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# Using ecological momentary assessment to assess the temporal relationship between sleep quality and cravings in individuals recovering from substance use disorders

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## HIGHLIGHTS

- Max. daily drug cravings predicted worse sleep quality at the within- and between-person level.
- Worse sleep predicted higher levels of drug cravings at the within- and between-person level.
- Willpower mediated the association between sleep quality and cravings.

## ARTICLE INFO

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## ABSTRACT

*Introduction:* The causal direction of the relationship between sleep disturbance and drug cravings is unknown. Based on resource depletion literature, we hypothesized that sleep difficulties lead to cravings. We tested whether sleep quality predicts craving at the within- or between-person level, with perceived willpower as a multilevel mediator.

*Methods:* We used ecological momentary assessments (EMA) to compare two models of temporal precedence. Participants in addiction treatment ($N = 122$) were sent four surveys each day for three weeks. Participants rated previous night's sleep quality and level of cravings and willpower.

*Results:* The between- ($\beta = -0.18$, $SE = 0.06$) and within-person ($\beta = -0.02$, $SE = 0.02$) effects of maximum daily craving on sleep quality were significant, as were the between- ($\beta = -0.33$, $SE = 0.08$) and within-person ($\beta = -0.08$; $SE = 0.03$) effects of daily sleep quality on maximum daily cravings. In the mediation analysis of the indirect effect of sleep quality on cravings via willpower, both the indirect effect for the between-person pathway ($\beta = -0.27$, $SE = 0.07$) and the indirect within-person pathway ($\beta = -0.01$, $SE = 0.01$) were significant.

*Conclusions:* EMA methodology allowed for disentanglement of the temporal relationship between sleep and cravings. We found support for the resource depletion hypothesis, operationalized by linking sleep quality to cravings via willpower. However, the magnitude of the association between sleep quality and cravings was stronger at the between-person level, suggesting a potentially cumulative effect of poor sleep on cravings. These results suggest that clinicians should ask patients about chronic sleep problems, as these may pose a risk for relapse.

## 1. Introduction

Studying antecedents to relapse episodes is important, as this knowledge may inform possible interventions. Drug or alcohol craving, or experiencing an urge to use, is one risk factor for relapse: Evidence supports a strong link between cravings and subsequent use of illegal and/or illicit substances (Serre, Fatseas, Swendsen, & Auriacombe, 2015). However, there is a great deal of within- and between- person variation with respect to the probability of relapse following craving (Serre et al., 2015). Identifying contextual factors that predict cravings and relapse would be beneficial. So far, the field has focused on both internal (i.e., affect, Serre et al., 2015) and external (i.e., time of day, Ramirez & Miranda, 2014; day of week, Lane, Carpenter, Sher, & Trull, 2016; and location, Lane et al., 2016) contextual predictors of craving,

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but more can be done to bolster the literature on this topic.

Sleep is an under-explored correlate of drug or alcohol cravings with promising intervention potential. There is a known association between sleep problems and cravings (Lydon-Staley et al., 2017), but the causal direction is unknown: people struggling with cravings may have difficulty sleeping, or people who have difficulty sleeping may have more subsequent cravings. There is some evidence that nicotine cravings can negatively impact sleep: Riemerth, Kunze, and Groman (2009) found evidence that approximately 20% of patients taking part in a smoking cessation program awoke in the night and had to smoke a cigarette before returning to sleep. Riemerth and colleagues deemed this symptom "nocturnal sleep-disturbing nicotine craving" (Riemerth et al., 2009; Rieder, Junze, Groman, Kiefer, & Schoberberger, 2001), and this construct may theoretically be present for other substances of addiction as well.

However, another theory suggests that the causal pathway leads from sleeping difficulties to cravings because sleep deficits are linked with resource depletion, which may in turn give rise to more cravings. The theory of resource depletion posits that self-regulation draws upon limited cognitive resources; prolonged effortful regulation depletes the cognitive resources, leading to "self-regulatory failures" (Baumeister, Bratslavsky, Muraven, & Tice, 1998). We hypothesized that sleep disturbance can influence one's self-regulatory capacity, thereby lowering the threshold for resource depletion. Sleep disruption has been linked with alcohol consumption (Christiansen, Cole, & Field, 2012), binge eating (Trace et al., 2012), and self-harm (Wong, Brower, & Zucker, 2011). Furthermore, sleep disruption has been linked to resource depletion more directly: Barber, Munz, Bagsby, and Powell (2010) found that consistent sleep practices, not just a sufficient amount of sleep, decreased psychological strain (their measure of resource depletion). However, it is important to highlight that there is also evidence that sleep disruption is not directly linked to resource depletion (Vohs, Glass, Maddox, & Markman, 2011). Further research investigating the relationship between sleep and resource depletion is warranted.

Thus, we hypothesized that sleep may play an important role in predicting drug cravings and use, with decreased self-reported willpower to resist temptations as a potential mediator of this relationship, our operationalization of reduced self-regulatory capacity. Importantly, no studies have provided direct empirical evidence to support the hypothesized causal pathway linking sleep with cravings or relapse; this is a major gap in the literature.

## 2. The present study

Without the ability to randomly assign sleep quality, we must rely on temporal precedence to infer causation (Shadish, Cook, & Campbell, 2002). To obtain robust measures of temporality, we used ecological momentary assessment (EMA) methodology. EMA is a method for collecting data in real-time and in variety of ecologically-valid conditions or states throughout a day (Stone & Shiffman, 1994). EMA allows researchers to inquire about a specific symptom or construct in the moment, rather than retrospectively, which is beneficial when studying topics like mood or drug cravings (Shiffman, 2009). For instance, previous studies have shown that participants tend to overestimate the degree to which they experience positive emotions and underestimate the degree to which they experience negative emotions in retrospective surveys compared to their responses on momentary surveys (Ebner-Priemer & Trull, 2009). Because it provides intensive repeated measures, EMA provides the opportunity to parse cross-sectional between-person processes from longitudinal within-person processes (Curran & Bauer, 2011). This is essential to our ability to establish directionality in the association between sleep quality and cravings.

In the only existing EMA study of sleep quality and drug cravings, Lydon-Staley et al. (2017) sampled 68 patients in residential treatment for nonmedical use of prescription drugs. They found that sleep quality was related to next-day cravings for prescription drugs, with lower positive affect (but not higher negative affect) partially mediating this effect. While this study provides important evidence about the mechanism of the association between sleep quality and cravings, the authors did not take full advantage of the method's ability to provide strong support for the hypothesized causal direction because the study did not consider nightly sleep quality as an outcome of daily cravings. We seek to extend this body of work by testing the temporal relationship between craving and sleep problems. We will then test the hypothesis that lower willpower mediates the relationship between sleep problems and subsequent cravings, consistent with the resource-depletion hypothesis.

## 3. Methods

### 3.1. Participants

We recruited 128 participants from inpatient and outpatient addiction recovery programs in the Triangle area of North Carolina (including Wake, Durham, Orange, and Chatham counties). We recruited participants via their clinics and through direct mailings to those whose UNC healthcare records indicated that they might be eligible to participate in the study. Participants were screened for inclusion and exclusion criteria by phone before enrollment in the study. To satisfy enrollment criteria, participants must have been at least 18 years of age, be actively receiving treatment for a substance use disorder, have been abstinent from the substance for which they were receiving treatment for < 12 months, not have been pregnant, and must have had regular access to a private mobile phone. Additionally, we excluded 6 participants from the present analyses for not completing any of the daily EMA surveys.

Of the 122 participants included in the analyses, 61.40% described themselves as White and 35.09% described themselves as Black. 4.24% described themselves as Hispanic. Participants had an average age of 41.70 years ($SD$ = 11.00; range 22–68), and were 74.79% female. There were more females in our sample because one of the clinics from which we recruited was a women-only clinic. In terms of highest level of education, 15.52% of the sample never completed high school, 26.72% had completed high school, 37.07% had completed some college, and 20.69% had an Associate's degree or higher.

The majority of participants (55.74%, $n$ = 68) were poly-drug users. The substance(s) that participants were treated for at the time of the study are as follows (note that these categories are not mutually exclusive): alcohol (52.46%, $n$ = 64), cocaine (41.80%, $n$ = 51), heroin (30.33%, $n$ = 37), prescription opiates (28.69%, $n$ = 35), methamphetamine (7.38%, $n$ = 9), cannabis (22.95%, $n$ = 28), and "other," including benzodiazepines and dextromethorphan (1.64%, $n$ = 2).

We recruited participants who had used substances within the past 12 months, but who were actively enrolled in a recovery program because we were interested in studying the process of recovery at an early stage. Forty-five participants (36.89%) were enrolled in inpatient programs at the time of recruitment and 77 (63.11%) were enrolled in outpatient programs. Fifty-three (43.44%) participants received some sort of medication management related to substance use recovery. We retained participants who changed or left treatment programs during the course of the study.

### 3.2. Procedure

After consent procedures, participants were instructed to fill out our baseline survey, and trained research assistants then explained the EMA protocol in person. For each week-long measurement burst (most often beginning the day after completing the baseline survey, but sometimes delaying further based on participants' schedule/ preference), participants received four brief surveys each day for seven days. These surveys were delivered via text message (12.30%, $n$ = 15) or automated phone