

Momentary Positive and Negative Affect Preceding Marijuana Use Events in Youth

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ABSTRACT. Objective: Desire to self-regulate affect, including to maintain or enhance positive affect and to reduce negative affect, may be a primary motivation for marijuana use among young people. This study examined how positive and negative affect differ before marijuana use compared with other times. **Method:** Forty medical outpatients ages 15–24 years who used marijuana recreationally at least twice a week ($M = 18.7$ years; 58% female) reported momentary positive affect, negative affect, companionship, perceived ease of obtaining marijuana, and marijuana use several times a day for 2 weeks on a handheld computer. Mean momentary positive affect and negative affect scores in the 24 hours leading up to a marijuana use event ($n = 294$) were compared with affect scores in times further from subsequent use. Generalized estimating equation models considered as potential moderators perceived ease

of obtaining marijuana and being with friends. **Results:** Positive affect did not differ in the 24 hours before marijuana use compared with times further before use. Negative affect was significantly higher before marijuana use compared with other times. Being with friends and perceived easy marijuana availability did not moderate the associations. The association between negative affect and subsequent marijuana use was attenuated when negative affect was examined only for the moment just before use, suggesting that use may follow a period of increased negative affect. **Conclusions:** The findings support an affect regulation model for marijuana use among frequently using youth. Specifically, these youth may use marijuana to manage increased negative affect. (*J. Stud. Alcohol Drugs*, 75, 781–789, 2014)

MARIJUANA USE AMONG YOUTH has been on the rise in the United States. Recent data on U.S. 12th graders indicate that more than 1 in 5 report some past-30-day use, and nearly 1 in 15 report daily use (Johnston et al., 2012). Frequent marijuana use at a young age is associated with substantial medical, cognitive, psychiatric, and social problems in adulthood (Brook et al., 2002; Caldeira et al., 2012; Ellickson et al., 2004; Fergusson and Horwood, 1997; Stefanis et al., 2004). It is important to improve understanding of modifiable factors associated with marijuana use among youth to develop more effective treatment interventions for this at-risk population.

Marijuana acutely alters affect, reducing tension and producing positive effects such as euphoria (Hart et al., 2010). Among young adults who use marijuana at least once a week, more frequent users report less anxiety after use than do less frequent users (Metrik et al., 2011), which may reinforce tension-reduction expectancies for this population. Although individuals who use marijuana frequently

may develop tolerance to many effects of cannabinoids (e.g., perceptual, amnestic), they may continue to experience the euphoric effects (D'Souza et al., 2008). Further, daily marijuana users report increases in irritability and anxiety and decreases in mood within 1 day of ceasing use (Kouri and Pope, 2000). As a result, desire to self-regulate affect, including to reduce negative affect and to maintain or enhance positive affect, may be a primary motivation for use among frequently using youth.

In support of the importance of affect regulation as a motivation for marijuana use, adolescents and young adults frequently endorse enhancement and coping motives for marijuana use (Buckner, 2013; Buckner et al., 2013; Fox et al., 2011; Lee et al., 2007; Zvolensky et al., 2007). Further, enhancement motives (e.g., using marijuana for pleasure, fun, excitement, or to get high; Simons et al., 1998) are related to positive affectivity, and coping motives are related to negative affectivity (Zvolensky et al., 2007). Enhancement motives have been associated with more frequent marijuana use (Lee et al., 2007; Zvolensky et al., 2007) and more problems associated with use (Lee et al., 2007). Coping motives have also been associated with marijuana-related problems (Buckner, 2013; Fox et al., 2011; Lee et al., 2007) and may be more prevalent than other types of motives among frequent marijuana users (Buckner, 2013; Buckner et al., 2013).

Regardless of the findings, studies on marijuana motives typically inquire about reasons for use of marijuana in general, recalled after and out of the context in which the use occurred. Far less is known about actual affective

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states preceding marijuana use. Research using ecological momentary assessment (EMA), an approach to collecting data on experience and behaviors as they are occurring in the natural environment (Shiffman, 2000, 2009), has begun to address this void. Previous EMA research with adolescents and young adults who use marijuana at least twice a week found that as momentary positive and negative affect each increased, desire to use marijuana increased (Shrier et al., 2012). Similarly, an EMA study of undergraduates found that momentary anxiety predicted urge to use marijuana; however, momentary anxiety did not predict actual marijuana use (Buckner et al., 2012), consistent with earlier research using momentary assessment methods (Tournier et al., 2003).

In contrast, among adults attempting to quit, EMA-measured negative affect was increased just before marijuana use; positive affect was not associated with subsequent marijuana use when considered simultaneously with negative affect (Buckner et al., 2013). It remains unknown whether momentary negative affect beyond anxiety and momentary positive affect are associated with subsequent marijuana use among youth and among individuals who are not seeking to discontinue their marijuana use.

EMA methods are particularly well suited to measuring cognitive and social factors that may moderate associations between momentary affect and subsequent marijuana use. In one EMA study, desire to use marijuana was higher when frequently using youth were with friends rather than with their parents or alone (Shrier et al., 2012). Other EMA research has shown that marijuana use may be facilitated by the presence of peers, particularly if those peers are using marijuana (Buckner et al., 2012; Shrier et al., 2013). In general, being with peers is associated with increased momentary positive affect (Rusby et al., 2013). However, it is not known whether being with peers, especially friends, enhances associations between positive affect and use or attenuates associations between negative affect and use.

Perceived availability of marijuana is independently associated with marijuana desire and use. On an individual level, a school level, and a country level, perceived easy availability of marijuana has been associated with greater likelihood of use in adolescents (Bjarnason et al., 2010; Piontek et al., 2013; Swaim, 2003). On a momentary basis, desire to use marijuana may be lower when marijuana is thought to be less-than-easy to obtain (Shrier et al., 2012). Together, these studies suggest that marijuana use for affect regulation may be modified by perceptions of marijuana availability. Under conditions of easy availability, youth may be more likely to desire and use marijuana to regulate their affective states. However, if they believe that marijuana cannot be easily obtained, then they may seek other means of managing their affect.

In an effort to reconcile the literature on reasons for marijuana use and contextual factors that may be related to use

with actual experience, we conducted an EMA study of momentary affective states, social context, perceived marijuana availability, and marijuana use with a sample of frequently using adolescents and young adults. The objective of this study was to determine how positive and negative affect differed in the hours leading up to a marijuana use event, compared with other times. Specifically, in considering that marijuana may be used to maintain high positive affect, enhance low positive affect, and reduce high negative affect, we hypothesized that (a) momentary positive affect will be either higher or lower and (b) momentary negative affect will be higher than average in the hours leading up to a marijuana use event compared with other times more distant before use.

As Shiffman (2009) observed, studies may miss the full trajectory of affect if analyses focus only on the time close to the event and not also examine broader time frames. For example, Shiffman and Waters (2004) examined momentary negative affect preceding a smoking lapse (the behavioral event of interest), both aggregated over a day and as individual moments up until the lapse. The findings showed that negative affect was increased during the 6 hours before the lapse, not just proximal to the lapse.

We were interested in whether differences in momentary affective states could be observed just proximal to marijuana use or whether they could be identified only when looking at momentary affect accumulated over a longer period. Accordingly, we explored whether any differences in momentary positive and negative affect over 24 hours would be strengthened or attenuated if we analyzed affect measured only just before marijuana use. We also explored whether momentary contextual factors that would facilitate use (being with friends or perceived easy marijuana availability) modified the associations between momentary affect and marijuana use.

Method

Participants

Patients who received care in one of two adolescent/young adult medical clinics affiliated with an urban pediatric hospital were recruited if they were between 15 and 24 years of age and reported using marijuana an average of two or more times a week. Medical and mental health care providers referred patients who reported current marijuana use. Study brochures were also available in the clinics inviting patients to self-refer. To participate, otherwise eligible youth needed to be able to comprehend written English and be willing to provide contact information. They were not enrolled if they appeared or reported that they were high at the time of enrollment, if their provider felt that they had emotional problems or cognitive limitations that would interfere with providing informed consent or with study participation, or if their provider had concerns for their safety were they

to participate in the study. The study was approved by the hospital's institutional review board with a waiver of parental consent for individuals younger than 18. A Certificate of Confidentiality was obtained from the National Institute on Drug Abuse to protect participants' identifying information from forced disclosure.

Of 44 patients enrolled, 40 (91%) reported at least one marijuana use event during the momentary assessment period (2 participants were lost to follow-up, 1 did not provide any momentary data, and 1 did not report any marijuana use events). The sample had a mean age of 18.7 years ($SD = 2.1$) and was 58% female. At baseline, participants reported using marijuana an average of 9.7 times per week ($SD = 16.6$). Almost two thirds (25/39, 64%) met criteria for cannabis dependence disorder (according to the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*; American Psychiatric Association, 1994), of which approximately one half (12/25, 48%) reported physiological dependence to cannabis (one participant was missing data pertaining to dependence criteria). More than one half of participants (55%) reported alcohol use, and three participants (7.5%) reported other drug use in the previous 2 weeks (items adapted from the Adolescent Diagnostic Interview [ADI]; Winters and Henly, 1993). Most participants (68%) reported symptoms of poorer mental health (identified on latent class analysis as having lower positive affect, higher negative affect, higher depressive symptoms, higher state anxiety, higher trait anxiety, and higher social anxiety on a battery of validated assessments; Shrier et al, 2013).

Procedure

Participants completed a baseline computer-assisted self-interview on their demographic characteristics and substance use history. They were then trained to use a handheld computer (Palm Tungsten E2; palmOne, Inc., Milpitas, CA) to complete momentary assessments several times a day in their natural environment. The handheld computer was programmed with the Configurable Electronic Real-Time Assessment System (CERTAS) program (PICS, Inc., Reston, VA).

The computer emitted an auditory signal at a random time within 3-hour intervals during each participant's self-identified typical waking hours, approximately 4–6 signals per day, for 14 days. In response, participants were asked to complete a momentary assessment ("signal-prompted report"), which included their affective states, companionship, perceived availability of marijuana, and recent marijuana use. To maximize capture of information about the moments immediately surrounding a marijuana use event, participants were also asked to self-initiate reports just before and just after using marijuana. Each report was automatically date and time stamped. Participants were offered up to \$140 in gift cards based on study visit attendance and signal response

rate. Additional details of the study procedures have been reported elsewhere (Shrier et al., 2012, 2013).

Participants completed 3,657 reports ($M = 91.4$ /participant, $SD = 39.0$), which included 2,868 signal-prompted reports (response rate $M = 70.9\%$, $SD = 20.7\%$), 435 reports just before using marijuana, and 354 reports just after using marijuana.

Measures

Participant characteristics. On the baseline assessment, participants reported their age (in years) and sex (male or female). Items from the ADI (Winters and Henly, 1993) were used to identify cannabis dependence disorder with and without physiological dependence (American Psychiatric Association, 1994). Although the ADI was developed to assess substance use in adolescents up to age 18 years, the questions pertaining to substance use disorder criteria are not specific to a developmental age group and thus were asked of young adult as well as adolescent participants (Breyer et al., 2014).

Marijuana use events. On the signal-prompted reports, participants indicated whether they had used marijuana since the last signal they answered. If so, they were asked to specify the time of use. Using the information about date and time of a marijuana use event collected on all three types of reports (signal-prompted, just before use, and just after use), we reconciled multiple reports of the same event to identify unique marijuana use events ($n = 390$; $M = 9.75$ per participant, $SD = 8.6$).

The following items from the signal-prompted reports were assessed "at the time of signal."

Positive and negative affect. Six positive affect states (interested, strong, proud, alert, inspired, determined) and six negative affect states (distressed, upset, guilty, scared, hostile, irritable) were adapted from the Positive Affect–Negative Affect Schedule (Shrier et al., 2005; Watson et al., 1988). The 5-point Likert-type response scale for each item ranged from 1 = *not at all* to 5 = *extremely*. Positive affect and negative affect subscale scores were calculated from the sum of the responses (range: 6–30 for each subscale; Cronbach's $\alpha = .84$ and $.85$, respectively). Scores were individual-mean standardized so that momentary affect scores represent deviations from an individual's mean level of affect (in standard deviation units). The positive affect z -scores and the negative affect z -scores were very weakly correlated ($r = .03$, $p = .0500$).

Companionship. One question assessed whether participants were alone. If they responded in the negative, a second question asked them to indicate the main person they were with (boyfriend/girlfriend, other friends, parents, other family, other). For the purposes of these analyses, we categorized the responses as being with friends (boyfriend/girlfriend or other friends) versus not being with friends (with other types of companions or alone).

Perceived marijuana availability. Perceived marijuana availability was assessed with the question, "How difficult or easy do you think it would have been for you to get marijuana, if you wanted some at the time of the signal?" (adapted from Monitoring the Future; Johnston et al., 2009). The 5-point Likert-type response scale ranged from 1 = *probably impossible* to 5 = *very easy*. For these analyses, we categorized the responses as easy (4 or 5) versus not easy (1, 2, or 3) to get marijuana.

Data analysis

To determine the association between affect and subsequent marijuana use, we compared positive and negative affect on reports collected in the 24 hours before a marijuana use event with affect on reports collected at times more distant before use. We chose to examine affect over a 24-hour period to account for diurnal variation (Caminada and de Bruijn, 1992). Specifically, using the reported start time for each marijuana use event, we identified the 24-hour block of time leading up to the event, provided no other marijuana use event occurred during this time; 294/390 events (75.4%) had at least one report of affect in the prior 24 hours and were thus included in these analyses ($n = 294$ pre-marijuana blocks).

We defined times distant before marijuana use as all times that were neither 24 hours or less before marijuana use nor up to 6 hours after marijuana use, a period during which momentary affect would be both experienced and reported under the influence of marijuana ($n = 113$ distant-before-use blocks; Kauert et al., 2007). Within each pre-marijuana time block and each distant-before-use time block, we calculated mean momentary positive affect and mean momentary negative affect from all reports occurring in the time block. Being with friends for a block was determined as the percentage of reports of being with boyfriend/girlfriend or other friends. Similarly, perception of easy marijuana availability in a block was determined as the percentage of reports with a response of easy or very easy.

For the main analyses, we used logistic regression to determine whether mean momentary positive and negative affect differed between blocks of time just before marijuana use and time blocks more distant before use. In these models, block type (prior vs. distant) was the dependent variable, and mean momentary positive and negative affect were the independent variables. Because observations were presumed to be correlated within participant, the logistic regression models used generalized estimating equations with an exchangeable (compound-symmetric) working correlation structure.

First, unadjusted models were fit separately for positive and negative affect main effects. Following unadjusted analyses, the models included both affect variables simultaneously and age, sex, and cannabis dependence diagnosis

as covariates. Based on our previous research noting an association between poorer mental health and marijuana use (Shrier et al., 2013), we also examined the influence of the following individual-level measures: depressive symptoms; state, trait, and social anxiety; coping and enhancement motives for marijuana use; and trait impulsivity and sensation seeking. None of these measures substantively changed the estimates in any of the models and were thus dropped from the analyses.

In the secondary analyses to determine whether substance use followed an extended period of increased or decreased affect or a momentary change in affect, we compared the positive and negative affect on the report self-initiated just before marijuana use with the mean affect in the distant-before-use blocks. To test moderating hypotheses regarding facilitating contextual factors, interaction terms between affect and companionship or perceived easy marijuana availability were added to the model. For all statistical tests, significance was defined a priori as $p < .05$. Analyses were conducted using SAS software (Version 9.2; SAS Institute Inc., Cary, NC).

Results

Descriptive statistics

Mean and standard deviation for block-level mean momentary positive and negative affect are presented in Table 1. For positive affect, the mean was close to 0 in both the 24-hour pre-marijuana time blocks and the distant-before-use time blocks, signifying that mean positive affect scores within both block types approximated individuals' personal mean scores assessed across the study. For negative affect, the mean was 0.28 (corresponding to the 61st percentile) in the 24-hour pre-marijuana time blocks and approximately 0 (corresponding to individuals' personal mean scores) in the distant-before-use time blocks.

On average, participants reported being with friends on 45% of reports in the 24 hours before using marijuana and on 32% of reports during times more distant before marijuana use. Participants perceived marijuana as easy to get during most reports in both the 24-hour pre-marijuana time blocks and the distant-before-use time blocks (80% and 77% of reports, respectively).

Positive and negative affect before marijuana use versus at other times

Table 2 shows the results of unadjusted and multivariate generalized estimating equation models of block-level momentary positive and negative affect in the 24 hours before a marijuana use event compared with other times.

There were no significant differences in positive affect in the 24 hours before marijuana use compared with other

TABLE 1. Descriptive statistics for study variables in the 24 hours before marijuana use, just proximal to use, and at times more distant before use

Variable	24 hours before use		Just proximal to use		Distant time before use	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Positive affect	-0.003	0.80	0.06	1.01	0.004	0.63
Negative affect	0.28	1.20	0.25	1.29	-0.02	0.54
Being with friends (% reports)	45	37	46	50	32	29
Easy to get marijuana (% reports)	80	35	–	–	77	35

Notes: Positive affect and negative affect are presented as individually standardized z-scores, which were determined from the mean and standard deviation of an individual's raw affect scores. For the 24 hours before use and distant-before-use time blocks, mean affect was calculated within each time block. The means and standard deviations of these block characteristics are presented by block type. Being with friends was determined as the percentage of reports within the block indicating companionship with boyfriend/girlfriend or other friends. Similarly, perception that marijuana is easy to get was determined as the percentage of reports in a block with a response of *easy* or *very easy*. For time just proximal to use, mean and standard deviation for affect and percentage of reports of being with friends are presented for the reports made just before marijuana use. Marijuana availability was not assessed just proximal to use, as participants were about to use marijuana. *N*s = 294 24-hour pre-marijuana time blocks and 113 distant-before-use time blocks, 284 just-proximal-to-use reports with positive affect and 287 with negative affect.

times more distant before use ($\beta = -.024$, $SE = .13$, $p = .85$; adjusted odds ratio [AOR] = 0.98, 95% CI [0.76, 1.26]). However, mean negative affect was higher in the 24 hours before marijuana use compared with more distant times. Specifically, in the multivariate model, the odds of the time block being before marijuana were 43% higher with a 1-unit (1 *SD*) increase in mean negative affect ($\beta = .36$, $SE = .10$, $p < .01$; AOR = 1.43, 95% CI [1.17, 1.73]).

Being with friends and ease obtaining marijuana did not moderate any of the associations (i.e., none of the interactions between each of these variables and the affect variables was significant).

When only the report most proximal to marijuana use (self-initiated report just before use) was compared with reports further in time before marijuana use, there were again no significant differences in positive affect just before use compared with other times longer before use ($\beta = .10$, $SE = .15$, $p = .51$; AOR = 1.10, 95% CI [0.83, 1.47]). The association between negative affect and marijuana use remained significant but was attenuated ($\beta = .25$, $SE = .09$, $p < .01$; AOR = 1.29, 95% CI [1.07, 1.55]).

Discussion

The results of this study suggest that youth who use marijuana frequently experience increased negative affect over the 24 hours before a marijuana use event. Further, we observed that the association was attenuated when we examined negative affect only just before use, which may indicate that marijuana use follows a period—not just a single moment—of increased negative affect. These findings are consistent with an affect regulation model of use, specifically a model of marijuana use to self-medicate or reduce negative affective states (Khantzian, 1997; Swendsen et al., 2000).

Much of the research on negative affect associated with use has focused on anxiety, with evidence for the effect of anxiety on marijuana use being mediated by tension-reduction expectancies (de Dios et al., 2010) and coping motives for use (Johnson et al., 2009). EMA research with young, frequent marijuana users has suggested that the association between anxiety and subsequent marijuana use may be mediated by the effects of anxiety on craving (Buckner et al., 2012). In support of this premise, momentary negative affect

TABLE 2. Associations of positive and negative affect with time 24 hours before marijuana use and time just proximal to marijuana use vs. more distant times

Variable	Unadjusted models			Multivariate models			AOR	[95% CI]
	β	<i>SE</i>	<i>p</i>	β	<i>SE</i>	<i>p</i>		
24 hours before marijuana use								
Mean positive affect	-.021	.12	.86	-.024	.13	.85	0.98	[0.76, 1.26]
Mean negative affect	.34	.09	<.001	.36	.10	<.001	1.43	[1.17, 1.73]
Just proximal to marijuana use								
Positive affect	.05	.13	.68	.10	.15	.51	1.10	[0.83, 1.47]
Negative affect	.24	.08	.004	.25	.09	.007	1.29	[1.07, 1.55]

Notes: For the models examining affect 24 hours before marijuana use, *N*s = 294 24-hour pre-marijuana time blocks and 113 distant-before-use time blocks. For the models examining affect just proximal to marijuana use, *N*s = 284 reports with positive affect and 287 reports with negative affect. The multivariate models included both positive affect and negative affect and adjusted for age, sex, and cannabis dependence diagnosis. AOR = adjusted odds ratio; CI = confidence interval.

has been linked to stronger desire to use marijuana among adolescents and young adults (Shrier et al., 2012).

In a study of young adolescents (sixth graders), another negative affect state, anger, was associated with initiation of marijuana use 1 year later (Nichols et al., 2008). College students attempting to discontinue marijuana use reported increased momentary negative affect just before use episodes and coping with negative affect as the most common reason for use (Buckner et al., 2013). It will be important that research continues to examine the broad range of negative affective experience in relation to marijuana use. Further, our findings suggest that treatment for marijuana use that targets negative affective states may be effective in decreasing use, as demonstrated by reduced substance use among adolescents receiving cognitive-behavioral treatment for depressive symptoms (Rohde et al., 2012).

Increased negative affect is a common symptom of withdrawal from marijuana (Buckner et al., 2013; Kouri and Pope, 2000), which may have contributed to the findings. Although withdrawal symptoms have been reported within 24 hours of cessation of marijuana among both adult (Kouri and Pope, 2000) and adolescent (Dawes et al., 2006) users, the onset of symptoms associated with marijuana withdrawal typically occurs 1–3 days into abstinence (Budney et al., 2003). In analyzing affect over shorter periods before use, our study was not designed to specifically examine withdrawal, but overall the findings do not support a withdrawal time course for the increased negative affect preceding use.

In contrast to the findings for negative affect, momentary positive affect did not vary before using marijuana compared with other times. Although adolescents and young adults commonly report using marijuana for mood enhancement (Brodbeck et al., 2007; Hathaway, 2003; Lee et al., 2007; Zvolensky et al., 2007), this sample of youth who use marijuana frequently did not appear to be responding to a desire to either increase low positive affect or maintain high positive affect. For these young people, their near-daily use may be more likely to be in response to the need for negative affect regulation rather than the desire for recreation, consistent with research in college students attempting to cease marijuana use (Buckner et al., 2013).

Of importance, we did not see evidence for positive affect buffering the impact of negative affect, as has been described in research on individual-level affect and substance use over time (Wills et al., 1999). Positive affect and negative affect varied independently in relation to marijuana use, consistent with a two-dimensional structure to affective space (Watson and Tellegen, 1985).

Being with friends did not moderate the associations between either positive or negative affect and subsequent marijuana use. Marijuana is commonly used with companions; event-level studies have noted that approximately three quarters of marijuana use episodes occurred in the presence

of other people (Buckner et al., 2012; Shrier et al., 2013). Peer use (Pinchevsky et al., 2012; Stoddard et al., 2012) and approval of use (Keyes et al., 2011) appear to substantially influence initiation and continuation of use among adolescents and young adults.

On a momentary basis, being with friends has been associated with desiring marijuana (Shrier et al., 2012). Momentary research also has found that adolescents experience greater positive affect when with their friends (Schneiders et al., 2007). However, our findings do not show that companionship alters the association between momentary affect and a subsequent marijuana use event, perhaps because antecedent negative affect is the more relevant momentary experience related to an episode of marijuana use, and being with friends is a positive affective experience. Further, we did not observe that increased positive affect from being with friends (Rusby et al., 2013) attenuated the association between negative affect and subsequent marijuana use, again suggesting the independence of positive and negative affect in relation to marijuana use.

We also did not find perceived marijuana availability to moderate the affect–use associations. Among this sample of frequent marijuana users, marijuana was perceived to be easy to obtain on a large majority of momentary reports (78%–80%). Lack of variability in perceived marijuana availability may have hindered our ability to detect differences.

This study contributes to the literature on affect regulation and marijuana use in four important methodological ways. First, we evaluated affect in a specified time frame preceding marijuana use, thereby permitting us to determine temporal ordering consistent with affect regulation. Second, we standardized affect scores to individuals' personal experience. In EMA research, ecological validity is assumed (Shiffman, 2000), but it is challenging to formally validate scales assessing subjective momentary experience. In our research (e.g., Shrier et al., 2012), we have seen considerable variability in responses to momentary affect scales between individuals. Because each participant in our study may have interpreted the range and magnitude of the affect items differently, we chose to evaluate for relative differences in positive and negative affect within person, rather than differences in absolute scores on the affect scales (Buckner et al., 2012). Third, we add to the limited previous research (e.g., Buckner et al., 2013) that has considered negative affect in general, using multiple items to assess a broad range of negative affect states. Fourth, we included positive affect in the same models as negative affect, allowing us to simultaneously examine the relative contributions of these two affect dimensions (Buckner et al., 2013). Thus, in keeping with a model of positive and negative affect independence (Watson and Tellegen, 1985), we were able to test in our sample of frequent users whether, in addition to negative affect reduction, positive affect enhancement could have been contributing to marijuana use.

These strengths must be considered in light of several limitations. Youth needed to be emotionally and cognitively able to consent to the research and participate in the intensive data collection. The high rate of psychological distress in our sample indicates that we did not exclude youth with emotional problems and is consistent with other research on marijuana-using adolescents recruited from urban, primary care clinical settings (Bohnert et al., 2014). Nonetheless, the findings may not be generalizable to populations of substantially impaired individuals. Generalizability may also be limited to adolescent clinic populations. Future research is needed to determine whether the associations between affect and marijuana use observed in this study will be found in other populations of frequently using youth.

Although the signal response rate was comparable to rates reported in other EMA studies of affect and marijuana use (61%–74%; Black et al., 2014; Buckner et al., 2011, 2012, 2013), momentary positive or negative affective states could have been related to nonresponse. Similarly, affective states preceding marijuana use events that were not reported could have been different from affective states preceding events for which we obtained data. Participants in a feasibility study for this research reported that it was difficult to complete reports immediately following use (reports of marijuana use events) in part because reporting detracted from their feeling high (Black et al., 2014).

Finally, in our sensitivity analysis, we compared affect on one report just before use with mean affect on all reports in the distant-before-use time block. Although it would have been ideal to have the same number of reports in the comparison groups to have the same characteristics of error and variability, to obtain affect information as close as possible to the marijuana event, we necessarily considered affect from only the report just before use in this secondary analysis.

Although EMA offered many advantages, the method may have resulted in reporting, behavioral, or affective reactivity to the frequent, repeated assessments. Studies using EMA over extended periods (e.g., 8–12 weeks) have found both increased (Hensel et al., 2012) and decreased (Collins et al., 1998) substance use, which may be indicative of either reporting or behavioral reactivity. However, EMA studies involving shorter assessment periods (e.g., up to 2 weeks) have demonstrated minimal or no reactivity effects (Heron and Smyth, 2013; Hufford et al., 2002; Rowan et al., 2007).

By measuring actual affective states preceding marijuana use events, this study indicates that negative affect regulation may be a crucial reason that youth use marijuana frequently, whether or not they are able to report coping or tension-reduction motivations for use. These findings point toward several areas for further investigation, including testing the correlation between antecedent affect and self-identified reasons for marijuana use, whether specific negative affective states are more likely to be followed by marijuana use, and whether the associations between negative affect and use

are mediated by marijuana craving. In addition, the results of this study suggest that approaches to treatment of marijuana use disorders may be improved by intervening in increased negative affect as it is occurring, shortly before a potential episode of marijuana use.

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