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MOBILE HEALTH (K GARRISON, SECTION EDITOR)

Intensive Longitudinal Methods for Studying the Role of Self-Regulation Strategies in Substance Use Behavior Change

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Abstract

Purpose of Review Many psychosocial interventions for substance use disorders (SUDs) focus on teaching self-regulation strategies. Research using intensive longitudinal methods (ILM), such as ecological momentary assessment and daily diaries, is critical for elucidating if and how these strategies function as mechanisms of change among individuals with SUDs. We review this emerging area of research.

Recent Findings We found a small number of studies using ILM to study self-regulation strategies in SUD ($n = 18$ studies), with most conducted among college student drinkers ($n = 9$) and cigarette smokers ($n = 7$), and few among treatment-engaged individuals, and those with other drug use disorders. There is preliminary evidence that the use of specific self-regulation strategies commonly taught in psychosocial interventions for SUDs (i.e., cognitive reappraisal, problem-solving, stimulus control, harm reduction) is associated with decreased momentary or daily substance use, at the within-person level.

Summary There is a need for further ILM research on self-regulation strategies as mechanisms of substance use behavior change. Such research can inform the development, refinement, and personalization of interventions that teach self-regulation strategies, including mobile interventions that facilitate strategy use in the moment. One key next step is developing psychometrically validated ILM assessments of self-regulation strategy use.

Keywords Ecological momentary assessment · Daily diary design · Intensive longitudinal methods · Self-regulation strategies · Substance use disorder

Introduction

Self-regulation is theorized to play a key role in the development, maintenance, and recovery from substance use disorders (SUDs) [1–4]. Although conceptualizations vary, self-regulation is commonly defined as intentionally modulating one's behavior to maintain or achieve a desired goal in the context of continually fluctuating internal and external challenges [5]. For individuals with SUDs, internal (e.g., negative affect) and external (e.g., people, places, stressful events) stimuli can become triggers for craving and for using substances due to conditioning processes [6]. Hence, it is theorized that the employment of adaptive self-regulation strategies is necessary to effectively avoid, reduce, or otherwise modify one's craving and/or substance use behavior in the context of these triggers [7, 8]. Moreover, clinicians commonly teach such adaptive self-regulation strategies to help individuals avoid and reduce substance use and related harm. For example, among various manualized psychosocial interventions for SUDs, cognitive-behavioral therapies (CBT) [7, 9–12] and mindfulness- and acceptance-based therapies (MABT) [13–18] are well known for having a strong focus on teaching adaptive self-regulation strategies. Specifically, CBTs and MABTs typically teach both "general" strategies that are related to general or common life situations (e.g., responding to stressful events or negative affect, improving quality of life, increasing positive affect), as well as "substance-specific" strategies that are directly related to

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Table 1 Types of self-regulation strategies taught in cognitive-behavioral therapies (CBTs) and mindfulness- and acceptance- based therapies (MABTs)

A. Cognitive-behavioral therapies

	General	**Substance-specific**
	Examples of how the strategy is enacted for general situations in life	**Examples of how the strategy is enacted for decreasing substance use/harm**
Cognitive reappraisal	When I was upset, I changed the way I was thinking about things to make myself feel better	When I had a craving, I tried to "rethink" things and remind myself about the costs of using/benefits of not using drugs
Stimulus control	When needed, I changed my environment or surroundings to improve my mood	I avoided or left situations that trigger a craving to use alcohol or drugs
Distraction	I did something to distract myself and keep my mind off stressful things	When I had a craving, I did something to distract myself from the craving
Seeking social support	When I was upset, I reached out to others for support or guidance	When I had a craving, I reached out to friends or family for help
Problem-solving	When I was upset, I identified the problem at hand and took steps to deal with it	I came up with a plan to avoid using alcohol or drugs in a risky situation
Goal setting	I took the time to set a personal goal for myself or keep track of my progress towards my goals	I committed myself to a specific goal for changing my alcohol or drug use (ex. achieve 3 consecutive weeks of abstinence or no binge use)
Active communication	I directly communicated my needs or wishes to others in a clear and calm way	I directly refused an offer for alcohol or drugs, or asked others not to use around me
Positive activity engagement	I made plans for/got involved in a positive or enjoyable activity	I made plans for/got involved in an enjoyable activity that did not involve alcohol or drugs
Arousal reduction	I did something to calm myself down (such as taking deep breaths or going for a walk)	I did something to reduce the intensity of a craving (such as taking deep breaths or going for a walk)
Harm reduction	___	I made an effort to stay safe and avoid risks while using alcohol or drugs (ex. limiting amount, going slowly, being around people I trust)
Physiological management	I made an intentional effort to practice good physical health habits (nutrition, exercise, sleep, taking medication consistently, etc.)	I took medication to reduce cravings (ex. nicotine replacement products, anti-craving pills like naltrexone, opioid replacement medications)

B. Mindfulness- and acceptance-based therapies

	General	**Substance-specific**
	Examples of how the strategy is enacted for general situations in life	**Examples of how the strategy is enacted for decreasing substance use/harm**
Mindful awareness	I tried to be fully aware of how I felt and what I was doing in the present moment	When I had a craving, I tried to be fully aware of myself and my actions in the moment
Mindful acceptance	I tried to accept unpleasant thoughts and feelings and let them be, instead of fighting them or getting caught up in them	When I had a craving, I tried to accept it and let it come and go, instead of trying to fight or escape it
Savoring	I tried to notice and savor the "little pleasures" in life—like food, being outside, music, or a warm shower	I tried to savor or appreciate pleasant activities that did not involve alcohol or drugs
Values clarification	I reflected on my personal values and what kind of person I want to be	I reflected on how changing my substance use is important to me and my values

decreasing substance use and related harm. CBT protocols for SUDs commonly focus on teaching the following types of self-regulation strategies [7, 9, 10, 19–22]: cognitive reappraisal (changing how one thinks about a situation), stimulus control (controlling one's exposure to environmental stimuli), distraction (engaging in behaviors to divert one's attention away from challenging experiences), seeking social support (reaching out to other people for support and/or guidance), problem-solving (identifying a problem and actively brainstorming/planning/executing solutions), goal setting (actively defining specific, measurable, and attainable target goals and tracking progress), active communication (assertively communicating one's needs and wishes to others), positive activity engagement (active efforts to plan for/engaged in positive or enjoyable activities), arousal reduction (engaging in behaviors or activities to reduce emotional arousal), harm reduction (intentional efforts to minimize harm when using substances), and physiological management (intentional efforts to regulate physiological states (e.g., energy level, hunger, thirst, craving) by engaging in health behaviors related to nutrition, exercise, sleep, and medication use). See Table 1A for examples (developed by the current authors) that describe how these types of strategies are enacted as general self-regulation strategies and as substance-specific strategies for decreasing substance use and related harm.

MABT protocols for SUDs feature a strong focus on complementary types of self-regulation strategies [13–16, 23, 24], including mindful awareness (intentional monitoring and recognition of experiences in the moment, i.e., thoughts, emotions, sensations, actions, sounds, sights), mindful acceptance (adopting an open, accepting, and nonjudgmental attitude towards experiences in the moment), savoring (actively attending to and appreciating present moment experiences, particularly positive or naturally rewarding experiences), and values clarification (identifying, affirming, and committing to living by deeply held personal values). See Table 1B for examples (developed by the current authors) that describe how these strategies are enacted.

Although self-regulation is theoretically linked to recovery, and although these strategies are a prominent component of CBTs and MABTs for SUDs, it remains unclear whether and how specific self-regulation strategies play a role in substance use behavior change. Indeed, there is a relatively small amount of research on the effectiveness of specific self-regulation strategies among individuals with SUDs. Some studies have used retrospective measures (e.g., reports on average behavior in the past month) at single timepoints to evaluate the effectiveness of specific strategies among individuals with SUDs [25–30]. Other studies have taken a laboratory-based approach in which individuals are trained in one or more self-regulation strategies, and then asked to employ these strategies during a craving task [31–39]. However, while these studies are useful, they do not shed light on the dynamic, intra-individual process over time by which strategies may help individuals avoid or reduce substance use in varying situational contexts.

Over the past several decades, intensive longitudinal methods (ILM; such as ecological momentary assessment and daily diaries, see below) have emerged as promising approaches for studying dynamic, intra-individual processes over time among individuals with SUDs [40–43]. ILM research on self-regulation strategy use in SUD populations is especially appealing because it has the potential to provide a nuanced understanding of how individuals use self-regulation strategies over time amidst continually fluctuating internal (e.g., negative affect, craving) and external conditions (e.g., drug cues) in one's momentary or daily situational context.

To our knowledge, only 18 studies have been published using ILM to study specific self-regulation strategies among individuals with SUDs. This is a rather small number considering the rapid growth of ILM research in the SUD field more broadly. Specifically, the number of ILM studies focusing on self-regulation strategies in SUDs pales in comparison with the hundreds of ILM studies that have examined within-person associations among constructs such as stress, affect, and craving among individuals with SUDs [43–49]. Given the prominence of self-regulation strategies in psychosocial interventions for SUD, we believe that more ILM research on self-regulation strategy use in SUD is needed. Such research can have direct implications for developing, optimizing, and personalizing interventions, including novel mobile interventions (e.g., smartphone apps) that assist individuals in using self-regulation strategies in the moment during their daily lives [50].

Accordingly, in this paper, we (a) briefly review ILM, (b) provide a narrative review of published ILM studies that measured self-regulation strategy use on a momentary or daily basis among individuals reporting substance use or who have SUDs, and (c) outline recommendations for future research. For our review, we searched PubMed and Google Scholar with various combinations of the following search terms for studies in humans, published in English before March 1, 2020: "ecological momentary assessment," "daily diary," "intensive longitudinal methods," "experience sampling," "ambulatory assessment," "mobile app," "smartphone app," "self-regulation strategies," "emotion regulation strategies," "protective behavioral strategies," "harm reduction strategies," "coping," "alcohol," "smoking," "substance use," "drinking," "cannabis," and "addiction." Of note, the delineation of CBT and MABT strategies described above and in Table 1 is primarily intended to provide a guiding framework for this paper. In our literature search itself, we did not restrict our search to papers that studied only CBT or MABT self-regulation strategies. Yet, given that CBTs and MABTs teach a wide array of self-regulation strategies, all of the ILM studies identified in our search and included in our review examined self-

regulation strategies that are taught within CBT or MABT intervention protocols.

The Promise of Intensive Longitudinal Methods

ILM is an umbrella term that refers to repeated and frequent collection of data from people in their natural environment, at a relatively micro timescale [51•]. For example, ecological momentary assessment (EMA) studies often involve collecting data multiple times a day using brief surveys conducted via a person's smartphone or some other handheld device. In "signal-contingent" EMA surveys, participants are signaled at random timepoints during their day (e.g., via a text alert) and asked to complete a brief survey in the moment. Researchers often employ signal-contingent surveys on a "quasi-random" basis in which participants are signaled to complete one EMA survey within several blocks of time during the day (e.g., five 90-min blocks of time spaced throughout the day). In "time-contingent" EMA surveys, participants are instructed to complete assessments within a specific time window during the day (e.g., within 30 min of waking up or before going to bed). In "event-contingent" EMA, participants are instructed to self-initiate a brief survey before, during, or after pre-specified events that might occur during their day, such as a stressful situation, a craving episode, or substance use. A daily diary design is another common type of ILM, in which participants complete daily surveys over a period of time, such as 1 week or 1 month.

Relative to retrospective assessment, ILM has several advantages [40], including the following: (1) reduction of memory biases that occur when people try to recall behaviors that occurred in the past; (2) greater ecological validity, because individuals are assessed in their natural environments; (3) greater context specificity, because researchers can assess the immediate contextual conditions (e.g., external environment, craving levels) in which a behavior is embedded; (4) greater temporal granularity that allows investigation of dynamic processes over time; (5) the ability to investigate intra-individual or within-person associations (i.e., how two variables are related to each other within the same individual over time), in addition to inter-individual or between-person associations (i.e., how individual differences in one variable relate to individual differences in another variable); (6) it allows assessment of cross-level interactions that can reveal how within-person associations are moderated by individual differences (e.g., gender as moderator of the within-person association between negative affect and smoking); and (7) the capacity to examine intra-individual variability, or how one's experience (e.g., negative affect, craving) fluctuates over time.

Studies Using ILM to Study Self-Regulation Strategies Among Cigarette Smokers

To our knowledge, seven studies have used ILM to study self-regulation strategies among cigarette smokers. Table 2A provides a summary of the key methodological approaches and findings from those studies. Notably, these studies are relatively old, with five studies conducted more than 9 years ago [55–59], and two studies conducted more than 20 years ago [58, 59]. Three of these studies used EMA with portable handheld devices or smartphones [55, 58, 59], two studies used an EMA method in which participants carried a tape recorder with them each day and recorded information about how they coped with cravings [56, 57], and two studies involved tracking of participant behavior as part of a smartphone-based intervention [52, 54]. Four studies included signal-contingent surveys [55, 58, 59], while two studies (those that used tape recording) involved event-contingent reports in which participants were instructed to document their coping attempts whenever they had cravings to smoke [56, 57].

One EMA study simply asked participants to indicate whether or not participants tried to cope with stress during a stressful episode using a simple yes/no [55]. The authors found that coping during a stressful episode was not associated with less smoking, and concluded that coping following a quit attempt may not help smokers stay abstinent. However, given the imprecise yes/no measure of coping, it is difficult to draw a meaningful conclusion from this study.

Three studies assessed whether individuals used cognitive strategies (e.g., thinking of the negative consequences of smoking) or behavioral strategies (e.g., avoiding triggers) for coping with cravings. However, these studies did not report which specific self-regulation strategies participants engaged in. One study examined between-person effects and found that participants who lapsed did not differ from those who maintained abstinence on the frequency of reported cognitive and behavioral coping strategies [58]. Among the studies examining within-person effects, one found that use of cognitive strategies, but not behavioral strategies, was associated with lower lapse risk during a craving episode [59], whereas the other study found that the combined use of cognitive and behavioral strategies was most effective for reducing lapse risk during craving episodes [56••].

One study involved a comprehensive analysis of several specific self-regulation strategies [56••]. In this study, within-person analyses revealed that numerous behavioral and cognitive self-regulation strategies, including stimulus control, distraction, arousal reduction, and cognitive reappraisal, were each associated with lower lapse risk during craving episodes. They also found that total number of strategies used during a craving episode was associated with lower lapse risk and a reduction in cravings. Hence, this study offers the strongest evidence that the use of specific self-regulation

Table 2 Summary of studies using ILM to study self-regulation among substance-using populations

A. Studies among cigarette smokers

	Sample	ILM approach	Measures of self-regulation strategies	Key findings
Zeng et al. 2016 [52]	84 adult smokers interested in quitting who were receiving the smartphone app "SmartQuit" as part of a randomized trial [53], and who provided data at the 2-month follow-up	As part of the app-based intervention, participants tracked how often they used a skill each day	Single item in which individuals tracked how often each day they "let cravings pass" (i.e., mindful acceptance)	At the between-person level, a greater number of times of tracked practice of "letting cravings pass" (in total throughout the intervention) was associated with greater odds of 7-day point prevalence smoking abstinence and greater odds of having a reduction in smoking at the 2-month follow-up *Of note, both the Zeng et al. 2016 [52] and Heffner et al. 2015 [54] described below conducted secondary analyses from the same parent trial Bricker et al. 2014 [53]. The analyses were conducted slightly differently in each manuscript and reveal the same substantive conclusion.
Heffner et al. 2015 [54]	76 adult smokers interested in quitting who received the smartphone app "SmartQuit" as part of a randomized trial [53], and opened the app at least once	As part of the app-based intervention, participants tracked how often they used a skill each day	Single item in which individuals tracked how often each day they "let cravings pass" (i.e., mindful acceptance)	At the between-person level, high use (i.e., above median score for number of tracked times skills was used during intervention) vs. low use of the "letting cravings pass" was associated with greater odds of 30-day point prevalence smoking abstinence at the 2-month follow-up.
Minami et al. 2011 [55]	372 adult cigarette smokers who reported at least one stressful event and coping episode. Participants in a clinical trial of bupropion SR and individual smoking cessation counseling	EMA (four to seven random surveys a day) for 2 weeks pre-quit and 4 weeks post-quit.	Single item asking participants whether they tried to cope with stress (yes or no).	At the within-person level, initial coping during the outset of a stressful episode was not associated with smoking 48 h following a stressful episode, while total coping during a stressful episode was associated with greater risk of concurrent smoking during the 48 h following the stressful episode.
O'Connell et al. 2007 [56••]	62 adult cigarette smokers interested in quitting	Participants carried a tape recorder during their quit attempt for up to 17 days and were instructed to record info about how they coped with cravings.	Coping strategies were coded by raters from the audio-recordings. Strategies included keeping busy, food/drink, deep breathing, avoid/leave situation, movement/exercise, focusing thoughts away from smoking, encouraging/calming self-talk, think about negative effects of smoking/benefits of quitting, optimism about success in quitting.	At the within-person level, use of each strategy during a craving episode was associated with lower lapse risk, and total number of strategies during a craving episode was associated with lower lapse risk and reduction in cravings (pre-coping craving level and post-coping craving levels were recorded).
O'Connell et al. 2006 [57]	61 adult cigarette smokers interested in quitting	Participants carried a tape recorder for 2 weeks following a quit attempt and were instructed to record info about how they coped with cravings.	Coping strategies were coded by raters from the audio-recordings. Strategies were coded as either cognitive or behavioral strategies, or no coping.	At the within-person level, using any cognitive or behavioral strategies (relative to no coping strategies at all) was associated with lower lapse risk, and combined use of cognitive and behavioral

Table 2 (continued)

				strategies (relative to a single behavioral strategy, single cognitive strategy, or multiple behavioral strategies) was associated with lower lapse risk.
Shiffman et al. 1996 [58]	151 cigarette smokers who recently quit smoking following a cognitive-behavioral group treatment	EMA (multiple random surveys per day) for up to 23 days. Participants also asked to record episodes of temptation.	Two single items asking whether participants engaged in any cognitive or behavioral coping response during a temptation episode.	At the between-person level, participants who lapsed did not differ from participants who maintained abstinence on frequency of cognitive and behavioral coping responses during temptation episodes.
Shiffman et al. 1996 [59]	108 cigarette smokers who recently quit following a behavioral smoking cessation treatment program	EMA (five random surveys per day) for 4 weeks following the first 24 h of abstinence after a quit attempt	Two single items asking whether participants engaged in any cognitive or behavioral coping response during a temptation episode.	At the within-person level, cognitive coping (but not behavioral coping) was associated with lower lapse risk during a temptation episode.

B. Studies among individuals using alcohol and/or cannabis

	Sample	ILM approach	Measures of self-regulation strategies	Key findings
Pearson et al. 2019 [60•]	43 college student marijuana users	12 consecutive days of web-based daily diaries	Abbreviated Protective Behavioral Strategies for Marijuana (PBSM) [61]. Example items include: avoid using marijuana before work or school, limit the amount you smoke in one sitting.	At the within-person level, PBSM (total score) was associated with fewer marijuana use sessions and lower subjective high on a given day, but not associated with negative consequences or number of grams on a given day during the 12-week assessment period.
Linden-Carmichael et al. 2018 [62•]	256 college students reporting at least 1 day of heavy drinking	Measurement-burst design involving 14 consecutive web-based daily diaries for each semester from Fall of first Year to Fall of fourth year. A "burst" design involves a series of "bursts" (e.g., 14-day EMA period) that are administered periodically over time, instead of continuous EMA assessment.	Abbreviated Protective Behavioral Strategies Survey (PBSS) [63] that assessed "Manner of Drinking" Strategies (avoid drinking fast, avoid drinking games, avoid shots) and "Serious Harm Reduction" Strategies (avoid serious consequences by watching drink, going home with friend, use designated driver).	At the within-person level, the use of manner of drinking and serious harm reduction strategies were associated with a lower risk of negative alcohol-related consequences, and these associations were strongest for high intensity drinking occasions (8+/10+ standard drinks for women/men).
Sell et al. 2018 [64]	69 female college students reporting heavy drinking	14 consecutive days of web-based daily diaries	Abbreviated Protective Behavioral Strategies Survey (PBSS) [63] that assessed "Manner of Drinking" Strategies and "Stopping/Limiting Drinking" Strategies. Four items from the Dating Self-Protection Against Rape Scale (DSPARS) [65] were used to measure sexual assault prevention strategies (e.g., had a trusted friend walk home with me).	At the within-person level, manner of drinking and stopping/limiting strategy use were associated with less drinking. Yet, at the within-person level, sexual assault protective strategies were associated with greater drinking, suggesting women used more sexual assault protective strategies than usual on days they drank more than usual.
Dulin and Gonzalez 2017 [66••]	28 adults with alcohol use disorder participating in a trial of a smartphone-based intervention that involved momentary delivery of	During the 6-week intervention, the smartphone-based app recorded which coping strategies participants chose to use whenever they reported craving during a	Participants could choose among several features on the app that taught/facilitated the use of coping strategies as part of the momentary smartphone-based	At the within-person level, relative to using a non-intervention suggested strategy, use of urge surfing, distracting activity, view reasons for change, view reminder photo

Table 2 (continued)

	guidance for using coping strategies to manage cravings	daily survey or self-initiated survey during a craving episode	intervention: urge surfing, distracting activity, view reasons for change, view reminder photo related to reasons for changing, contact a support person, escape a trigger, contact a friend or family member, other non-intervention suggested strategy.	related to reasons for changing, contact a support person, or escape a trigger were associated with lower risk of drinking during a craving episode.
Weiss et al. 2017 [67••]	1640 college students reporting alcohol use at least twice in past month	30 consecutive days of web-based daily diaries	Single item measures of the following emotion regulation strategies: distraction (I tried to distract myself and keep my mind off of a problem), reappraisal (I tried to see the problem in a positive light), problem-solving (I put aside other activities /suppressed other thoughts to focus on a problem that needed my attention), and avoidance (I avoided dealing with a situation).	At the within-person level, use of distraction, reappraisal, or problem-solving earlier in the day was associated with lower odds of marijuana use and lower odds of co-using alcohol and marijuana. At the within-person level, heavy drinking, marijuana use, or co-use of alcohol and marijuana on a given day was associated with lower odds of using problem-solving the next day. Also, at the within-person level, heavy drinking on a given day increased odds of next day avoidance, whereas use of marijuana on a given day increased odd of reappraisal the next day.
Ehrenberg et al. 2016 [68]	722 college students reporting alcohol use twice in the past month	30 consecutive days of web-based daily diaries	Drawing from the Brief COPE [69], avoidance coping was measured with two items: "I avoided dealing with a situation" and "I tried to distract myself and keep my mind off of a problem." Approach coping was measured with two items: "I actively dealt with a problem/I did what needed to be done" and "I put aside/suppressed other thoughts to focus on a problem that needed my attention."	At the within-person level, avoidance coping on a given day was associated with higher levels of drinking to cope motivation, particularly among individuals with higher aggregate negative affect. At the within-person level, neither avoidance nor active coping were associated with alcohol use.
Pearson et al. 2013 [70]	40 college students endorsing at least one alcohol-related problem in the past 90 days	15 consecutive days of web-based daily diaries	Abbreviated Protective Behavioral Strategies Survey (PBSS) [63] that assessed "Limiting/Stopping Drinking" Strategies "Manner of Drinking," and "Serious Harm Reduction" Strategies.	At the within-person level, use of manner of drinking strategies on a given day was associated with less alcohol use, whereas serious harm reduction strategies on a given day were associated with more alcohol use and alcohol-related negative consequences.
Lewis et al. 2012 [71]	1028 college students who recently turned 21 and reported at least some drinking	Up to 10 web-based daily diaries during 21st day birthday week	Abbreviated Protective Behavioral Strategies Survey (PBSS) [63] that assessed "Limiting/Stopping Drinking" Strategies "Manner of Drinking" Strategies, and "Serious Harm Reduction" Strategies.	At the within-person level, use of manner of drinking strategies was associated with less alcohol use and alcohol-related consequences, whereas limiting/stopping strategies and serious harm reduction strategies were associated with more alcohol use and alcohol-related consequences.
	365 college students			

Table 2 (continued)

Aldrige-Gerry et al. 2011 [72]		5 consecutive days of web-based daily diaries	Items drawn primarily from the Brief COPE [69] assessing seeking social support, problem-focused coping, minimization of stressor, emotional rumination, and religious coping	At the within-person level, seeking social support, minimization of stressor, and emotional rumination were associated with more alcohol use. At the within-person level religious coping was associated with less alcohol use among African Americans.
Litt et al. 2009 [73••]	110 adults with alcohol use disorder participating in clinical trial of packaged cognitive-behavioral therapy (CBT) or individualized CBT	A telephone-based interactive voice response (IVR) system that is programmed to call participants, ask questions, and record verbal responses. IVR prompted3236 participants 8 times per day (quasi-random). IVR employed 2 weeks before treatment and for 2 weeks after the 12-weeks of treatment	Single items assessing different craving-specific coping responses during craving episodes, including avoid situations, distracted self, drank something else, refused drink, sought social support, went elsewhere, thought about negative or relapse, thought about positive of sobriety, thought pleasant thoughts, prayed, told self not to drink, told self to stay sober, waited out craving, or did nothing.	Relative to participants in packaged CBT, participants in individualized CBT had higher total number of coping responses, and were more likely to report avoiding situations, distracting oneself, refusing a drink, going elsewhere, and waiting out a craving during craving episodes following treatment. Increases in total coping from pre-treatment to post-treatment was associated with greater percent days abstinent following treatment.
Park et al. 2004 [74]	137 college students	28 consecutive days of web-based daily diaries	Items adapted from the Brief COPE [69] assessing emotion approach coping (e.g., I've been allowing myself to express my emotions), avoidance coping (I've been giving up trying to deal with it), and problem-focused coping (I've been taking action to try to make the situation better).	At the within-person level, problem-focused coping on a given day was associated with less drinking.

strategies, particularly those taught in CBT (see Table 1A), may reduce risk of momentary lapse to smoking during a craving episode.

Finally, two secondary data analysis studies (each using slightly different analytic methods) of the same parent intervention trial evaluated the effectiveness of a mindful acceptance strategy i.e., ("letting cravings pass"; [52, 54]. Participants tracked how often they used this strategy on their smartphone as part of a smartphone-based intervention integrating MABT and CBT elements. Both analyses converged on the finding that greater use of this strategy during the intervention was associated with better smoking outcomes at the 2-month follow-up. Of note, these studies evaluated between-person effects with aggregated daily data, rather than within-person effects on a momentary or daily basis.

Studies Using ILM to Study Self-Regulation Strategies Among Individuals Using Alcohol and/or Cannabis

Table 2B provides a summary of the 11 studies we found in this category. Nine of 11 studies were conducted among college students, and all nine of these studies used daily diary designs [60, 62, 64, 67, 68, 70–72, 74]. Two studies included treatment-engaged individuals; one of these used a mix of time- and event-contingent EMA assessments [66••], while the other used only signal-contingent EMA [73••]. Out of the 11 studies, nine studies were among individuals reporting alcohol use [62, 64, 68, 70–72, 74], one study among individual reporting cannabis use [60•], and one study among individuals reporting both alcohol and cannabis use [67••]. We were unable to find any studies using ILM to study self-regulation strategies among individuals reporting use of drugs other than cigarettes, alcohol, and cannabis.

Four of the studies used daily diaries to measure college students' use of alcohol-related protective behavioral strategies (PBS), which are harm reduction strategies aimed at minimizing potential harm or negative consequences from alcohol use. Several of those studies showed that "manner of drinking" PBS (i.e., changing the manner in which one consumes alcohol, such as drinking slowly, and avoiding drinking games and "pre-gaming") were associated with lower alcohol use or negative alcohol-related consequences at the within-person level [62, 64, 70, 71]. However, some of the same studies found that "stopping/limiting" PBS (e.g., setting a drink limit; [71], "serious harm reduction" PBS (e.g., using a designated driver; [70, 71], and "sexual assault prevention" PBS (e.g., had a trusted friend walk me home; [64] were associated with more alcohol use or negative alcohol-related consequences on a given occasion at the within-person level. One possible explanation for these associations is that college students may plan to use certain PBS in advance when they know they will be drinking heavily on a given occasion.

Two daily diary studies focused on how self-regulation strategies for managing general distress were related to alcohol use among college student drinkers [67, 74]. Both of these studies found that problem-solving was related to less daily drinking at the within-person level. One study examined bi-directional relationships between the use of self-regulation strategies and substance use [67]. Interestingly, they found that (a) heavy drinking, marijuana use, or co-use of alcohol and marijuana was associated with lower odds of using problem-solving the next day; (b) heavy drinking increased odds of next day use of avoidance strategies; and (c) marijuana use increased odds of using reappraisal the following day. This study highlights the importance of considering reciprocal effects over time and that substance use itself may warrant subsequent self-regulation.

One randomized clinical trial used EMA to measure the use of CBT coping strategies during 2-week periods before and after packaged CBT or individualized CBT for alcohol use disorder [73]. Individualized CBT involved using the 2-week pre-treatment EMA data—which included measurements of mood, cognitions, triggers, and coping strategies—to tailor CBT to each individual. Results showed that individualized CBT, relative to packaged CBT, led to significantly greater pre- to post-treatment increases in the momentary use of several CBT coping strategies during temptation episodes: distraction, active communication (i.e., refusing offers to drink), and stimulus control. However, this study did not examine how specific self-regulation strategies were differentially associated with alcohol use outcomes at the within-person level.

One study offered a smartphone-based app that facilitated the use of coping strategies for managing cravings in the moment among individuals with alcohol use disorder [66]. As part of this study, the app tracked participants' use of specific coping strategies. At the within-person level, they found that the momentary use of several specific coping strategies (offered within the app) was associated with a lower risk for drinking during craving episodes. These strategies included mindful acceptance (i.e., "urge surfing"), distraction (i.e., distracting activity), values clarification (i.e., "viewing reasons for change"), seeking social support (i.e., contacting a support person), and stimulus control (i.e., escape a trigger).

Summary and Recommendations for Future Research

It is difficult to draw definitive conclusions based on the relatively small number of ILM studies on self-regulation strategies in SUDs. Yet, it is important to note that there are some preliminary findings about the effectiveness of specific self-

regulation strategies at the within-person level, which are unique to ILM. Specifically, there is preliminary evidence that (1) stimulus control, distraction, arousal reduction, and cognitive reappraisal are each associated with reduced momentary lapse risk among smokers [56]; (2) "manner of drinking" PBS is associated with lower daily drinking [64, 70, 71] or negative alcohol-related consequences [62, 71] among college student drinkers; (3) problem-solving during stressful situations is associated with lower daily alcohol use among college student drinkers [67, 74]; and (4) smartphone app-assisted use of mindful acceptance, distraction, values clarification, seeking social support, and stimulus control are each associated with lower risk of drinking during a craving episode among individuals with alcohol use disorder [66]. As such, these preliminary findings suggest that ILM research has the potential to offer useful insights about the within-person effects of using specific self-regulation strategies.

Ultimately, we believe that research using ILM to study self-regulation strategies in SUD can be valuable in multiple ways, such as clarifying whether CBT-based, MABT-based, or other self-regulation strategies are effective at the within-person level, how contextual and individual difference factors moderate self-regulation strategy effectiveness, and how strategies may function as mechanisms of change within or across psychosocial interventions. Altogether, such insights have the potential to directly inform interventions for SUD, including those that already focus on self-regulation strategies, such as CBTs and MABTs. Furthermore, this line of research may be especially fruitful in developing and refining the next wave of mobile app-based interventions that aid individuals in using effective self-regulation strategies in the moment [50]. Thus, we encourage SUD researchers to employ ILM and integrate measures of self-regulation strategies into ongoing and new work. Consistently, below we include key recommendations for future research using ILM to study self-regulation in SUD.

Categorizing Self-Regulation Strategies

Self-regulation strategies can be organized into many different categories or classes depending on particular dimensions of focus that might be shared by any given set of strategies. Both within and outside the SUD field [57, 75–78], researchers have used various categorization schemes for self-regulation strategies (e.g., cognitive vs. behavioral; problem-focused vs. emotion-focused; approach vs. avoidant; antecedent-focused vs. response modulation). Indeed, various categorization schemes for self-regulation strategies can be useful depending on the specific scientific research aims at hand. For research aimed at informing the improvement of psychosocial interventions for SUD, we believe that it is useful to organize self-regulation strategies into "CBT-focused" and "MBAT-focused" strategies as well as "general" and "substance-specific." Accordingly, we created Table 1 to provide a guiding conceptual framework that may be useful for ILM research on putatively adaptive self-regulation strategies among individuals with SUD.

We think categorizing self-regulation strategies as "CBT" or MBAT" strategies is of practical utility because this categorization corresponds with current intervention protocols. Therefore, research using this framework can clearly and directly inform these interventions, and provide insight about whether CBTs and MBAT intervention packages or procedures are indeed mobilizing the mechanisms they intend to target. Overall, the SUD treatment field has much to learn about how different types of intervention packages, modules, or procedures actually influence changes in the use self-regulation strategies. Hence, we encourage researchers to measure both CBT and MABT self-regulation strategies in their studies when possible, even if only one particular intervention (e.g., CBT) is under study. In this way, the field can gain a better understanding of both shared and diverging mechanisms of change between what we consider to be CBT or MABT intervention approaches.

We believe that the categories of "general" and "substance-specific" self-regulation strategies are useful for gaining a more nuanced understanding of self-regulation (see Table 1). Several other SUD treatment researchers have made the distinction between "general" and "substance-specific" self-regulation [27–29, 79]. General strategies and substance-specific strategies may interact over time or in particular contexts to influence substance use behavior and related harm (e.g., lapse to any use, relapse to persistent use, substance-related accident or overdose). For example, deficits in the use of general self-regulation strategies (e.g., problem-solving, seeking social support) may contribute to an accumulation of stress in daily life, which in turn may impair one's ability to use substance-specific self-regulation strategies during situations posing a high-risk for using substances. Of note, we do not believe that the use of general self-regulation strategies is "orthogonal" from the use of substance-specific regulation. Rather, the use of general substance-specific self-regulation strategies can be viewed as highly overlapping and intertwined processes over time.

Developing and Validating New ILM-Specific Measures of Self-Regulation Strategy Use

ILM-specific measures are those specifically intended as a momentary or daily measure of one or more constructs. The development and psychometric validation of such ILM-specific measures is a relatively new direction in psychological science in general and SUD science in particular. Psychometric validation of an ILM-specific measure involves using EMA or daily diary data to evaluate the psychometric properties (e.g., internal consistency reliability, construct,

convergent, and discriminant validity) at both the within- and between-person level.

Recently, one study developed and validated a multi-item momentary measure of impulsivity suitable for EMA research [80]. This study provides an excellent example of how ILM-specific measures can be developed and validated. However, in the broad field of psychological science, there is still a lack of validated ILM-specific measures dedicated to assessing momentary or daily variability over time in the use of self-regulation strategies. Not surprisingly, there is also a lack of validated ILM-specific measures of self-regulation strategies particularly relevant to SUD populations (i.e., assessing strategies for changing substance use behavior; see Table 1). Importantly, such psychometrically validated (at the within-person level) ILM-specific measures are needed in order to synergize ILM research efforts moving forward and ensure that self-regulation strategies are being assessed in a reliable, valid, and standardized manner. Accordingly, one potential fruitful future direction is the development and psychometric validation of momentary or daily ILM measures that assess the use of specific self-regulation strategies commonly taught in CBTs and MABTs for SUD, as well as general and substance-specific strategies (see Table 1).

ILM measures that include multiple items for measuring a single self-regulation strategy would be psychometrically useful because reliability of these measures can be assessed. As shown in Table 1, there are many self-regulation strategies that can be measured, and these strategies can be applied in different ways. Hence, to avoid the creation of excessively long measures, researchers developing ILM-specific measures with multiple items for each strategy might consider focusing on measuring a select number of "key" self-regulation strategies that are deemed particularly important in a given subpopulation or for a particular line of research.

Adapting Items from Traditional Self-Report Measures of Self-Regulation Strategies

As noted, there is currently a lack of psychometrically validated ILM-specific measures of self-regulation strategies. Hence, in the meantime, researchers conducting ILM studies on self-regulation strategies in SUD populations may need to adapt a select number of items (as well as the instructions) from longer traditional retrospective questionnaires on self-regulation strategies. Indeed, most of the ILM studies discussed in the current review (see Table 2) used such adaptations [60, 62, 64, 67, 68, 70–72, 74]. Until ILM-specific measures are validated, this may be the best approach. However, it should be noted that traditional measures of self-regulation strategies typically focus on examining nomothetic or "inter"-individual variations (e.g., difference in one's use of self-regulation strategies compared with others) assuming homogeneity in dynamic self-regulatory processes, whereas ILM-specific measures could focus on assessing idiographic or "intra"-individual variations (e.g., changes in one's use of self-regulation strategies in different contexts or time periods). Hence, when items adapted from between-person level questionnaires are used in ILM studies, researchers are fundamentally asking different research questions. In addition, as recently demonstrated in studies on affect [81], there can be quite different psychometric properties (e.g., reliability, factor structures, validity) between the traditional retrospective (between-person level) questionnaires of self-regulation strategies and ILM-specific measures on self-regulation strategies.

The use of single items to measure specific self-regulation strategies may be disadvantageous from a psychometric perspective (i.e., internal consistency reliability). However, we think that a "single item per strategy" approach may be particularly appropriate and valuable in both EMA or daily diary research under certain circumstances, such as when there is strong interest in people's regulatory repertoire [2], and/or when surveys need to be kept as brief as possible. In regard to regulatory repertoire, measuring a broad range of self-regulation strategies may be useful for adequately capturing an individual's overall repertoire ("toolkit") of strategies over time and/or for capturing patterns of strategy use in a given moment or day. Using single items to measure strategies in ILM designs can also significantly reduce participant burden and may be necessary if there are concerns about overly lengthy surveys and assessment fatigue.

Choosing Appropriate Design Features for ILM Studies

Daily diary designs for assessing self-regulation strategies may be quite useful, and should not necessarily be regarded as less valuable than EMA designs with multiple assessments per day. Although daily diary designs do not provide "real-time" assessment of self-regulation strategy use, they still significantly reduce the time window for recalling past use of strategies, relative to traditional retrospective measures. Moreover, relative to EMA, daily diaries are less intensive to administer, provide less burden on participants, and allow for longer surveys at each assessment occasion. Thus, daily diaries may be useful when researchers have a strong interest in using ILM to assess numerous self-regulation strategies per assessment occasion, with multiple items for each strategy. End-of-day or evening daily diaries (e.g., a survey completed 30 min before going to bed each day) may be particularly useful for studying self-regulation strategies [67]. For example, individuals can report the frequency of using strategies that day (e.g., "So far today, how often have you used the following strategies?"). Another possibility is to assess general self-regulation strategies using daily diaries (e.g., as part of a longer end-of-day report) in combination with assessing substance-specific strategies multiple times per day with

EMA. This particular diary + EMA design may be useful when researchers are primarily interested in understanding substance-specific self-regulation before, during, or after particular substance-related high-risk episodes within a day, and are also interested in how "background" general self-regulation during preceding days or on the same day may influence substance-specific self-regulation.

EMA is more suitable when there is a strong interest in how self-regulation strategies function on a momentary basis throughout the day or relative to specific daily events (e.g., stressors). Administering multiple quasi-random signal-contingent EMA assessments each day may be a useful approach for "casting a wide net" and capturing people's use of self-regulation strategies at different times throughout the day. Event-contingent assessments may be useful when there is strong interest in evaluating self-regulation before, during, or after key events, such specified cues or stressors tied to substance use. Combining signal- and event- contingent EMA assessments can be useful for capturing self-regulation strategies used throughout the day, as well as strategies used before, during, or after key events – as well as their combined dynamics. Of note, event-contingent EMA assessments alone may not be sufficient to examine use of self-regulation strategies because individuals may not remember to (or choose to) initiate a survey for a given event-type (e.g., a lapse), biasing the data.

Further, we believe that it is important to consider the instructions about the time frame for reporting on self-regulation strategies in ILM, and perhaps particularly in EMA. For example, asking "Right now, which of the following strategies are you using …" may be confusing for participants because they may not perceive that they are using strategies in that exact moment. Although the instruction "Since the last report …" is often used in EMA studies, this type of instruction can be also problematic when participants have varying levels of compliance and miss reports throughout the day, thereby reporting on different time windows. We currently believe that instructions that specify a recent time window are most appropriate, such as "In the past hour." In such cases, it may also be most appropriate or more interpretable to have binary response options to indicate whether or not a strategy was used within the specified time window because the frequency-based Likert scales (e.g., the differences between using a strategy "occasionally" vs. "frequently") may be confusing with a short time frame. As an alternative, the total number of times using a strategy per day or over a given time period can be computed by summing the responses from the binary yes/no items on each individual EMA survey.

Here we focus mostly on ILM measures of the frequency of using self-regulation strategies, yet there may be other important quantitative or qualitative measures that assess self-regulation strategies. For example, researchers could ask quantitative questions about how much perceived effort a person put into using a strategy or the perceived success or effectiveness of executing a given strategy. Researchers could also employ qualitative measures that ask participants verbally record details about how a strategy was used or what a person did overall to cope or respond to a given situation.

For EMA studies, researchers should consider the use of "branching" in which participants only receive a portion of an EMA survey if they provide a certain response to an item. For example, researchers might only ask about substance-specific strategies when participants report cravings or exposure to external drug cues like social events, drug paraphernalia, or drugs. Using this strategy could help researchers to gather rich EMA data on use of self-regulation strategies while reducing response burden for participants. However, researchers need to be aware that participants may learn the branching logic and adjust their answers to avoid answering further questions.

Expanding to a Broader Range of SUD Populations

Most of the research using ILM to study self-regulation strategies in SUD has been among college student drinkers and cigarette smokers. Future research is needed among a broader range of individuals with SUDs (e.g., individuals using opioids, cocaine, cannabis, or multiple drugs) in order to establish similarities and differences in the use and effectiveness of self-regulation strategies across them.

Integrating ILM in Clinical Trial Research

We identified only a few ILM studies among treatment-engaged individuals with SUDs. We encourage researchers to integrate ILM into clinical trials to examine the momentary or daily use of self-regulation strategies as a mechanism of change. We believe this is especially important for clinical trials evaluating CBTs or MABTs, which both emphasize training in self-regulation strategies. Importantly, ILM allows researchers to examine different patterns of change throughout an intervention, as compared with merely investigating changes from pre- and post-treatment. For example, with recent statistical advancements (e.g., time-varying effects model, functional data analysis), researchers can explore not only the overall shape of change (e.g., increasing, decreasing, fluctuating), but also when a clinically meaningful change occurs during an intervention, or whether the rate of change is consistent throughout the study period [82–84].

Examining the Role of Contextual Factors

ILM allows for nuanced measurement of fluctuating intra-individual factors in the immediate situational context [2], such as the occurrence and intensity of daily hassles, negative affect, positive affect, craving, the presence of drug cues, and the accessibility of substances. Further research is needed on

how these intra-individual factors in the immediate situational context influence the use and effectiveness of self-regulation strategies. For example, it is plausible that substance-specific strategies like escaping cues (stimulus control) and drug refusal (active communication) may be particularly effective for preventing or reducing the immediate use of substances during high-risk situations in which individuals experience intense cravings and/or are exposed to cues or substances in their immediate environment. Additionally, it is plausible that substance-specific strategies like thinking of the future negative consequences of drug use (cognitive reappraisal) and noticing and accepting a craving without judgment and letting it pass (mindful acceptance) may be particularly effective as strategies to frequently implement throughout one's day (e.g., for passing cravings of varying levels of intensity that arise throughout the day) in order to prevent escalations in craving intensity over time.

Contextual factors in the broader context in which an individual is embedded may also influence the use and effectiveness of self-regulation strategies. The broader context may include major life events (e.g., losing one's job, traumatic events), environmental conditions (e.g., discrimination, socioeconomic status, social support), and person-level dispositions or characteristics (e.g., gender, race/ethnicity, substance use disorder severity, psychiatric and medical comorbidities). For example, the use of general self-regulation strategies for managing stress may play a particularly important role in the SUD recovery process among individuals experiencing frequent and severe demands in their lives (e.g., an individual experiencing co-occurring depression and chronic pain, a history of trauma, low-income status, and frequent incidences of racial and gender discrimination).

Importantly, hypotheses regarding the role of contextual factors can be empirically tested with ILM research. For further guidance on how to consider contextual variables in the study of self-regulation among individuals with SUD, readers are referred to the first author's paper proposing a contextual model of self-regulation change mechanisms [2].

Conclusions

Overall, there are still a relatively small number of studies using ILM to study self-regulation strategies among individuals with SUDs. However, extant studies highlight the promise of ILM and provide preliminary evidence that certain self-regulation strategies are associated with decreased substance use at the within-person level. We believe that ILM research is particularly well suited to enhance our understanding of the dynamic, intra-individual process in which self-regulation strategies facilitate substance use behavior change over time. This research has the potential to directly inform the refinement and personalization of CBTs and MABTs for SUD, as well as other interventions. Specifically, this research can inform the next generation of mobile, technology-based interventions for SUDs that help individuals implement self-regulation strategies in the moment during their daily lives [50, 85–87]. In this article, we have provided several recommendations for future research using these methods, with a particular focus on how self-regulation strategies are measured. We look forward to the next wave of ILM research on self-regulation strategies among individuals with SUDs.

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References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1. Kober H, Bolling D. Emotion regulation in substance use disorders. In: Handbook of emotion regulation, vol. 2; 2014. p. 428–46.
2.•• Roos CR, Witkiewitz K. A contextual model of self-regulation change mechanisms among individuals with addictive disorders. Clin psychol rev. 2017;57:117–28 **This article describes a theoretical model aimed at helping SUD researchers conceptualize how various contextual factors may influence the use and effectiveness of self-regulation strategies. Moreover, this article provides practical recommendations on how to empirically evaluate if and how the role of self-regulation strategies is moderated by context.**
3. Cheetham A, Allen NB, Yücel M, Lubman DI. The role of affective dysregulation in drug addiction. Clin Psychol Rev. 2010;30(6):621–34.
4. Marlatt G, Gordon J. Relapse prevention: maintenance strategies in the treatment of addictive behaviors. New York: Guilford; 1985.
5. Carver CS, Scheier MF. On the self-regulation of behavior: Cambridge University Press; 2001.
6. Skinner MD, Aubin H-J. Craving's place in addiction theory: contributions of the major models. Neurosci Biobehav Rev. 2010;34(4):606–23.
7. Marlatt GA, Donovan DM. Relapse prevention: maintenance strategies in the treatment of addictive behaviors: Guilford press; 2005.
8. Witkiewitz K, Marlatt GA. Relapse prevention for alcohol and drug problems: that was Zen, this is Tao. 2009.
9. Carroll K. A cognitive-behavioral approach: treating cocaine addiction: US Department of Health and Human Services, National Institutes of Health …; 1998.
10. Monti PM. Treating alcohol dependence: a coping skills training guide: Guilford Press; 2002.
11. Carey KB, Scott-Sheldon LA, Carey MP, DeMartini KS. Individual-level interventions to reduce college student drinking: a meta-analytic review. Addict Behav. 2007;32(11):2469–94.
12. Magill M, Ray L, Kiluk B, Hoadley A, Bernstein M, Tonigan JS, et al. A meta-analysis of cognitive-behavioral therapy for alcohol or other drug use disorders: treatment efficacy by contrast condition. J Consult Clin Psychol. 2019;87(12):1093–105.

13. Bowen S, Chawla N, Marlatt GA. Mindfulness-based relapse prevention for addictive behaviors: a clinician's guide: Guilford Press; 2011.
14. Garland EL. Mindfulness-oriented recovery enhancement for addiction, stress, and pain: NASW Press, National Association of Social Workers Washington, DC; 2013.
15. Linehan M. DBT? Skills training manual: Guilford Publications; 2014.
16. Hayes SC, Strosahl KD, Wilson KG. Acceptance and commitment therapy: the process and practice of mindful change: Guilford Press; 2011.
17. Cavicchioli M, Movalli M, Maffei C. The clinical efficacy of mindfulness-based treatments for alcohol and drugs use disorders: a meta-analytic review of randomized and nonrandomized controlled trials. Eur Addict Res. 2018;24:137–62.
18. Goldberg SB, Tucker RP, Greene PA, Davidson RJ, Wampold BE, Kearney DJ, et al. Mindfulness-based interventions for psychiatric disorders: a systematic review and meta-analysis. Clin Psychol Rev. 2018;59:52–60.
19. McHugh RK, Hearon BA, Otto MW. Cognitive behavioral therapy for substance use disorders. Psychiatr Clin. 2010;33(3):511–25.
20. Perkins KA, Conklin CA, Levine MD. Cognitive-behavioral therapy for smoking cessation: a practical guidebook to the most effective treatments: Taylor & Francis; 2008.
21. Kadden R. Cognitive-behavioral coping skills therapy manual: a clinical research guide for therapists treating individuals with alcohol abuse and dependence: US Department of Health and Human Services, Public Health Service, National …; 1995.
22. Guven F, Camsari U, Senormanci O, Oguz G. Cognitive behavioral therapy in cannabis use disorder. Handbook of cannabis and related pathologies: Elsevier; 2017. p. 1056–65.
23. Brewer JA, Mallik S, Babuscio TA, Nich C, Johnson HE, Deleone CM, et al. Mindfulness training for smoking cessation: results from a randomized controlled trial. Drug Alcohol Depend. 2011;119(1–2):72–80.
24. Vidrine JI, Spears CA, Heppner WL, Reitzel LR, Marcus MT, Cinciripini PM, et al. Efficacy of mindfulness-based addiction treatment (MBAT) for smoking cessation and lapse recovery: a randomized clinical trial. J Consult Clin Psychol. 2016;84(9):824–38.
25. Sjöberg L, Samsonowitz V. Coping strategies and relapse in alcohol abuse. Drug Alcohol Depend. 1985;15(3):283–301.
26. Litman GK, Stapleton J, Oppenheim A, Peleg M, Jackson P. The relationship between coping behaviours, their effectiveness and alcoholism relapse and survival. Br J Addict. 1984;79(3):283–91.
27. Dolan SL, Rohsenow DJ, Martin RA, Monti PM. Urge-specific and lifestyle coping strategies of alcoholics: relationships of specific strategies to treatment outcome. Drug Alcohol Depend. 2013;128(1–2):8–14.
28. Rohsenow DJ, Martin RA, Monti PM. Urge-specific and lifestyle coping strategies of cocaine abusers: relationships to treatment outcomes. Drug Alcohol Depend. 2005;78(2):211–9.
29. Brodbeck J, Bachmann MS, Znoj H. Distinct coping strategies differentially predict urge levels and lapses in a smoking cessation attempt. Addict Behav. 2013;38(6):2224–9.
30. Pearson MR. Use of alcohol protective behavioral strategies among college students: a critical review. Clin Psychol Rev. 2013;33(8):1025–40.
31. Kober H, Kross EF, Mischel W, Hart CL, Ochsner KN. Regulation of craving by cognitive strategies in cigarette smokers. Drug Alcohol Depend. 2010;106(1):52–5.
32. Naqvi NH, Ochsner KN, Kober H, Kuerbis A, Feng T, Wall M, et al. Cognitive regulation of craving in alcohol-dependent and social drinkers. Alcohol Clin Exp Res. 2015;39(2):343–9.
33. Suzuki S, Mell MM, O'Malley SS, Krystal JH, Anticevic A, Kober H. Regulation of craving and negative emotion in alcohol use disorder. Biological psychiatry: cognitive neuroscience and neuroimaging. 2020;5(2):239–50.
34. Westbrook C, Creswell JD, Tabibnia G, Julson E, Kober H, Tindle HA. Mindful attention reduces neural and self-reported cue-induced craving in smokers. Soc Cogn Affect Neurosci. 2013;8(1):73–84.
35. Litvin EB, Kovacs MA, Hayes PL, Brandon TH. Responding to tobacco craving: experimental test of acceptance versus suppression. Psychol Addict Behav. 2012;26(4):830–7.
36. Serfaty S, Gale G, Beadman M, Froeliger B, Kamboj SK. Mindfulness, acceptance and defusion strategies in smokers: a systematic review of laboratory studies. Mindfulness. 2018;9(1):44–58.
37. Szasz PL, Szentagotai A, Hofmann SG. Effects of emotion regulation strategies on smoking craving, attentional bias, and task persistence. Behav Res Ther. 2012;50(5):333–40.
38. Rogojanski J, Vettese LC, Antony MM. Coping with cigarette cravings: comparison of suppression versus mindfulness-based strategies. Mindfulness. 2011;2(1):14–26.
39. Beadman M, Das RK, Freeman TP, Scragg P, West R, Kamboj SK. A comparison of emotion regulation strategies in response to craving cognitions: effects on smoking behaviour, craving and affect in dependent smokers. Behav Res Ther. 2015;69:29–39.
40. Shiffman S, Stone AA, Hufford MR. Ecological momentary assessment. Annu Rev Clin Psychol. 2008;4:1–32.
41. Tennen H, Affleck G, Armeli S, Carney MA. A daily process approach to coping: linking theory, research, and practice. Am Psychol. 2000;55(6):626–36.
42. Trull TJ, Ebner-Priemer U. Ambulatory assessment. Annu Rev Clin Psychol. 2013;9:151–76.
43. Shiffman S. Ecological momentary assessment (EMA) in studies of substance use. Psychol Assess. 2009;21(4):486–97.
44. Serre F, Fatseas M, Swendsen J, Auriacombe M. Ecological momentary assessment in the investigation of craving and substance use in daily life: a systematic review. Drug Alcohol Depend. 2015;148:1–20.
45. Jones A, Remmerswaal D, Verveer I, Robinson E, Franken IH, Wen CKF, et al. Compliance with ecological momentary assessment protocols in substance users: a meta-analysis. Addiction. 2019;114(4):609–19.
46. Epstein DH, Willner-Reid J, Vahabzadeh M, Mezghanni M, Lin J-L, Preston KL. Real-time electronic diary reports of cue exposure and mood in the hours before cocaine and heroin craving and use. Arch Gen Psychiatry. 2009;66(1):88–94.
47. Preston KL, Kowalczyk WJ, Phillips KA, Jobes ML, Vahabzadeh M, Lin J-L, et al. Exacerbated craving in the presence of stress and drug cues in drug-dependent patients. Neuropsychopharmacology. 2018;43(4):859–67.
48. Preston KL, Schroeder JR, Kowalczyk WJ, Phillips KA, Jobes ML, Dwyer M, et al. End-of-day reports of daily hassles and stress in men and women with opioid-use disorder: relationship to momentary reports of opioid and cocaine use and stress. Drug Alcohol Depend. 2018;193:21–8.
49. Preston KL, Vahabzadeh M, Schmittner J, Lin J-L, Gorelick DA, Epstein DH. Cocaine craving and use during daily life. Psychopharmacology. 2009;207(2):291–301.
50. Nahum-Shani I, Smith SN, Spring BJ, Collins LM, Witkiewitz K, Tewari A, et al. Just-in-time adaptive interventions (JITAIs) in mobile health: key components and design principles for ongoing health behavior support. Ann Behav Med. 2018;52(6):446–62.
51.• Bolger N, Laurenceau J-P. Intensive longitudinal methods: an introduction to diary and experience sampling research: Guilford Press; 2013. **This is an excellent book on ILM.**
52. Zeng EY, Heffner JL, Copeland WK, Mull KE, Bricker JB. Get with the program: adherence to a smartphone app for smoking cessation. Addict Behav. 2016;63:120–4.

53. Bricker JB, Mull KE, Kientz JA, Vilardaga R, Mercer LD, Akioka KJ, et al. Randomized, controlled pilot trial of a smartphone app for smoking cessation using acceptance and commitment therapy. Drug Alcohol Depend. 2014;143:87–94.
54. Heffner JL, Vilardaga R, Mercer LD, Kientz JA, Bricker JB. Feature-level analysis of a novel smartphone application for smoking cessation. The American journal of drug and alcohol abuse. 2015;41(1):68–73.
55. Minami H, McCarthy DE, Jorenby DE, Baker TB. An ecological momentary assessment analysis of relations among coping, affect and smoking during a quit attempt. Addiction. 2011;106(3):641–50.
56.•• O'Connell KA, Hosein VL, Schwartz JE, Leibowitz RQ. How does coping help people resist lapses during smoking cessation? Health Psychol. 2007;26(1):77 **Although this is an older study, it is still an important study demonstrating how specific self-regulation strategies help smokers cope with cravings and resist smoking in the moment during their daily lives.**
57. O'Connell KA, Hosein VL, Schwartz JE. Thinking and/or doing as strategies for resisting smoking. Research in nursing & health. 2006;29(6):533–42.
58. Shiffman S, Gnys M, Richards TJ, Paty JA, Hickcox M, Kassel JD. Temptations to smoke after quitting: a comparison of lapsers and maintainers. Health Psychol. 1996;15(6):455–61.
59. Shiffman S, Paty JA, Gnys M, Kassel JA, Hickcox M. First lapses to smoking: within-subjects analysis of real-time reports. J Consult Clin Psychol. 1996;64(2):366–79.
60.• Pearson MR, Bravo AJ, Conner BT, Parnes JE. A day in the life: a daily diary examination of marijuana motives and protective behavioral strategies among college student marijuana users. J Drug Issues. 2019:0022042619890837 **Overall, there is limited research using ILM to study self-regulation strategies among marijuana users. Hence, this is a unique and important study that explores the role of protective behavioral strategies, at a daily level, among college student marijuna users.**
61. Pedersen ER, Huang W, Dvorak RD, Prince MA, Hummer JF. The protective behavioral strategies for marijuana scale: further examination using item response theory. Psychol Addict Behav. 2017;31(5):548–59.
62.• Linden-Carmichael AN, Calhoun BH, Patrick ME, Maggs JL. Are protective behavioral strategies associated with fewer negative consequences on high-intensity drinking days? Results from a measurement-burst design. Psychol Addictive Behav. 2018;32(8):904 **This study demonstrates that a measurement-burst design (involving 14 consecutive daily surveys for each semester from fall of first year to fall of fourth year) may be a useful approach for ILM studies on the use of self-regulation strategies over time among college student drinkers.**
63. Martens MP, Ferrier AG, Sheehy MJ, Corbett K, Anderson DA, Simmons A. Development of the protective behavioral strategies survey. J Stud Alcohol. 2005;66(5):698–705.
64. Sell NM, Turrisi R, Scaglione NM, Cleveland MJ, Mallett KA. Alcohol consumption and use of sexual assault and drinking protective behavioral strategies: a diary study. Psychol Women Q. 2018;42(1):62–71.
65. Moore CD, Waterman CK. Predicting self-protection against sexual assault in dating relationships among heterosexual men and women, gay men, lesbians, and bisexuals. J Coll Stud Dev. 1999.
66.•• Dulin PL, Gonzalez VM. Smartphone-based, momentary intervention for alcohol cravings amongst individuals with an alcohol use disorder. Psychology of addictive behaviors. 2017;31(5):601 **This study is an excellent study on a novel mobile app-based interventions for alcohol use disorder that helps individuals use coping strategies in the moment. Also, this study shows that mobile apps can track strategy use over time and this data can be utilized to examine within-person effects of strategy use.**
67.•• Weiss NH, Bold KW, Sullivan TP, Armeli S, Tennen H. Testing bidirectional associations among emotion regulation strategies and substance use: a daily diary study. Addiction. 2017;112(4):695–704 **This study is unique in demonstrating how substance use is associated with subsequent next-day use of self-regulation strategies. Hence, this study suggests that future studies should explore the bi-directional associatios over time between self-regulation strategies and substance use.**
68. Ehrenberg E, Armeli S, Howland M, Tennen H. A daily process examination of episode-specific drinking to cope motivation among college students. Addict Behav. 2016;57:69–75.
69. Carver CS, Scheier MF, Weintraub JK. Assessing coping strategies: a theoretically based approach. J Pers Soc Psychol. 1989;56(2):267–83.
70. Pearson MR, D'Lima GM, Kelley ML. Daily use of protective behavioral strategies and alcohol-related outcomes among college students. Psychol Addict Behav. 2013;27(3):826–31.
71. Lewis MA, Patrick ME, Lee CM, Kaysen DL, Mittman A, Neighbors C. Use of protective behavioral strategies and their association to 21st birthday alcohol consumption and related negative consequences: a between-and within-person evaluation. Psychol Addict Behav. 2012;26(2):179–86.
72. Aldridge-Gerry AA, Roesch SC, Villodas F, McCabe C, Leung QK, Da Costa M. Daily stress and alcohol consumption: modeling between-person and within-person ethnic variation in coping behavior. J Stud Alcohol Drugs. 2011;72(1):125–34.
73.•• Litt MD, Kadden RM, Kabela-Cormier E. Individualized assessment and treatment program for alcohol dependence: results of an initial study to train coping skills. Addiction. 2009;104(11):1837–8.
74. Park CL, Armeli S, Tennen H. The daily stress and coping process and alcohol use among college students. J Stud Alcohol. 2004;65(1):126–35.
75. Gross JJ, Thompson RA. Emotion regulation: conceptual foundations. 2007.
76. Moos RH, Holahan CJ. Dispositional and contextual perspectives on coping: toward an integrative framework. J Clin Psychol. 2003;59(12):1387–403.
77.•• Litt MD, Kadden RM, Tennen H. The nature of coping in treatment for marijuana dependence: Latent structure and validation of the Coping Strategies Scale. Psychol Addict Behav. 2012;26(4):791 **Although a relatively older study, this is an important study that capitalizes on EMA to investigate the role of coping as a mechanism of change in CBT for alcohol use disorder. This study provides an excellent example of how EMA can be integrated in clinical trials to understand momentary self-regulation as a mechanism of change.**
78. Lazarus RS, Folkman S. Stress, appraisal, and coping: Springer publishing company; 1984.
79. Moggi F, Ouimette PC, Moos RH, Finney JW. Dual diagnosis patients in substance abuse treatment: relationship of general coping and substance-specific coping to 1-year outcomes. Addiction. 1999;94(12):1805–16.
80. Tomko RL, Solhan MB, Carpenter RW, Brown WC, Jahng S, Wood PK, et al. Measuring impulsivity in daily life: the momentary impulsivity scale. Psychol Assess. 2014;26(2):339–49.
81. Rush J, Hofer SM. Differences in within-and between-person factor structure of positive and negative affect: analysis of two intensive measurement studies using multilevel structural equation modeling. Psychol Assess. 2014;26(2):462–73.
82. Tan X, Shiyko MP, Li R, Li Y, Dierker L. A time-varying effect model for intensive longitudinal data. Psychol Methods. 2012;17(1):61–77.
83. Timms KP, Rivera DE, Collins LM, Piper ME. A dynamical systems approach to understanding self-regulation in smoking cessation behavior change. Nicotine Tobacco Res. 2013;16(Suppl_2):S159–S68.

84. Dziak JJ, Li R, Tan X, Shiffman S, Shiyko MP. Modeling intensive longitudinal data with mixtures of nonparametric trajectories and time-varying effects. Psychol Methods. 2015;20(4):444–69.
85. Litvin EB, Abrantes AM, Brown RA. Computer and mobile technology-based interventions for substance use disorders: an organizing framework. Addict Behav. 2013;38(3):1747–56.
86. Carroll KM, Kiluk BD. Cognitive behavioral interventions for alcohol and drug use disorders: through the stage model and back again. Psychol Addict Behav. 2017;31(8):847–61.
87. Kiluk BD. Computerized cognitive behavioral therapy for substance use disorders: a summary of the evidence and potential mechanisms of behavior change. Perspectives on Behavior Science. 2019;42(3):465–78.