Real-World Simultaneous Alcohol and Cannabis Use: An Ecological Study of Situational Motives and Social and Physical Contexts

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Objective: Given the adverse outcomes associated with simultaneous alcohol and marijuana (SAM) use, understanding factors that give rise to occasions of simultaneous use is critical. This study examines the relationships between situational motives and contexts and three situational outcomes: simultaneous alcohol and marijuana use (SAM) use versus cannabis-only use, number of cannabis uses, and subjective effects. *Method:* Past-month SAM users (*n* = 341; 52% female; 75% White; 10% Latinx/Hispanic; age 18–24) from three U.S. college campuses completed 8 weeks of surveys up to five times a day. Three-level generalized linear mixed-effects models tested the effects of situational motives and social and physical contexts on occasion type (SAM vs. cannabis-only), cannabis use, and subjective effects. *Results:* Situational social and enhancement motives were related to greater odds of SAM relative to cannabis-only use; expansion motives were reported more often on cannabis-only occasions. Using with others and at friends' places, being with others consuming cannabis, and being with others who are intoxicated were more likely when combining alcohol with cannabis. Increased number of cannabis uses and subjective effects in a social context were evident only on cannabis-only occasions. Using alone and using at home were greater on cannabis-only occasions and were associated with lower cannabis use and subjective effects. *Conclusions:* The combination of alcohol and cannabis use occurs during social situations and when motivated by positive reinforcement but number of cannabis uses is not increased when consuming cannabis with alcohol in social situations. Characterizing the complex interplay of situational factors that contribute to risky use will inform interventions.

Public Health Significance Statement
Situational motives for and social and physical contexts of cannabis use may be determinants of whether cannabis is consumed simultaneously with alcohol versus on its own as well as amount of cannabis used and subjective effects of use.

Keywords: alcohol, cannabis, motives, context, situational

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The prevalence of cannabis use is high in young adulthood, including among college students (Miech et al., 2018). Furthermore, rates of cannabis use are on the rise, coinciding with changes in legalization of recreational cannabis and normative trends supporting cannabis use (Bae & Kerr, 2020; McCabe et al., 2021). Along with a rise in cannabis use in young adults are increases in the co-use of alcohol and cannabis (McCabe et al., 2021). Cannabis is frequently consumed with alcohol, often at the same time or so their effects overlap (simultaneous alcohol and marijuana [SAM], use; Patrick et al., 2019; Subbaraman & Kerr, 2015; Terry-McElrath & Patrick, 2018), which can result in greater cognitive impairment (Hartman et al., 2015; Ronen et al., 2010), risky sexual behaviors (Metrik et al., 2016), and unsafe driving (Ramaekers et al., 2004; Terry-McElrath et al., 2015).

Studies examining whether substance use is greater when alcohol is consumed with cannabis have typically compared simultaneous alcohol and marijuana use (SAM) to alcohol-only days/occasions. The vast majority of work has shown greater alcohol involvement for SAM users relative to alcohol-only users (Egan et al., 2019; Haas et al., 2015; Lee et al., 2020; Linden-Carmichael et al., 2019; Metrik et al., 2018; Patrick et al., 2018; Subbaraman & Kerr, 2015). However, these associations are often attenuated or eliminated once drinking level is controlled (Lee et al., 2020; Lipperman-Kreda et al., 2017; Mallett et al., 2019; Sokolovsky et al., 2020) suggesting that it may be the presence of alcohol that contributes to increased risk associated with SAM use. Little research has examined whether SAM users report more frequent cannabis use relative to cannabis users who do not simultaneously use alcohol (Subbaraman & Kerr, 2015), in part because the prevalence of cannabis-only users is low, especially among college students (Jackson et al., 2020). A recent daily diary study of young adult SAM users indicated that neither amount of use nor subjective intoxication differed between SAM and cannabis-only days, although SAM days had more negative consequences than cannabis-only days (Linden-Carmichael et al., 2020). To date, no work has examined whether amount of cannabis consumed differs on SAM occasions compared to cannabis-only occasions, or whether acute subjective effects vary across the type of occasion, with the exception of one study in which young adults perceived greater subjective effects (e.g., clumsy, dizzy, difficulty concentrating) for SAM, relative to cannabis-only, use but the opposite was true for "high" and "feeling marijuana effects" (Lee et al., 2017). The present study fills a gap in the literature by comparing SAM with cannabis-only situations and examining number of cannabis uses and subjective intoxication using a repeated daily survey design.

Conceptual Model

The present study is informed by a conceptual model (adapted from Pakula et al., 2009), that incorporates functional (motivational) and circumstantial (contextual) aspects of simultaneous substance use. The functional aspect suggests that the user chooses substances based on reasons for use where use is linked to perceived pharmacological or social outcomes. The circumstantial aspect examines substance combinations within the context of settings and environmental constraints. Substance use, thus, is influenced by (a) motivations that are considered to be pharmacological (coping, enhancement, expansion) versus social (social, conformity) and (b) context, including physical setting (where) and social context (with whom).

Motivational Influences

Substance use motives are an individual's reasons for using substances (Patrick et al., 2011; Simons et al., 2000)—that is, individuals engage in a behavior specifically for the purpose of obtaining some outcome (Cox & Klinger, 1988). Cooper identified four types of motives for drinking: enhancement (to have fun), social, coping, and conformity (Cooper, 1994; Cooper et al., 2016). Positive reinforcement motives include social and enhancement and are motives for social rewards or to enhance one's mood, respectively; negative reinforcement motives include coping and conformity, which are motives to cope with negative affect or avoid negative evaluation, respectively. These motives are also applicable to cannabis use, with a fifth motive, expansion, that accounts for the psychedelic effect of cannabis (i.e., expanding awareness; Simons et al., 1998).

Historically, motives were assumed to be trait-like, with substances used for the same reasons across time and context (O'Hara et al., 2015). Yet, significant within-person variation in motives exists whereby motives vary from day-to-day (Cooper, 1994). Indeed, person-level coping motives do not always generalize to day-level motives (see Votaw & Witkiewitz, 2021). In the alcohol field, drinking in response to same-day negative affect is associated with proximal but not global coping motives to drink, and the same is true of positive affect and enhancement motives (Arbeau et al., 2011); it is likely that this finding applies to motives for cannabis use. Event-level (situational) enhancement and social motives are highly endorsed by youth (Buckner et al., 2019; Shrier et al., 2013) and these situational motives are associated with a higher number of drinks per occasion (Kuntsche & Labhart, 2013; Piasecki et al., 2014). Event-level conformity (Pearson et al., 2020), enhancement and social (Bonar et al., 2017), and expansion (Buckner et al., 2019; Pearson et al., 2020) motives likewise are associated with more frequent cannabis use, larger quantities of cannabis consumed, and higher subjective effects. Coping motives at the situational-level also increase cannabis use quantity (Bonar et al., 2017) as well as level of alcohol use (Dvorak et al., 2014; O'Hara et al., 2014), and the likelihood of negative drinking outcomes (Mihic et al., 2009).

SAM-specific motives replicate the motives typically observed for alcohol and cannabis use, with social and coping motives each associated with more frequent use (Conway et al., 2020; Patrick et al., 2018), suggesting that occasions of SAM use and cannabis-only use are similarly motivated. However, Skalisky et al. (2019) found that users of both alcohol and cannabis reported higher levels of enhancement and coping motives than did alcohol-only users; however, no work has examined whether motives differentially predict SAM versus cannabis-only occasions. Given that alcohol use is a highly social activity especially in college, social and enhancement motives are likely to be more salient in cannabis users who use alcohol at the same time. In the only study to date comparing *situational* motives on SAM days to motives on single-substance use days (i.e., alcohol or cannabis), Arterberry et al. (2020) found that greater social, enhancement, and conformity (but not coping) motives were associated with increased likelihood of co-use days compared to cannabis-only days.

O'Hara et al. (2016) found that among college student co-users, those who had a general motivation to use substances for social and enhancement reasons used the two substances in a complementary fashion, whereby higher consumption of alcohol led to greater likelihood of cannabis on the same evening—that is, type of substance use occasion moderated the motive-outcome link. In contrast, alcohol consumption was associated with lower

likelihood of engaging in cannabis use for those endorsing coping motives, suggesting that co-use occasions may not necessarily have greater risk than cannabis-only occasions because one substance may be sufficient to alleviate negative affect (O'Hara et al., 2016). Whether association between motives and *amount* of substance use varies as a function of whether cannabis use is combined with alcohol has not yet been tested. The present study examines the predictive utility of situational motives including whether associations between motives and substance use outcomes vary as a function of whether the occasion involves SAM or cannabis-only use.

Contextual Influences

Our conceptual model postulates that the *social context* and *physical context* each influence SAM use. With respect to *social context*, research in the alcohol field indicates that young adults are more likely to drink alcohol (including at risky levels) in a social facilitation context, including when in groups and with friends (Beck et al., 2008; Hughes et al., 2014) and with others who are drinking or intoxicated (Lipperman-Kreda et al., 2018; Trim et al., 2011). Although there is less research on context for cannabis use, use often occurs in social situations and while using with others (Buckner et al., 2015; Phillips et al., 2018). Nonetheless, a large portion of high school seniors and young adult cannabis users report using cannabis while alone (McCabe et al., 2014; Shrier et al., 2013).

SAM use likewise occurs in social contexts (Terry-McElrath et al., 2013), and SAM use events are more likely to involve being around others who are intoxicated, at least as compared to alcohol-only events (Lipperman-Kreda et al., 2017, 2018). Furthermore, peers influence each other by modeling specific behaviors, including SAM use (Linden-Carmichael et al., 2019; White et al., 2019). It is unclear whether SAM use occasions are more or less likely to occur in group/party settings compared to cannabis-only occasions and whether using cannabis when alone would be less common when alcohol is also being consumed.

Physical context is also important in understanding substance use behaviors. Both survey and within-subject studies show that underage drinking frequently occurs at friends' houses (Lipperman-Kreda et al., 2018), in public settings (Demers et al., 2002; Keough et al., 2015), or in multiple locations (Connor et al., 2014). Endorsing being in these settings is associated with greater consumption, intoxication, and consequences (Braitman et al., 2017; Patrick et al., 2016). The impact of physical context on cannabis use is less well understood, with one study indicating users report commonly using cannabis at both home and a friend's house (Shrier et al., 2013).

It is also not apparent the extent to which social and physical contexts for SAM use differ from settings for single substance use occasions. Pakula et al. (2009) argued that SAM use is more strongly influenced by socioenvironmental factors (e.g., availability, setting) than pharmacological or motivational factors, suggesting that contexts facilitating opportunistic use may correlate with SAM use versus single-substance use occasions. Thus, there may be different contexts for SAM use occasions than cannabis-only occasions. Further, associations between contexts and use outcomes may vary as a function of whether the occasion is SAM or cannabis-only use. The present study will use occasion-level data to examine associations between both physical and social context and number of cannabis uses and subjective effects.

Inter-Relations Between Motives and Context

Substance use may be more likely to occur at times when there is an optimal "fit" between the context and ones' motivations for using, as posited in Cooper's motivational model (Cooper, 1994). An individual who endorses social motives and is in a social setting may be more likely to engage in substance use than one who does not endorse social motives or who is not in a social setting (Cooper et al., 1992). Alcohol research has shown that motives serve to moderate the social context at the event-level. Smit et al. (2015) found more drinks were consumed among men with low coping motives when more male friends were present, suggesting that those who drink a lot with many friends may be the non-coping drinkers; likewise, for women high on enhancement motives, the association between number of male friends present and number of drinks consumed was stronger. Similarly, motives for cannabis use were differentially associated with the social context of use: those with stronger social and conformity motives were more likely to use cannabis at parties; those with stronger enhancement motives were more likely to use at bars; and those with stronger coping motives were more likely to use at home (Shrier et al., 2013). Thus, the tendency to engage in substance use is not merely a product of the immediate context, but rather is a function of an individual's response to such contexts— that is, individuals with motivational profiles indicating sensitivity to certain social, internal, or environmental stimuli are at greater risk of substance use in contexts where those stimuli are present.

The Present Study

Given the lack of studies comparing SAM use occasions to cannabis-only occasions, the present study examines situational motivational and contextual influences for substance use occasions, comparing occasions where alcohol and cannabis are both consumed (i.e., SAM) to cannabis-only use occasions. We examine whether motives and contexts differentially predict odds of a SAM-use occasion relative to a cannabis-only occasion, as well as whether number of cannabis uses and subjective effects vary for cannabis-only versus SAM use occasions. We also test whether elevated risk of use due to situational motives may be moderated by in vivo context.

We hypothesize that social and enhancement motives, using with friends, using at a friend's house, and using with a greater number of people who are also using cannabis or who are intoxicated will increase the odds of SAM use relative to cannabis-only use and will be related to greater number of cannabis uses and higher subjective effects, especially on SAM use occasions. In contrast, we hypothesize that coping and expansion motives, using at home, and using while alone will be associated with more cannabis-only than SAM use occasions, fewer cannabis uses, and lower subjective effects.

Furthermore, we hypothesize that motive-context match, but not a motive-context mismatch, will be related to greater number of cannabis uses and higher subjective effects. We examine motive-context matches: (a) motives to have fun (enhancement) and using with friends; (b) motives to be social and using with friends; and (c) coping motives and using alone. We also test motive-context mismatches: (a) social motives and using alone and (b) coping motives and using with friends. We further test whether these hypothesized match and mismatch interactions vary as a function of occasion type (SAM vs. cannabis-only).

Method

Participants and Procedure

Phase 1

In the first phase, 24,000 students at three state universities in states with different laws regarding recreational cannabis possession (illegal, decriminalized, legal) were recruited to take an online screening survey (see White et al., 2019 for details about study procedures and sample representativeness). Email lists were obtained from each university with 2,000 randomly selected students per graduating class (8,000 students per university); only full-time students between 18 and 24 years of age were included on the registrar's list. Students were sent emails alerting them of the study and offered a small incentive (lottery for a $100 Amazon.com gift card) for completion of a screening survey. The screening survey was open for 5 days and was completed by 7,000 (29.2%) invited students. Based on registrar information, completers were fairly representative of those invited, with the screener more likely to be completed by younger students, women, and White, Asian, and Latinx students but fewer black students (all small effect sizes; White et al., 2019).

Of those completing the screening survey, 2,874 (41.1%) were deemed eligible for Phase 1, which included two web surveys, 3 months apart. Phase 1 inclusion criteria included full-time enrollment at one of the universities, being 18–24 years old, past-year alcohol and cannabis use, and being on the registrar's list (confirmed via email address). Participants were stratified based on frequency of alcohol and cannabis use, over-sampling past-month alcohol and cannabis users to ensure sufficient base rates of simultaneous use in Phase 2 of the study (see below).

A stratified random sample of 2,501 of the 2,874 eligible students was invited to take the baseline survey; 1,390 provided complete responses that were consistent with eligibility criteria. The full sample was 62.4% female with a mean age of 19.8 years ($SD = 1.3$); 12.2% were Latinx/Hispanic and 30.7% were non-White (3.4% Black, 12.7% Asian, 0.4% Native American, 0.6% Asian Pacific, 3.9% other, and 9.8% more than one race). Students received a $25 gift card for completing the baseline survey and a $35 gift card for the 3-month follow-up survey.

Phase 2

Phase 2 involved two bursts of 28-day data collection of five daily surveys administered 3 months apart. All participants who indicated SAM use (using "alcohol and marijuana at the same time so that their effects overlapped") in the past month at baseline were eligible for Phase 2; half of the sample met this criterion. As females were over-represented in the baseline sample, we oversampled male participants to provide a more equal sex distribution. We also oversampled those who reported frequent SAM use (3+ times in the past month). Of those who were eligible, 596 were invited via email to participate in the daily surveys; 506 (84.9%) accepted the invitation, however 127 had done so after the quota for their category (SAM frequency/birth sex) had been reached. Thus, 379 participants were provided access to the app to be used for the daily diary data collection; 343 (90.5%) enrolled by logging into the app (note that 341 participants were retained for analysis; two provided data only on the first 2 days which were dropped for all participants due to technical issues). The second burst was completed by 316 participants (92.1%). Most of the 25

participants who did not participate in the second burst ($n = 21$) were non-responsive to repeated contact attempts. The present study sample ($n = 341$) participants had a mean age of 19.8 years; 51.9% were female; 24.8% self-identified as non-White, 10% Latinx/Hispanic.

Participants completed up to 5 daily reports using a smartphone app developed for the study. Daily alcohol and cannabis use were assessed across the full 24-hr period through frequent and predictable survey times (9:00 a.m., 2:00 p.m., 5:00 p.m., 8:00 p.m., 11:00 p.m.). The 9:00 a.m. morning survey assessed behavior for the prior day during the interval between the last survey taken and bedtime; it also assessed negative consequences experienced the prior day attributable to substance use. To accommodate the college student sleep schedule, the 9:00 a.m. survey was open through 2:00 p.m.; other surveys had a 2-hr window for completion. The 2:00 p.m. survey assessed behavior between wake time (as reported in the morning survey) and current time, and the subsequent three surveys assessed behavior between the prior survey completion time and the current time. If one survey was missed, the current survey pulled the completion time from the prior completed survey as a starting time anchor (e.g., for a missing 8:00 p.m. survey, the 11:00 p.m. survey pulled the completion time of the 5:00 p.m. survey as an anchor). If more than one survey was missed, the survey used the prior survey scheduled time as an anchor (e.g., for missing 5:00 p.m. and 8:00 p.m. surveys, the 11:00 p.m. survey used 5:00 p.m. as an anchor). This design allowed for the collection of a full day's coverage even if a survey was missed. As a result, over 75% of days have complete coverage (11,915 of 15,749 days). Average duration of time since last survey completed ranged across surveys from 3.06 (11:00 p.m.-bedtime) to 5.30 hr (wake to 2:00 p.m.). In-app notifications to complete a survey showed up as a banner on the home screen and a text reminder was sent 15 min prior to survey closing if the survey had not yet been completed. Each survey took 1–2 min to complete; the morning survey took 3–5 min. See Supplemental Materials for detailed description of the surveys as well as screenshots. Procedures were approved by the coordinating university institutional review board and a Certificate of Confidentiality was obtained from NIDA to preserve confidentiality. Participants received $1 for each completed survey with weekly bonus opportunities and a bonus for consistent participation.

Measures

Peak Subjective Effects

Data on subjective effects were taken from a graphical interface (see Supplemental Materials) built into the study app. Participants were asked to draw a line with their finger across their screen to indicate "how you felt" during the interval since the last survey. The X-axis corresponded to time of day and the Y-axis ranged from *Not at all* to *Very* high/drunk. Peak subjective effects were the maximum intoxication reported on a given survey.

Number of Cannabis Uses and Drinks

On the same graphical interface as subjective effects, participants were asked to tap the screen at the corresponding time they used cannabis. Number of cannabis uses at a given survey was a sum of the taps for cannabis uses. A separate screen captured drinks; number of drinks was summed (for descriptive purposes here). Given the skewed distribution of cannabis use, we capped values at 12, corresponding to 99%.

Type of Substance Use Survey (Occasion)

A SAM survey was defined as a survey in which both alcohol and cannabis were used during the survey period.[1] In addition, participants indicated whether a study survey was SAM, alcohol-only, cannabis-only, or non-use, based on the item "What did you use between *X* and *Y*?" with response options: Both alcohol and marijuana (1), Alcohol (2), Marijuana (3), Neither (4). This item was used to determine the wording stem for motive and context items (see below).

Motives

Participants were asked a single item: "What motivated you to … between [time *X* (actual time last survey was taken)] and [time *Y* (actual current time)]?" Wording was specific to survey type ("use marijuana" if a cannabis-only occasion was endorsed; "drink and use marijuana" if a SAM occasion was endorsed). Participants selected all that apply (yes vs. no) for eight motives: "to be social" (social), "to cope" (coping), "to have fun" (enhancement), "it was offered," "to fit in" (conformity), "expand awareness" (expansion)," "get higher from another drug," and "was too high from the other drug." Items were selected from a psychometrically valid measure of SAM motives (Patrick et al., 2018) as well as validated measures of alcohol (Drinking Motives Questionnaire Revised; Cooper, 1994) and cannabis (Marijuana Motives Measures; Simons et al., 1998) use motives.

Physical and Social Context

Participants reported physical location(s) during the time since the last survey: Home, Friend's Place, Party, Bar/restaurant, Outside, Study space, Athletic facility, Elsewhere (all that apply). A follow-up item assessed whether each endorsed location was a location where they consumed alcohol and/or cannabis ("Where were you while you were using …"), with item wording relevant to the use occasion ("using marijuana" vs. "using alcohol and marijuana"). Social context was assessed in a similar manner, assessing who they were with since the last survey with response options Alone, Significant Other, Roommate, Friend, Family, Strangers, Acquaintance, Someone Else (all that apply) and then assessing substance-specific context for each response option endorsed ("Who were you with while you were using …"). Given that "party" could reflect a location or a social event, we do not examine it in this study.

Number of people intoxicated and number of people using cannabis in that location were also assessed. "How many of the people you were with were intoxicated between [time *X*] and [time *Y*]?") had response options of 0 = None, 1 = Some, 2 = Most, 3 = All. "How many of the people you were with were using marijuana between [time *X*] and [time *Y*]?" had response options ranging from 0 to 10+ (bottom coded as 10 for analysis). If the participant indicated being with one person they were asked "Was this person intoxicated?" A value of No was recoded to 0 = None and a value of Yes was recoded to 3 = All.

Covariates

Any tobacco and illicit drug use (yes/no) were assessed at each survey. Weekend (defined as Friday and Saturday) versus weekday status was coded from survey date. Sex assigned at birth, race, ethnicity, and age (21+ vs. <21) were obtained at baseline.

Analytic Plan

Data management and analyses were conducted in SAS 9.4 TM; plots of interactions were generated using "ggplot2" in R version 4.0.3 (R Foundation for Statistical Computing, 2018). Data analyzed were surveys (Level-1) nested within days (Level-2) nested within person (Level-3). We collected 15,749 days across participants (86% of 18,360 possible days): 24.8% cannabis-only; 12.8% SAM; 13.1% alcohol-only; 49.2% no use. This yielded 59,315 completed surveys. Given the aims of the present study, all analyses were restricted to cannabis-only surveys (*n* = 8,527; 14.4%) and SAM surveys (*n* = 2,343; 3.9%; surveys are henceforth referred to as "occasions"). Alcohol-only occasions (*n* = 4,167; 7.0%) and non-use occasions (*n* = 44,278; 74.6%) were excluded. This included 333 participants who endorsed at least one cannabis-only or SAM use survey (occasion) across the 54 study days (56% male; M_{age} = 19.91; 19% non-White; 8% Latinx/Hispanic).

Three-level generalized linear mixed-effects models (GLMMs) were used for all analyses to account for the clustering of surveys (Level-1) within days (Level-2) within person (Level-3; Hedeker, 2005), with binary (SAM vs. cannabis-only occasion), count (number of cannabis uses; negative binomial distribution), and ordinal (peak subjective effects) outcomes. Consistent with recommendations, Level-1 (survey) effects were day-mean centered; Level-2 (day) effects were person-mean centered, and Level-3 (person) effects were grand-mean centered (Curran & Bauer, 2011). For categorical focal variables, we first examined the frequencies of motives and contexts assessed at each occasion and selected those for analyses that were endorsed at least 5% of the time (Agresti, 2006) for both SAM use and cannabis-only occasions. Results for occasion (Level-1; survey) effects represent deviations from a given day (Level-2) and take into account typical endorsement of a given motive or context for a given person across all study days (Level-3). Because occasion (survey) effects are deviation scores, they are continuous in nature.

In separate models, we first examined the effects of motives (conformity, coping, social, enhancement, expansion), social context (alone, significant other, friends, number of people intoxicated, number of people using cannabis), and physical context (home, friend's place) on type of use occasion (SAM vs. cannabis-only). (Direction and significance of effects were unchanged when all motives were included in the same model. Thus, for interpretability, we present univariate models.) Because of the low endorsement of conformity motives for cannabis-only occasions (2.04%) and particularly SAM occasions (0.70%) we do not consider conformity further. We adjusted for tobacco and other drug use at Level-1, daily survey phase burst (Wave 1 or Wave 2) and weekend at Level-2, and sex, race, ethnicity, age, and school (School C as the reference group) at Level-3.

Next, we examined the moderating effect of use occasion on the effects of motives and contexts on number of cannabis uses and peak subjective effects. Finally, we tested whether the interactions between (a) hypothesized motive-context matches (Enhancement × Friends, Social × Friends, Social × Number of People Using Cannabis, Social × Number of People Intoxicated, Coping × Alone) and (b) hypothesized motive-context mismatches (Social × Alone,

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[1] We compared alcohol and cannabis co-use/SAM occasions when operationalized within 1–240 min in increments of 1 min and found no differences in acute consequences or subjective intoxication, irrespective of its operationalization (Sokolovsky et al., 2020).

Coping × Friends) varied as a function of use occasion. We first tested the motives-context interactions on type of use as an outcome (SAM vs. cannabis-only) followed by three-way interactions to determine whether type of use moderated the motives–context interaction on number of cannabis uses and peak subjective effects. We included the covariates described above in all interaction models.

Results

On average, study participants reported using cannabis 2.56 times ($SD = 2.19$) and an average peak subjective effect of 1.79 ($SD = 0.80$) on a given survey (occasion). Number of cannabis uses on SAM use occasions ($M = 2.76$ uses, $SD = 2.21$) was greater than on cannabis-only occasions ($M = 2.52$, $SD = 2.18$), $t = -2.90$, $p < .01$. Peak subjective effects were greater for SAM occasions ($M = 1.97$, $SD = 0.80$) compared to those reported on cannabis-only occasions ($M = 1.75$, $SD = 0.79$), $t = -12.17$, $p < .001$. Nicotine use was reported on 8% of surveys and other drug use on 3% of surveys. Specific to SAM occasions, participants reported consuming an average of 3.50 drinks ($SD = 2.50$) on a given occasion. Table 1 presents descriptive statistics for motives and context. Table S1 presents bivariate correlations among study variables at the occasion level (Level-1) on the bottom diagonal and person-level (Level-3) on the top diagonal. Correlations between context and situational motives were low ($r \leq .30$; primarily small effects, $r = .10$).

Level-1 Main Effects

SAM Versus Cannabis-Only Occasions

Main effects are presented in Table 2. Level-1 social and enhancement motives were related to greater odds of SAM use (vs. cannabis-only), whereas expansion motives exhibited greater odds of cannabis-only use. The effect of coping motives was not statistically significant. Using with a significant other, friends, greater number of

Table 1
Descriptive Statistics by Type of Use Occasion (SAM vs. Cannabis-Only)

Predictors	SAM ($n = 2,343$)	Cannabis-only ($n = 8,527$)
	Motives (n/%)	
Conformity	47 (2.04%)	59 (0.70%)
Coping	270 (11.74%)	1,312 (15.55%)
Social	1,043 (45.35%)	1,194 (14.15%)
Enhancement	1954 (84.96%)	6,540 (77.50%)
Expansion	218 (9.48%)	1,147 (13.59%)
	Contexts (n/%)	
Alone	289 (12.51%)	2,673 (31.54%)
With significant other	488 (21.12%)	1,153 (13.61%)
With friends	1,543 (66.77%)	3,263 (38.51%)
At home	1,209 (52.25%)	5,869 (69.19%)
At friend's place	826 (35.70%)	1,598 (18.84%)
# people intoxicated		
"None"	696 (30.18%)	7,295 (86.34%)
"Some"	499 (21.64%)	623 (7.37%)
"Most"	556 (24.11%)	218 (2.58%)
"All"	555 (24.07%)	313 (3.70%)
# people using cannabis (M/SD)	2.87 ($SD = 3.22$)	2.67 ($SD = 2.60$)

Note. SAM = simultaneous alcohol and marijuana use.

people intoxicated, and greater number of people using cannabis was related to greater odds of a SAM use occasion, whereas using alone was related to greater odds of cannabis-only use. Using at home demonstrated greater odds of using cannabis only, whereas being at a friend's place exhibited greater odds of SAM use.

Cannabis Uses

Level-1 social and enhancement motives were both related to a greater number of cannabis uses, whereas effects for coping and expansion motives were not significant. Using with a significant other, friends, greater number of intoxicated people, or greater number of people who were using cannabis were each related to a greater number of cannabis uses, whereas using alone was related to significantly fewer cannabis use. Using at a friend's place was linked to more cannabis uses; the effect for using at home was not significant.

Subjective Effects

Level-1 coping, social, and enhancement motives were each related to higher peak subjective effects; the effect for expansion motives was not statistically significant. Consistent with the models predicting cannabis uses, using with a significant other, friends, a greater number of intoxicated people, or a greater number of people using cannabis were each linked to greater odds of higher peak subjective effects, whereas using alone was related to lower odds of higher peak subjective effects. Using at a friend's place was associated with greater odds of higher peak subjective effects, whereas using at home was linked to lower odds of higher peak subjective effects. See Table S2 for Level-2 and Level-3 effects.

Moderation by Type of Substance Use

The 2-way interaction effects between motives/contexts by type of use (SAM vs. cannabis-only) on number of cannabis uses and peak subjective effects are shown in Table 3 (also see Figure 1 for plots of selected interactions). The interaction between social motives and type of use was significant, such that the positive relationship between endorsing social motives and cannabis uses was stronger on a cannabis-only occasion (simple slope = 0.23, $p < .01$) than a SAM occasion (simple slope = 0.02, $p = .66$). The relation between being with a greater number of people using cannabis and cannabis uses was stronger on a cannabis-only occasion (simple slope = 0.07, $p < .01$) versus a SAM occasion (simple slope = 0.03, $p < .01$). Following a similar pattern, using at a friend's place was linked to significantly more cannabis uses on a cannabis-only occasion (simple slope = .25, $p < .01$), whereas this relation was weaker on a SAM occasion (simple slope = .12, $p = .04$). The interaction between type of use and using with a friend was very similar in pattern to the interaction for using at a friend's place. One interaction between motives/contexts and type of use on peak subjective effects was significant, such that the slope between using at home and peak subjective effects was minimal on cannabis-only occasions (simple slope = .04, $p = .29$) whereas the slope between using at home and peak subjective effects was negative and significant on SAM occasions (simple slope = -.20, $p < .01$).

Motive–Context Interactions

Endorsing social motives and being around more people using cannabis were associated with greater odds of being a SAM occasion,

Table 2
Level-1 Effects (Main Effects) on Type of Use Occasion, Number of Cannabis Uses, and Peak Subjective Effects

Predictors	SAM versus cannabis-only			Number of cannabis uses			Peak subjective effects		
	OR	95% CI	*p* value	IRR	95% CI	*p* value	*OR*	95% CI	*p* value
Motives									
Coping	0.80	[0.51, 1.25]	.32	1.00	[0.90, 1.12]	.98	0.69	[0.52,0.91]	<.01
Social	15.83	[11.28, 22.20]	<.01	1.21	[1.14, 1.28]	<.01	2.58	[2.12, 3.13]	<.01
Enhancement	4.85	[3.47, 6.80]	<.01	1.11	[1.04, 1.19]	<.01	2.54	[2.06, 3.15]	<.01
Expansion	0.29	[0.19, 0.46]	<.01	1.06	[0.97, 1.16]	.21	0.77	[0.58, 1.01]	.06
Social context									
Alone	0.21	[0.15, 0.28]	<.01	0.93	[0.88, 0.98]	.01	0.53	[0.44, 0.63]	<.01
With significant other	2.64	[1.61, 4.33]	<.01	1.12	[1.01, 1.25]	.03	1.89	[1.36, 2.64]	<.01
With friends	7.67	[5.92, 9.92]	<.01	1.25	[1.19, 1.32]	<.01	2.74	[2.32, 3.23]	<.01
Number of people intoxicated	5.01	[4.20, 6.20]	<.01	1.09	[1.07, 1.12]	<.01	2.42	[2.20, 2.65]	<.01
Number of people using cannabis	1.76	[1.64, 1.89]	<.01	1.06	[1.02, 1.11]	<.01	1.40	[1.35, 1.46]	<.01
Physical context									
At home	0.40	[0.30, 0.52]	<.01	0.97	[0.91, 1.03]	.28	0.79	[0.66, 0.96]	.02
At friend's place	4.02	[2.98, 5.42]	<.01	1.18	[1.11, 1.25]	<.01	2.07	[1.68, 2.55]	<.01

Note. $N = 315$. SAM = simultaneous alcohol and marijuana use; *OR* = odds ratio; IRR = incidence rate ratio. Each motive and context were estimated in a separate model. All models adjusted for Level-2 (day-level) and Level-3 (person-level) aggregates of each predictor, as well as age (age 21+ vs. not), school (School A, School B vs. School C [ref]), sex (male vs. female [ref]), race (white vs. non-white [ref]), ethnicity (Hispanic vs. non-Hispanic [ref]), wave (daily phase burst two vs. one [ref]), weekend (vs. weekday [ref]), any other drug use (yes vs. no [ref]) on a given survey, and any nicotine use (yes vs. no [ref]) on a given survey. Null models were conducted for each outcome to determine the intraclass correlation coefficients (ICC) at Level-2 and Level-3 for each outcome: SAM vs. cannabis ($ICC_{Level-2} = .49$, $ICC_{Level-3} = .24$), cannabis consumption ($ICC_{Level-2} = .49$, $ICC_{Level-3} = .24$), and peak subjective effects ($ICC_{Level-2} = .88$, $ICC_{Level-3} = .69$).

vs. cannabis-only; interaction est. = -0.38, $SE = 0.12$, $OR = 0.67$, 95% CI [0.52, 0.86], $p < .01$. There was a stronger slope between social motives and likelihood of being a SAM occasion for those reporting fewer people using cannabis (simple slope = 2.87, $p < .01$) than more people using cannabis (simple slope = 2.00, $p < .01$). The interaction between social motives and using alone (motive-context mismatch) was also significant, such that the relation between endorsing social motives and number of cannabis uses was amplified if the participant endorsed using alone on that occasion, est. = 0.44, $SE = 0.12$, $p < .01$, IRR = 1.55, 95% CI [1.22, 1.97]. There was a stronger slope between social motives and cannabis uses when using alone (simple slope = 0.28, $p < .01$) than when not (simple slope = .09, $p = .03$); see Figure 2.

We observed one significant 3-way interaction between social motives, number of people intoxicated, and type of use (est. = 0.20, $SE = 0.10$, $p = .05$). Relations between social motives and cannabis uses were positive for cannabis-only occasions, with slopes between social motives and cannabis uses being similar for those with low versus high number of intoxicated people around them (simple slopes = 0.17, $p < .01$; simple slopes = 0.21, $p < .01$, respectively), although number of uses was greater for those around more people who were intoxicated. In contrast, the association between social motives and cannabis use was negative for SAM use occasions, with a more negative slope between social motives and cannabis uses for those with a high number of intoxicated

Table 3
*Level-1 Effects (Interaction Effects) on Number of Cannabis Uses and Peak Subjective Effects*

Predictors	Number of cannabis uses			Peak subjective effects		
	IRR	95% CI	*p* value	*OR*	95% CI	*p* value
Motives						
Coping × SAM	1.20	[0.93, 1.55]	.15	0.93	[0.42, 2.02]	.85
Social × SAM	0.81	[0.71, 0.94]	<.01	0.77	[0.49, 1.23]	.27
Enhancement × SAM	0.86	[0.73, 1.01]	.06	1.33	[0.77, 2.29]	.30
Expansion × SAM	0.86	[0.70, 1.06]	.17	1.57	[0.76, 3.26]	.22
Social context						
Alone × SAM	1.15	[0.95, 1.40]	.16	0.68	[0.41, 1.14]	.15
With significant other × SAM	0.89	[0.69, 1.15]	.38	0.75	[0.32, 1.74]	.51
With friends × SAM	0.88	[0.77, 1.00]	.05	1.50	[0.97, 2.31]	.07
Number of people intoxicated × SAM	0.99	[0.93, 1.05]	.73	1.14	[0.92, 1.42]	.21
Number of people using cannabis × SAM	0.95	[0.93, 0.97]	<.01	0.93	[0.86, 1.02]	.11
Physical context						
At home × SAM	1.04	[0.90, 1.21]	.54	0.45	[0.28, 0.72]	<.01
At friend's place × SAM	0.82	[0.72, 0.94]	<.01	0.86	[0.53, 1.39]	.53

Note. $N = 315$. SAM = simultaneous alcohol and marijuana use; *OR* = odds ratio; IRR = incidence rate ratio. Each motive and context were estimated in a separate model. All models adjusted for Level-2 (day-level) and Level-3 (person-level) aggregates of each predictor, as well as age (age 21+ vs. not [ref]), school (School A, School B vs. School C [ref]), sex (male vs. female [ref]), race (white vs. non-white [ref]), ethnicity (Hispanic vs. non-Hispanic [ref]), wave (daily phase burst two vs. one [ref]), weekend (vs. weekday [ref]), any other drug use (yes vs. no [ref]) on a given survey, and any nicotine use (yes vs. no [ref]) on a given survey.

Figure 1

Plots of Statistically Significant Two-Way Interactions Between Motives/Contexts for Cannabis-Only and Simultaneous Alcohol and Marijuana Use Occasions on Cannabis Consumption
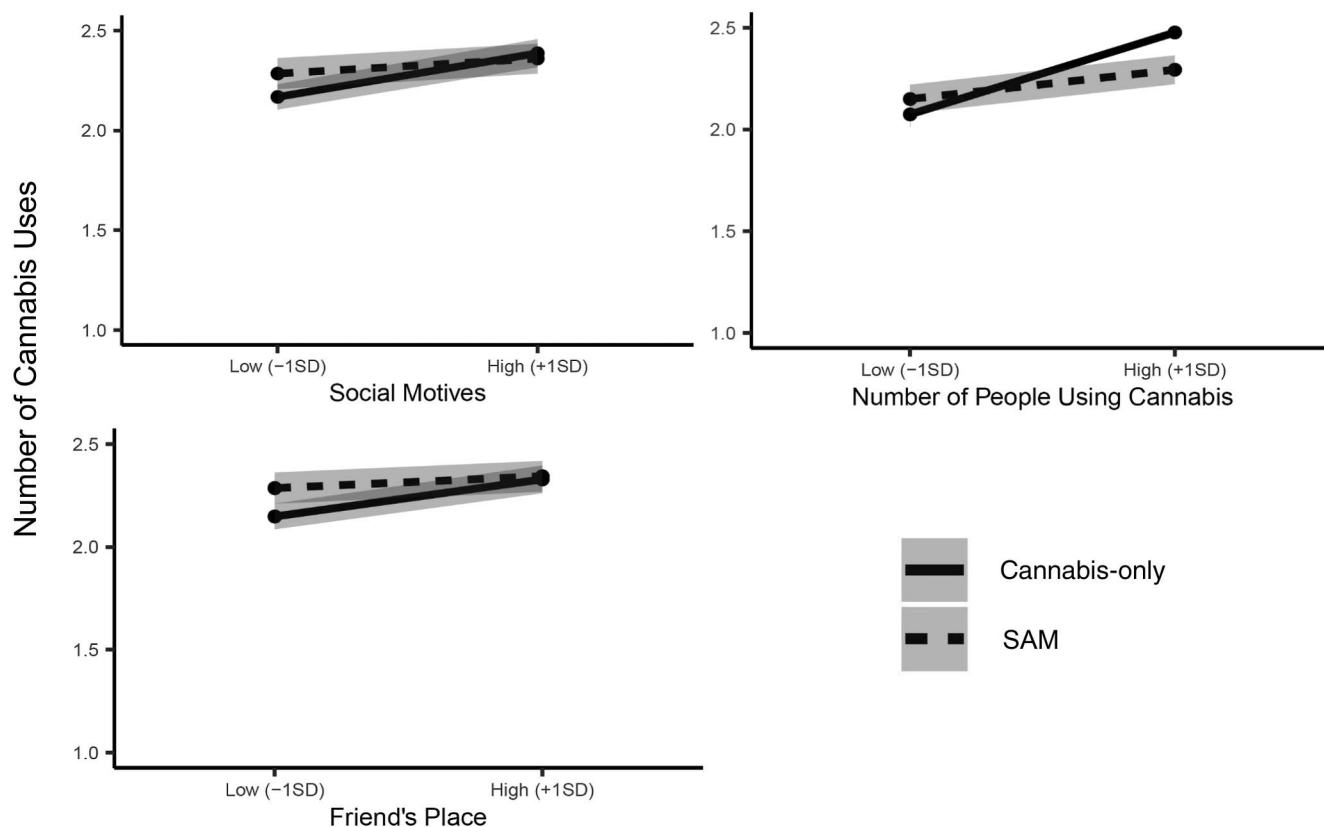
Note. Gray shading represents standard errors of fitted values. Level 1 effects (*x*-axis) are continuous deviation scores that take into account typical endorsement of a given motive or context; this is necessary for model convergence as uncentered Level-1 effects would be highly correlated with the Level-2 day-level effects of that same construct.

people around them (simple slope $= -0.03$, $p = .61$) than those with a low number of intoxicated people around them (simple slope $= -0.02$, $p = .78$), though, notably, the simple slopes were not significantly different from zero; again number of uses was greater for those who were around more people who were intoxicated; see Figure 2.

Discussion

The present study extended the small body of work examining situational motives for substance use and is one of only two studies to examine situational motives for simultaneous alcohol and cannabis use relative to use of a single substance (Arterberry et al., 2020). We explored the influence of the surrounding social and physical context by examining with whom the participant was using cannabis (and alcohol), whether others were also using cannabis or were intoxicated, and where they were doing so, and we compared these factors as a function of whether alcohol was added to the cannabis occasion. We tested whether there was a match between motive and context. In addition to examining motives and context on SAM versus cannabis-only occasions, we also examined cannabis uses and subjective effects experienced.

Situational Motives

Enhancement motives were the most highly endorsed motives for both types of use occasions. Social motives were endorsed on roughly half of all SAM occasions, although much more rarely (14%) on cannabis-only occasions. The college student drinking literature shows the greatest support for alcohol positive reinforcement motives both at the person-level (Cooper et al., 2016) and at the episode/daily level (Arbeau et al., 2011; Kairouz et al., 2002); thus, it is logical that the addition of alcohol to a cannabis use occasion would reflect more positive reinforcement motives. As the present study did not directly compare SAM occasions with alcohol-only occasions, it is not clear whether the converse is true; future work should test whether motivational (and contextual) influences vary across drinking occasions where cannabis is and is not also consumed. The desire to expand ones' awareness is a frequently cited motive for cannabis use, again both at the person-level (Simons et al., 1998) and at the episode/daily level (Bonar et al., 2017; Buckner et al., 2015), although in our study this motive was not endorsed frequently. Overall, our endorsement rates are consistent with other work looking at situational cannabis motives in showing that enhancement motives were most strongly endorsed across

Figure 2
Plot of Statistically Significant Motive-Context Two-Way (Top) and Three-Way (Bottom) Interactions
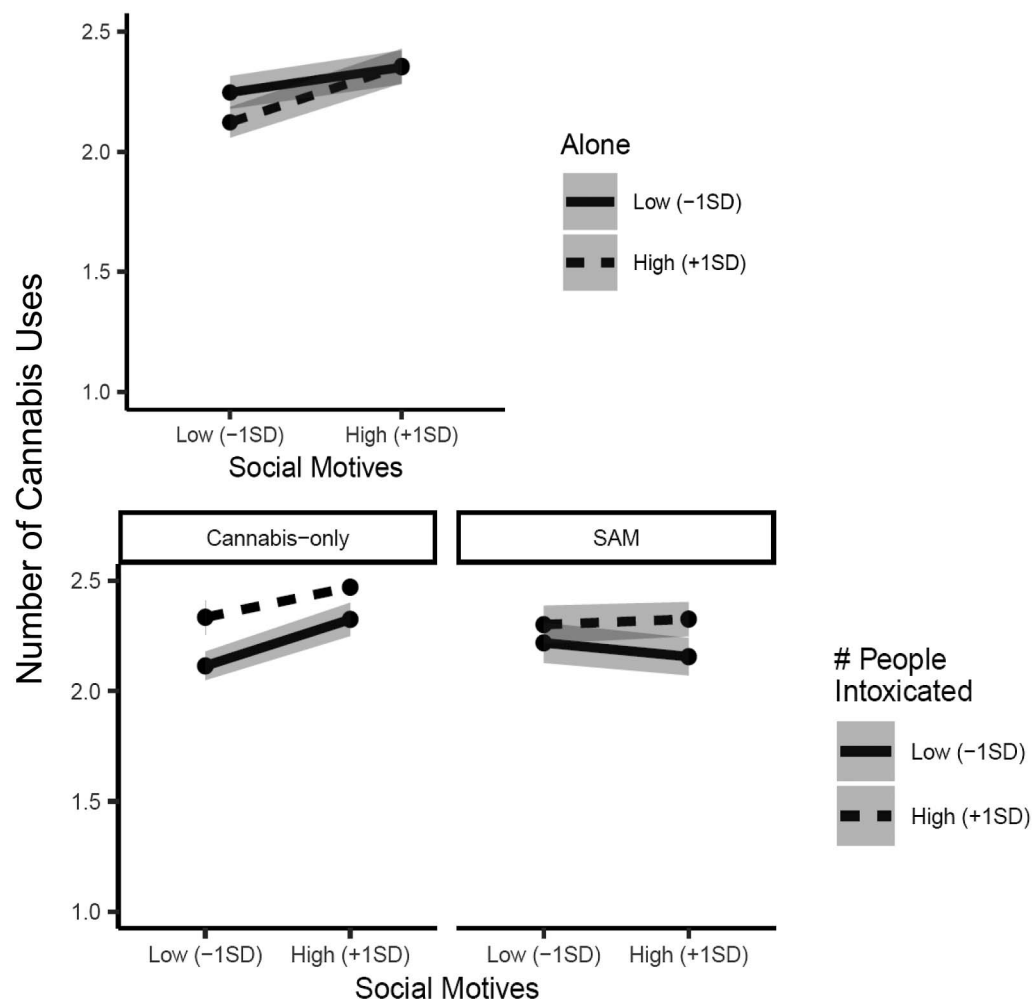
Note. Gray shading represents standard errors of fitted values. Level 1 effects are continuous deviation scores that take into account typical endorsement of a given motive or context; this is necessary for model convergence as uncentered Level-1 effects would be highly correlated with the Level-2 day-level effects of that same construct.

cannabis use occasions and conformity motives least strongly endorsed (Bonar et al., 2017; Buckner et al., 2015; Pearson et al., 2020; Shrier et al., 2013).

Situational motives endorsement rates also replicate findings by Arterberry et al. (2020) indicating that daily-level enhancement and social motives were endorsed more often on co-use days than cannabis only days. Our rigorous tests of differences in situational motives as a function of use occasion included controls for demographics (age, sex, race, ethnicity), design features (school site, burst-level), weekday/weekend status, and contemporaneous drug or nicotine use as well as aggregated person- and day-level motives. Consistent with hypotheses, both social and enhancement motives were related to greater odds of SAM use versus cannabis-only. That is, on occasions when alcohol was also being consumed with cannabis, participants reported being motivated to have fun and be social. The associations with these positive reinforcement motives also were evident at the person-level, replicating prior work

examining SAM motives (Conway et al., 2020; Patrick et al., 2018, 2019). Also consistent with our hypotheses, seeking to expand ones' awareness was reported more often in situations of consuming cannabis only, without also consuming alcohol. Neither our study nor the study by Arterberry et al. (2020) found differences in type of use as a function of situational coping motives.

When we examined associations between situational motives and cannabis outcomes, we found that those who consumed substances for the purpose of being social and for enhancement on a given occasion reported more cannabis uses on that occasion and also experienced higher peak subjective effects. This finding is consistent with the few studies on situational cannabis motives that demonstrated a higher number of cannabis joints (Bonar et al., 2017) and cannabis use sessions (e.g., Pearson et al., 2020) on days when enhancement motives were endorsed. Further, the increased cannabis consumption associated with endorsing social motives was stronger when the occasion was cannabis-only than

when it was a SAM occasion. Cannabis uses were greater on SAM occasions regardless of motives, but when the occasion was cannabis only, cannabis uses were higher when the use was socially motivated. Situational coping motives were not associated with cannabis use but were associated with subjective effects. Coping motives tend to be most strongly associated with substance-related problems (Cooper et al., 2016; Dvorak et al., 2014) and may not apply to our measure of use. O'Hara et al. (2016) found that college students who use substances to cope with negative affect and stress are more likely to substitute alcohol for cannabis rather than to combine them (as complements). It may be that participants who needed to cope with negative affect felt high after using cannabis, regardless of whether alcohol was also consumed. We did not replicate prior work showing that situational expansion motives are uniquely associated with greater subjective effects (Pearson et al., 2020). Neither our study nor prior day-level studies (Bonar et al., 2017; Pearson et al., 2020) found associations of expansion motives with cannabis consumption.

Context

The most common setting for cannabis use was at home; this context was more likely to be endorsed when using cannabis only than combining it with alcohol. Cannabis may be difficult to conceal in public settings (due to its odor) especially when using leaf products (which accounts for the most often used form of cannabis use in this age group; Gunn et al., 2020). We did not assess type of home location, but it may further account for differences in substance type (e.g., alcohol is more easily used in residence halls than cannabis). Interestingly, using at home was associated with fewer cannabis uses and lower subjective effects, and this was particularly true on SAM occasions; this finding merits further examination. Using cannabis at a friend's place was more likely when the situation included alcohol; likewise, being with friends or significant others was a more commonly endorsed social context of cannabis use when the participant was also using alcohol. These findings are in line with the well-established social nature of college student drinking and support the literature reviewed earlier suggesting that many of the effects of simultaneous use are driven by alcohol (Jackson et al., 2020; Linden-Carmichael et al., 2019).

Findings extend prior work showing that SAM use is more likely than cannabis-only use when surrounded by people who are consuming substances and/or intoxicated; prior work has demonstrated this relative to alcohol-only situations (Lipperman-Kreda et al., 2017, 2018), but this is the first study to show it relative to cannabis-only situations. As hypothesized, being surrounded by intoxicated people was associated with more use on that occasion. Further, when in the company of a greater number of others using cannabis, there were more uses when the occasion was cannabis only compared to SAM. Being alone was more common when using only cannabis, consistent with work showing that cannabis is frequently consumed alone (McCabe et al., 2014; Shrier et al., 2013). This may be due to greater acceptability of using cannabis alone, in contrast to drinking alone, which may be more stigmatized. Cannabis also may be used alone when used for therapeutic reasons; college students report using cannabis for sleep and for physical and mental health conditions (depression, anxiety; Smith et al., 2019). However, when cannabis was used on a given occasion, being alone was related to less use.

Using at a friend's house was associated with more cannabis consumed and greater subjective effects on that occasion. This latter finding was pronounced when the occasion was cannabis-only. Similar to the above finding for social motives, use was higher on SAM occasions regardless of context, but when only using cannabis, use was greater when the user was at a friend's place. The general pattern of results suggests that the combination of alcohol and cannabis occurs during social situations (and when motivated by positive reinforcement) but there is no evidence of increased cannabis use when also consuming alcohol in social situations. Moreover, using with friends or a significant other was associated with greater use and greater subjective effects on that occasion. In contrast, use at home was associated with lower subjective effects. Type of substance use did not alter associations between context and subjective effects.

Motives–Context Match/Mismatch

Across both cannabis-only and SAM occasions, there were more cannabis uses on occasions with high social motives, regardless of whether the participant was using alone. However, for occasions with low social motive endorsement, cannabis use was greater when using alone.[2] Social motives seemingly operate differently depending on the situation, highlighting the importance of considering both cognitions and context. Additionally, those who were socially motivated and using with others who were intoxicated reported a greater number of uses when it was a cannabis-only occasion but not a SAM occasion. This may be evidence of substitution where those who are particularly socially motivated are consuming more alcohol and less cannabis, regardless of their social context.

Strengths and Limitations

This is the first study to examine the joint influence of situational motives and context on the simultaneous use of alcohol and cannabis; we extend the field by comparing SAM occasions to cannabis-only occasions, as the majority of work in this emergent field treats alcohol-only as the reference group. Our study benefitted from repeated surveys with full-day coverage for the majority of days. Rigorous multi-level analyses controlled for possible confounding factors as well as aggregated daily- and person-level values, permitting isolation of the true effect of within-person situational motives and context. In addition, we included students attending three universities in states with varying cannabis laws, thus increasing generalizability.

At the same time, findings should be interpreted in the context of limitations. Given the difficulty measuring cannabis consumption (Freeman & Lorenzetti, 2020) and the lack of a standardized measure of quantity consumed (especially at the survey level), we developed a visual interface permitting participants to self-define what constitutes a cannabis "use." Given that this visual interface has not yet been validated our findings should be replicated with different operationalizations of cannabis use (number of hits, joints, or grams). Subjective effects were assessed using the same visual interface and used nonspecific axes ("drunk/high") that do not

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[2] This "mismatch" finding should be considered against the backdrop that at the person-level (Level 3), those high on social motives consumed less cannabis.

correspond to type of substance. This measure was informed by preliminary qualitative data on the difficulty of disambiguating the relative contributions of alcohol versus cannabis to a given state of intoxication, but studies with greater specificity in intoxication (e.g., Lee et al., 2017) are needed to replicate our findings. However, any limitations in assessment of cannabis use or subjective effects are mitigated by testing effects within-person. Although surveys were fine-grained and repeated often, reports still required a degree of retrospection, especially when one survey was missed and the reporting interval increased. Individuals may reconstruct their motives as a function of their substance use or consequences experienced (O'Hara et al., 2014). It is possible that missed surveys led to underreporting of substance use, which could bias the findings, although ancillary analyses demonstrated that there was no association between incomplete coverage and substance use as measured by next-morning reports ($r = .004$, $r = .06$, and $r = .003$ for SAM, cannabis-only, and alcohol-only). In addition, for the daily surveys, SAM use was determined by whether alcohol and cannabis were reported on a given survey which differed from some standard definitions of SAM use. Nonetheless, our definition of a SAM use occasion has been validated by prior research (Sokolovsky et al., 2020).

Further, the reliability of single-item situational motives measures is unknown, and we did not measure non-recreational motives (e.g., for sleep or to reduce anxiety). Selection of a small number of single items was done to minimize participant burden. The rapid evolution of how cannabis is used and legal and medical access to use may be accompanied by changes in *why* cannabis is used, making it important for researchers to assess contemporary motives. In the daily survey phase of our study we did not differentiate between medical and nonmedical use of cannabis. Future research may benefit from taking this distinction into account when assessing motives for use. Additionally, given the focus on cannabis-only comparisons, it is not possible to conclude whether the same processes distinguish SAM occasions from alcohol-only occasions.

The sample is comprised of college students who reported past-month SAM use. Findings may not generalize to other college students, noncollege attending youth, or other age groups. However, other work with young adults shows that SAM users are more likely to attend college full-time (Patrick et al., 2019), suggesting this is an important population to study. The majority were White, which limits generalizability to non-White young adults.

Implications for Intervention and Future Directions

The knowledge gained in this study will be important for informing interventions leveraging data on motivational and social contexts. For example, universities seeking to implement preventative interventions may choose to highlight how social and enhancement motives lead to excessive consumption and intoxication when providing didactic education about situational risk. Similarly, interventionists may encourage the presence of sober or abstinent friends to reduce risk given the added risks associated with socially motivated cannabis use when around others who are using. Programs that focus solely on the rational aspects of decision-making and neglect the social-ecological context may have limited effectiveness due to constraints on the ability to make sound decisions in a highly charged, typically social, context (Chein et al., 2011).

Novel approaches to intervention such as just-in-time adaptive interventions (JITAIs) and ecological momentary interventions (EMIs) are increasingly targeting substance use in the natural environment, at a time when behavior is opportune for modification (Berman et al., 2016; Wright et al., 2018). For these situationally proximal interventions, effectiveness will likely depend substantially on the delivery of relevant intervention ingredients at relevant times (Heron & Smyth, 2010; Shrier et al., 2018). One key implication of our findings for situationally proximal interventions is the generally additive nature of the observed effects. Significant findings were primarily main effects, as opposed to interactions. This suggests that rather than developing overly nuanced tailoring algorithms, future interventions targeting proximal situations can prioritize the detection of high-risk antecedents such as location or social context. Given the notable influence of number of intoxicated people on number of cannabis uses and peak subjective effects, geospatial data might be leveraged to detect the presence of proximal peers and accelerometry data to inform their level of intoxication when conditioning intervention delivery. Future intervention development research should thus focus not only on further characterizing complex situational factors and their relationships but also on their practical assessment in the real-world that is necessary for effective implementation.

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Correction to Cummins, Lindgren, and De Houwer (2020)

In the article "On the Role of (Implicit) Drinking Self-Identity in Alcohol Use and Problematic Drinking: A Comparison of Five Measures" by Jamie Cummins, Kristen P. Lindgren, and Jan De Houwer (*Psychology of Addictive Behaviors*, 2021, Vol. 35, No. 4, pp. 458–471. https://doi.org/10.1037/adb0000643), the Open Data and Open Materials badges were omitted in error from the advance online publication version of this article.

All versions of this article have been corrected.

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