuses on consequences of substance use, but does not measure actual intake. Additionally, we did not collect specific age information from our population. The repercussions of this are two-fold. First, we are unable to determine the influence of the legal context of alcohol consumption specifically in our population. In the United States, alcohol cannot be consumed by anyone under the age of 21. Additional studies investigating how this may influence drinking behaviors (particularly drinking in secret or binge drinking) are necessary. Second, we are unable to determine whether age influenced drinking or drug-use behaviors.

Author contributions Mallory Jones was responsible for the study conceptualization. All authors contributed equally to survey design. Letting Go Questionnaire and Y-BOCS adaptation were completed by Mallory Jones. Data collection and analysis were performed by Mallory Jones under the guidance and direction of Paul Verhaeghen. Paul Verhaeghen was predominantly responsible for data and analytical interpretation with input from Mallory Jones. The first draft of the manuscript was written by Mallory Jones. All authors commented on and edited the current manuscript. All authors have read and approved this final manuscript.

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Data availability All data will be made available with the submission of this manuscript.

Code availability Not applicable.

Declarations

Ethics approval and consent to participate The study was conducted in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments; it was approved by the Institutional Review Board at the Georgia Institute of Technology as protocol H22378 with a waiver of documentation of consent (i.e., because the study was conducted online, participants indicated consent with a button press instead of an actual signature).

Competing interests We have no conflicts of interest to report.

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