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

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Abstract

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 (EMA) methods captured affective (positive: energized, excited, sociable, happy, relaxed; negative: bored, tense, sad, stressed) and situational factors in real-world settings during a one-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, while 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

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Marijuana is the most commonly used illicit drug in the United States (U.S.), 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 U.S. using daily (SAMHSA, 2017). Moreover, nearly 1 in 5

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Some of the data reported in this study were presented in other published manuscripts. Most notably, the treatment outcomes of this randomized controlled trial were published elsewhere (Miranda et al., 2017). Previous versions of these analyses were also presented at the 41st scientific meeting of the Research Society on Alcoholism.

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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.

Difficulty regulating substance use is a longstanding criterion for substance use disorders (Hasin et al., 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 et al., 1995). This compromised control develops early in the course of addiction (Leeman et al., 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 et al., 1998; Leeman et al., 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 et al., 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 U.S. and beyond, where availability of legalized marijuana is increasing.

Youth frequently experience intense emotions (Arnett, 1999; Larson et al., 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 et al., 2012; Pearson & Henson, 2013; Shrier et al., 2014; Simons et al., 2014; Swendsen et al., 2000). Heightened affective states are also important predictors of unsuccessful quit attempts among marijuana users (Buckner et al., 2013; Scott et al., 2018). Similarly, drug craving — the subjective state of wanting or desire to use a substance — exhibits strong cross-sectional (Buckner, Crosby, Wonderlich et al., 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 et al., 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 et al., 2013; Ramirez & Miranda, 2014) and drug availability (Shrier et al., 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 et al., 2016; Hohman et al., 2014), while 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 et al., 2010; McCarthy et al., 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, pre-medication EMA period. Youth were recruited from the community. All participants used marijuana at least twice weekly in the past 30 days. The sample was 55% White, 4% American Indian/Alaskan Native, 2% Asian, 29% Black/African American, 1% Native Hawaiian/Pacific Islander, and 1% another race; 18% were Hispanic.

Exclusion criteria were marijuana treatment in the past 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. Females 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 pre-medication 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 semi-structured interview based on the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; 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 (*random assessments*) within 3-hr blocks (e.g., 12–3 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 (*morning reports*), wherein they reported their marijuana use plans for the day. Participants also completed assessments before and after they used marijuana (*begin* 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 non-yes response (i.e., *no* or *undecided*) was provided. Our sample was comprised largely of daily users and so, as expected based on prior research (Slavet et al., 2006), explicit plans to abstain were rare (77 person-days, ~15%) while ambivalence (i.e., *undecided*) about use was more common (192 person-days, ~36%). An *unplanned use day* was operationalized as any day where a non-yes response 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 et al., 2005) and the Positive and Negative Affect Schedule - Expanded Form (PANASX; Watson & Clark, 1999). Previous research supports the internal consistency and criterion validity of these affective items assessed using EMA (Hoeppner et al., 2014; Treloar Padovano et al., 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 (0) absence or (1) presence 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 (0) unavailability or (1) availability.

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 vs. planned use days, we estimated multilevel models (MLM) 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 non-independence of observations that results from the nesting of time-varying observations within persons. Data were analyzed with Stata (Version 15) and followed a modelbuilding 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 vs. 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 = not 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 ($N_{completed} = 1{,}730$) and 86% of the morning reports ($N_{completed} = 527$). 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 percent 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. Males also had more missed random prompts than females, $M_{difference} = 0.2$, $t(83) = 2.21$, $p = .030$. Average morning report compliance ranged from 60100% ($SD = 10.3\%$) 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 percent use days during the EMA period was correlated with the percent 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 grams ($SD = 1.0$) 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 while 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. Below 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 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 non-significant 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 Postive 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 non-significant 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 non-significant 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. Lastly, youth were more likely to 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 Postive Affect and Negative Affect × Day Type interactions were added simlutaneously. 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 non-significant 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 non-significant 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 non-significant 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 non-significant 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 to 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.

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), percent 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 ($b = -0.28$, $p = .002$), while higher average craving ($b = 0.19$, $p < .001$) and percent 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.

On the whole, youth had difficulty controlling their use on one of every three unplanned days, using an average of 1.9 grams 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 to 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 unexpected, 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 more or less 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 to 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; Wills et al., 1999; Simons et al., 2014). 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 et al., 2007; Dvorak & Day, 2014; Simons et al., 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, while 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 to transdermal biochemical verification (Simons et al., 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 lifespan 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 differneces 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, in particular, may 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 may have particular significance in youth seeking to reduce or stop using and thus warrants further empirical attention.

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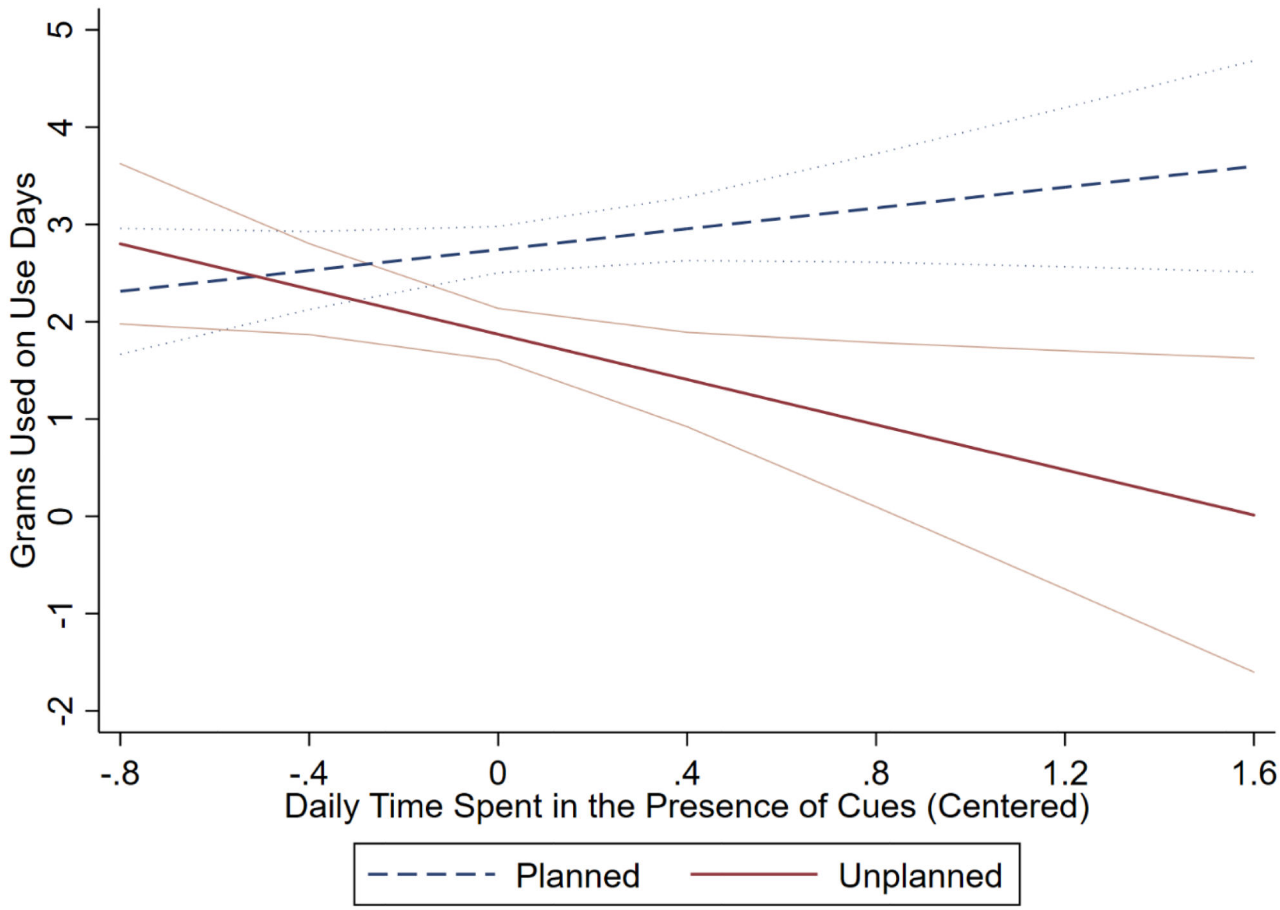

Figure 1. Simple Slopes with 95% Confidence Bands of Daily Percent Time Spent in the Presence of Marijuana-related Cues Predicting Grams Used on Use Days by Day Type.

Note. 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-hour 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).

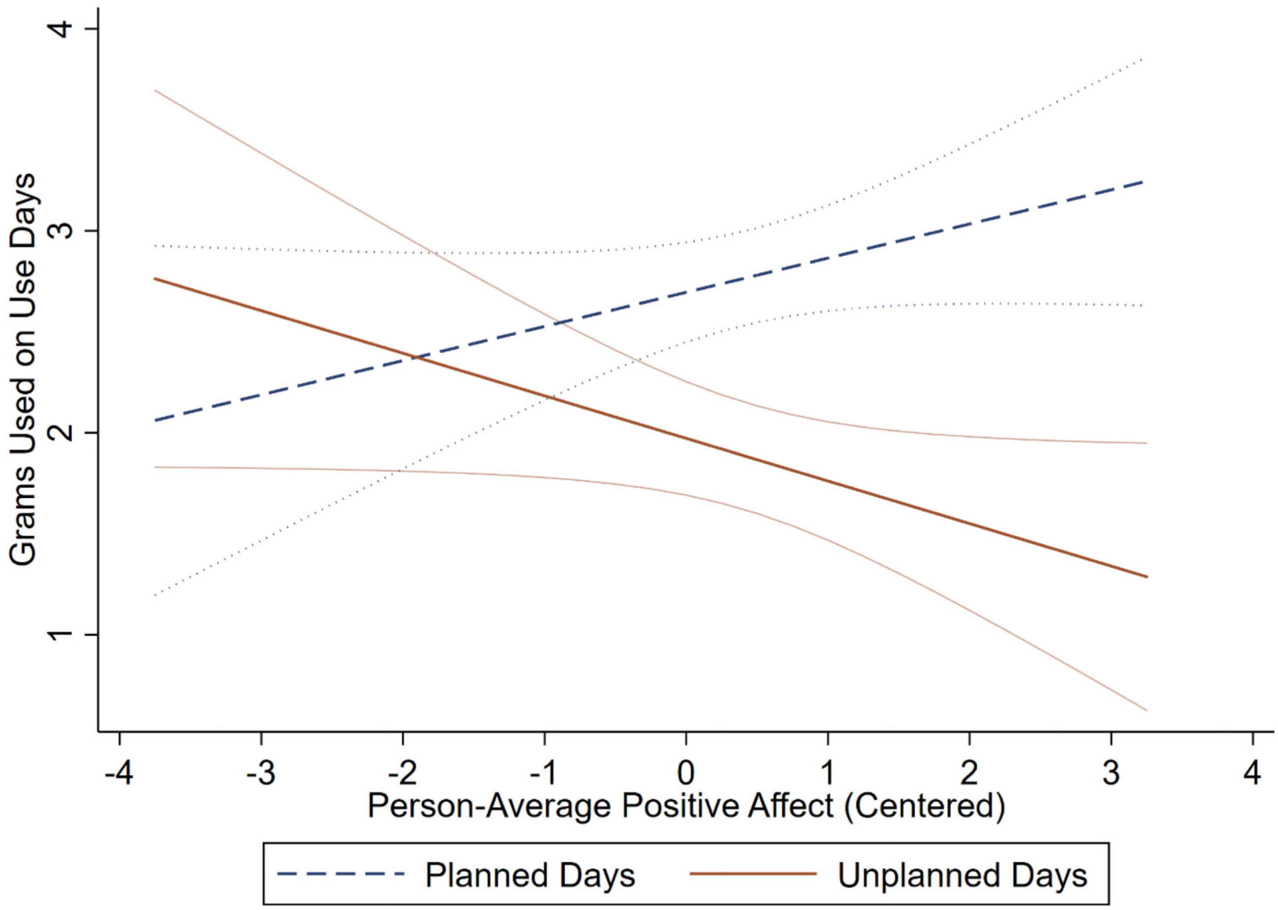

Figure 2. Simple Slopes with 95% Confidence Bands of Person-Average Positive Affect Predicting Average Grams Used on Use Days by Day Type.

Note. 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).

Table 1

Descriptive Statistics of Level 1 and Level 2 Variables

Variables	*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: $N = 85$. Level 1 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.

Table 2

Multilevel Model of Likelihood of Use

Variable	*b*	*OR*	*SE*	*p*-value	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. Level 1 observations = 462 person-days. Values are unstandardized coefficients. Within persons = Day Level (L1). Between Persons = Person Level (L2). Gender (men = 0; women = 1). Bold face denotes significance.

[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.

Table 3

Multilevel model of quantity used on use days

Variable	*b*	*OR*	*SE*	*p*-value	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. Within Persons = Day Level (L1). Between Persons = Person Level (L2). Day type (0 = planned; 1 = unplanned). Gender (men = 0; women = 1). Bold face denotes significance.

[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.