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Why Don't They Stop? Understanding Unplanned Marijuana Use Among Adolescents and Young Adults

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Difficulty regulating substance use is a core feature of addiction that can manifest as unplanned use. This study sought to identify internal and situational influences on unplanned marijuana use among youth ages 15 to 24 years (N = 85; 48% female; 27% age <18 years). Additionally, we disentangled person-level associations from within-person day-to-day influences. Ecological momentary assessment methods captured affective (positive: energized, excited, sociable, happy, relaxed; negative: bored, tense, sad, stressed) and situational factors in real-world settings during a 1-week monitoring period. Participants reported no plan to use on 51% of days (269/527), and youth ultimately used marijuana on 35% of these unplanned days. At the day level, on days when youth spent more time in the presence of marijuana-related cues than they typically do, they used more grams on planned days and less on unplanned days. Regardless of use plans, youth were more likely to use on days when they spent more time with using friends and if they reported greater availability of marijuana in general across the monitoring period. At the person level, youth who generally reported higher positive affect, relative to other participants, used more on planned days and less on unplanned days. Regardless of use plans, youth who generally reported greater craving and time in the presence of marijuana-related cues used more grams, whereas youth who generally reported greater negative affect used less. Together, findings revealed several factors, with clear clinical relevance, which may explain why some youth struggle to control their marijuana use.

Keywords: ecological momentary assessment, marijuana use, unplanned use, positive affect, peer influence

Marijuana is the most commonly used illicit drug in the United States, with the highest prevalence rates among adolescents and young adults (Johnston et al., 2018). Data from the Substance Abuse and Mental Health Services Administration (SAMHSA) indicate that marijuana use typically begins and peaks during the teenage years, with an estimated 8.1 million youth in the United States using daily (SAMHSA, 2017). Moreover, nearly one in five marijuana users will experience problems associated with their use and ultimately develop cannabis use disorder (CUD; SAMHSA, 2017). Although the harmful effects of marijuana use are well documented, the fundamental question concerning why some youth struggle to moderate their use remains largely unanswered.

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Some data reported in this study were presented in other published articles. Most notably, the treatment outcomes of this randomized controlled trial were published elsewhere (Miranda et al., 2017). In addition, previous versions of these analyses were presented at the 41st Annual Scientific Meeting of the Research Society on Alcoholism, June 16–20, 2018, San Diego, California.

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Difficulty regulating substance use is a longstanding criterion for substance use disorders (Hasin, Hatzenbuehler, Keyes, & Ogburn, 2006). Impaired control manifests as a failure to abstain or reduce the frequency of use or an inability to limit consumption during use episodes (Hasin et al., 2006; Kahler, Epstein, & McCrady, 1995). This compromised control develops early in the course of addiction (Leeman, Toll, Taylor, & Volpicelli, 2009), represents one of the first symptoms to appear in adolescents and adults (Behrendt et al., 2008; Buu et al., 2012; Langenbucher & Chung, 1995), and predicts poor clinical outcomes (Heather, Booth, & Luce, 1998; Leeman, Fenton, & Volpicelli, 2007).

One way to exhibit impaired control is through unplanned use (Pearson & Henson, 2013). Research on unplanned use has focused almost exclusively on alcohol, finding that unplanned drinking is associated with trait measures of impulsivity and affect regulation (Leeman, Patock-Peckham, & Potenza, 2012, 2014; Pearson & Henson, 2013). Little is known, however, about factors associated with unplanned use of other substances, including marijuana, and no study has examined unplanned use in adolescents or young adults. This represents a significant gap in knowledge given the rapidly changing climate surrounding marijuana use in the United States and beyond, where availability of legalized marijuana is increasing.

Youth frequently experience intense emotions (Arnett, 1999; Larson, Moneta, Richards, & Wilson, 2002) and research using ecological momentary assessment (EMA) methods, where individuals use electronic devices (e.g., mobile phones) to record information in real time in their daily lives, shows positive concurrent and prospective associations between positive and negative affect and substance use in this age group (Buckner, Crosby, Silgado, Wonderlich, & Schmidt, 2012; Pearson & Henson, 2013; Shrier, Ross, & Blood, 2014; Simons, Wills, & Neal, 2014; Swendsen et al., 2000). Heightened affective states are also important predictors of unsuccessful quit attempts among marijuana users (Buckner, Zvolensky, & Ecker, 2013; Scott, Dennis, & Gustafson, 2018). Similarly, drug craving—the subjective state of wanting or desire to use a substance—exhibits strong cross-sectional (Buckner, Crosby, Wonderlich, & Schmidt, 2012) and prospective associations with use (Buckner, Crosby, Silgado, et al., 2012; Miranda et al., 2014, 2016; Ramirez & Miranda, 2014) and unsuccessful quit attempts (Fatseas, Serre, Swendsen, & Auriacombe, 2018; Scott et al., 2018).

Situational factors also influence substance use. The presence of peers is associated with increased risk of substance use among adolescents and young adults (Treloar Padovano & Miranda, 2018). Similarly, exposure to substance-related cues is thought to trigger processes that drive substance-seeking behavior (Robinson & Berridge, 2003). Indeed, studies find that substance use in daily life is associated with exposure to substance-related cues (Marhe, Waters, van de Wetering, & Franken, 2013; Ramirez & Miranda, 2014) and drug availability (Shrier, Sarda, Jonestrask, & Harris, 2018). As such, the presence of marijuana cues or peers with whom youth use marijuana as well as marijuana availability may be important contexts that give rise to unplanned use.

In this study, we leveraged EMA methods to elucidate factors associated with unplanned marijuana use among youth in their daily lives. Few studies have used EMA to assess marijuana use among youth and, to our knowledge, this is the first study to examine real-time predictors of unplanned use. We examined associations of affective states and situational factors with *unplanned use events*, defined as using marijuana on a day when use was not planned. Ambivalence about marijuana use is common among youth (Feldstein Ewing, Apodaca, & Gaume, 2016; Hohman, Crano, Siegel, & Alvaro, 2014), whereas explicit plans to abstain from marijuana are rare (Slavet et al., 2006). Thus, to maximize clinical applicability, we focused on use that occurred in the absence of a plan to use rather than exclusively on use that occurred despite firm intentions to abstain. We anticipated that day-to-day influences of internal states (i.e., negative and positive affect, marijuana craving) and situations (i.e., presence of friends who use, places where youth typically use, marijuana-related cues, and marijuana availability) would have associations with unplanned marijuana use that may not be apparent when examined in aggregate (averaged) across days. This expectation fits with theories that posit important day- and person-level contributors to substance misuse (Colder, Chassin, Lee, & Villalta, 2010; McCarthy, Curtin, Piper, & Baker, 2010). Specifically, we hypothesized that the aforementioned internal states and situational factors would be positively related to the likelihood and quantity of unplanned use.

Method

Participants

Participants were 85 youth (41 females, 48%), ages 15 to 24 years (M = 19.8, SD = 2.1; 27% age <18 years), interested in receiving a psychosocial intervention combined with a medication that may help them reduce their marijuana use. Details regarding the parent clinical trial are published elsewhere (Miranda et al., 2017). The sample was comprised of adolescents and young adults, herein referred to as *youth*. The current study is a secondary analysis of data from the pre-randomization, premedication EMA period. Youth were recruited from the community. All participants used marijuana at least twice weekly in the last 30 days. The sample was 55% White, 29% Black/African American, 18% Hispanic, 4% American Indian/Alaskan Native, 2% Asian, 1% Native Hawaiian/Pacific Islander, and 1% another race.

Exclusion criteria were marijuana treatment in the last 30 days, court-mandated to treatment, current Axis I psychopathology other than cannabis, alcohol, nicotine, or disruptive behavior disorders, actively suicidal or psychotic, and medical conditions or medications that contraindicated the study medication. Female participants were excluded if they were pregnant, nursing, or unwilling to use birth control.

Procedure

Interested youth completed phone screens, and those tentatively eligible completed an in-person screening. Young adults and parents of minors completed informed consent; assent was obtained from minors. The Brown University Institutional Review Board approved the study. Participants completed baseline assessments, received handheld devices (Omnia, Samsung Electronics, Ridgefield Park, NJ), learned how to use the EMA program, and completed an EMA monitoring period of approximately 1 week prior to receiving any treatment; this premedication period is the focus of the current study. Length of participation was targeted for 1 week. To accommodate scheduling appointments for the parent trial, however, as few as 3 days and as many as 14 days of data were collected per participant (M = 6.9, SD = 1.6) with 95% providing 5 to 10 days of data. Youth were not instructed to alter their marijuana use.

Baseline Demographic and Clinical Characteristics

Demographics included gender, age, race, and ethnicity. For descriptive purposes, psychiatric diagnoses, including CUD, were assessed using the Kiddie Schedule for Affective Disorders for School-Age Children (Kaufman et al., 1997), a semistructured interview based on the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev.; *DSM–IV–TR*; American Psychiatric Association, 2000). There are notable differences in CUD between *DSM–IV–TR* and the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; *DSM–5*; American Psychiatric Association, 2013), including the removal of a diagnostic distinction between abuse and dependence. The legal problems criterion was also dropped in *DSM–5* and craving was added. Therefore, to more closely match both diagnostic systems, we provide information on *DSM–IV–TR* diagnoses of abuse and dependence, as determined by case consensus. We also report the total number of CUD symptoms, excluding legal problems and craving. Thus, participants could meet up to 10 total criteria, and all criteria were represented in this sample.

EMA Measures

The EMA program generated audible prompts for participants to complete brief ~2-min assessments at random times (i.e., random assessments) within 3-hr blocks (e.g., 12 p.m. to 3 p.m.) throughout the 24-hr day, except when they were unable to respond (e.g., driving, sleeping). Random assessments included measures of affect, craving, and situational factors. Participants also completed assessments upon waking (i.e., morning reports), wherein they reported their marijuana use plans for the day. Participants also completed assessments before and after they used marijuana (i.e., begin use reports and end use reports), in which they reported the amount of marijuana they used and completed items about the subjective effects of use that were not used in the present analyses. These prompts provided information regarding the timing of participants' use. Participants received $10 per day for complying with the EMA protocol.

Marijuana-use plan. Whether a participant planned to use marijuana on a given day was assessed by a single item administered during the morning report. Response options were "no," "yes," and "undecided." An *unplanned day* was operationalized as any day where a "no" or "undecided" response was provided. Our sample comprised largely daily users, and so, as expected based on prior research (Slavet et al., 2006), explicit plans to abstain were rare (77 person days, ~15%), whereas ambivalence (i.e., undecided) about use was more common (192 person days, ~36%). An *unplanned use day* was operationalized as any day where a response other than "yes" was provided, and the person later reported marijuana use that day. In contrast, a *planned day* was operationalized as any day where a "yes" response was recorded, and a *planned use day* was any day where a "yes" response was provided, and the person used marijuana that day.

Affect. At random assessments, participants reported on positive (energized, excited, sociable, happy, relaxed) and negative (bored, tense, sad, stressed) affect using 11-point scales (0 = *not at all* to 10 = *extremely*). Affect items were derived from the circumplex model of affect (Posner, Russell, & Peterson, 2005) and the Positive and Negative Affect Schedule–Expanded Form (Watson & Clark, 1999). Previous research supports the internal consistency and criterion validity of these affective items assessed using EMA (Hoeppner, Kahler, & Gwaltney, 2014; Treloar Padovano, Janssen, Emery, Carpenter, & Miranda, 2019).

Marijuana craving. At random assessments, marijuana craving was assessed with a single-item measure of urge to use on an 11-point scale from 0 (*no urge*) to 10 (*strongest ever*).

Situational marijuana-related factors. During random assessments, participants indicated if they were in a setting where they typically use marijuana (*yes* = 1, *no* = 0) or in the presence of people with whom they typically use marijuana (*yes* = 1, *no* = 0). Participants also identified the presence of marijuana-related cues in the environment and the availability of marijuana. For marijuana-related cues, participants selected one of three options: *no* = 0, *visible directly* = 1, *visible indirectly* = 2 (e.g., photo). The latter two options were combined, and the resulting variable represented the absence (0) or presence (1) of marijuana-related cues. For marijuana availability, participants selected one of three response options: *no* = 0; *yes, with difficulty* = 1; *yes, easily* = 2. Again, the latter two options were combined, resulting in a dichotomous variable reflecting marijuana unavailability (0) or availability (1).

Marijuana use. Marijuana use at baseline was assessed using the 90-day Timeline Follow-Back (TLFB) Interview (Sobell & Sobell, 1992). Marijuana use during the EMA period was assessed by participant-initiated marijuana use reports. Participants were instructed to self-initiate a begin-use report just before using any marijuana and an end-use report immediately after each marijuana use event (e.g., bowl, joint). At each end-use report, participants recorded the quantity of marijuana used in grams. If participants shared marijuana with others, the total weight reported was divided by the number of users. Whether a person used on a given day and the total grams used on a use day were the focal outcomes of the analysis.

Analysis Plan

To test the hypothesized day- and person-level associations for use on unplanned versus planned use days, we estimated multilevel models (MLMs) with random intercepts. The data had a two-level structure with days (Level 1 [L1]) nested within persons (Level 2 [L2]). MLM accounts for the nonindependence of observations that results from the nesting of time-varying observations within persons. Data were analyzed with Stata (Version 15; StataCorp, 2017) and followed a model-building approach (i.e., increasing model complexity in steps) to sequentially examine effects while maintaining a parsimonious model. Likelihood ratio tests examined the relative fit of nested models (i.e., the difference in −2 log-likelihood statistics between pairs of base and expanded models).

First, we estimated an MLM with the likelihood of use on a given day as the outcome (i.e., binary outcome: used = 1, did not use = 0). Next, we estimated an MLM with total grams used on use days as the outcome (i.e., quantity of use on use days). Given that outcomes were assessed daily, all internal states and situational factors assessed at random assessments were aggregated within each day to align 1:1 with outcomes and avoid inflating the *n* for analyses. Day-level affect aggregates were daily averages of positive and negative affective states. Day-level situational aggregates were calculated as the proportion of prompts where youth indicated they were in one of these contexts: places associated with use, the presence of marijuana-related cues, and with marijuana available. For ease of interpretation, hereafter these are referred to as *proportion of time spent* in each of these contexts.

Day-level (L1) effects allowed us to elucidate within-person processes associated with unplanned use, such that on days when youth experience certain stronger affective states or situational contexts (e.g., presence of marijuana-related cues) they may be more likely to engage in unplanned use and consume greater quantities of marijuana. By contrast, person-level (L2) effects allowed us to understand whether individuals who, on average and relative to the overall sample, experience stronger affective states or situational contexts may be more likely to engage in unplanned use and consume greater quantities of marijuana. L1 variables were centered within persons by subtracting person-averages from day-level values (i.e., person-centered). L2 variables were centered within the sample by subtracting sample-averages of each day type (i.e., planned and unplanned) from person-level averages (grand-mean centered). In this context, person-centered variables reflect daily deviations from a person's average level, and grand-mean-centered variables reflect person deviations from the overall average for the sample on that day type.

Initial intercept-only models (without any predictors) estimated intraclass correlations (i.e., variability in use that can be attributed to between-person influences, relative to within-person influences). To test the specificity of predictors of planned and unplanned marijuana use, each substantive predictor in the model was interacted with a dichotomous variable indicating the day type (planned = 0, unplanned = 1). To mitigate possible effects of use on our predictors, we excluded assessments that occurred just before (i.e., begin-use reports) and up to 90 min after a use episode. The inclusion of marijuana availability as a focal predictor also accounts for any covariance between use plans and availability. Also, at L1, weekend status (weekday = 0, weekend = 1) was included as a covariate. Inclusion of weekend status addresses weekend versus weekday variation in marijuana use as well as reducing potential serial autocorrelation across days (Mohr et al., 2001). At L2, gender (men = 0, women = 1) was included as an additional covariate to account for potential gender differences in use rates, which is commonly seen in youth (Schepis et al., 2011). Lastly, L2 covariates of age, race (0 = White, 1 = non-White), and ethnicity (non-Hispanic or Latinx = 0, Hispanic or Latinx = 1) were also included on an exploratory basis given the generative nature of this work.

Results

Descriptive Statistics

All participants reported at least one CUD symptom. Eighty percent met criteria for a CUD according to the *DSM–IV–TR*, with a mean age of onset of 16.5 ± 2.0 years for abuse and 17.3 ± 2.0 years for dependence. Nineteen percent (n = 16) met criteria for cannabis abuse and 61% (n = 52) for dependence.

Participants had good EMA compliance, completing 84% of the random assessments ($N_{\text{completed}}$ = 1,730) and 86% of the morning reports ($N_{\text{completed}}$ = 527). The average number of completed random assessments per day was 3.3 (SD = 1.5). On most days (95%) participants missed two or fewer random assessments (range = 0–8 missed; M = 0.6, SD = 1.0). At the person level, the number of missed random assessments was correlated with marijuana-use days during the EMA period (r = .22, p = .048), but was not correlated with 90-day TLFB percentage use days, 90-day TLFB grams per use day, CUD symptom count, age, or grams smoked per use day during the EMA period (ps = .091–.771). Male participants also had more missed random prompts than did female participants ($M_{\text{difference}}$ = 0.2), $t(83)$ = 2.21, p = .030. Average morning report compliance ranged from 60% to 100% (SD = 10.3%) and exhibited a marginal negative association with average missed random prompts (r = −0.21, p = .050). Of the completed random assessments, 462 occurred within 90 min following marijuana use and thus were excluded to aid with temporal ordering. That left 1,268 eligible random observations over 527 person days. There were 541 begin-use and 525 end-use reports completed over the EMA period, which translates to a 97% match rate.

At baseline, participants reported an average of 43.7 total grams (SD = 46.7) of marijuana used over 62.5 (SD = 24.5) of the previous 90 days. Forty percent used marijuana on at least 78 of the previous 90 days and approximately 10% used daily. Over the EMA period, participants reported using marijuana on 58% of study days and reported an average of 0.5 (SD = 0.4) grams per use day. Participants' average grams per use day during the EMA period was correlated with the average grams used as reported in the 90-day TLFB at baseline (r = .30, p = .005), and percentage use days during the EMA period was correlated with the percentage use days as reported in the 90-day TLFB at baseline (r = .23, p = .044). Fifty-one percent of days were unplanned (269/527) and youth used marijuana on 35% of these unplanned days, consuming an average 1.9 g (SD = 1.0) per unplanned use day. See Table 1 for descriptive statistics of L1 and L2 variables.

Unplanned use varied across persons and days. The intraclass correlations were 0.18 and 0.40 for the likelihood and quantity of use on an unplanned day, respectively. This indicates that 18% of the variance in the likelihood of using on an unplanned day was due to between-person factors and the remaining 82% was due to day-to-day within-person fluctuations. For quantity, 40% of the variance was due to between-person differences, whereas 60% was due to within-person day-to-day variability.

Predictors of Use Outcomes

At each step, joint tests of conceptually related effects (i.e., a test of all effects being zero) were conducted and likelihood ratio tests determined whether additional fixed effects improved model fit. Separate model-building procedures were implemented for likelihood and quantity. In the following text, we present the results of the model-building steps for both the likelihood and quantity models and review the findings of each final model.

Likelihood model building. First, we estimated an MLM containing only main effects of focal variables and hypothesized covariates (i.e., gender, weekend) on a dichotomous daily use outcome (i.e., used = 1, did not use = 0). This was used as the

Table 1
Descriptive Statistics of Level 1 (L1) and Level 2 (L2) Variables

Variable	M	SD	Skew
Day level (L1)			
Negative affect	2.21	1.78	0.97
Positive affect	5.20	1.87	0.02
Craving	4.06	3.00	0.32
Time with friends[a]	0.46	0.40	0.40
Time in places[a]	0.54	0.40	−0.05
Time with cues[a]	0.32	0.39	1.04
Time with marijuana available[a]	0.63	0.43	−0.21
Use days	0.50	0.50	0.00
Grams used on use days	1.23	1.60	1.47
Person level (L2)			
Negative affect	2.26	1.37	0.56
Positive affect	5.28	1.36	0.01
Craving	4.10	2.37	0.17
Time with friends[b]	0.47	0.25	0.15
Time in places[b]	0.55	0.27	−0.28
Time with cues[b]	0.33	0.28	0.63
Time with marijuana available[b]	0.65	0.29	−0.36
Use days	0.46	0.27	−0.06
Grams used on use days	1.15	0.94	1.00

Note. N = 85. L1 observations = 462 person days.
[a] Represents the proportion of prompts youth indicated they were in one of these contexts on that given day. [b] Average proportion of prompts that person spends in that type of context across all study days.

base model. Next, the main effects of exploratory covariates were added as a set. After this, interactions between day type (i.e., planned vs. unplanned) and conceptually related sets of focal predictors were systematically introduced into the model. Interactive effects of focal predictors were tested first at L1 then at L2 as cross-level interactions.

First, exploratory covariates of age, race, and ethnicity were simultaneously added to the model and improved fit, $\Delta\chi^2(3, N = 85) = 8.23$, $p = .041$. Race ($p = .094$) and ethnicity ($p = .347$), however, were not significant. Thus, for parsimony, these two nonsignificant predictors were dropped and the step re-estimated. In the resulting model, the addition of age ($b = 0.03$, $p = .028$) remained a significant improvement, $\Delta\chi^2(1, N = 85) = 4.71$, $p = .030$, and thus was retained and treated as the new base model. Second, day-level Positive and Negative Affect × Day Type interaction terms were simultaneously introduced to the model. These additions did not significantly improve the model, $\Delta\chi^2(2, N = 85) = 5.51$, $p = .064$, and thus these interactions were removed. Next, a day-level Craving × Day Type interaction was introduced. This was not a significant addition to the model, $\Delta\chi^2(1, N = 85) = 0.93$, $p = .336$, and was removed. In the next step, day-level time spent in the presence of cues, time spent with using friends, and Time Spent in Using Places × Day Type interactions were added to the model. These did not result in a significant addition, $\Delta\chi^2(3, N = 85) = 1.18$, $p = .758$, and were dropped from the model. The following step added a day-level Time With Marijuana Available × Day Type interaction, but this was a nonsignificant addition, $\Delta\chi^2(1, N = 85) = 0.11$, $p = .744$, and was removed.

The next step introduced person-level Positive and Negative Affect × Day Type cross-level interactions. These did not represent a significant addition, $\Delta\chi^2(2, N = 85) = 0.61$, $p = .737$, and were removed. Next, a person-level Craving × Day Type cross-level interaction term was entered into the model, resulting in a nonsignificant addition, $\Delta\chi^2(1, N = 85) = 0.04$, $p = .837$, and thus, was removed. After this, person-level Time Spent in the Presence of Cues, Time Spent with Using Friends, and Time Spent in Using Places × Day Type cross-level interactions were added. These did not result in a significant addition, $\Delta\chi^2(3, N = 85) = 2.98$, $p = .394$, and were dropped from the model. In the final step, a person-level Time With Marijuana Available × Day Type cross-level interaction was added. Once again, this is was not a significant addition, $\Delta\chi^2(1, N = 85) = 0.27$, $p = .603$, and was therefore removed. In all, none of the interactions represented significant additions. Thus, as shown in Table 2, the final model consisted of only main effects.

Final likelihood model summary. As shown in Table 2, participants were less likely to use on unplanned days than planned days ($b = -0.22$, $p < .001$) and more likely to use on weekdays than weekends ($b = -0.10$, $p = .038$). At the day level (i.e., within persons), spending more time with friends with whom participants typically use marijuana was associated with an increased likelihood of use on both unplanned and planned days ($b = 0.28$, $p < .001$). At the person level (i.e., between persons), greater average time spent in the presence of marijuana-related cues ($b = -0.34$, $p = .008$) and in places one typically uses ($b = -0.33$, $p = .003$) were both associated with the likelihood of use on both unplanned and planned days. In contrast, greater average time spent in the presence of friends with whom youth typically use ($b = 0.60$, $p < .001$) and with marijuana available ($b = 0.42$, $p = .001$) were both associated with an increased likelihood of use on unplanned and planned use days. Likewise, greater average craving ($b = 0.03$, $p = .040$) was related to an increased likelihood of use on both planned and unplanned use days. Last, youth were more likely to

Table 2
Multilevel Model of Likelihood of Use

Variable	*b*	*OR*	*SE*	*p*	95% CI
Within-persons					
Use plans	**−0.22**	**0.80**	**0.05**	**<.001**	**[−.31, −.13]**
Negative affect	−0.02	0.98	0.02	.402	[−.06, .02]
Positive affect	0.02	1.02	0.02	.373	[−.02, .06]
Craving	−0.01	0.99	0.01	.207	[−.04, .01]
Time with friends[a]	**0.28**	**1.32**	**0.07**	**<.001**	**[.14, .42]**
Time in places[a]	0.06	1.06	0.07	.415	[−.09, .21]
Time with cues[a]	0.10	1.10	0.08	.222	[−.06, .25]
Time with marijuana available[a]	0.03	1.03	0.07	.649	[−.11, .18]
Weekend	**−0.10**	**0.90**	**0.05**	**.038**	**[−.18, −.01]**
Between-persons					
Negative affect	−0.05	0.96	0.02	.052	[−.10, .01]
Positive affect	0.01	1.02	0.02	.864	[−.04, .05]
Craving	**0.03**	**1.03**	**0.01**	**.040**	**[.01, .06]**
Time with friends[b]	**0.60**	**1.82**	**0.14**	**<.001**	**[.32, .89]**
Time in places[b]	**−0.33**	**0.72**	**0.11**	**.003**	**[−.55, −.11]**
Time with cues[b]	**−0.34**	**0.71**	**0.13**	**.008**	**[−.59, −.09]**
Time with marijuana available[b]	**0.42**	**1.52**	**0.13**	**.001**	**[.18, .66]**
Age	**0.03**	**1.03**	**0.02**	**.028**	**[.01, .06]**
Gender	0.02	1.02	0.05	.664	[−.08, .13]

Note. $N = 85$. Values are unstandardized coefficients. Boldface type denotes significance. Level 1 observations = 462 person days. Within-persons = day level (L1); between-persons = person level (L2); gender (men = 0; women = 1).
[a] Represents the proportion of prompts youth indicated they were in one of these contexts on that given day. [b] Average proportion of prompts that person spends in that type of context across all study days.

use if they were older (b = 0.03, p = .028). There were no other significant effects in the final model.

Quantity model building. In this model, the primary outcome was the number of grams used on use days. Following the same approach as the likelihood model, we began with a simple multilevel main effects model including focal predictors and hypothesized covariates. This was the base model. After this, exploratory covariates and interactions between the focal predictors and day type (i.e., planned vs. unplanned) were systematically added. First, the demographic factors age, ethnicity, and race were simultaneously introduced to the model. These additions did not result in significant model improvement, $\Delta\chi^2(3, N = 73) = 2.94$, $p = .402$, and were consequently dropped. Second, day-level Positive Affect and Negative Affect × Day Type interactions were added simultaneously. These additions did not result in significant improvement in fit, $\Delta\chi^2(2, N = 73) = 0.01$, $p = .995$, and these interactions were not retained. Next, a day-level Craving × Day Type interaction was introduced to the model. This did not significantly improve the model, $\Delta\chi^2(1, N = 73) = 2.50$, $p = .114$, and was removed. In the next step, day-level Time Spent in the Presence of Cues ($b = -1.80$, $p = .005$), Time Spent with Using Friends (p = .396), and Time Spent in Using Places × Day Type (p = .832) interactions were entered simultaneously, contributing significantly to improved model fit, $\Delta\chi^2(3, N = 73) = 8.26$, $p = .041$. However, two of the three interaction effects were not significant. Thus, for parsimony, the nonsignificant interactions were dropped and the step re-estimated. In the resulting model, the addition of the Time Spent in the Presence of Cues × Day Type ($b = -1.67$, $p = .005$) interaction in isolation remained a significant improvement, $\Delta\chi^2(1, N = 73) = 7.51$, $p = .006$, and thus, was retained and treated as the new base model. The next step added a day-level Time with Marijuana Available × Day Type interaction. This was a nonsignificant addition, $\Delta\chi^2(1, N = 73) = 0.00$, $p = .982$, and was removed.

The following steps introduced person-level focal variables as cross-level interactions with day type. Positive Affect ($b = -0.33$, $p = .017$) and Negative Affect × Day Type (p = .180) cross-level interactions improved model fit, $\Delta\chi^2(2, N = 73) = 9.47$, $p = .009$, but negative affect was not significant. For parsimony, the nonsignificant Negative Affect × Day Type interaction was dropped, and the step re-estimated including only the person-level Positive Affect × Day Type (b = 0.38, p = 005) cross-level interaction. This addition remained significant and became the new base model, $\Delta\chi^2(1, N = 73) = 7.71$, $p = .006$.

After this, a person-level Craving × Day Type cross-level interaction was added but did not result in a significant addition to the model, $\Delta\chi^2(1, N = 73) = 0.06$, $p = .812$, and was therefore removed. Next, person-level Time Spent in the Presence of Cues, Time Spent with Using Friends, and Time Spent in Using Places × Day Type cross-level interactions were added to the model. These additions did not result in a significant improvement, $\Delta\chi^2(3, N = 73) = 0.88$, $p = .831$, and were dropped from the model. In the last step, a person-level Time With Marijuana Available × Day Type cross-level interaction was added. This was a nonsignificant addition, $\Delta\chi^2(1, N = 73) = 0.67$, $p = .413$, and was removed. The resulting final model, which consisted of main effects for the focal predictor as well as covariates and the day-level Time Spent in the Presence of Cues × Day Type interaction and person-level Positive Affect × Day Type cross-level interaction, was compared with the main effects only model and favored the expanded model, $\Delta\chi^2(2, N = 73) = 15.22$, $p < .001$. The final model estimates are presented in Table 3.

Table 3
Multilevel Model of Quantity Used on Use Days

Variable	*b*	*OR*	*SE*	*p*	95% CI
Within-persons					
Use plans	**−0.71**	**0.49**	**0.19**	**<.001**	**[−1.09, −0.33]**
Negative affect	−0.13	0.88	0.08	.189	[−0.31, 0.06]
Positive affect	−0.17	0.84	0.08	.050	[−0.33, 0.01]
Craving	−0.01	0.99	0.05	.796	[−0.11, 0.09]
Time with friends[a]	0.07	1.07	0.31	.823	[−0.54, 0.67]
Time in places[a]	−0.53	0.59	0.31	.093	[−1.14, 0.08]
Time with cues[a]	0.54	1.71	0.35	.130	[−0.16, 1.23]
Time with marijuana available[a]	0.03	1.03	0.31	.919	[−0.57, 0.64]
Time With Cues × Day Type[a]	**−1.70**	**0.18**	**0.59**	**.004**	**[−2.86, −0.54]**
Weekend	−0.29	0.74	0.19	.133	[−0.66, 0.09]
Between-persons					
Negative affect	**−0.28**	**0.76**	**0.09**	**.002**	**[−0.46, −0.11]**
Positive affect	0.17	1.19	0.10	.098	[−0.03, 0.37]
Craving	**0.19**	**1.21**	**0.05**	**<.001**	**[0.08, 0.29]**
Time with friends[b]	−0.58	0.56	0.57	.315	[−1.70, 0.55]
Time in places[b]	0.63	1.88	0.44	.154	[−0.23, 1.49]
Time with cues[b]	**1.23**	**3.42**	**0.45**	**.006**	**[0.35, 2.10]**
Time with marijuana available[b]	−0.28	0.76	0.45	.538	[−1.15, 0.60]
Positive Affect × Day Type[b]	**−0.38**	**0.68**	**0.14**	**.005**	**[−0.65, −0.11]**
Gender	0.27	1.31	0.20	.178	[−0.12, 0.66]

Note. N = 73. Level 1 observations = 231 person days. Values are unstandardized coefficients. Boldface type denotes significance. Within-persons = day level (L1); between-persons = person level (L2); day type (0 = planned, 1 = unplanned); gender (men = 0, women = 1).
[a] Represents the proportion of prompts youth indicated they were in one of these contexts on that given day. [b] Average proportion of prompts that person spends in that type of context across all study days.

Final quantity model summary. As shown in Table 3, on days where youth used marijuana, participants used fewer grams of marijuana on unplanned days than planned days ($b = -0.71$, $p < .001$). At the day level (i.e., within-person), percentage time spent in the presence of marijuana-related cues interacted with day type ($b = -1.70$, $p = .004$). As shown in Figure 1, simple slopes revealed that spending more time in the presence of marijuana-related cues, relative to each person's own average, was associated with less use on unplanned days ($b = -1.16$, $p = .021$) but not on planned days ($b = 0.54$, $p = .130$). At the person level (i.e., between-person), greater average negative affect was associated with using less marijuana on both day types ($b = -0.28$, $p = .002$), whereas higher average craving ($b = 0.19$, $p < .001$) and percentage time in the presence of cues ($b = 1.23$, $p = .006$) were associated with using more marijuana on both day types. Positive affect interacted with day type ($b = -0.38$, $p = .005$). As shown in Figure 2, simple slopes revealed that person average positive affect, relative to the overall sample average for that day type, was negatively associated with marijuana on unplanned use days ($b = -0.21$, $p = .045$) but not on planned days ($b = 0.17$, $p = .098$). There were no other significant effects in the final model.

Discussion

This study leveraged EMA methods to identify factors that may explain why some youth struggle to control their marijuana use. We examined within-person processes and between-person differences that confer liability for both the likelihood and quantity of unplanned use on a given day. Specifically, we tested the hypothesis that certain internal states, namely negative and positive affect and marijuana craving, and situational factors, including the presence of friends who use, places where youth typically use, marijuana-related cues, and marijuana availability, would be positively related to the likelihood and quantity of unplanned use.

Overall, youth had difficulty controlling their use on one of every three unplanned days, using an average of 1.9 g of marijuana each unplanned use day. As expected, youth were more likely to use marijuana on planned versus unplanned days. No internal or situational variable uniquely predicted the likelihood that youth would engage in unplanned marijuana use as compared with planned use. At the day level, youth were more likely to use marijuana, planned and unplanned, on weekdays and on days when they spent more time with friends with whom they typically use. At the between-person level, participants with greater craving and who spent more time with using friends, on average and relative to the rest of the sample, had more use days. These effects were observed even after controlling for marijuana availability, which also predicted more use days at the person level, suggesting peer influences extend beyond simply providing a conduit to access marijuana. By contrast, and contrary to our expectations, youth who spent more time in places where they typically use or in the presence of marijuana-related cues, relative to the rest of the sample, were less likely to use, regardless of use plans.

In this first look, we also examined whether internal and situational factors predict how much marijuana youth use on unplanned and planned use days. Unlike our findings regarding the likelihood of unplanned use, we found relationships between use plans and the quantity of marijuana used on a given day. At the day level, youth used less marijuana on unplanned use days and this effect was heightened on days when youth were in the presence of marijuana cues more than typical. This finding, which was unex-

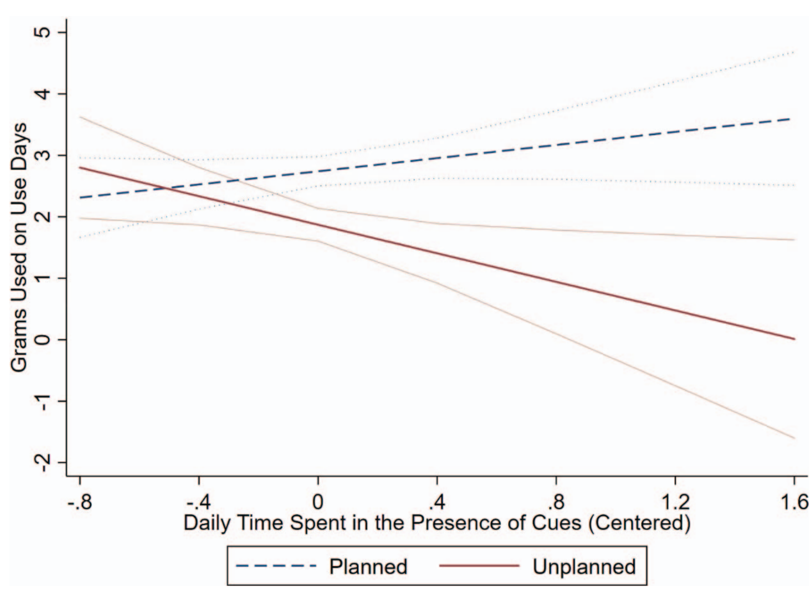

Figure 1. Simple slopes with 95% confidence bands of daily percentage of time spent in the presence of marijuana-related cues predicting grams used on use days by day type. Values on the *x*-axis reflect the proportion of prompts youth indicated they were in the presence of marijuana-related cues on that given day. This value can exceed 1.0 because the days are defined by the sleep–wake cycle, rather than the 24-hr clock. Daily time spent in the presence of cues was centered within-person; thus, these values reflect daily deviations from a person's average level (i.e., 0). See the online article for the color version of this figure.

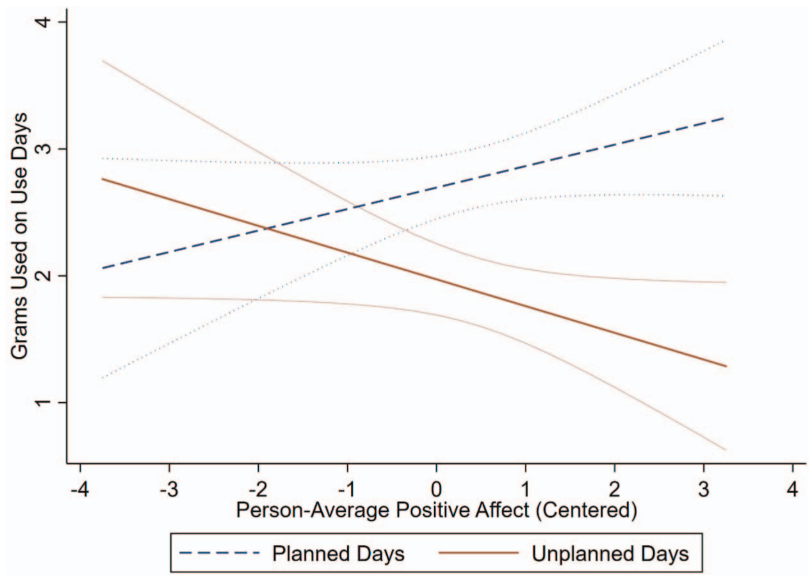

Figure 2. Simple slopes with 95% confidence bands of person-average positive affect predicting average grams used on use days by day type. Variables were averaged within-persons across the monitoring period (i.e., person-average). Person-average positive affect was centered at the grand-mean; thus, these values reflect a person's deviation from the overall average for the sample on that day type (i.e., 0). See the online article for the color version of this figure.

pected, suggests that associations between marijuana cues and the quantity of use vary as a function of whether youth planned to use. Although the reason for this finding is unclear, it is possible that cues were negatively associated with the quantity of use on unplanned days because youth were trying to self-regulate and limit their intake and thus were less reactive to marijuana cues. It is important to keep in mind, however, that we also found a positive between-person association for cues and quantity, such that participants who spent more time around cues in general used more, regardless of day type.

We also found that participants with higher positive affect, on average and relative to the rest of the sample on that day type, used more marijuana when use was planned and less when use was unplanned. This effect represented the only between-person predictor that varied by use plans. This finding suggests that a tendency to experience greater positive affect serves as both a risk and protective factor for youth when it comes to their marijuana use, and use plans may determine, in part, the relation of positive affect to use. The finding that higher overall positive affect predicted greater quantities of planned use is consistent with evidence that shows positive affect is at its highest when a person is planning on using in the immediate future (Buckner et al., 2015).

Findings also suggest that high dispositional positive affect may be protective against using more marijuana when use is not planned. Participants with higher positive affect overall used less when use was unplanned, on average and relative to the rest of participants in this sample. It is possible that youth with higher average positive affect can better regulate their emotions and control their behavior, including their marijuana use. Future research is needed, however, to directly test this idea.

Youth with lower positive affect, on average and relative to the rest of this sample on that day type, did not appear to use either more or less marijuana, depending on their use plans. This is reflected by overlapping confidence intervals at low levels of positive affect for planned and unplanned use days when relating average positive affect to grams of marijuana used on use days (see Figure 2). The lack of a use plan effect at the lower end of positive affect in this sample may reflect more compulsive-use efforts to overcome the anhedonia, marked by low positive affect, commonly observed in chronic marijuana users (Leventhal et al., 2017). This is highlighted by the finding, indicated by the significant simple slope, that youth with lower average positive affect during the monitoring period used more marijuana on unplanned use days compared with youth with higher average positive affect. Other studies have found negative associations between trait positive affect and alcohol and marijuana use among adolescents and young adults (Colder & Chassin, 1997; Simons et al., 2014; Wills, Sandy, Shinar, & Yaeger, 1999). This association may also be a function of limited substance-free reinforcers among frequent marijuana users with low positive affect, a common risk factor for youth substance use (Leventhal et al., 2015). This idea is generally consistent with reward-deficiency models that posit that persons less responsive to natural rewards (e.g., characterized by relatively lower positive affect) experience increased risk for substance use to enhance positive affective states (Bowirrat & Oscar-Berman, 2005; Yacubian & Büchel, 2009). Again, future research is needed to elucidate mechanisms responsible for these findings.

Other between-person characteristics predicted greater quantities of marijuana use regardless of whether it was planned or unplanned. People with higher negative affect, on average, used fewer grams regardless of use plans. This finding fits with prior research that suggests negative affect is more closely associated with marijuana problems than use (Buckner, Bonn-Miller, Zvolensky, & Schmidt, 2007; Dvorak & Day, 2014; Simons, Gaher, Correia, Hansen, & Christopher, 2005). Moreover, high trait negative affect is associated with less marijuana use in youth (Emery & Simons, 2017). On the whole, this finding coupled with the effects for positive affect highlights the potential difference between low positive affect and high negative affect, a distinction debated in the literature (e.g., Colder et al., 2010).

Participants who experienced higher average marijuana craving had a greater proportion of use days and used more grams when they used, regardless of use plans. This finding is consistent with contemporary models of addiction that describe craving as a key motivational determinant of use (Drummond, 2001; McCarthy et al., 2010; Robinson & Berridge, 1993) and adds further support for the clinical importance of craving in substance use disorders. Yet, despite extensive research with adults, our knowledge about the role of craving in marijuana use among youth remains limited to a small number of studies. This gap is striking given that adolescence and young adulthood are key periods in the development of marijuana misuse (Winters & Lee, 2008). As such, future investigations of craving on use in this population are warranted.

Our findings also revealed several situational factors that were associated with unplanned use, albeit most also predicted planned use. At the within-person level, we examined the impact of time spent in the presence of marijuana-related cues and in places one typically uses on unplanned use. Contrary to hypotheses, at the day level, spending more time around marijuana-related cues did not increase the amount of marijuana used on unplanned use days. Although our likelihood analyses showed that participants who, on average, spent more time in places where they typically use or around marijuana-related cues had fewer use days, overall, when they do use, participants who spent more time around cues used greater quantities. Taken together, situational location and marijuana-related cues did not appear to initiate substance seeking, but, rather, were a correlate of using at higher levels, in general. Future research is needed to decompose the likelihood of use and the quantity of use, as they appear to exhibit different patterns of associations.

Limitations

This study had several limitations. Analyses were correlational and not causal. Further, it is important to consider that use plans may change throughout the day. Although future research may benefit from momentary assessments of use plans to prospectively evaluate unplanned use at the event level, repeated assessments of intentions to use may also alter use plans. We are unaware, however, of an EMA study designed specifically to evaluate reactivity to repeated assessment of use intentions. Next, this sample consisted of youth recruited for a clinical trial of a pharmacotherapy plus a psychosocial intervention to reduce marijuana use. It is unclear whether findings would generalize to youth with different clinical profiles. In addition, our EMA monitoring period was brief, limiting the number of observations per participant. Additionally, whereas it is a common approach, our assessment of marijuana use required participants to self-initiate reports during a use episode without any form of verification to catch missed use episodes or possible under reporting. Participants were not tested for marijuana metabolites during the monitoring period. This leaves the potential that the estimates of use here reflect under or over representations. That said, there is work in the alcohol field suggesting that self-reported substance use data collected via EMA is valid compared with transdermal biochemical verification (Simons, Wills, Emery, & Marks, 2015). Currently, there is no form of biochemical verification for marijuana use that could accurately detect missed use at the event level. The development of such methodology would greatly benefit future research. Participants may also have varied in their ability to access marijuana, which could have influenced findings. This concern is mitigated, however, because we included marijuana availability in our models and thus significant predictors of use represent unique effects after controlling for differences in availability. Moreover, situational influences on use may vary across the life span and our sample consisted of both adolescents and young adults, spanning at least two developmental periods. The inclusion of age in our models accounts for at least some of these differences; however, future research is warranted to better understand developmental differences in unplanned use.

Conclusions

Our understanding of the factors associated with unplanned marijuana use among youth is at a nascent stage. This study provides the first characterization of unplanned marijuana use and offers the first test of unique within- and between-person risk factors associated with use. The analytic approach distinguished variables that predicted the likelihood of using marijuana and variables that predicted the amount (i.e., quantity) of marijuana used on use days. Findings identified several factors that may explain why some youth struggle to control their marijuana use, especially when it comes to how much marijuana youth consume on unplanned use days. The present work suggests positive affect might be differentially associated with use across days with and without use plans and sustained positive affect may serve as both a risk and protective factor. This observation could have significance particularly in youth seeking to reduce or stop using and thus warrants further empirical attention.

References

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: Author.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author. http://dx.doi.org/10.1176/appi.books.9780890425596

Arnett, J. J. (1999). Adolescent storm and stress, reconsidered. *American Psychologist, 54,* 317–326. http://dx.doi.org/10.1037/0003-066X.54.5.317

Behrendt, S., Wittchen, H. U., Höfler, M., Lieb, R., Low, N. C., Rehm, J., & Beesdo, K. (2008). Risk and speed of transitions to first alcohol dependence symptoms in adolescents: A 10-year longitudinal community study in Germany. *Addiction, 103,* 1638–1647. http://dx.doi.org/10.1111/j.1360-0443.2008.02324.x

Bowirrat, A., & Oscar-Berman, M. (2005). Relationship between dopaminergic neurotransmission, alcoholism, and reward deficiency syndrome. *American Journal of Medical Genetics. Part B, Neuropsychiatric Genetics, 132B*(1), 29–37. http://dx.doi.org/10.1002/ajmg.b.30080

Buckner, J. D., Bonn-Miller, M. O., Zvolensky, M. J., & Schmidt, N. B. (2007). Marijuana use motives and social anxiety among marijuana-using young adults. *Addictive Behaviors, 32,* 2238–2252. http://dx.doi.org/10.1016/j.addbeh.2007.04.004

Buckner, J. D., Crosby, R. D., Silgado, J., Wonderlich, S. A., & Schmidt, N. B. (2012). Immediate antecedents of marijuana use: An analysis from ecological momentary assessment. *Journal of Behavior Therapy and Experimental Psychiatry, 43,* 647–655. http://dx.doi.org/10.1016/j.jbtep.2011.09.010

Buckner, J. D., Crosby, R. D., Wonderlich, S. A., & Schmidt, N. B. (2012). Social anxiety and cannabis use: An analysis from ecological momentary assessment. *Journal of Anxiety Disorders, 26,* 297–304. http://dx.doi.org/10.1016/j.janxdis.2011.12.006

Buckner, J. D., Zvolensky, M. J., Crosby, R. D., Wonderlich, S. A., Ecker, A. H., & Richter, A. (2015). Antecedents and consequences of cannabis use among racially diverse cannabis users: An analysis from ecological momentary assessment. *Drug and Alcohol Dependence, 147,* 20–25. http://dx.doi.org/10.1016/j.drugalcdep.2014.12.022

Buckner, J. D., Zvolensky, M. J., & Ecker, A. H. (2013). Cannabis use during a voluntary quit attempt: An analysis from ecological momentary assessment. *Drug and Alcohol Dependence, 132,* 610–616. http://dx.doi.org/10.1016/j.drugalcdep.2013.04.013

Buu, A., Wang, W., Schroder, S. A., Kalaida, N. L., Puttler, L. I., & Zucker, R. A. (2012). Developmental emergence of alcohol use disorder symptoms and their potential as early indicators for progression to alcohol dependence in a high-risk sample: A longitudinal study from childhood to early adulthood. *Journal of Abnormal Psychology, 121,* 897–908. http://dx.doi.org/10.1037/a0024926

Colder, C. R., & Chassin, L. (1997). Affectivity and impulsivity: Temperament risk for adolescent alcohol involvement. *Psychology of Addictive Behaviors, 11,* 83–97. http://dx.doi.org/10.1037/0893-164X.11.2.83

Colder, C. R., Chassin, L., Lee, M. R., & Villalta, I. K. (2010). Developmental perspectives: Affect and adolescent substance use. In J. D. Kassel (Ed.), *Substance abuse and emotion* (pp. 109–135). Washington, DC: American Psychological Association. http://dx.doi.org/10.1037/12067-005

Drummond, D. C. (2001). Theories of drug craving, ancient and modern. *Addiction, 96,* 33–46. http://dx.doi.org/10.1046/j.1360-0443.2001.961333.x

Dvorak, R. D., & Day, A. M. (2014). Marijuana and self-regulation: Examining likelihood and intensity of use and problems. *Addictive Behaviors, 39,* 709–712. http://dx.doi.org/10.1016/j.addbeh.2013.11.001

Emery, N. N., & Simons, J. S. (2017). A reinforcement sensitivity model of affective and behavioral dysregulation in marijuana use and associated problems. *Experimental and Clinical Psychopharmacology, 25,* 281–294. http://dx.doi.org/10.1037/pha0000131

Fatseas, M., Serre, F., Swendsen, J., & Auriacombe, M. (2018). Effects of anxiety and mood disorders on craving and substance use among patients with substance use disorder: An ecological momentary assessment study. *Drug and Alcohol Dependence, 187,* 242–248. http://dx.doi.org/10.1016/j.drugalcdep.2018.03.008

Feldstein Ewing, S. W., Apodaca, T. R., & Gaume, J. (2016). Ambivalence: Prerequisite for success in motivational interviewing with adolescents? *Addiction, 111,* 1900–1907. http://dx.doi.org/10.1111/add.13286

Hasin, D., Hatzenbuehler, M. L., Keyes, K., & Ogburn, E. (2006). Substance use disorders: *Diagnostic and Statistical Manual of Mental Disorders,* fourth edition and *International Classification of Diseases,* tenth edition. *Addiction, 101*(Suppl. 1), 59–75. http://dx.doi.org/10.1111/j.1360-0443.2006.01584.x

Heather, N., Booth, P., & Luce, A. (1998). Impaired Control Scale: Cross-validation and relationships with treatment outcome. *Addiction, 93,* 761–771. http://dx.doi.org/10.1046/j.1360-0443.1998.93576112.x

Hoeppner, B. B., Kahler, C. W., & Gwaltney, C. J. (2014). Relationship between momentary affect states and self-efficacy in adolescent smokers. *Health Psychology, 33,* 1507–1517. http://dx.doi.org/10.1037/hea0000075

Hohman, Z. P., Crano, W. D., Siegel, J. T., & Alvaro, E. M. (2014). Attitude ambivalence, friend norms, and adolescent drug use. *Prevention Science, 15,* 65–74. http://dx.doi.org/10.1007/s11121-013-0368-8

Johnston, L. D., Miech, R. A., O'Malley, P. M., Bachman, J. G., Schulenberg, J. E., & Patrick, M. E. (2018). *Monitoring the Future National Survey results on drug use: 1975–2017: Overview, key findings on adolescent drug use*. University of Michigan, Institute for Social Research. http://dx.doi.org/10.3998/2027.42/148123

Kahler, C. W., Epstein, E. E., & McCrady, B. S. (1995). Loss of control and inability to abstain: The measurement of and the relationship between two constructs in male alcoholics. *Addiction, 90,* 1025–1036. http://dx.doi.org/10.1111/j.1360-0443.1995.tb01055.x

Kaufman, J., Birmaher, B., Brent, D., Rao, U., Flynn, C., Moreci, P., . . . Ryan, N. (1997). Schedule for Affective Disorders and Schizophrenia for School-Age Children–Present and Lifetime Version (K-SADS-PL): Initial reliability and validity data. *Journal of the American Academy of Child & Adolescent Psychiatry, 36,* 980–988. http://dx.doi.org/10.1097/00004583-199707000-00021

Langenbucher, J. W., & Chung, T. (1995). Onset and staging of *DSM–IV* alcohol dependence using mean age and survival-hazard methods. *Journal of Abnormal Psychology, 104,* 346–354. http://dx.doi.org/10.1037/0021-843X.104.2.346

Larson, R. W., Moneta, G., Richards, M. H., & Wilson, S. (2002). Continuity, stability, and change in daily emotional experience across adolescence. *Child Development, 73,* 1151–1165. http://dx.doi.org/10.1111/1467-8624.00464

Leeman, R. F., Beseler, C. L., Helms, C. M., Patock-Peckham, J. A., Wakeling, V. A., & Kahler, C. W. (2014). A brief, critical review of research on impaired control over alcohol use and suggestions for future studies. *Alcoholism, Clinical and Experimental Research, 38,* 301–308. http://dx.doi.org/10.1111/acer.12269

Leeman, R. F., Fenton, M., & Volpicelli, J. R. (2007). Impaired control and undergraduate problem drinking. *Alcohol and Alcoholism, 42,* 42–48. http://dx.doi.org/10.1093/alcalc/agl095

Leeman, R. F., Patock-Peckham, J. A., & Potenza, M. N. (2012). Impaired control over alcohol use: An under-addressed risk factor for problem drinking in young adults? *Experimental and Clinical Psychopharmacology, 20,* 92–106. http://dx.doi.org/10.1037/a0026463

Leeman, R. F., Toll, B. A., Taylor, L. A., & Volpicelli, J. R. (2009). Alcohol-induced disinhibition expectancies and impaired control as prospective predictors of problem drinking in undergraduates. *Psychology of Addictive Behaviors, 23,* 553–563. http://dx.doi.org/10.1037/a0017129

Leventhal, A. M., Bello, M. S., Unger, J. B., Strong, D. R., Kirkpatrick, M. G., & Audrain-McGovern, J. (2015). Diminished alternative reinforcement as a mechanism underlying socioeconomic disparities in adolescent substance use. *Preventive Medicine, 80,* 75–81. http://dx.doi.org/10.1016/j.ypmed.2015.05.021

Leventhal, A. M., Cho, J., Stone, M. D., Barrington-Trimis, J. L., Chou, C. P., Sussman, S. Y., . . . Strong, D. R. (2017). Associations between anhedonia and marijuana use escalation across mid-adolescence. *Addiction, 112,* 2182–2190. http://dx.doi.org/10.1111/add.13912

Marhe, R., Waters, A. J., van de Wetering, B. J. M., & Franken, I. H. A. (2013). Implicit and explicit drug-related cognitions during detoxification treatment are associated with drug relapse: An ecological momentary assessment study. *Journal of Consulting and Clinical Psychology, 81,* 1–12. http://dx.doi.org/10.1037/a0030754

McCarthy, D. E., Curtin, J. J., Piper, M. E., & Baker, T. B. (2010). Negative reinforcement: Possible clinical implications of an integrative model. In J. D. Kassel (Ed.), *Substance abuse and emotion* (pp. 15–42). Washington, DC: American Psychological Association. http://dx.doi.org/10.1037/12067-001

Miranda, R., Jr., MacKillop, J., Treloar, H., Blanchard, A., Tidey, J. W., Swift, R. M., . . . Monti, P. M. (2016). Biobehavioral mechanisms of topiramate's effects on alcohol use: An investigation pairing laboratory and ecological momentary assessments. *Addiction Biology, 21,* 171–182. http://dx.doi.org/10.1111/adb.12192

Miranda, R., Jr., Monti, P. M., Ray, L., Treloar, H. R., Reynolds, E. K., Ramirez, J., . . . Magill, M. (2014). Characterizing subjective responses to alcohol among adolescent problem drinkers. *Journal of Abnormal Psychology, 123,* 117–129. http://dx.doi.org/10.1037/a0035328

Miranda, R., Jr., Treloar, H., Blanchard, A., Justus, A., Monti, P. M., Chun, T., . . . Gwaltney, C. J. (2017). Topiramate and motivational enhancement therapy for cannabis use among youth: A randomized placebo-controlled pilot study. *Addiction Biology, 22,* 779–790. http://dx.doi.org/10.1111/adb.12350

Mohr, C. D., Armeli, S., Tennen, H., Carney, M. A., Affleck, G., & Hromi, A. (2001). Daily interpersonal experiences, context, and alcohol consumption: Crying in your beer and toasting good times. *Journal of Personality and Social Psychology, 80,* 489–500. http://dx.doi.org/10.1037/0022-3514.80.3.489

Pearson, M. R., & Henson, J. M. (2013). Unplanned drinking and alcohol-related problems: A preliminary test of the model of unplanned drinking behavior. *Psychology of Addictive Behaviors, 27,* 584–595. http://dx.doi.org/10.1037/a0030901

Posner, J., Russell, J. A., & Peterson, B. S. (2005). The circumplex model of affect: An integrative approach to affective neuroscience, cognitive development, and psychopathology. *Development and Psychopathology, 17,* 715–734. http://dx.doi.org/10.1017/S0954579405050340

Ramirez, J., & Miranda, R., Jr. (2014). Alcohol craving in adolescents: Bridging the laboratory and natural environment. *Psychopharmacology, 231,* 1841–1851. http://dx.doi.org/10.1007/s00213-013-3372-6

Robinson, T. E., & Berridge, K. C. (1993). The neural basis of drug craving: An incentive-sensitization theory of addiction. *Brain Research Brain Research Reviews, 18,* 247–291. http://dx.doi.org/10.1016/0165-0173(93)90013-P

Robinson, T. E., & Berridge, K. C. (2003). Addiction. *Annual Review of Psychology, 54,* 25–53. http://dx.doi.org/10.1146/annurev.psych.54.101601.145237

Schepis, T. S., Desai, R. A., Cavallo, D. A., Smith, A. E., McFetridge, A., Liss, T. B., . . . Krishnan-Sarin, S. (2011). Gender differences in adolescent marijuana use and associated psychosocial characteristics. *Journal of Addiction Medicine, 5,* 65–73. http://dx.doi.org/10.1097/ADM.0b013e3181d8dc62

Scott, C. K., Dennis, M. L., & Gustafson, D. H. (2018). Using ecological momentary assessments to predict relapse after adult substance use treatment. *Addictive Behaviors, 82,* 72–78. http://dx.doi.org/10.1016/j.addbeh.2018.02.025

Shrier, L. A., Ross, C. S., & Blood, E. A. (2014). Momentary positive and negative affect preceding marijuana use events in youth. *Journal of Studies on Alcohol and Drugs, 75,* 781–789. http://dx.doi.org/10.15288/jsad.2014.75.781

Shrier, L. A., Sarda, V., Jonestrask, C., & Harris, S. K. (2018). Momentary factors during marijuana use as predictors of lapse during attempted abstinence in young adults. *Addictive Behaviors, 83,* 167–174. http://dx.doi.org/10.1016/j.addbeh.2017.12.032

Simons, J. S., Gaher, R. M., Correia, C. J., Hansen, C. L., & Christopher, M. S. (2005). An affective-motivational model of marijuana and alcohol problems among college students. *Psychology of Addictive Behaviors, 19,* 326–334. http://dx.doi.org/10.1037/0893-164X.19.3.326

Simons, J. S., Wills, T. A., Emery, N. N., & Marks, R. M. (2015). Quantifying alcohol consumption: Self-report, transdermal assessment, and prediction of dependence symptoms. *Addictive Behaviors, 50,* 205–212. http://dx.doi.org/10.1016/j.addbeh.2015.06.042

Simons, J. S., Wills, T. A., & Neal, D. J. (2014). The many faces of affect: A multilevel model of drinking frequency/quantity and alcohol dependence symptoms among young adults. *Journal of Abnormal Psychology, 123,* 676–694. http://dx.doi.org/10.1037/a0036926

Slavet, J. D., Stein, L. A. R., Colby, S. M., Barnett, N. P., Monti, P. M., Golembeske, C., Jr., & Lebeau-Craven, R. (2006). The marijuana ladder: Measuring motivation to change marijuana use in incarcerated adolescents. *Drug and Alcohol Dependence, 83,* 42–48. http://dx.doi.org/10.1016/j.drugalcdep.2005.10.007

Sobell, L. C., & Sobell, M. B. (1992). Timeline follow-back: A technique for assessing self-reported alcohol consumption. In R. Z. Litten & J. P. Allen (Eds.), *Measuring alcohol consumption: Psychosocial and biochemical methods* (pp. 41–72). Totowa, NJ: Humana Press. http://dx.doi.org/10.1007/978-1-4612-0357-5_3

StataCorp. (2017). Stata Statistical Software (Version 15) [Computer software]. College Station, TX: StataCorp LP.

Substance Abuse and Mental Health Services Administration. (2017). *Key substance use and mental health indicators in the United States: Results from the 2016 National Survey on Drug Use and Health*. Rockville, MD: Center for Behavioral Health Statistics and Quality. Retrieved from https://www.samhsa.gov/data/

Swendsen, J. D., Tennen, H., Carney, M. A., Affleck, G., Willard, A., & Hromi, A. (2000). Mood and alcohol consumption: An experience sampling test of the self-medication hypothesis. *Journal of Abnormal Psychology, 109,* 198–204. http://dx.doi.org/10.1037/0021-843X.109.2.198

Treloar Padovano, H., Janssen, T., Emery, N. N., Carpenter, R. W., & Miranda, R., Jr. (2019). Risk-taking propensity, affect, and alcohol craving in adolescents' daily lives. *Substance Use & Misuse, 54,* 2218–2228. http://dx.doi.org/10.1080/10826084.2019.1639753

Treloar Padovano, H., & Miranda, R. (2018). Subjective cannabis effects as part of a developing disorder in adolescents and emerging adults. *Journal of Abnormal Psychology, 127,* 282–293. http://dx.doi.org/10.1037/abn0000342

Watson, D., & Clark, L. A. (1999). *The PANAS-X: Manual for the Positive and Negative Affect Schedule–Expanded form*. Iowa City: The University of Iowa. http://dx.doi.org/10.17077/48vt-m4t2

Wills, T. A., Sandy, J. M., Shinar, O., & Yaeger, A. (1999). Contributions of positive and negative affect to adolescent substance use: Test of a bidimensional model in a longitudinal study. *Psychology of Addictive Behaviors, 13,* 327–338. http://dx.doi.org/10.1037/0893-164X.13.4.327

Winters, K. C., & Lee, C.-Y. S. (2008). Likelihood of developing an alcohol and cannabis use disorder during youth: Association with recent use and age. *Drug and Alcohol Dependence, 92*(1–3), 239–247. http://dx.doi.org/10.1016/j.drugalcdep.2007.08.005

Yacubian, J., & Büchel, C. (2009). The genetic basis of individual differences in reward processing and the link to addictive behavior and social cognition. *Neuroscience, 164,* 55–71. http://dx.doi.org/10.1016/j.neuroscience.2009.05.015

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