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Cannabis and Alcohol Use, Affect, and Impulsivity in Psychiatric Outpatients' Daily Lives

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Abstract

Background and Aims—Cannabis and alcohol are the most commonly used (il)licit drugs worldwide. We compared the effects of cannabis and alcohol use on within-person changes in impulsivity, hostility, and positive affect at the momentary and daily levels, as they occurred in daily life.

Design—Observational study involving ecological momentary assessments collected via electronic diaries 6 random times a day for 28 consecutive days.

Setting—Outpatients' everyday life contexts in Columbia, MO, USA.

Participants—Ninety-three adult psychiatric outpatients (85% female; *M*=30.9 years old) with Borderline Personality or Depressive disorders, who reported using only cannabis (*n*=3), only alcohol (*n*=58), or both (*n*=32) at least once during the study period.

Measurements—Real-time, standard self-report measures of impulsivity, hostility, and positive affect, as impacted by momentary reports of cannabis and alcohol use.

Findings—Cannabis use was associated with elevated feelings of impulsivity at the day level (*b*=0.83, 95% *Confidence Interval* [*CI*]=0.17–1.49) and increased hostility at the momentary (*b*=0.07, 95% *CI*=0.01–0.12) and person (*b*=0.81, 95% *CI*=0.15–1.47) level. Alcohol use was associated with elevated feelings of impulsivity at the momentary (*b*=0.42, 95% CI=0.13–0.71) and day level (*b*=0.82, 95% *CI*=0.22–1.41) and increased positive affect at the momentary (*b*=0.12, 95% *CI*=0.06–0.18) and day (*b*=0.33, 95% *CI*=0.16–0.49) level.

Conclusions—Cannabis and alcohol use are associated with increases in impulsivity (both), hostility (cannabis), and positive affect (alcohol) in daily life, and these effects are part of separate processes that operate on different time scales (i.e., momentary versus daily).

Keywords

Alcohol; Borderline Personality Disorder; Cannabis; Depressive Disorder; Ecological Momentary Assessment; Impulsivity; Hostility; Marijuana; Positive Affect

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Cannabis Use, Affect, and Impulsivity in Daily Life

Cannabis is the most commonly used illicit drug worldwide [1,2], and there is great controversy over the relative benefits versus adverse effects of its use [3,4]. Two important factors involved in cannabis use are affect and impulsivity, both of which are implicated in theories of substance use and abuse. For example, the self-medication (or drive-reduction) perspective [5] suggests that substance use is an attempt to regulate or alleviate negative affect, and thus may become negatively reinforcing [6]. Individuals higher in impulsivity report greater stress-reduction from substance use [7], making repeated use more likely. Substance use may also be an attempt to heighten positive affect and may become positively reinforcing [8]. The pharmacological effects of substance use can also influence affect and impulsivity. For example, substance use may increase positive affect and arousal in small doses, decrease negative affect in small to moderate doses, increase negative affect after prolonged heavy consumption and withdrawal, and increase disinhibition [9–11].

Consistent with these perspectives, cannabis use is associated with psychiatric disorders characterized by affective and impulsivity problems (e.g., [12]), and cannabis users can be differentiated from non-users by their low scores on the personality traits of agreeableness and conscientiousness (indicating antagonism and impulsivity; e.g., [13]). Concerning impulsivity, laboratory research indicates that acute cannabis use adversely affects performance on tasks tapping attention, inhibition, working memory, and risk-taking (e.g., [14–15]). Others have focused on the effects of cannabis use on neurological structure and functioning (e.g., [17,18]), and a recent meta-analysis of neuro-imaging studies identified deficits of motor control in cannabis users and reduced activation in prefrontal brain regions (implicated in cognitive control) among chronic cannabis users [19]. Furthermore, the acute administration of cannabis resulted in the activation of brain regions associated with increased effort to engage inhibitory control, and structural imaging studies also documented reduced prefrontal volume and white matter integrity, suggesting reduced cognitive and emotional control among cannabis users.

Ecological Momentary Assessment

Despite the important information gleaned from these studies, less well-studied are the proximal effects of cannabis on affect and impulsivity during daily life. Ecological momentary assessment (EMA; [20]) can reveal micro-associations between cannabis use and psychological constructs as they naturally unfold in daily life. In EMA, ambulatory data collection methods (often electronic diaries or smartphones) are used to minimize retrospective reporting and maximize temporal resolution of dynamic psychological processes. EMA assessments are both ecological (in the participant's natural environment) and momentary (about immediate experiences and requiring minimal retrospection).

Relatively few EMA studies have examined the associations between affect and/or impulsivity and cannabis use. Several of these examined effects at the *daily level*. Hughes and colleagues [21] found that cannabis use was associated with lower hostility, anxiety, and sadness, but greater alcohol use in daily cannabis users making retrospective reports of the prior day. Bhushan, Blood, and Shrier [22] studied depressed outpatients' substance use (cannabis/alcohol) at the day level and found that the range of reported affect (both positive

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and negative) was restricted prior to substance use, especially cannabis. Ansell, Laws, Roche, and Sinha [23] examined prospective daily cannabis use, adjusting for reported alcohol use, and found that cannabis use was associated with increased hostility and perceptions of hostility in others on the day of use but not the day following use. Additionally, cannabis use was associated with increased same-day and following-day impulsivity.

Providing more temporal resolution are studies that examined *momentary effects*. Chakroun and colleagues [24] assessed the relations between affect and substance use and found that momentary positive affect was positively associated with subsequent cannabis and alcohol use, and depressed affect was negatively associated with subsequent cannabis use. Similarly, in individuals with schizophrenia or schizoaffective disorder, Swendsen and colleagues [25] found that depressed affect was negatively associated with subsequent cannabis use in the moment. However, anxious affect and perceived negative events were positively associated with cannabis and alcohol use. Prospectively, there were no effects of alcohol or cannabis use on anxiety or depression. Buckner and colleagues [26] observed that daily cannabis users reported less anxiety on use days than non-use days, but more momentary anxiety during use reports than non-use reports. In another study, Buckner and colleagues [27] found that positive affect was higher on cannabis use days than non-use days; however, there were no differences in positive affect before or after use at the momentary level. Also at the momentary level, negative affect increased prior to use and decreased after use.

Aims of the Present Study

Using secondary data analysis of existing data we sought to replicate and extend previous findings on the effects of cannabis use on affect, especially hostility and positive affect, and impulsivity.

Aim 1: To compare the effects of cannabis use on within-person changes in impulsivity, hostility, and positive affect at the momentary and daily levels, as they occur in daily life. To address this aim, we sampled psychiatric outpatients who were likely to show more variability in their levels of affect and impulsivity and for whom problematic substance use has been associated with mood disorder and disinhibition.

Aim 2: To also evaluate the effects of simultaneous alcohol use so we could determine whether relations were specific to cannabis, or extend to substance use more generally. There is increasing evidence that cannabis users may use alcohol simultaneously (e.g., [28]), significantly impairing motor skills (e.g., driving) more than either substance alone. Therefore, it appears that co-use may influence the relations between affect, impulsivity, and substance use.

Given previous EMA findings, we hypothesized: (1) concurrently, cannabis (and alcohol) use will be associated with higher levels of *impulsivity* at the day and momentary level; (2) concurrently, cannabis use will be associated with higher levels of *hostility* at the day and momentary level; and (3) concurrently, cannabis (and alcohol) use will be associated with higher levels of *positive affect* at the day level.

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Methods

Design and Setting

We conducted a longitudinal EMA study that collected observational data from psychiatric outpatients residing in Columbia, MO, USA and the surrounding areas. Participants completed short assessments using electronic diaries that they carried as they went about their daily lives.

Participants[1]

Participants were drawn from a sample of 131 individuals with borderline personality (BPD; $N = 81$) and depressive (DD; $N = 50$) disorders who were recruited from local psychiatric outpatient clinics between 2005 and 2008 for a study examining affective instability [29]. The original study focused on emotion dysregulation in BPD with the inclusion of the DD group as a clinical control group also characterized by emotion dysregulation. The final sample used in the current study consisted of 60 participants who met DSM-IV-TR [35] diagnostic criteria for BPD and 33 participants who met criteria for DD, all of whom reported using cannabis, alcohol, or both at least once during the study period. Participants in the BPD group were required to meet the DSM-IV-TR affective instability criterion for BPD, given the aims of the larger study. Participants who met this BPD criterion were excluded from the DD group; however, only two individuals were excluded from the DD group for this reason. General exclusion criteria included having a psychotic disorder, history of severe head trauma, intellectual disability, severe substance dependence, or severe neurological dysfunction. Individuals between the ages of 18 and 65 were eligible to participate.

Previous studies reported on differences between these two diagnostic groups in terms of mean levels (e.g. [29,31,33,34]) and associations between some variables that we include in the present analyses [32,34], though not cannabis use. Although there were mean level differences in the 28-day averages of some of these variables between groups (e.g. impulsivity, hostility), there were no differences in the associations (i.e., we examined all substance use by group interactions and none were statistically significant). Therefore, we pooled the data across groups. Demographic information for included participants is provided in Table 1. The current subsample did not differ significantly on any of the demographic variables relative to those who were excluded (due to a lack of cannabis/alcohol use during the study period).

Procedures

Participants who passed an initial eligibility screening participated in semi-structured interviews to obtain diagnostic information ([36,37]; see [29,34] for details). Eligible participants were issued an electronic diary (Palm Zire 31© handheld computer) that they carried for approximately 28 days ($M = 28.5$, $SD = 3.4$). The electronic diary (ED) alarmed randomly six times per day, prompting the individual to answer questions about current

[1]Results from the full sample with different foci are published in Trull et al. [29], Jahng, Wood, & Trull [30], Solhan, Trull, Jahng, & Wood [31], Jahng et al. [32], and Tomko et al. [33,34].

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affect, impulsivity, and substance use (see [29] for more details). The compliance in the sample, calculated as the between-person average of each individual's ratio of completed prompts to total received prompts, was high (M = 90.5%), with participants completing an average of 144.5 prompts each. This was achieved via thorough screenings/interviews and various incentive structures, and is consistent with compliance rates observed in this type of research more broadly (see [29,34] for details). In total, 13,439 reports were included in the present analyses.

Measures

Positive and Negative Affect—Affect was assessed using items from the *Positive and Negative Affect Schedule-Extended* (PANAS-X; [38]). Items were presented on the ED at each prompt. Respondents were asked to rate the extent to which they felt the particular affective state on a 5-point Likert scale (1=very slightly or not at all, to 5=extremely) since the last prompt. The negative affect (NA) items composed three negative emotion scales: hostility (6 items), anxiety (6 items), and sadness (5 items). Following Ansell and colleagues [23], we focus primarily on the hostility subscale. Parallel analyses including anxiety and sadness are presented in the Supplementary Material (Table S1). Positive affect (PA) was measured using ten items from the original PANAS.

Momentary Impulsivity **(Momentary Impulsivity Scale; MIS; [33,34])—**At each prompt, participants were asked to rate their impulsivity since the last prompt. Participants responded to 4 items using a 5-point Likert scale (1=very slightly or not at all, to 5=extremely). Items were summed to create a total score. Responses to the MIS scale items were only available for a subset of 77 cannabis and/or alcohol users (51 BPD, 26 DD) due to a change in the response format midway through data collection.

Substance Use—At each prompt, participants indicated if they had used cannabis or alcohol since the last prompt (1=yes, 0=no). Descriptive statistics of the frequency of cannabis and alcohol use across persons, days, and occasions are presented in Table 1. The pattern of results and reported significant effects did not differ if we limited the analyses to only users of both substances (n = 32), or users of only alcohol (n = 58).

Covariates—Age was centered on the sample mean, gender was effect coded (female = −1, male = 1), and both were included as covariates in all analyses (in order to provide interpretable sample-wide average estimates) given past epidemiological evidence regarding age and gender differences in both cannabis and alcohol use (e.g., see [23,39]). Both a categorical variable indexing day of the week and an indicator for the first measurement of the day were included in order to adjust for circadian and diurnal trends in affect, respectively (see Supplementary Material). We also effect coded group (DD = −1, BPD = 1) and included it as a covariate, given previously reported mean level differences in affect and substance use in this sample [29,32].

Analyses

We were interested in the concurrent (i.e. same measurement occasion) and lagged (i.e. previous measurement occasion [~2 hours] and previous day) effects of substance use on

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individuals' ratings of affect (hostility and positive affect) and impulsivity. The lagged effects were of interest as they allow for more nuanced interpretations of the temporal process linking substance use and affect/impulsivity – namely that adjusting for momentary substance use allows us to interpret lagged substance use as an antecedent to the same time point associations [40]. We used multilevel modeling to examine the associations between substance use and momentary reports of impulsivity, hostility, and positive affect at varying levels of experience (i.e., occasion, day, and person). This allows for the disaggregation of measures with multiple levels of variability into their component parts [41; see Supplementary Material]. Thus, we separately modeled momentary reports of impulsivity, hostility, and positive affect as a function of the current and previous occasion's cannabis and alcohol use (level 1), an individual's average cannabis and alcohol use for that day and the previous day (level 2), and an individual's overall person-average of cannabis and alcohol use across the entire diary period (level 3). These were all estimated as fixed effects. Also estimated were ten random effects (see Supplementary Material). Each of the cannabis and alcohol use predictors were centered such that occasion-level variables were centered on the person-average for that day, day-level variables were centered on the person-average of day-averages for that person across the diary period, and person-level variables were centered on the average of person-averages across the diary period. Given that we were testing multiple effects for each substance across three outcome measures, we calculated familywise *p*-value adjustments using the method recommended by Benjamini and Hochberg [42]. The effects that remained statistically significant after the adjustment are shown in Table 2.

Results

Impulsivity

Table 2 presents results from the analysis of cannabis and alcohol use predicting momentary impulsivity ratings. At the momentary level, only alcohol use at a particular occasion was positively related to impulsivity reported on the same occasion. At the day level, both cannabis use and alcohol use were independently associated with increased mean impulsivity scores on that day. There was little evidence of across-day lagged associations between substance use and impulsivity, and similarly, there were no statistically significant associations between individuals' overall levels of cannabis and alcohol use on person-level impulsivity ratings.

Hostility

At the momentary level, cannabis use at a particular occasion was associated with increased ratings of hostility on the same occasion. However, there was evidence of a lagged effect also, such that cannabis use on the previous occasion was associated with lower hostility at the current occasion, essentially counteracting the same time point increase. In addition, individuals who were more frequent cannabis users overall tended to report higher levels of hostility at any given moment. Alcohol use was generally unassociated with hostility.

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Positive Affect

In general, cannabis use was not predictive of momentary positive affect, but there were a number of concurrent and lagged associations between alcohol use and reported positive affect. At the momentary level, current alcohol use was associated with increased ratings of positive affect on the same reporting occasion, but as with cannabis and hostility, previous occasion's alcohol use was associated with lower current positive affect. Similarly, alcohol use days were associated with increased mean positive affect on that day, but lower mean positive affect on the following day.

Discussion

We examined the association between both cannabis and alcohol use with affect and impulsivity in daily life, both within day and across days. Our results indicated a number of significant concurrent associations: *current occasion* (i.e., momentary) cannabis use was associated with hostility; *current day* cannabis use was associated with impulsivity; *current occasion* alcohol use was associated with both impulsivity and positive affect; and *current day* alcohol use was associated with both impulsivity and positive affect. There were few significant lagged effects of substances on affect or impulsivity: *previous day* alcohol use was negatively related to positive affect and *previous occasion* cannabis use was negatively related to hostility. Finally, person-level effects were strongest between cannabis use and hostility.

We found mixed evidence supporting the *self-medication or drive-reduction* effects of cannabis use as predicted by self-medication theory. On the one hand, previous occasion use of cannabis was associated with decreases in hostility, whereas current use of cannabis did not result in decreases in hostility (or decreases in negative affect more generally; see Table S1). Alcohol use was more robustly related to positive affect at the occasion and day levels than to hostility or negative affect (See Table S1). Thus, these results support a positive reinforcement model of alcohol use. Specifically, increases in positive affect associated with alcohol may have reinforced use of this substance, making use more likely to be repeated in the future.

Cannabis use was significantly and concurrently associated with self-reported impulsivity at the day level, whereas this association was found for alcohol use at the occasion and day levels. There is ample literature on the association between alcohol administration and certain aspects of impulsivity as measured through behavioral tasks in the laboratory (e.g., [43–46]), but fewer studies have examined the effects of cannabis administration on performance on these tasks [14–16]. In addition, it is important to note that performance on these laboratory tasks does not correlate highly or robustly with questionnaire measures of impulsivity (e.g., [47]). Testing this association in daily life, however, Ansell and colleagues [23] reported associations with both current- and prior-day marijuana use and daily self-reported ratings of impulsivity. Although we replicated this association for the current day, we did not find a lagged association between prior day cannabis use and impulsivity. Possible explanations for the lack of replication include the use of different impulsivity items, our sampling of outpatients, and our focus on assessing cannabis use and impulsivity at the occasion (versus day) level.

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Cannabis use was also associated with occasion-level self-reports of hostility, suggesting an acute effect. Previous studies have reported increased feelings of paranoia or unfriendliness following use of cannabis in the laboratory as well as during daily life (e.g., [48,49]). This also provides at least partial support for the finding of Ansell and colleagues [23] that cannabis use was significantly associated with average ratings of self- versus others'-hostility during interpersonal interactions on a given day. However, our method differed from theirs in two ways. First, our hostility items reflected internal feelings, whereas Ansell and colleagues' participants rated their own (and others') *behavior*. Furthermore, as Ansell and colleagues only reported day-level associations, it is unknown if their findings generalize to occasion-level hostility.

Strengths of our study include the measurement of affect, impulsivity, and substance use at the momentary level. This allowed for more precision compared to only analyzing data at the daily level or to asking participants to aggregate across day. For example, we were able to demonstrate significant relations between cannabis use and hostility at the occasion level, but not the day level. This is consistent with an acute effect but perhaps not a longer-lasting one. We also examined multiple affects and substances in our analyses to better assess the specificity of findings for cannabis use. Regarding the latter, we found that the affective profiles associated with cannabis use and alcohol use differed. Specifically, unlike cannabis use, alcohol use was consistently associated with positive affect at the day and occasion level. Finally, we sampled psychiatric outpatients, who may have more intense and variable moods and impulsivity than non-clinical participants, and for whom substance use problems may be more salient.

Our study did have limitations, however. First, we cannot establish temporal precedence in our concurrent findings, even at the occasion level, because affect, impulsivity, and substance use were rated over the period of time since the last answered prompt (typically 2–3 hours). Second, our study did not record the amount or strength of the cannabis used. Therefore, we were unable to distinguish between effects related to higher versus lower THC intoxication. Similarly, we operationalized alcohol use in a binary fashion for the analyses so that cannabis and alcohol effects could be interpreted on the same scale. However, it seems reasonable to expect that the effect of a single drink in a two hour span could be quite different than the effect of six in the same time period. Reanalyzing the data using quantity of alcohol consumed (i.e., number of standard drinks) as the variable of interest, revealed a pattern of results (and statistical significance) very similar to that for binary alcohol use. Finally, we did not know participants' cannabis (or alcohol) use history. Therefore, it will be important to replicate these results using additional samples to determine generalizability, particularly given that the current sample was recruited between 2005–2008 and cannabis use and related laws have changed substantially in the United States since then.

Conclusions

Cannabis use is associated with increases in impulsivity and hostility in daily life, and these effects are part of separate processes that operate on different time scales (i.e., momentary versus daily). There was only limited support for the drive-reduction (negative

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reinforcement) model of cannabis use, with the majority of findings indicating a positive association of cannabis use with hostility. These results suggest that cannabis users tend to be higher in hostility than others, and the use of cannabis is likely to increase, not decrease, these feelings in the moment. If individuals engage in cannabis use in an effort to reduce hostility, our findings suggest that the opposite effect may actually be occurring. Future research might examine alternative methods of coping with hostility in cannabis users to prevent abuse and dependence.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of sample (n = 93) that either used alcohol or cannabis over the 28-day ecological momentary assessment (EMA) period.

	All participants (n = 93)		**BPD (n = 60)**		**DD (n = 33)**	
	N (%)	***Per person M (SD)***	***N (%)***	***Per person M (SD)***	***N (%)***	***Per person M (SD)***
Persons						
Age		30.9 (11.2)		29.6 (11.0)		33.3 (11.2)
Female	79 (85.0%)	–	54 (90.0%)	–	25 (75.8%)	–
Race/Ethnicity						
Caucasian	80 (86.0%)	–	50 (83.3%)	–	30 (90.9%)	–
African American	6 (6.5%)	–	4 (6.7%)	–	2 (6.1%)	–
Hispanic	3 (3.2%)	–	2 (3.3%)	–	1 (3.0%)	–
Other	4 (4.3%)	–	4 (6.7%)	–	0 (0.0%)	–
Income						
< US$25,000	64 (68.8%)	–	40 (66.7%)	–	24 (72.7%)	–
US$25,000 – US$49,999	14 (15.1%)	–	10 (16.7%)	–	4 (12.1)	–
US$50,000 – US$74,999	7 (7.5%)	–	4 (6.7%)	–	3 (9.1%)	–
≥ US$75,000	8 (8.6%)	–	6 (10.0%)	–	2 (6.1%)	–
Current Anxiety Disorder	71 (78.0%)	–	38 (63.3%)[a]	–	33 (100.0%)[a]	–
Current Mood Disorder	70 (77.8%)	–	46 (76.7%)	–	24 (72.7%)	–
Alcohol Users	90 (96.8%)	–	58 (96.7%)	–	32 (97.0%)	–
Cannabis Users	35 (37.6%)	–	27 (45.0%)[a]	–	8 (24.2%)[a]	–
Alcohol & Cannabis Users	32 (34.4%)	–	25 (41.7%)[a]	–	7 (21.2%)[a]	–
Alcohol Users Only	58 (62.4%)	–	33 (55.0%)[a]	–	25 (75.8%)[a]	–
Cannabis Users Only	3 (3.2%)	–	2 (3.3%)	–	1 (3.0%)	–
Mean PANAS Hostility	93 (100.0%)	1.5 (0.5)	60 (100.0%)	1.5 (0.6)[a]	33 (100.0%)	1.3 (0.3)[a]
Mean PANAS Impulsivity	77 (82.8%)	6.0 (1.5)	51 (85.0%)	6.2 (6.2)	26 (78.8%)	5.7 (1.2)
Mean PANAS Positive Affect	93 (100.0%)	2.2 (0.6)	60 (100.0%)	2.1 (0.6)	33 (100.0%)	2.3 (0.7)
Days						
Alcohol Days	658 (24.9%)	7.1 (6.7)	434 (25.1%)	7.2 (7.0)	224 (24.4%)	6.8 (6.3)
Cannabis Days	364 (13.9%)	3.9 (8.0)	327 (19.1%)	5.5 (9.5)[a]	37 (4.1%)	1.1 (2.5)[a]

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	All participants (*n* = 93)		BPD (*n* = 60)		DD (*n* = 33)	
	N (%)	***Per person M (SD)***	***N (%)***	***Per person M (SD)***	***N (%)***	***Per person M (SD)***
Alcohol and Cannabis Days	123 (4.7%)	1.3 (3.4)	108 (6.3%)	1.8 (4.0)[a]	15 (1.6%)	0.5 (1.2)[a]
Occasions						
Alcohol Occasions	948 (7.1%)	10.2 (13.0)	629 (7.3%)	10.5 (13.1)	319 (6.7%)	9.7 (13.0)
Cannabis Occasions	821 (6.3%)	8.8 (22.1)	775 (9.1%)	12.9 (26.6)[a]	46 (1.0%)	1.4 (3.4)[a]
Alcohol and Cannabis Occasions	133 (1.0%)	1.4 (4.4)	124 (1.4%)	2.1 (5.4)[a]	9 (0.2%)	0.3 (0.7)[a]

[a]Values in the same rows are significantly different at $p < 0.05$; PANAS = Positive and Negative Affect Scale.

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Table 2

Effects of concurrent and lagged cannabis and alcohol use on impulsivity, hostility, and positive affect.

	Impulsivity		Hostility		Positive Affect	
Effect	***Estimate***	***95% CI***	***Estimate***	***95% CI***	***Estimate***	***95% CI***
Intercept	5.80***	[5.33, 6.28]	1.49***	[1.33, 1.64]	2.33***	[2.16, 2.50]
Occasion level						
Current occasion cannabis use	0.35†	[0.00, 0.70]	**0.07***	[0.01, 0.12]	0.02	[−0.11, 0.15]
Previous occasion cannabis use	−0.21†	[−0.42, 0.01]	**−0.06***	[−0.12, −0.01]	0.02	[−0.05, 0.09]
Current occasion alcohol use	**0.42****	[0.13, 0.71]	0.00	[−0.04, 0.04]	**0.12*****	[0.06, 0.18]
Previous occasion alcohol use	0.09	[−0.12, 0.30]	0.02	[−0.03, 0.06]	**−0.07***	[−0.14, −0.01]
Day level						
Current day cannabis use	0.83*	[0.17, 1.49]	0.22†	[−0.02, 0.46]	0.11	[−0.21, 0.43]
Previous day cannabis use	−0.31	[−1.10, 0.49]	−0.07	[−0.33, 0.18]	0.11	[−0.16, 0.39]
Current day alcohol use	**0.82****	[0.22, 1.41]	0.00	[−0.14, 0.14]	**0.33*****	[0.16, 0.49]
Previous day alcohol use	−0.02	[−0.48, 0.44]	0.15†	[−0.03, 0.32]	**−0.17***	[−0.33, −0.02]
Person level						
Degree of cannabis use	−0.05	[−1.96, 1.86]	**0.81***	[0.15, 1.47]	0.58	[−0.15, 1.32]
Degree of alcohol use	−1.26	[−5.05, 2.54]	−0.06	[−1.25, 1.13]	0.41	[−0.90, 1.73]
Covariates						
Group (DD = −1, BPD = 1)	0.29	[−0.42, 1.00]	0.15	[−0.08, 0.39]	−0.12	[−0.38, 0.14]
Sex (female = −1, male = 1)	−0.55	[−1.49, 0.39]	0.14	[−0.16, 0.44]	0.36*	[0.03, 0.70]
Age	−0.02	[−0.05, 0.01]	0.01	[0.00, 0.01]	0.01*	[0.00, 0.02]
First daily measurement	−0.16***	[−0.24, −0.07]	−0.03**	[−0.05, −0.01]	−0.16***	[−0.19, −0.14]
Weekday (Saturday is reference)						
Sunday	−0.13	[−0.32, 0.07]	−0.04	[−0.10, 0.02]	0.00	[−0.06, 0.07]
Monday	−0.33***	[−0.53, −0.13]	−0.04	[−0.10, 0.02]	−0.08*	[−0.14, −0.02]
Tuesday	−0.12	[−0.32, 0.07]	0.04	[−0.02, 0.10]	0.01	[−0.05, 0.07]
Wednesday	−0.11	[−0.30, 0.08]	0.00	[−0.06, 0.06]	0.02	[−0.04, 0.08]
Thursday	−0.10	[−0.30, 0.09]	0.01	[−0.05, 0.07]	0.01	[−0.05, 0.08]

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	Impulsivity		Hostility		Positive Affect	
Effect	***Estimate***	***95% CI***	***Estimate***	***95% CI***	***Estimate***	***95% CI***
Friday	−0.05	[−0.24, 0.15]	0.01	[−0.05, 0.07]	−0.01	[−0.08, 0.05]

Note. 95% CI = 95% confidence interval. Bold-type values are estimates relating to the primary hypotheses that are still statistically significant after a Benjamini and Hochberg (1995) adjustment on the effects of each substance.

$^{\dagger}p < .10$,

$^{*}p < .05$,

$^{**}p < .01$,

$^{***}p < .001$

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