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Thought suppression as a mediator of the association between depressed mood and prescription opioid craving among chronic pain patients

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Abstract Emerging research suggests that prescription opioid craving is associated with negative mood and depression, but less is known about cognitive factors linking depressive symptoms to opioid craving among adults with chronic pain. The present cross-sectional study examined thought suppression as a mediator of the relation between depression and prescription opioid craving in a sample of chronic pain patients receiving long-term opioid pharmacotherapy. Data were obtained from 115 chronic pain patients recruited from primary care, pain, and neurology clinics who had taken prescription opioids daily or nearly every day for ≥90 days prior to assessment. In this sample, 60 % of participants met DSM-IV criteria for current major depressive disorder. Depressed mood ($r = .36$, $p < .001$) and thought suppression ($r = .33$, $p < .001$) were significantly correlated with opioid craving. Multivariate path analyses with bootstrapping indicated the presence of a significant indirect effect of thought suppression on the association between depressed mood and opioid craving (indirect effect = .09, 95 % CI .01, .20). Sensitivity analyses showed a similar indirect effect of suppression linking major depressive disorder diagnosis and opioid craving. Attempts to suppress distressing and intrusive thoughts may result in increased craving to use opioids among chronic pain patients with depressive symptoms. Results highlight the need for interventions that mitigate thought suppression among adults with pain and mood disorders.

Keywords Opioid craving · Suppression · Depression · Emotion regulation · Self-medication · Allostasis · Chronic pain · Opioid misuse

Introduction

It has long been observed that individuals consume opioids to alleviate emotional as well as physical pain; such use of opioids harkens back millennia. The ancient Greeks used opium to treat melancholy (Dormandy, 2012); in Book Four of Homer's *Odyssey*, such use was referred to in the following passage: "Into the bowl in which their wine was mixed, she slipped a drug that had the power of robbing grief and anger of their sting and banishing all painful memories. No one who swallowed this dissolved in their wine could shed a single tear that day, even for the death of his mother or father…" (Fitzgerald, 1963), Despite the long history of such usage of intoxicants derived from the poppy plant, few empirical studies of chronic pain patients have explored the cognitive factors linking emotional distress to the urge to self-medicate with prescription opioids.

In contrast to this lacuna in the literature, the comorbidity of chronic pain and depression is well-established (Lépine & Briley, 2004). Rates of depression are 10–30 % higher among individuals reporting chronic pain conditions than the general population (McWilliams et al., 2004; Von Korff et al., 2005). Somatic symptoms associated with depression often include complaints of pain in the back,

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neck, stomach, joints, and chronic headaches (Currie & Wang, 2004; Ohayon & Schatzberg, 2003). Individuals with chronic pain and depression also tend to have greater pain chronicity (Gureje et al., 2001) and pain intensity (Lamb et al., 2000) compared to persons without depression. Depressed chronic pain patients are more likely to receive long-term opioid therapy compared to their non-depressed counterparts (Grattan et al., 2012), and have poorer health-related quality of life (Lépine & Briley, 2004).

Depressed individuals often engage in ineffective cognitive strategies in an attempt to achieve positive mental states, such as the chronic suppression of unwanted thoughts and emotions (Szasz, 2009). Maladaptive regulation of distressing thoughts is a key component of persistent negative thinking in psychopathology that can promote the maintenance of anxious and depressive symptoms (Purdon & Clark, 2001). A host of studies indicate that attempted suppression results in heightened levels of the very thoughts and emotions intended to be suppressed (Wenzlaff & Wegner, 2000). Moreover, suppression of emotionally-laden thoughts increases the intensity of subsequent emotional reactions (Wegner et al., 1990) and concomitant sympathetic nervous system arousal (Gross & Levenson, 1993). Despite the counterproductive effects of thought suppression as a means of emotion regulation, depressed individuals commonly employ this cognitive strategy (Szasz, 2009). Stemming from a desire to suppress unwanted thoughts and feelings, depressed persons with histories of substance use may experience heightened cravings or urges to use drugs as means of self-medication.

The self-medication hypothesis suggests that a dispositional inability to regulate distressing emotions contributes to the perpetuation of negative affective states and ineffective coping, which may in turn lead individuals to relieve emotional distress through substance use (Khantzian, 1997). From this perspective, emotional distress from comorbid depression and chronic pain might impel self-medication motives through substance craving and in turn increase vulnerability to substance misuse (Grattan et al., 2012; Morasco et al., 2013). In support of this contention, depressed mood and depressive thinking styles predict opioid craving among chronic pain patients (Martel et al., 2013, 2014b; Wasan et al., 2009, 2012), and data indicate that mood and anxiety disorders are concurrent with (Green et al., 2011) and antecedent to the onset of opioid misuse and dependence (Edlund et al., 2007; Martins et al., 2012).

Although existing evidence suggests that opioids may be misused as a means of alleviating affective distress, little is known about cognitive mechanisms that underlie cravings for prescription opioids among individuals with chronic pain and depression. Hypothetically, depressed individuals who are prone to seek relief through substance use may consequently experience greater craving for opioids as means of suppressing depressed moods. The current cross-sectional study examined thought suppression as a statistical mediator of the relationship between depression and opioid craving among a sample of chronic pain patients receiving long-term opioid pharmacotherapy. We posited that symptoms of depressed mood would be positively correlated with opioid craving, and that thought suppression would statistically mediate this association between depressed mood and opioid craving, after controlling for the influence of pain severity, a known correlate of both opioid craving (Edwards et al., 2011; Ren et al., 2009) and depression (Bair et al., 2008). Notably, women report higher opioid craving than men (Back et al., 2011), and age is inversely associated with craving (Hintzen et al., 2011; Hulse et al., 2010). Moreover, age and gender are correlated with thought suppression (Erskine et al., 2007; Wegner & Zanakos, 1994). Hence, we also controlled for these demographic variables in our path analyses to reduce confounding of our estimate of the indirect effect of suppression on the association between depressed mood and opioid craving.

Methods

Participants

Participants (N = 115) met study inclusion criteria if they reported recurrent pain (i.e., pain on more days than not) stemming from chronic benign (i.e., non-cancer-related) pain conditions, arthritis or fibromyalgia and had been prescribed and taken opioids for analgesia daily or nearly every day (≥5 days/week) for at least the past 90 days (Chou et al., 2009). Participants were recruited between 2011 and 2012 from primary care clinics, pain clinics, and neurology clinics in Tallahassee, FL through posted flyers, as well as from online classified ads. Participants were assessed for comorbid psychiatric disorders with the Mini-International Neuropsychiatric Interview 6.0 (Sheehan et al., 1998) and excluded if they were actively suicidal or psychotic.

Procedure and measures

Following a preliminary phone screening for eligibility, potential participants were screened in the first author's lab. Individuals who met eligibility criteria and agreed to participate in the study completed an assessment where they reported demographic and clinical information on questionnaires, after which they completed a psychophysiological measurement protocol (not discussed in the present

manuscript). Informed consent and study procedures were conducted in compliance with the Florida State University Human Subjects Committee (where the first author was located at the time of data collection).

Thought suppression

Frequency of thought suppression, the counterproductive tendency to avoid or suppress undesirable cognitions and emotions, was assessed with the 15-item White Bear Suppression Inventory ($\alpha = .94$) (Wegner & Zanakos, 1994). Participants indicated their level of agreement (1 = strongly disagree, 5 = strongly agree) with items such as "I always try to put problems out of mind" and "I often do things to distract myself from my thoughts." Items were summed to produce a total score, with higher scores indicative of greater trait thought suppression. Although earlier factor analyses supported the notion of a single thought suppression factor (Muris et al., 1996; Wegner & Zanakos, 1994), a review of later factor analytic studies of the WBSI (Schmidt et al., 2009) revealed two factors consisting of a suppression subscale ($\alpha = .88$) and an intrusive thoughts subscale ($\alpha = .91$). These subscales have tended to correlate at $r > .60$ in prior studies. Because our interest was in suppression as a mediator of the association of depressed mood and opioid craving (and not in intrusive thoughts per se), in the present study we computed primary analyses with the suppression subscale of the WBSI as the subscale of interest.

Prescription opioid craving

A prescription opioid version of the Obsessive Compulsive Drug Use Scale-Revised (OCDS-R; $\alpha = .91$) (Morgan et al., 2004) was used to assess opioid craving in the past month. Participants responded to 10 items rated on a five-point Likert-type scale (0 = *never*, 5 = *very often*) regarding how often in the past 30 days they had the urge to use opioids. Higher scores on the OCDS-R are indicative of more compulsive behaviors or obsessive thinking regarding the use of substances such as opioids. The original OCDS-R validation study conducted with patients treated for substance abuse found internal consistencies that ranged from .91 to .88 from baseline scores to end of treatment scores (Morgan et al., 2004). Moreover, it was found that OCDS-R scores were positively correlated with the rate of recent substance use, overall substance use severity, number of substance use consequences, and severity of substance dependence (Morgan et al., 2004). Other studies have successfully used the OCDS-R to assess relationships between the frequency of prescription opioid craving and attentional biases among opioid dependent chronic pain patients compared to non-dependent opioid users (Garland et al., 2013a). Because the OCDS-R contains two items that are related to the construct of thought suppression (e.g., "How much of an effort do you make to resist or turn away from thoughts related to using [opioids]?" and "How successful are you in stopping or diverting these thoughts?"), we dropped these two items and computed a trimmed OCDS-R score without these items ($\alpha = .86$) to prevent spurious associations with thought suppression.

Average pain severity

Average pain severity in the past week was measured with a single item from the Brief Pain Inventory; a well-validated measure widely used to assess acute and chronic pain (Cleeland, 1994). Participants reported their average pain over the past week. Response options ranged from 0 (*no pain*) to 10 (*pain as bad as I can imagine*).

Depressed mood

The depression subscale ($\alpha = .89$) of the 56-item Calgary Symptoms of Stress Inventory (Carlson & Thomas, 2007) was used to assess depressed mood in this study. The C-SOSI is comprised of 8, internally-consistent subscales with adequate convergent and discriminant validity, that has been used to assess affective symptoms secondary to stress in individuals with medical conditions like chronic pain (Cho et al., 2015; Garland et al., 2014b), cancer (Carlson & Thomas, 2007), and irritable bowel syndrome (Zernicke et al., 2013). The 8-item depression subscale is comprised of items such as "During the last week, have you felt like life is entirely hopeless?" and "During the last week, have you felt unhappy and depressed?" that are rated on a 5-point scale ranging from *never* to *frequently*. In prior validation research, scores on this subscale converged with depression scores on the Profile of Mood states ($r = .87$) (Carlson & Thomas, 2007).

Major depressive disorder

The major depressive disorder assessment from the MINI (Sheehan et al., 1998) was used to determine whether participants met DSM-IV-TR criteria for a current major depressive disorder. This clinical measure of depression has good inter-rater reliability and convergent validity with other validated self-report measures of depressed mood (Sheehan et al., 1998).

Opioid dose

Participants were asked to report their opioid prescriptions in terms of types of opioid agent prescribed, dosage per pill, and frequency of administration. To account for potential overuse, participants were asked to report the total amount taken per day and not the amount prescribed per day. Total opioid dose per day was computed by converting each opioid prescription into morphine equivalent daily doses (MEDD) via equianalgesic conversion table (Agency Medical Directors Group, 2015) and computing the total MEDD consumed per day.

Data analysis

Pearson correlations were used to examine zero-order associations between study variables. Potential multicollinearity issues were screened by examining the variance inflation factor (VIF) of each variable. To examine whether the relation between depressive mood symptoms (C-SOSI) and opioid craving (OCDS-R) was mediated by thought suppression, multivariate path analysis was conducted with AMOS 17.0, which uses Full Information Maximum Likelihood (FIML) methods to estimate missing data. The model controlled for average pain severity, gender, and age. Statistical mediation was tested with boostrapping procedures (Preacher & Hayes, 2008). Unstandardized indirect effects were computed for each of 1,000 bootstrapped samples, and the 95 % confidence interval was computed by determining the indirect effects at the 2.5th and 97.5th percentiles. Significance of the indirect effect was indicated by the upper and lower limits of the 95 % confidence interval not spanning zero. This method has been recommended as superior to a normal theory approach to testing mediation (e.g., Sobel test) because it does not assume normality of the indirect effect sampling distribution. Overall model fit (Bentler, 1990) was assessed by examining the Chi square statistic and the Comparative Fit Index (CFI) and Incremental Fit Index (IFI). Non-significant Chi square values are indicative of adequate model fit. CFI values approaching 1 indicate better model fit, with .90 being the conventional cut-off for a model with adequate fit.

We conducted a series of sensitivity analyses to ensure the robustness of our findings. We first tested a path model where a variable representing presence/absence of a current DSM-IV major depression disorder was used in place of the C-SOSI depressed mood variable to examine mediators of the association between depression and opioid craving. By running separate models with a measure of depressed mood as a continuous variable and major depressive disorder as a dichotomous variable, we bolstered the statistical and conceptual validity of our findings—indeed, patients with a clinical diagnosis of major depressive disorder might differ with regard to their suppression and opioid craving in important ways from non-depressed individuals with subclinical depressive symptoms. Next, due to significant missingness on the MEDD variable (40 % missing), a separate sensitivity analysis with this variable as a covariate was conducted with the subsample of participants with complete MEDD data. Because other model specifications are always possible with cross-sectional data, we tested a series of alternative path models in which different causal orders between variables were assessed. The relative quality and parsimony of these models was assessed with the IFI, CFI, Chi square statistic, and the Akaike Information Criterion (AIC).

Results

Descriptive statistics

The most common current chronic pain condition reported by participants was low back pain, followed by fibromyalgia, arthritis, cervicalgia, and "other" pain conditions. More than half (60.0 %) of participants met DSM-

Table 1 Demographic and clinical characteristics of prescription opioid using chronic pain patients (N = 115)

Measure	(N = 115)
Demographics	
Female, N (%)	78 (68 %)
Age	48.3 ± 13.6
Pain and psychiatric diagnoses	
Primary pain condition, N (%)	
Low back pain	65 (57 %)
Fibromyalgia	23 (20 %)
Arthritis	8 (7 %)
Cervicalgia	7 (6 %)
Other	12 (10 %)
Major depressive disorder, N (%)	69 (60 %)
Generalized anxiety disorder, N (%)	35 (31 %)
Post-traumatic stress disorder, N (%)	14 (12 %)
Alcohol use disorder, N (%)	15 (13 %)
Non-opioid substance use disorder, N (%)	10 (9 %)
Clinical characteristics	
C-SOSI depressed mood	11.1 ± 7.1
WBSI total score	48.8 ± 13.6
WBSI thought suppression subscale	20.4 ± 5.7
BPI average pain severity	5.8 ± 1.7
Morphine equivalence daily dose	180.2 ± 469.9

OCDS-R Obsessive Compulsive Drug Use Scale-Revised (Morgan et al., 2004); *WBSI* White Bear Suppression Inventory (Wegner & Zanakos, 1994); *C-SOSI* Calgary Symptoms of Stress Inventory (Carlson & Thomas, 2007); *BPI* Brief Pain Inventory (Cleeland, 1994)

Table 2 Zero-order correlations between study variables (N = 115)

	C-SOSI depressed mood	Major depressive Dx	OCDS-R opioid craving	WBSI total score	WBSI suppression subscale	BPI average pain	MEDD opioid dose
C-SOSI depressed mood	1						
Major depressive Dx	.25**	1					
OCDS-R opioid craving	.36***	.10	1				
WBSI total score	.50***	.26**	.36***	1			
WBSI suppression subscale	.44***	.24*	33***	.85***	1		
BPI pain severity	.44*	.24*	.13	.06	.05	1	
MEDD opioid dose	.16	.02	.26*	.29*	.20	.11	1

* $p < .05$; ** $p < .01$; *** $p < .001$

OCDS-R Obsessive–Compulsive Drug Use Scale-Revised (Morgan et al., 2004); *WBSI* White Bear Suppression Inventory (Wegner & Zanakos, 1994); *C-SOSI* Calgary Symptoms of Stress Inventory (Carlson & Thomas, 2007); *Major Depressive Dx* MINI major depressive disorder dx (Sheehan et al., 1998); *BPI* = Brief Pain Inventory (Cleeland, 1994)

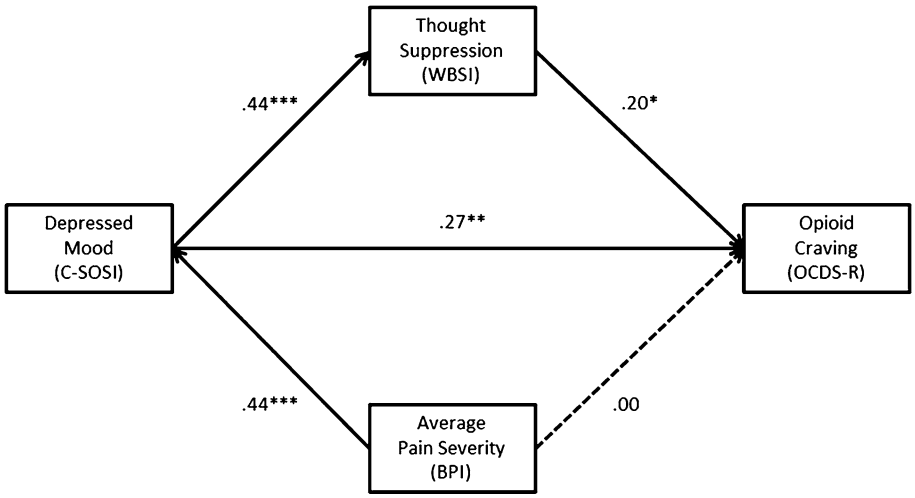

Fig. 1 Multivariate path model testing the mediating effect of thought suppression on the relationship between depressed mood and opioid craving (N = 115). The bootstrapped unstandardized indirect effect was .09, and the 95 % confidence interval ranged from .01 to .20. *Legend*: *Dashed lines* indicate nonsignificant pathways. This model controlled for age and gender, which are not shown for the sake of parsimony. *C-SOSI* Calgary Symptoms of Stress depressed mood subscale, *OCDS-R* Obsessive Compulsive Drug Use Scale-Revised, *WBSI* White Bear Suppression Inventory suppression subscale score, *BPI* Brief Pain Inventory average pain severity item

IV criteria for current major depressive disorder, and other psychiatric disorders were less common in the sample. See Table 1 for a sample description.

Zero-order correlations

Table 2 depicts zero-order correlations between study variables, which tended to be moderate-to-small in strength. C-SOSI depressed mood and WBSI thought suppression scores were significantly correlated with each other and with OCDS-R opioid craving scores. Depressed mood was correlated with average pain severity, but neither suppression nor opioid craving were significantly correlated with average pain intensity. MEDD opioid dose was significantly correlated with craving and the WBSI total scale score, but not with other study variables.

Mediators of the association between depression and opioid craving

The multivariate path model testing our primary hypothesis (model 1; see Fig. 1) indicated that the standardized regression coefficient between C-SOSI depressed mood

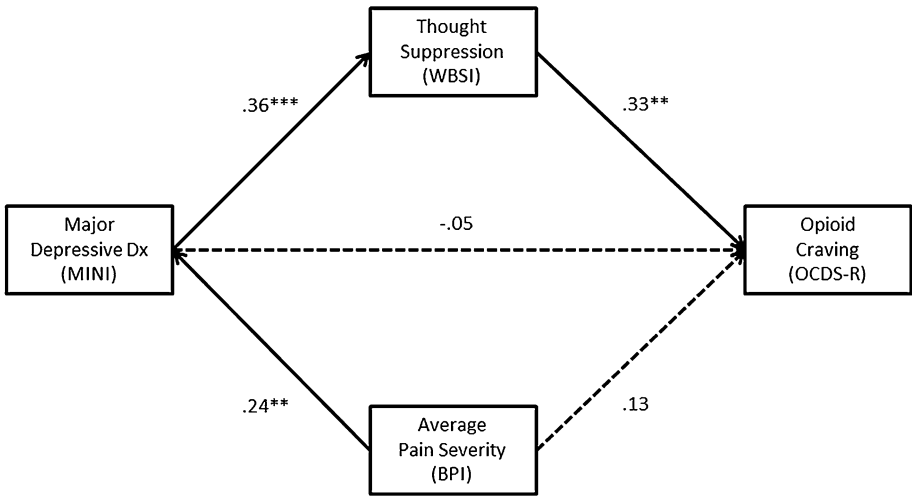

Fig. 2 Multivariate path model testing the mediating effect of thought suppression on the relationship between current major depressive disorder diagnosis and opioid craving (N = 115). The bootstrapped unstandardized indirect effect was 1.51, and the 95 % confidence interval ranged from .37 to 4.03. *Legend*: *Dashed lines* indicate nonsignificant pathways. This model controlled for age and gender, which are not shown for the sake of parsimony. Major depressive Dx = major depressive disorder diagnosis (obtained via Mini-International Neuropsychiatric Interview); *OCDS-R* Obsessive Compulsive Drug Use Scale-Revised, *WBSI* White Bear Suppression Inventory suppression subscale score, *BPI* Brief Pain Inventory average pain severity item

scores and WBSI suppression scores was statistically significant, as was the standardized regression coefficient between WBSI suppression scores and OCDS-R scores. Model fit statistics were excellent ($\chi^2/df = 1.03$, $p = .40$; IFI = 1.0; CFI = 1.0). The bootstrapped unstandardized indirect effect was .09, and the 95 % confidence interval ranged from .01 to .20. Thus, the indirect effect of thought suppression on opioid craving was statistically significant.

In a sensitivity analysis (model 2; see Fig. 2), a multivariate path model using major depressive disorder diagnosis in place of the C-SOSI depressed mood variable showed the same pattern as above: the standardized regression coefficient between major depressive disorder diagnosis and WBSI suppression scores was statistically significant, as was the standardized regression coefficient between WBSI suppression scores and OCDS-R scores. Model fit statistics remained excellent ($\chi^2/df = .42$, $p = .86$; IFI = 1.0; CFI = 1.0). The bootstrapped unstandardized indirect effect was 1.51, and the 95 % confidence interval ranged from .37 to 4.03. Thus, the indirect effect of thought suppression on opioid craving was statistically significant. However, there was no direct effect between major depressive disorder diagnosis and opioid craving.

A final sensitivity analysis controlling for MEDD did not significantly change the valence or significance of any of the observed paths. The bootstrapped unstandardized indirect effect was .09, and the 95 % confidence interval ranged from .01 to .26, indicating that suppression mediated the association between depressed mood and opioid craving after controlling for individual differences in MEDD.

Alternative model specifications

Due to the cross-sectional nature of the data, alternate model specifications are possible (see Table 3 for fit statistics and tests of the indirect effect). We first tested a series of models (models 3 and 4) in which OCDS-R opioid craving was the independent variable, WBSI suppression was the mediator, and depressed mood or depression diagnosis were used as the dependent variables. In these models, model fit statistics were excellent, and the indirect effect of OCDS-R scores on depressed mood and depression through WBSI suppression scores was significant. In a second series of models, BPI average pain severity was examined as the independent and dependent variable in two models (models 5 and 6), with WBSI suppression scores the mediator. Though these models fit the data well, the indirect effect of WBSI suppression was non-significant. A final set of models explored WBSI suppression as an independent variable, but these models either fit the data poorly or did not contain significant indirect effects.

Discussion

Study findings were consistent with our hypotheses. Depressed mood was significantly associated with opioid craving, and this association was statistically mediated by thought suppression, such that chronic pain patients with greater depressed mood tended to engage in more frequent use of thought suppression, which in turn was associated with greater opioid craving. This mediational relationship

Table 3 Comparison of alternative path model specifications in a sample of chronic pain patients receiving long-term opioid pharmacotherapy (N = 115)

Model	Independent variable	Mediator variable	Dependent variable	Fit statistics				Estimate indirect effect (95 % C.I.)
				χ^2 *p* value	CFI	IFI	AIC	
1	C-SOSI	WBSI	OCDS-R	.40	1.0	1.0	48.19	.09 (.01, .20)
2	MDD Dx	WBSI	OCDS-R	.86	1.0	1.0	44.54	1.51 (.37, 4.03)
3	OCDS-R	WBSI	C-SOSI	.86	1.0	1.0	44.50	.12 (.04, .25)
4	OCDS-R	WBSI	MDD Dx	.88	1.0	1.0	44.44	.05 (.01, .13)
5	C-SOSI	WBSI	BPI	.54	1.0	1.0	36.17	−.01 (.04, .00)
6	BPI	WBSI	OCDS-R	.88	1.0	1.0	34.68	.03 (−.23, .30)
7	WBSI	OCDS-R	C-SOSI	.60	1.0	1.0	45.53	.08 (−.01, .17)
8	WBSI	C-SOSI	OCDS-R	.00	.57	.66	67.39	.22 (.01,.44)

All models controlled for age, gender, and average pain severity. *C-SOSI* Calgary Symptoms of Stress depressed mood subscale; *MDD Dx* major depressive disorder diagnosis (obtained via Mini-International Neuropsychiatric Interview); *OCDS-R* Obsessive Compulsive Drug Use Scale-Revised; *WBSI* White Bear Suppression Inventory suppression subscale score; *BPI* Brief Pain Inventory average pain severity item; *IFI* incremental fix index; *CFI* comparative fit index; χ^2 *p* = *p* value of the Chi square statistic; *AIC* Akaike information criterion; *C.I.* confidence interval

remained significant after accounting for the influence of potential confounding variables including average pain severity, age, gender, and opioid dose. Sensitivity analyses indicated a similar pattern—there was a significant indirect effect of suppression linking major depressive disorder diagnosis to opioid craving. Taken together, findings suggest that chronic pain patients may experience heightened opioid craving when trying to suppress distressing thoughts occasioned by depressed mood states, irrespective of the intensity of their pain symptoms.

These results converge with findings from a sample of prescription opioid dependent individuals in acute detoxification and long-term outpatient treatment, 94 % of whom reported frequent misuse of opioids to self-medicate negative affect (Garland et al., 2014a). Similarly, findings parallel those observed by Martel and colleagues, who found that maladaptive cognitive coping (i.e., catastrophizing) was associated with opioid misuse (Martel et al., 2013) and opioid craving (Martel et al., 2014) in patients with chronic pain, and that opioid craving mediated the association between negative affect and opioid misuse among pain patients (Martel et al., 2014). Consistent with prior studies (e.g., Wasan et al., 2009), there was only a weak and non-significant association with pain severity and opioid craving in the present sample—suggesting that the desire for opioids can be independent from pain and driven by appetitive motivations and/or the need to alleviate negative affect. The current study extends findings from previous research by indicating that above and beyond the drive to obtain pain relief, individuals may experience elevated opioid craving when they attempt to suppress depressive thoughts and feelings. Plausibly, this effect would be strongest among patients with a history of misusing opioids as a means of self-medication. However, to be clear, the WBSI measures the frequency rather than the content of suppression, so the aforementioned interpretation must remain provisional at best.

Among persons with substance use disorders, thought suppression may impair successful regulation of emotional distress and craving. A recent review of the research indicates that attempted suppression of unwanted cognitions and affect associated with addictive behaviors may inadvertently increase intrusive thoughts and emotions and exacerbate substance use (Moss et al., 2015). For example, when instructed to suppress cravings following alcohol cue exposure, alcoholics evidenced faster reaction times to alcohol-related statements than neutral phrases (Palfai et al., 1997). Similarly, alcoholics exhibited greater Stroop interference for the word "alcohol" after suppressing alcohol-related thoughts as compared to individuals who expressed such thoughts (Klein, 2007). Beyond increasing cognitive accessibility of substance-related thoughts, suppression may cause rebound effects on appetitive behavior. Indeed, suppression of thoughts of smoking (Erskine et al., 2011) and eating (Erskine & Georgiou, 2010) leads to significantly greater engagement in such behaviors. To explain these rebound effects, Wegner's ironic process theory (Wegner, 1994) posits that attempts to control the mind involve two processes: (1) a conscious process that searches for desired cognitive content, and (2) an underlying monitoring process that searches for cognitive content unrelated to the desired mental state. When individuals exert effort and fail to suppress negative thoughts, the monitoring process is deployed and replaces the desired

mental state with unwanted cognitions, emotions, and behavioral impulses (Wegner & Erber, 1992). Ironically, distressing thoughts are amplified by processes intended to control them (Abramowitz et al., 2001). Consequently, suppression may tax self-regulatory resources (Baumeister, 2003). In support of this notion, among a sample of alcoholics, thought suppression was associated with attenuated cue-elicited heart rate variability responses during an alcohol cue-reactivity protocol, putatively indicative of depletion of neurocognitive resources needed for inhibitory control and emotion regulation (Garland et al., 2012).

Deleterious effects of chronic thought suppression among patients with pain and depressed mood may be magnified by the effects of addictive behaviors on affective neural circuitry. Addiction is associated with dysregulation of brain stress and reward systems, which may lead to loss of control over substance intake (Koob & Le Moal, 2001). Specifically, allostatic alterations to the extended amygdala are thought to result in sensitization to emotional distress (Shurman, et al. 2010) and insensitivity to reward, resulting in hedonic deficits and increased dysphoria (Koob & Le Moal, 2008). Hypothetically, attempts to suppress depressed mood with opioids may increase the occurrence of intrusive thoughts, which in turn might drive the craving to misuse opioids, especially when such suppression attempts have exhausted resources needed for self-regulation (Baumeister, 2003). Future studies should assess to what extent chronic pain patients experience a rebound in negative cognitions following an episode of opioid self-medication (and suppression) of negative affect.

A primary limitation of this study was its cross-sectional nature, which precludes definitive conclusions about causal ordering of the variables under investigation. While our results suggest potential directional effects, it is uncertain if depressed mood is antecedent to thought suppression and if the suppression of thoughts is a precursor of opioid craving. Indeed, our alternative model specifications found that opioid craving was associated with increased thought suppression, which in turn mediated the linkage between opioid craving and depressed mood—suggesting that the attempt to suppress opioid craving may increase dysphoric mood states. Alternatively, given that dysregulation of serotonin-norepinephrine neurotransmission in endogenous pain pathways may contribute to persistent pain (Marks et al., 2009), and that the analgesic effects of opioids are partially mediated by monoamines (Yaksh, 1979), it is possible that opioids might be used to rectify a monoamine deficit rather than facilitate thought suppression. Recursive feedback loops might be at play, and cross-sectional research is incapable of fully capturing the dynamic at play. That said, study participants were chronic pain patients who had been prescribed opioids, and thus it is plausible that the natural history of their opioid craving began with legitimate use as a means of alleviating pain, followed by depression in the absence of adequate relief, which then may have resulted in opioid craving fueled by the desire to self-medicate negative affect (Garland et al., 2013c). Through a history of negative reinforcement conditioning from opioid-induced relief of depressive symptoms, participants might have developed the habit of suppressing negative affect via opioid misuse, or the tendency toward suppression might be a persistent, trait-level cognitive characteristic among depressed patients that confers risk for opioid craving and misuse. Due to the cross-sectional nature of the data, we could not assess the temporal stability of thought suppression in this sample, though prior studies have demonstrated this construct to be a fairly stable trait among individuals with (Spinhoven & van der Does, 1999) and without (Wegner & Zanakos, 1994) affective disorders. Longitudinal research will provide a more rigorous means of elucidating causal ordering of the relationships examined in this study.

Another concern is our use of the C-SOSI to measure depressed mood; although this measure of depression has been validated in chronic pain samples (Cho et al., 2015; Garland et al., 2014b; Zernicke et al., 2013), it has not been used as commonly as other measures like the BDI. The study was also limited by the lack of complete and validated data on opioid dosing and other psychotropic medication usage. We were unable to obtain MEDD for the whole sample due to non-responses and ambiguous responses (e.g., reporting opioid dose without reporting number of pills taken per day) on our self-report opioid dosing measure. Future studies should carefully track opioid dosing using prescription history, pill counts, and biochemical verification.

Despite these limitations, this study provides preliminary findings with implications for clinical practice. Our results suggest that thought suppression significantly mediates relationships between depression and opioid craving; thus, treatment of intrusive cognitions may be critical to providing effective services that conjointly address depressive and substance-related symptomology in chronic pain patients. Mindfulness-based interventions may provide an effective alternative to thought suppression and thereby offer promise as a means of treating addiction (Chiesa & Serretti, 2013). Mindfulness, which involves acceptance of unwanted cognitions and feelings, may help prevent the rebound effect associated with suppression of intrusive thoughts (Wegner, 2011), and thereby allow for exposure to and extinction of stress-primed addictive responses (Garland et al., 2013b). In that regard, among a sample of substance abusers, participation in a mindfulness program decreased thought sup-

pression which mediated the effect of mindfulness on alcohol consumption (Bowen et al., 2007). Similarly, a mindfulness intervention for alcoholics led to significant reductions in thought suppression that were correlated with decreased alcohol attentional bias and increased autonomic recovery from a stress-primed alcohol cue-reactivity protocol (Garland et al., 2010). Specific to chronic pain, Garland et al. (2014b) conducted a randomized controlled trial examining the effects of a Mindfulness Oriented Recovery Enhancement (MORE) intervention on prescription opioid misuse among chronic pain patients. MORE aims to address addictive responses by *exposing* individuals to unpleasant mental and somatic experiences rather than by *suppressing* them, which may allow for greater self-regulation of negative emotions and craving (Garland, 2013). Patients treated with MORE reported greater reductions in chronic pain, stress, and opioid craving than those who participated in a social support control group, and were less likely to meet criteria for opioid use disorder following treatment (Garland et al., 2014b). Future studies are needed to examine reductions in thought suppression as a potential mediator of the therapeutic effects of mindfulness-based interventions.

In summary, findings suggest that among adults with co-occurring depressive and chronic pain symptoms the tendency to suppress negative thoughts is significantly linked to the appetitive drive to consume opioid medication. Our study provides preliminary support for thought suppression as a mediator of the association linking depression and prescription opioid craving among chronic pain patients. Additional research examining the relationship of aversive thoughts and emotions to opioid self-medication is clearly warranted. Longitudinal studies are needed to elucidate cognitive-affective mechanisms implicated in the etiology of opioid use disorders among individuals with chronic pain and mood-related symptoms.

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Compliance with ethical standards

Conflict of interest Eric L. Garland, Samantha M. Brown, and Matthew O. Howard declares that they have no conflicts of interest to declare.

Human and animal rights and Informed consent All procedures followed were in accordance with ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study.

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