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Associations among interpretation bias, craving, and abstinence self-efficacy in adults with substance use disorders

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ABSTRACT

Objective: Interpretation bias is a crucial therapeutic target in emotional disorders. However, few studies have examined the role of interpretation bias in substance use disorders (SUDs). Our specific aims were: (1) to examine whether interpretation bias was associated with craving and abstinence self-efficacy, and (2) explore potential moderators of these associations, including anxiety severity, sex, and substance type.

Methods: Adults attending an inpatient SUD treatment program ($N = 224$; mean age = 38.95; 67% male/33% female; 68% primary alcohol use disorder/29% primary opioid use disorder) completed the Word-Sentence Association Paradigm (WSAP) with ambiguous situations related to general anxiety domains (e.g., daily stress, health, relationships), as well as measures of craving (Craving Scale), abstinence self-efficacy (Brief Situational Confidence Scale), and anxiety symptoms (Overall Anxiety Severity and Impairment Scale [OASIS] and Anxiety Sensitivity Index-3).

Results: Negative interpretation bias was modestly associated with more craving ($r = .23$, $p = .001$) and less confidence to resist using substances ($r = -0.23$, $p = .001$). In multiple linear regression models that included the anxiety measures, interpretation bias was the most robust predictor of craving and abstinence self-efficacy. Sex ($N = 224$) and substance type (opioid vs. alcohol; $n = 219$) did not moderate these relationships.

Conclusions: These findings suggest that interpretation bias might be an important individual difference within SUD populations.

1. Introduction

Interpretation bias, the tendency to interpret ambiguous situations or cues in a negative or threatening manner, is a well-established vulnerability in emotional disorders. Interpretation bias leads to negative affect, poor emotion regulation, and repetitive negative thinking, and has been associated with anxiety and depressive disorders (see Hirsch et al., 2016). Experimentally induced negative interpretation bias increases stress reactivity, supporting a causal association (Wilson et al., 2006). Consequently, psychological treatments, including Cognitive Behavioral Therapy (CBT) and Cognitive Bias Modification (CBM) target interpretation bias (Beck, 1979; MacLeod and Mathews, 2012), and the reduction of this cognitive bias leads to symptom improvement in emotional disorders (Hirsch et al., 2016; Jones and Sharpe, 2017).

Studies of interpretation bias in emotional disorders suggest an important distinction between two facets of interpretation bias: the presence of a negative interpretation bias versus the absence of a benign interpretation bias. Various measures of interpretation bias have demonstrated that negative and benign interpretation are not simply the opposite ends of a unipolar continuum. For example, socially anxious individuals tend to endorse negative and benign interpretations equally, whereas healthy controls favor benign interpretations over negative ones (Beard and Amir, 2009; Hirsch and Mathews, 2000). Thus, socially anxious individuals are thought to lack a healthy benign bias evident in non-socially anxious individuals. An individual's tendency to endorse negative and benign interpretations are only modestly correlated and may contribute uniquely and differently to psychopathology (Beard et al., 2017; Huppert et al., 2007); thus, studies recommend their separate examination (Hirsch et al., 2016).

Similar to emotional disorders, implicit cognitive processes are implicated in various theoretical models of substance use disorders (SUDs), including dual-process models, incentive salience theory,

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learning or habit theory, and negative reinforcement theories (see Stacy and Wiers, 2010 for a review). Implicit cognitive processes are posited to increase substance-relevant associations and interfere with explicit processes, such as self-regulation. To date, most work on implicit cognition in SUDs has focused on memory associations, attentional biases, or approach-avoidance action tendencies (see Stacy and Wiers, 2010). However, a handful of studies have investigated whether interpretation bias is also relevant in SUDs.

Several studies have demonstrated that the tendency to interpret ambiguous situations as alcohol-related may influence alcohol misuse (Ames et al., 2005; Ryan, 2002). For example, a heavy drinker might interpret the ambiguous situation (e.g., "You are out with friends and go to get something to drink") as alcohol-relevant (e.g., "booze" vs. "coffee"). In these studies, heavy drinkers were more likely to interpret ambiguous situations as alcohol-relevant compared to control groups (Chow et al., 2018; Salemink and Wiers, 2014; Woud et al., 2012, 2014). Moreover, an alcohol-relevant interpretation bias predicted heavier drinking in a student sample at a one-week follow-up assessment (Salemink and Wiers, 2014; Woud et al., 2015a). Extending these findings to a diagnosed alcohol-dependent sample, Woud et al. (2014) showed that alcohol-relevant interpretation bias predicted harmful drinking several weeks later within the clinical sample. This finding suggests that interpretation bias may not only be relevant as a between-group indicator of SUDs, but also as a prognostic, within-group individual difference variable (Woud et al., 2014).

Notably, all the studies reviewed here focused on alcohol-relevant contexts. However, it is plausible that an interpretation bias for non-substance relevant contexts may also contribute to SUDs via different pathways, i.e., increased negative affect and stress reactivity. A non-substance relevant negative interpretive style, like that observed in emotional disorders, might be relevant to SUDs for several reasons. Studies in emotional disorders have shown that a negative interpretation bias leads to increased negative affect and stress reactivity (Menne-Lothmann et al., 2014; Wilson et al., 2006), both of which have been found to be important in craving and relapse in SUDs (Sinha et al., 2006, 2011). Furthermore, the tendency to have a negative interpretation of arousal sensations and thoughts (i.e., anxiety sensitivity; Reiss, 1991) is associated with many facets of SUDs (Norton, 2001; Schmidt et al., 2007; Stewart et al., 1997). Despite these associations, no studies to date have directly tested whether SUD populations are characterized by interpretation bias for non-substance related situations. Of note, one study in a psychiatric sample found a trend for greater severity of substance misuse to correlate with a negative interpretation bias for anxiety and depression-relevant situations (r = .229) (Beard et al., 2017).

1.1. Current study

In contrast to the robust literature on interpretation bias in emotional disorders, very few studies have evaluated interpretation bias in individuals with SUDs. Empirical evidence linking interpretation bias to negative affect and stress reactivity in emotional disorders suggests that interpretation bias should theoretically lead to increased craving in individuals with a SUD. A better understanding of interpretation bias in SUD samples may help to identify risk factors for negative outcomes such as relapse. Characterizing interpretation bias in SUDs may also set the stage for including interpretation bias modification programs in SUD treatment, as this approach has had some success in patients with anxiety (Jones and Sharpe, 2017). Thus, the primary aim of the current study was to characterize interpretation bias for ambiguous situations in a SUD clinical sample.

Our first specific aim was to examine whether interpretation bias was associated with relevant SUD variables, specifically craving and confidence in the ability to maintain abstinence (abstinence self-efficacy). We hypothesized that an interpretation bias would be associated with greater craving and less abstinence self-efficacy. We included anxiety severity and anxiety sensitivity in models predicting craving and abstinence self-efficacy to determine whether interpretation bias contributed above and beyond the effects of comorbid anxiety.

Our second aim was to explore potential moderators of any association between interpretation bias and SUD characteristics. Given that anxiety is more prevalent in women (Kessler et al., 1994; McLean et al., 2011) and that women more frequently report using substances to regulate negative affect (McHugh et al., 2013; Thornton et al., 2012), we tested whether sex moderated associations between interpretation bias and substance variables. We also conducted exploratory tests of whether anxiety severity and primary type of substance (alcohol vs. opioid) moderated the hypothesized associations. We tested these hypotheses in a sample of adults attending an inpatient SUD treatment program.

2. Materials and methods

This study is part of a large, ongoing study of clinical characteristics of adults presenting for inpatient SUD treatment. For the current study, we added the WSAP interpretation bias assessment to the larger clinical battery from September 2015 to May 2017. Participants were recruited from an insurance-based inpatient detoxification unit of a private academic psychiatric hospital.

2.1. Participants

There were no exclusion criteria, and all patients attending this program were eligible to participate. A total of 293 participants enrolled in the parent study. A subgroup of participants did not complete the WSAP either because they declined this part of the study or because of time constraints (e.g., conflict with a clinical appointment). Thus, 224 participants (33% female) are included in the current analyses. The average age of the sample was 38.95 years (SD = 13.72, range 18–79). Based on self-report, the sample racial composition was 94% White and 93% non-Hispanic/Latinx. Half of the sample reported being never married, and 39% were employed full-time. Table 1 presents demographic and clinical characteristics of the sample.

2.2. Procedures

Study staff presented information on the study in group settings, and potential participants self-selected for participation. Participants were enrolled in a brief, inpatient stay focused on medical detoxification, with an average length of stay of 4 days. Participants were receiving inpatient detoxification using standard protocols, most commonly consisting of buprenorphine or chlordiazepoxide taper (for opioid use disorder and alcohol use disorder, respectively). Participants were enrolled after medical stabilization (day 2 or later of the inpatient stay) to ensure that they were not experiencing acute withdrawal symptoms and were not enrolled on the day of discharge due to logistical considerations. Following provision of informed consent, participants completed a brief (approximately 30-minute) battery of self-report measures on a tablet computer followed by a computer-based measure of interpretation bias (see below). Information on diagnosis was extracted from the medical chart. There were no incentives for participation. All procedures were approved by the local Intuitional Review Board.

2.3. Measures

2.3.1. Word-Sentence Association Paradigm (WSAP)

The WSAP (Beard and Amir, 2009) measures interpretation bias indirectly via an individual's endorsement or rejection of word-sentence pair associations. The WSAP is a commonly used measure of interpretation bias and includes many of the recommended features in recent reviews (Hirsch et al., 2016; Schoth and Liossi, 2017). It has

Table 1
Demographic and clinical characteristics.

Characteristic	Full Sample (N = 224) % or M (SD)	Primary Alcohol (n = 153) % or M (SD)	Primary Opioid (n = 66) % or M (SD)	Alcohol vs. Opioid $\chi 2$ or t
Age	38.95 (13.72)	43.41 (13.40)	29.73 (8.37)	9.15***
Gender				3.19
Male	67.0	63.40	75.76	
Female	33.0	36.60	24.24	
Race				4.16
Black	0.9	1.34	0.00	
White	94.0	93.29	95.24	
Asian	0.5	0.67	0.00	
American Indian	0.5	0.67	0.00	
Biracial/ Multiracial	0.5	0.00	1.59	
Other	3.7	4.03	3.17	
Ethnicity				2.14
NonHispanic/ Latinx	95	96.69	92.06	
Hispanic/Latinx	5	3.31	7.94	
Marital Status				38.27***
Never Married	50.7	37.09	80.0	
Married	21.7	29.14	4.62	
Divorced	15.8	21.19	4.62	
Separated	3.6	3.31	4.62	
Widow/Widower	0.9	1.32	0.0	
Partner	7.2	7.95	6.15	
Employment Status				9.56 [a]
Unemployed	30.3	25.83	41.54	
Full-Time	38.5	40.40	36.92	
Part-Time	11.3	11.26	9.23	
Student	4.1	3.97	1.54	
Retired	5.0	7.28	0.0	
Disabled	7.7	7.95	7.69	
Homemaker	3.2	3.31	3.08	
Education Level				39.08***
Some High School	4.5	2.61	9.09	
High School or GED	17.0	9.80	31.82	
Some college or 2-yr	35.3	32.03	42.42	
College degree (4 yr)	25.9	30.72	16.67	
Post-college educ.	17.4	24.84	0.0	
OASIS	11.56 (4.26)	11.44 (4.16)	11.52 (4.50)	−0.13
Craving Scale	4.26 (2.51)	3.65 (2.46)	5.45 (2.09)	−5.13***
BSCQ	5.88 (2.35)	6.10 (2.38)	5.53 (2.25)	1.64
ASI-3	26.33 (15.35)	27.06 (14.64)	23.84 (16.27)	1.44

Note: ASI-3 = Anxiety Sensitivity Index-3; BSCQ = Brief Situational Confidence Questionnaire; OASIS = Overall Anxiety Severity and Impairment Scale.
***$p < .001$.
[a] Employment status also did not significantly differ between primary substance groups when treated as a dichotomous variable (employed vs not).

demonstrated good internal consistency and test-retest reliability across various populations (Gonsalves et al., 2019). Salemink and Wiers (2014) previously used the WSAP to measure alcohol-relevant interpretation bias. In contrast, the current study used a version of the WSAP which presented ambiguous situations related to a range of daily life situations (see Appendix for examples). The WSAP presents negative and benign interpretations of ambiguous situations separately, and individuals are asked to make a relatedness judgment ("*Is the word related to the sentence?*").

We used the standard stimulus presentation timing and order (Beard and Amir, 2009). A trial began with a fixation cross (500 ms). Second, a word representing either the negative ("embarrassing") or benign ("funny") interpretation of an ambiguous sentence ("people laugh after something you said") appeared for 500 ms. Third, the ambiguous sentence appeared. Participants were instructed to press one key if the word and sentence were related or a different key if the word and sentence were not related. Participants completed 100 trials (50 negative; 50 benign). Stimuli were adapted from previous versions of the WSAP (Beard and Amir, 2009; Beard et al., 2011) and included ambiguous situations related to the following domains: daily stress, health, relationships, safety, and perfectionism. Following the standard use of the WSAP (see Gonsalves et al., 2019), we calculated participants' total endorsement rates across situations separately for benign and negative interpretations. Possible scores for each type of interpretation range from 0% to 100% of interpretations endorsed. Internal consistency in the current study was acceptable (split half reliability with spearman brown correction = .76).

2.3.2. Overall Anxiety Severity and Impairment Scale (OASIS; Norman et al., 2006)

The OASIS is a brief measurement of anxiety symptoms designed to capture symptoms across different types of anxiety disorders. The measure is comprised of five items assessing severity, frequency, and interference related to anxiety symptoms (sample item: "How often do you feel anxious") over the past week. Participants rate their experiences with anxiety on a scale from 0 to 4, with total scores ranging from 0 to 20. The OASIS has strong reliability and validity in clinical samples (Campbell-Sills et al., 2009). Internal consistency in the current study was strong (α = .849).

2.3.3. Anxiety sensitivity Index-3 (ASI-3; Taylor et al., 2007)

The ASI-3 is a revised version of the original Anxiety Sensitivity Index (Reiss et al., 1986). This 18-item measure assesses degree of fear and distress related to anxiety and anxiety-relevant sensations (sample item: "It is important for me not to appear nervous"). Items are rated on a Likert scale from 0 ("Very Little") to 4 ("Very Much") scale, and total scores range from 0 to 72. Previous studies have shown the ASI-3 to have good reliability and validity (Kemper et al., 2012; Taylor et al., 2007). Internal consistency in the current study was excellent (α = .922).

2.3.4. Craving Scale (Weiss et al., 2003)

The Craving Scale used in this study was originally developed as a measure of cocaine craving (Weiss et al., 2003), and has also been validated as a measure of craving in other substances including alcohol (McHugh et al., 2016) and opioids (McHugh et al., 2014). It contains three items assessing degree of current craving for substances (*"Please rate how strong your desire to use was in the past* 24 h*"*), retrospective craving when cued by something in the environment (*"Please rate how strong your urges are for drugs or alcohol when something in the environment reminds you of it")*, and perceived likelihood of substance use if given the opportunity (*"Please imagine yourself in the environment in which you previously used drugs or alcohol. If you were in this environment today, what is the likelihood you would use?"*), each rated on a scale from zero to ten with higher scores indicating stronger craving. Scores of the three items are then averaged for a total score. In the present study, participants were prompted to rate their craving for their primary substance of misuse. Internal consistency in the current study was satisfactory (α = .764).

2.3.5. Brief Situational Confidence Questionnaire (BSCQ; Sobell et al., 1996)

The BSCQ is an abbreviated eight-item version of the original Situational Confidence Questionnaire (Annis, 1986). Based on aspects of self-efficacy that are relevant to substance relapse, it evaluates perceived confidence in the ability to resist substance use in eight different types of situations and contexts (e.g., social, negative affect, and positive affect). Each item is rated on a zero to 100% confidence visual analogue scale. The BSCQ has good reliability and validity in clinical

samples (Breslin et al., 2000). Internal consistency in the current study was good (α = 0.869).

2.4. Data analytic plan

We used SPSS Version 25.0 for all analyses. We examined the range of interpretation endorsement scores and calculated the correlation between negative and benign interpretation endorsement scores. We calculated bivariate correlations between each interpretation index, anxiety, and SUD characteristics. We tested the unique contribution of interpretation bias and anxiety symptoms to craving and abstinence self-efficacy by conducting multiple linear regression analyses with the SUD variable as the dependent variable and interpretation bias, general anxiety severity, and anxiety sensitivity as the predictor variables. We included age as a covariate in both models. Cohen's *d* effect size estimates for independent groups were calculated by dividing the difference in group means by the pooled standard deviation (Cohen, 1988); d_z estimates for dependent *t*-tests were calculated by dividing the t-value by the square root of the sample size (Lakens, 2013).

We examined the potential interaction of anxiety severity and interpretation bias in predicting craving and abstinence self-efficacy. We examined multiple linear regression models to predict each SUD variable from anxiety severity (OASIS score, mean-centered), negative interpretation bias (WSAP score, mean-centered), and the interaction between anxiety and interpretation bias. We first confirmed that all assumptions of multiple linear regression were met (i.e., normality, homoscedasticity, and multicollinearity). We examined potential sex differences by conducting independent samples t-tests on WSAP scores and multiple linear regression models predicting SUD variables from sex (male = 1, female = 0), negative interpretation, and the interaction between sex and interpretation bias. Finally, we conducted similar analyses to test potential differences related to type of primary substance. The current inpatient SUD sample comprised mostly primary alcohol or opioid use disorders; thus, we created a substance type variable (alcohol = 1, opioid = 0). All comparisons involving substance type included 219 participants, as five participants reported other primary substances (e.g., benzodiazepines).

3. Results

Negative interpretation endorsement ranged from 6% to 98% (M = 47%, SD = 19), and benign endorsement ranged from 27% to 100% (M = 70%, SD = 14). Participants endorsed significantly more benign interpretations than negative, $t(223) = 10.02$, $p < .001$, $d_z = 0.67$. Negative and benign interpretation endorsement showed a negative, modestly sized correlation (r = -0.28, $p < .001$), supporting their independent examination. Table 2 presents bivariate correlations between the interpretation bias indices and symptom outcomes. Negative interpretation endorsement was positively correlated with general anxiety severity, anxiety sensitivity, and craving, and negatively correlated with abstinence self-efficacy. Benign interpretation endorsement was not correlated with any symptoms (all $ps > .4$). Consequently, we only included negative interpretation endorsement in all subsequent analyses.

Table 3
Multiple regression models predicting substance use characteristics (N = 224).

	B	SE	*t*	*p*-value
Model Predicting Craving ($F(4,214) = 11.435$, $p < .001$, $R^2 = 17.6\%$)				
Age	−0.06	.01	−4.87	< .001
Negative interpretation bias (WSAP)	1.92	.86	−2.223	.03
General anxiety severity (OASIS)	0.09	.05	2.03	.04
Anxiety sensitivity (ASI-3)	−0.01	.01	−.37	.72
Model Predicting Situational Confidence ($F(4,217) = 5.393$, $p < .001$, $R^2 = 9.0\%$)				
Age	0.02	.01	1.90	.06
Negative interpretation bias (WSAP)	−2.09	.85	2.46	.02
General anxiety severity (OASIS)	−0.06	.05	−1.23	.221
Anxiety sensitivity (ASI-3)	−0.01	.01	−0.81	.421

In multiple linear regression models, higher negative interpretation bias predicted more craving and less abstinence self-efficacy (see Table 3) above and beyond effects of general anxiety and anxiety sensitivity. The interaction of anxiety severity and negative interpretation bias did not predict craving (β = -0.05, SE = 0.20, t = -0.26, p = .799) or self-efficacy (β = -0.31, SE = 0.19, t = -1.64, p = .103).

Men and women did not differ in their negative ($t(222)$ = -0.34, p = .737, d = 0.05) or benign ($t(222) = 0.11$, p = .914, d = 0.02) interpretation endorsement on the WSAP. In the regression models including sex, the interaction of sex and negative interpretation bias was not a significant predictor of craving (β = 1.25, SE = 1.88, t = 0.67, p = .506) or self-efficacy (β = -0.04, SE = 1.74, t = -0.02, p = .981).

Interpretation bias also did not differ by type of primary substance (alcohol [n = 153] vs opioid [n = 66], see Fig. 1): negative interpretation ($t(217)$ = -1.27, p = .207, d = 0.19); benign interpretation ($t(217) = 1.68$, p = .094, d = -0.25). The interaction of substance type and negative interpretation bias was not a significant predictor of craving (β = -1.76, SE = 1.87, t = -0.94, p = .349) or self-efficacy (β = 1.23, SE = 1.85, t = 0.67, p = .506).

4. Discussion

We sought to extend the study of interpretation bias to individuals with SUDs. This adult SUD sample had a wide range of interpretation bias scores, with benign interpretation endorsement ranging from 27% to 100% and negative interpretation endorsement ranging from 6% to 98%. Overall, the sample favored benign interpretations (M = 70%) over negative interpretations (M = 47%). The range of interpretation scores, average values, and variability obtained in the current SUD sample are very similar to those obtained in a non-SUD, psychiatric hospital sample (benign M = 67%; negative M = 48%; Beard et al., 2017) and a healthy control sample (benign M = 71%; negative M = 49%; endorsement rates from the general (non-social) situations reported in Beard et al. (2009). Similar to previous findings in emotional disorders, negative and benign interpretation endorsement were only modestly correlated, supporting their separate examination. There were no differences in interpretation bias between individuals with an alcohol or opioid use disorder or between men and women.

Table 2
Correlations between interpretation bias indices and symptom outcomes (N = 224).

Craving	Negative Endorsement	Benign Endorsement	OASIS	ASI-3	Craving
Benign interpretation (WSAP) —	−.279***	—	—	—	—
Anxiety severity (OASIS) —	.201**	.053	—	—	—
Anxiety sensitivity (ASI-3) —	.270**	.013	.578***	—	—
SUD Craving (Craving Scale) —	.225**	.050	.227***	.123	—
Abstinence Self-Efficacy (BSCS) —	−.225**	−.038	−.193**	−.174**	−.449***

** p < .01, *** p < .001.

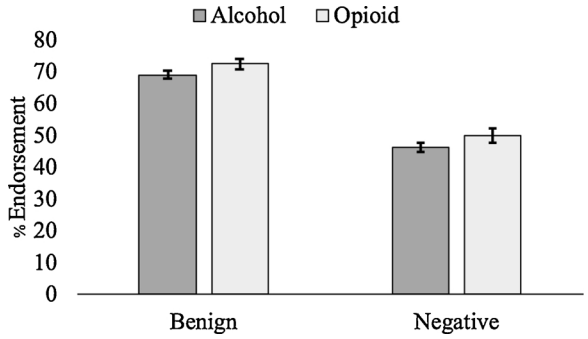

Fig. 1. WSAP Scores by Primary Substance Type.
Note: Error bars are equal to +/- 1 SE.

Results revealed that a tendency to endorse negative interpretations of ambiguous daily life situations correlated with substance use characteristics, whereas a tendency to endorse benign interpretations did not. Moreover, negative interpretation bias predicted craving and abstinence self-efficacy above and beyond general anxiety and anxiety sensitivity. In other words, individuals who interpreted daily life situations negatively experienced more craving and less confidence in their ability to resist urges to use, and this association was not simply due to anxiety comorbidity. These findings extend prior work with alcohol-relevant situations and suggest that a maladaptive interpretive style outside of a substance context might be an important individual difference factor relating to SUDs.

Anxiety severity and interpretation bias did not interact to predict substance use characteristics above and beyond the main effects of each variable. Rather, general anxiety and negative interpretation bias may have additive effects in predicting craving. Future studies might extend the current study by measuring these variables outside of inpatient treatment. For example, it is plausible that state anxiety and interpretation bias would interact to predict craving in-the-moment.

Men and women exhibited no significant difference in interpretation bias, and the association between interpretation bias and SUD variables was not moderated by sex. Few studies of interpretation bias in emotional disorders have examined potential sex differences. One exception in a psychiatric hospital sample also did not find sex differences in interpretation bias (Beard et al., 2017). However, this contrasts with findings suggesting that women with SUDs are more likely to have co-occurring anxiety and depressive disorders (Khan et al., 2013a, b), endorse more frequently using substances to cope with negative affect (McHugh et al., 2013; Thornton et al., 2012), and may have a greater impact of anxiety-related vulnerabilities on clinical symptoms (McHugh et al., 2017).

Our results suggest that interpretation operates, at least in part, independently of anxiety in SUD samples. Individuals with SUD who are prone to negative interpretation of ambiguous situations may experience the world as more threatening, less rewarding, and more hopeless and thus be more likely to use substances due to more frequent experiences of negative affect and stress reactivity. Helping these individuals to modify these negative interpretations could potentially lead to reduced craving and substance use. Although future research testing the temporal association between interpretation bias and substance-related outcomes will help to clarify the importance of this variable as a potential treatment target, interpretation bias has been shown to be modifiable via cognitive training tasks called Cognitive Bias Modification (CBM). For example, Cougle and colleagues (2017) observed improvements in interpretation bias and anger following an 8-session CBM intervention targeting hostile interpretation bias in individuals with high anger and alcohol use (Cougle et al., 2017). However, Woud and colleagues' attempt to reduce alcohol-relevant interpretation bias via CBM was not successful in hazardous male drinkers (Woud et al., 2015b). Given that many studies have demonstrated the efficacy of CBM in emotional disorders using non-substance related situations such as those used in the current study (Jones and Sharpe, 2017), future work should attempt to reduce the general negative interpretation bias for individuals with SUD who exhibit this bias. Future studies could inform such interventions by examining the association between interpretation bias and abstinence self-efficacy specifically during episodes of negative affect. Additionally, future studies should examine whether specific domains within the general interpretation bias (e.g., perfectionism vs daily stress) are more relevant to craving, self-efficacy, and ultimately relapse.

Strengths of the current study include the large clinical sample, examination of multiple SUD characteristics, and testing of potential moderators. The primary limitation is the cross-sectional design. Future work should extend these cross-sectional associations with prospective and experimental manipulation study designs. Such designs will also allow for consideration of state vs. trait anxiety and the temporal associations between anxiety and substance use. Additionally, future work might include multiple assessments of interpretation bias, craving, and self-efficacy during treatment to better understand their associations, as well as their association with relapse. The sample consisted of people with alcohol or opioid use disorders requiring an inpatient level of care; replication in other SUDs and at lower levels of care is needed to determine the generalizability of these findings. Age of onset for SUD was not available for the current study. Future studies should consider this when further characterizing the role of interpretation bias in SUD. We recruited participants following stabilization on the inpatient unit to ensure that participants were not experiencing acute withdrawal; however, inclusion of a withdrawal symptom measure would have strengthened our findings. Finally, the ethnoracial makeup of the sample is primarily White, and the education level indicates that individuals from this clinic have a high socioeconomic status. Future studies are needed in different regions and settings to determine whether the current findings generalize to individuals from other ethnoracial and economic backgrounds.

Future studies should also extend the current findings by including multiple types of ambiguous stimuli. For example, the current study did not include any situations related to anxiety sensitivity, the fear of the consequences of anxiety-related symptoms, which is also highly relevant to SUDs. Future studies should include situations related to ambiguous physical sensations and cognitive symptoms (Beard et al., 2016; Capron and Schmidt, 2016; Clerkin et al., 2015) to determine if an interpretation of anxiety-relevant symptoms as dangerous is associated with SUD outcomes. Finally, another direction for future research is the integration of interpretation bias measurement with other cognitive biases in SUDs. Theory and research in emotional disorders show that cognitive biases are interactive; for example, an attentional bias towards negative cues may also support or be influenced by a negative memory bias for such cues (Everaert et al., 2012; Hirsch et al., 2006). Given the strong evidence for other implicit cognitive biases in SUDs, future research should determine how potential biases in attention, approach, or memory may combine with interpretation bias in SUDs.

Contributors

CB contributed to the design, statistical analyses, and manuscript preparation. ADP contributed to the statistical and manuscript preparation. MLG contributed to manuscript preparation. RDW contributed to the design and manuscript preparation. NT contributed to data collection and manuscript preparation. RKM contributed to the design, data collection, analyses, and manuscript preparation. All authors contributed to and approved the final version of the manuscript.

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Declaration of Competing Interest

Roger Weiss consulted to GW Pharmaceuticals and Janssen Pharmaceuticals. No other conflicts of interest declared.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.drugalcdep.2019.107644.

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