Online Personalized Feedback Intervention Reduces Cannabis-Related Problems Among College Students With High Problem Distress

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Despite experiencing problems related to using cannabis, very few undergraduate cannabis users are interested in treatment for cannabis-related problems or benefit from cannabis-focused online personalized feedback interventions (PFIs). Thus, it may be important to determine whether individuals perceive their problems as distressing, as only those who are distressed by their problems may be motivated to change their cannabis use or benefit from cannabis-related interventions. The current study examined cannabis-related problem distress, its relation to motivation to change cannabis use, and whether problem distress impacted outcomes of a problem-focused online PFI. Past-month cannabis-using undergraduates who endorsed experiencing at least one cannabis-related problem in the past 3 months were randomized to a PFI ($n = 102$) or a personalized normative feedback (PNF)-only condition ($n = 102$). Problem distress was robustly related to readiness, importance, and confidence to change cannabis use at baseline. Among those with high levels of problem distress at baseline, those in the PFI condition reported a greater decrease in problems than those in the PNF-only condition. This was not the case among those with lower levels of problem distress. Further, the number of cannabis-related problems did not moderate intervention outcomes. Cannabis users who perceive their problems as more distressing may be more motivated to change their cannabis use and more likely to benefit from a problem-focused PFI relative to a PNF-only intervention. Results have implications for the personalization of cannabis-focused interventions to maximize the impacts of interventions and decrease cannabis-related problems.

Public Health Significance

The current study suggests that college cannabis users who perceive their cannabis-related problems as distressing appear to benefit from a problem-focused personalized feedback intervention. Interventions that identify experiences that are seen as most problematic for each individual may be more effective because they are congruent with individuals' existing motivation to change.

Keywords: personalized feedback intervention, cannabis use, college students, cannabis problems

College cannabis use is increasing (Miech, Patrick, O'Malley, & Johnston, 2017), and perceived risk of regular cannabis use among college-age individuals is decreasing (Okaneku, Vearrier, McKeever, LaSala, & Greenberg, 2015), which is concerning given that college cannabis use is related to experiencing cannabis-related problems. To illustrate, current (past-month) college cannabis users report experiencing an average of eight use-related problems in the past month (Pearson, Liese, & Dvorak, 2017). The most common problems endorsed by college students may likely impact students' academic performance, such as procrastination, lower productivity, and missing days of work or class (Buckner, Ecker, & Cohen, 2010). Cannabis users (regardless of frequency of

cannabis use) also report lower grade point average and worse academic outcomes compared to nonusers (Phillips, Phillips, Lalonde, & Tormohlen, 2015; Suerken et al., 2016). Frequent cannabis use among undergraduates is associated with a greater likelihood of depression, anxiety, and other substance use (Keith, Hart, McNeil, Silver, & Goodwin, 2015). Further, frequent cannabis use is related to negative effects on mental and physical health that persist into adulthood, even after decreasing or abstaining from use (Arria, Caldeira, Bugbee, Vincent, & O'Grady, 2016; Caldeira, O'Grady, Vincent, & Arria, 2012). These negative effects are particularly pronounced for individuals who maintain or increase their cannabis use following college (Arria et al., 2016; Caldeira et al., 2012); thus, the college years may be a critical time to implement intervention efforts to prevent or reduce cannabis-related problems. Despite experiencing problems related to cannabis use, the majority of college students report little interest in receiving treatment to help reduce cannabis-related problems (Buckner et al., 2010).

Online personalized feedback interventions (PFIs) may be one strategy to intervene with high-risk college cannabis users. Alcohol-focused online PFIs (Carey, Scott-Sheldon, Elliott, Bolles, & Carey, 2009; Leeman, Perez, Nogueira, & DeMartini, 2015) and standalone personalized normative feedback (PNF) interventions (Dotson, Dunn, & Bowers, 2015) have been efficacious in reducing alcohol use and related problems among college students. However, online PFIs for cannabis use have been largely understudied. PFIs appear to only reduce risky cannabis use among specific subsets of students, such as those with family history of substance use (Lee, Neighbors, Kilmer, & Larimer, 2010), those with greater readiness to change at baseline (Palfai, Tahaney, Winter, & Saitz, 2016), or frequent users (Riggs et al., 2018). College students tend to experience cannabis-related problems regardless of frequency of use (Phillips et al., 2015; Suerken et al., 2016), therefore, it is important to continue to develop and test the utility of novel online interventions to improve PFI outcomes for a wider range of cannabis users. Early intervention and prevention efforts may help reduce the likelihood of cannabis-related problems among college students.

Given that over 90% of college cannabis users who used cannabis at least once in the past month report experiencing at least one past-month cannabis-related problem (Pearson et al., 2017), including problem-focused intervention components may help increase the efficacy of PFIs for students experiencing cannabis-related problems. For example, cannabis-related problem normative beliefs (an individual's perception of the quantity of cannabis-related problems experienced by others) may be one novel target for college cannabis users. Cannabis-using students tend to overestimate others' use-related problems, and this overestimation is, in turn, related to experiencing more problems themselves (Ecker, Richter, & Buckner, 2014). Yet no known studies have included problem norms as an intervention component.

Further, the transtheoretical model of change (Prochaska & DiClemente, 1982) posits that problem recognition, one's awareness that a behavior (e.g., cannabis use) has caused problems, is one variable that is related to behavior change. However, among college students, higher problem recognition is associated with both greater costs and greater benefits of reducing cannabis use, suggesting that college students with higher problem recognition may be ambivalent about changing their use (Simons, Joseph

Clarke, Simons, & Spelman, 2016). Further, problem recognition does not appear to be a sufficient predictor of change in alcohol use following an alcohol-related intervention (Maisto et al., 2011), and baseline problem recognition did not moderate PFI outcomes for cannabis-using college students (Palfai et al., 2016). Taken together, these data suggest that problem recognition alone is not enough to motivate change in college substance use. Thus, it may be useful to determine whether individuals perceive cannabis-related problems as distressing, as these individuals may be more motivated to change their cannabis use and therefore be more likely to benefit from a cannabis-related intervention. To date, no studies of which we are aware have tested the relation between problem distress and motivation to change cannabis use or to intervention outcomes.

The current study aimed to investigate a novel measure of problem distress and test the relationship between problem distress on motivation to change at baseline and the impact of baseline problem distress on treatment response at follow-up. First, we examined problem distress and its relation to baseline motivation to change among undergraduate cannabis users with at least one cannabis-related problem. We hypothesized that, at baseline, problem distress would be positively and significantly related to motivation to change cannabis use (i.e., readiness, importance, and confidence) above and beyond cannabis use frequency and the number of cannabis-related problems. Second, we tested whether students who perceived their cannabis-related problems as more distressing at baseline were more likely to benefit from a problem-focused PFI. We hypothesized that baseline problem distress would moderate the relation between intervention condition and cannabis outcomes at follow-up, such that among those with greater baseline problem distress at baseline, those in the problem-focused PFI condition would evince less frequent cannabis use and fewer cannabis problems at 1-month follow-up than those in the PNF-only condition.

Method

Participants and Procedures

As described in Walukevich-Dienst, Neighbors, and Buckner (2019), participants were undergraduate students (N = 204) who endorsed current (past-month) cannabis use and reported experiencing at least one cannabis-related problem in the past three months. In an attempt to improve the efficacy of the problem-focused intervention, we recruited individuals who endorsed experiencing at least one cannabis-related problem, given that number of cannabis-related problems is associated with greater interest in treatment (Buckner et al., 2010). The current study is based on secondary analyses of the original data (Walukevich-Dienst et al., 2019). Data were collected from 2017 to 2018, in a state in which recreational cannabis remains illegal at the state level. Participants were recruited for a study on marijuana use from the psychology department's online research pool and through on-campus flyers. The university's institutional review board approved the study, and we obtained a certificate of confidentiality from the National Institutes of Health to further protect confidentiality.

First, participants completed a screening survey to determine eligibility using an online data collection website (Qualtrics). If participants were eligible, they were immediately directed to com-

plete the baseline assessment through Qualtrics, after which Qualtrics randomly assigned participants to an intervention condition (PFI or PNF-only). Participants completed the assigned intervention online, immediately after completing the baseline assessment. The follow-up Qualtrics survey was completed approximately one month after baseline. Demographic characteristics of the sample are reported in Table 1. Participants were compensated with research participation credits or $10 for baseline and $20 for follow-up. All participants who finished both surveys were entered into a drawing for a chance to win one of three cash prizes. Participant flow is depicted in a Consolidated Standards of Reporting Trials flow diagram in Figure 1.

Intervention Conditions

PNF-only condition. In the PNF-only condition (per Lee et al., 2010), participants viewed text that included personalized feedback on participants' past-month cannabis use frequency, their perceived cannabis use descriptive norms of other same-campus students who use cannabis, and corrective normative feedback on actual student norms:

> According to the information you provided us during the computer assessment, you used marijuana X times in the past month. You think the typical marijuana-using LSU [Louisiana State University] student uses X times per month. Based on research conducted at LSU, typical marijuana-using LSU students actually use marijuana less than once a month.

Same-campus normative data was obtained from a sample of approximately 230 undergraduate students who endorsed past-month cannabis use (Buckner, Lemke, & Walukevich, 2017).

PFI condition. The PFI condition included all components described in the PNF-only condition. Additionally, those in the PFI condition received psychoeducation (via text and images) on common problems related to risky or frequent cannabis use (legal consequences, physical health problems, dependence problems, cognitive impairment, productivity, low energy, procrastination, and education/occupational impairment). Further, participants completed interactive activities. For example, for the cognitive impairment section, participants were provided with a list of statements about cannabis and memory, and were asked whether they think each statement was true or false. Participants were then given feedback based on their responses. Participants also received psychoeducation on the symptoms of cannabis use disorder (CUD), as well as personalized feedback on the number of CUD symptoms the participant endorsed experiencing in the past year.

Participants also received PNF on their number of self-reported cannabis-related problems in the past 3 months, perceived cannabis-related problem norms of other same-campus students who use cannabis, and corrective normative feedback on actual problem norms for same-campus students. Additionally, participants received corrective normative feedback for each problem they reported that they endorsed, for example,

> You said that marijuana has caused you problems in your family and that this is a minor problem. You think X% of other marijuana users at LSU experience problems in their family because of their marijuana use. Based on research conducted at LSU, about 11% of typical

Table 1

Demographic and Baseline Characteristics of Sample by Condition

Characteristic	PNF-only ($n = 102$)	PFI ($n = 102$)	F or χ^2	p	d or Cramer's V
Age, M (SD)	19.85 (1.53)	19.81 (1.31)	0.04	.845	0.03
Gender (ref: female)	74.5%	79.4%	0.69	.406	0.06
Sexual orientation (ref: heterosexual)	84.3%	85.3%	0.05	.997	0.02
Gay or lesbian	2.9%	2.9%			
Bisexual	10.8%	9.8%			
Other	2.0%	2.0%			
Race/Ethnicity (ref: White/non-Hispanic/Latinx)	69.6%	72.5%	0.03	.871	0.02
White/Hispanic/Latinx	6.9%	3.9%			
African American/non-Hispanic/Latinx	13.7%	12.7%			
African American/Hispanic/Latinx	0.0%	1.0%			
Asian	2.9%	2.9%			
Multiracial/non-Hispanic/Latinx	4.9%	3.9%			
Multiracial/Hispanic/Latinx	1.0%	2.0%			
Other	1.0%	1.0%			
Class standing (ref: first year)	28.4%	29.4%	7.58	.104	0.19
Second year	24.5%	25.5%			
Third year	12.7%	33.3%			
Fourth year	15.7%	11.8%			
Fifth year	5.9%	0.0%			
Involved in Greek life	27.5%	35.3%	1.46	.227	0.09
Not receiving substance use treatment	99.0%	100.0%	1.01	.316	0.07
With family substance use history	48.0%	51.5%	0.18	.674	0.03
Past-month cannabis use frequency, M (SD)	3.95 (2.94)	3.90 (3.02)	0.01	.907	0.02
Number of past three-month cannabis-related problems, M (SD)	7.89 (5.27)	8.09 (5.28)	0.07	.791	0.04
Problem distress, M (SD)	9.75 (9.02)	11.19 (11.57)	0.98	.322	0.01
Readiness to change ruler score, M (SD)	4.35 (2.73)	4.49 (2.95)	0.12	.731	0.05
Importance to change ruler score, M (SD)	3.30 (3.03)	3.18 (3.05)	0.09	.765	0.04
Confidence to change ruler score, M (SD)	8.02 (2.65)	7.96 (2.48)	0.03	.870	0.02

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                        Assessed for eligibility (n = 425)
                                                                    Excluded ( n = 87)
                                                                    •   Not a current LSU student (n = 6)
                                                                    •   Under 18 years of age (n = 1)
                                                                    •   Denied past-month cannabis use
Excluded from randomization (n = 111)                                   on screener (n = 55)
•  Dropped out prior to randomization      Enrollment                •   Not willing to complete a follow-
   (n = 66)                                                              up survey in one month (n = 25)
•  <1 past 3-month cannabis problem
   (n = 35)                                 Randomized (n = 227)
•  Did not receive intervention due to
   program error (n = 10)

                                           Allocation

Allocated to intervention (PFI) (n = 118)        Allocated to PNF-only (n = 109)
   Received PFI (n = 115)                            Received PNF-only (n = 109)

Excluded from follow-up                                                    Excluded from follow-up
•  Failed attention check (n = 2)                                          •  Failed attention check (n = 1)

                                           Follow-Up

Lost to follow-up (did not respond to invite     Lost to follow-up (did not respond to invite
to complete assessment) (n = 14)                 to complete assessment) (n = 13)

Excluded from analyses (n = 11)                                            Excluded from analyses (n = 6)
•  Failed attention check (n = 5)                                          •  Failed attention check (n = 1)
•  Denied past-month cannabis                                             •  Denied past-month cannabis
   use at baseline (n = 6)             Analysis                              use at baseline (n = 5)

Analyzed at follow-up (n = 88)             Analyzed at follow-up (n = 89)
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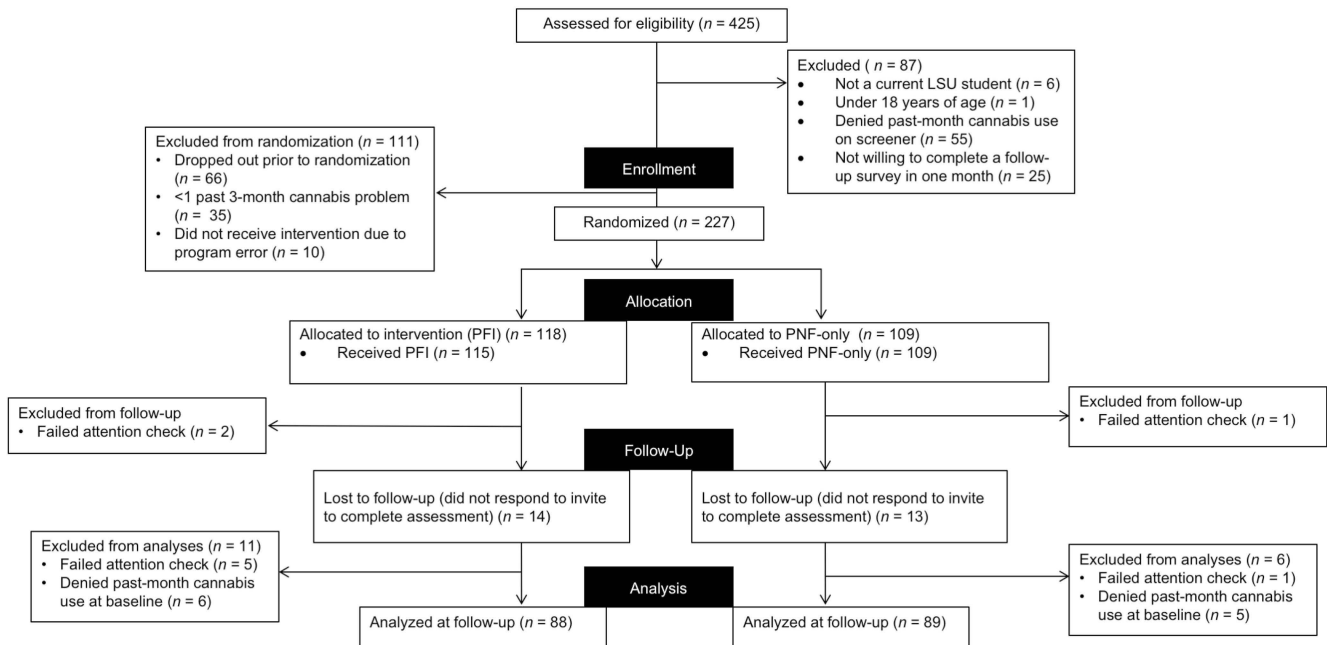
Figure 1. Participant flowchart following Consolidated Standards of Reporting Trials guidelines.

marijuana-using LSU students experience problems in their family because of their marijuana use.

Normative data regarding past-month use-related problems was obtained using a sample of approximately 230 undergraduates students who endorsed past-month cannabis use (Buckner et al., 2017).

Measures

Cannabis use frequency. Past-month cannabis use frequency was measured at baseline and follow-up using the Marijuana Use Form (Buckner, Bonn-Miller, Zvolensky, & Schmidt, 2007) with a 0–9 rating scale (0 = *once per month or less*, 5 = *5–6 times per month*, 9 = *21 times per week or more*). This measure demonstrated good convergent validity with an ecological momentary assessment of cannabis use (Buckner, Crosby, Silgado, Wonderlich, & Schmidt, 2012).

Cannabis-related problems. Cannabis-related problems were measured using a modified version of the Marijuana Problems Scale (MPS; Stephens, Roffman, & Curtin, 2000), a 19-item self-report questionnaire which asks participants to rate each item from 0 (*no problem*) to 2 (*serious problem*) to assess use-related problems (past 90-day problems at baseline, past-month problems at follow-up). The MPS was modified for the current study to contain an additional 13 items (e.g., problems with appetite/hunger; anxiety, worry, and/or paranoia; problems with speech; problems with concentration, focus, and/or disorientation; to act in an embarrassing way). The additional MPS items were derived from a sample of 300 cannabis users who reported additional problems related to their use (Lee et al., 2020), as part of a larger study described in Lee et al. (2013). Items scored 1 or 2 were counted to create a sum of cannabis-related problems, with higher MPS total scores indicating more cannabis-related problems (Lozano, Ste-

phens, & Roffman, 2006). The original 19-item measure demonstrated adequate consistency in prior work (Buckner et al., 2010) and convergent validity with *Diagnostic and Statistical Manual of Mental Disorders–IV* symptoms of CUD (Farris, Metrik, Bonn-Miller, Kahler, & Zvolensky, 2016). The 30-item modified version[1] used in the current study demonstrated excellent internal consistency (baseline α = .96, follow-up α = .98).

Cannabis-related problem distress. Participants were asked to indicate to what extent they are bothered by each problem they endorsed on the modified MPS on a scale from 0 (*not at all bothered*) to 4 (*extremely bothered*). Distress scores were summed to create a continuous problem distress total score, thus, problems endorsed as not distressing are not included in total problem distress score. For the current study, past 90-day problem distress was assessed at baseline.

Motivation to change rulers. Three rulers were used to assess the following regarding one's marijuana use at baseline: readiness to change, on a scale from 0 (*not ready to change*) to 10 (*trying to change*), importance of change on a scale from 0 (*not important*) to 10 (*very important*), and confidence about making a chance on a scale of 0 (*not at all confident*) to 10 (*most confident*), per prior work. The readiness to change ruler was adapted for cannabis from the Center on Alcoholism, Substance Abuse, and Addictions (1995) readiness ruler, and the importance and confidence rulers were adapted from Miller and Rollnick (2002), per prior work (e.g., Buckner, Jeffries, Terlecki, & Ecker, 2016). The readiness ruler showed convergent validity (Boudreaux et al., 2012; Maisto et al., 2011) and construct validity, as confidence to change increased following an intervention (Buckner & Schmidt,

[1] The extended MPS is available from Katherine Walukevich-Dienst by request.

2009), and increased confidence to change was related to decreased cannabis use (Gates, Norberg, Copeland, & Digiusto, 2012).

To detect careless or random responding, 3 attention check questions were included in both baseline and follow-up surveys (e.g., "Please select 'strongly agree' as your answer to this question"). Participants were excluded from data analysis if they failed the attention check (i.e., answered 2 or more attention check questions incorrectly; Meade & Craig, 2012). Nine participants (baseline $n = 3$, follow-up $n = 6$) failed the attention check questions and were excluded from data analyses.

Data Analytic Strategy

First, bivariate correlations were conducted to examine the relationships between baseline study variables and to test whether problem distress was related to cannabis use-related factors (i.e., frequency of use, motivation to change). Second, a series of hierarchical linear regression models were conducted to test whether at baseline problem distress was related to motivation to change after accounting for variance attributable to the number of cannabis-related problems and frequency of use. Separate regressions were conducted for each motivation to change outcome (i.e., readiness, importance, confidence). Baseline cannabis use frequency and baseline number of cannabis-related problems were entered at Step 1, and baseline problem distress was entered at Step 2 to ensure that effect at Step 2 could not be attributed to shared variance with variables in Step 1. Independent variables were centered to reduce multicollinearity. To test collinearity of cannabis-related problems and problem-related distress, we examined tolerance values and variance of inflation (VIF) values of the precentered and postcentered values of these variables. In all models, tolerance values (0.28) and VIF values (3.6) were within acceptable limits (tolerance $> .10$ and VIF < 6; Cohen, West, & Aiken, 2014).[2]

Third, we tested potential baseline differences between conditions and between study completers versus noncompleters using analysis of variance for continuous dependent variables (e.g., baseline cannabis use frequency) and chi-square analyses for categorical dependent variables (e.g., gender). Fourth, to test whether cannabis use and use-related problems decreased as a result of the PFI condition, we conducted a 2 (Experimental Condition: PNF-only, PFI) $\times$ 2 (Time: baseline use/problems, follow-up use/problems) mixed-model analysis of variance with condition as the between-subjects factor and time as the within-subject factor.

Fifth, to test whether intervention outcomes differed by baseline problem distress levels, moderation analyses were conducted using the PROCESS macro for SPSS to test for main and interaction effects (Hayes, 2018, SPSS Version 21). Separate models were tested for follow-up cannabis use frequency and cannabis-related problems with condition as the predictor (0 = PNF-only and 1 = PFI) and baseline problem distress as the moderator. Standardized residual change scores were computed for each outcome variable (i.e., follow-up cannabis use frequency, cannabis-related problems) by regressing each baseline variable onto its respective follow-up variable. Standardized residual scores were used as the dependent variable in the moderation models. Using the same strategy for problem distress described above, we also tested whether the number of cannabis-related problems endorsed (i.e.,

recognition of problems) moderated the relationship between condition and outcomes (i.e., follow-up cannabis use frequency, cannabis-related problems). Low, moderate, and high levels of problem distress were determined using 1 SD below the mean, the mean, and 1 SD above the mean, respectively.

Results

Correlations Among Baseline Variables

Among individuals who endorsed each problem, the highest levels of problem distress fell within the *slightly bothered* (1) to *moderately bothered* (2) range including difficulty sleeping ($M = 1.81$, $SD = 0.98$, $n = 26$), legal problems ($M = 1.71$, $SD = 0.95$, $n = 7$), medical problems ($M = 1.69$, $SD = 0.95$, $n = 13$), feeling freaked out or too high ($M = 1.6$, $SD = 1.12$, $n = 73$), anxiety/worry/paranoia ($M = 1.59$, $SD = 1.02$, $n = 103$), memory loss ($M = 1.58$, $SD = 0.96$, $n = 73$), blackouts ($M = 1.58$, $SD = 0.95$, $n = 19$), and financial difficulties ($M = 1.53$, $SD = 0.9$, $n = 34$). Problem distress was significantly and positively correlated with readiness to change, importance to change, and confidence to change, but was not correlated with past-month frequency of cannabis use (see Table 2).

Problem Distress and Motivation to Change Cannabis Use at Baseline

Next, the robustness of the relations between problem distress and motivation to change variables at baseline was tested (see Table 3). For the readiness to change model, covariates (i.e., baseline use frequency, number of cannabis-related problems) accounted for 9.1% of the variance in the model. Problem distress accounted for an additional 4.7% of the variance. When all three independent variables were included in the regression model, only problem distress remained significantly associated with readiness to change and accounted for 5.1% of the unique variance. Concerning the importance to change cannabis use (see Table 3), covariates accounted for 10.3% of the variance, and problem distress accounted for an additional 7.1% of the variance in importance of change. When all three independent variables were included in the regression model, only problem distress remained significantly associated with importance to change and uniquely accounted for 8.0% of the variance. Concerning confidence to change cannabis use (see Table 3), covariates accounted for 5.0% of the variance, and problem distress accounted for an additional 2.7% of the variance. When examined together, problem distress significantly accounted for 2.8% of unique variance.

Baseline Differences by Condition

Twenty-seven participants did not complete follow-up.[3] There was one outlier observed on cannabis-related problems at baseline. However, we retained this case in analyses because the case appeared genuine, as the participant correctly answered all attention check questions, and results did not differ when the outlier

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[2] Precentered and postcentered tolerance and VIF values did not differ.
[3] Results remained the same when baseline values were carried forward for the missing follow-up data.

Table 2

Bivariate Correlations Among Study Variables at Baseline (N = 204)

Variable	1	2	3	4	5	6
1. Past-month cannabis use frequency						
2. Number of past 3-month cannabis-related problems	0.073					
3. Problem distress	0.010	0.850***				
4. Readiness to change ruler score	−0.118	0.268***	0.348***			
5. Importance to change ruler score	0.045	0.320***	0.411***	0.723***		
6. Confidence to change ruler score	0.183***	−0.142*	−0.026	0.196***	0.097	
M	3.93	7.99	10.47	4.42	3.24	7.99
SD	2.97	5.26	10.37	2.84	3.03	2.56

*$p < .05$. ***$p < .001$.

was removed (Tabachnick & Fidell, 2013). Conditions did not significantly differ on retention rates, $\chi^2 (1, N = 204) = 0.04$, $p = .836$, $\varphi = −0.01$. Completers did not differ from noncompleters on demographic variables or number of cannabis-related problems at baseline ($ds = 0.09–0.41$). Compared to noncompleters, completers reported greater past-month cannabis use frequently ($M = 2.81$, $SD = 2.43$), $F(1, 203) = 4.42$, $p = .037$, $d = 0.44$. No significant differences were observed at baseline between conditions on demographic variables, past-month cannabis use frequency, or use-related problems (see Table 1).

Relationship Between Condition and Cannabis Outcomes

Regarding cannabis use frequency, the main effect of time showed a statistically significant decrease in cannabis use frequency from baseline to follow-up, $F(1, 175) = 20.20$, $p < .0001$. The Condition × Use Frequency interaction was not significant, $F(1, 175) = 1.35$, $p = .246$. Regarding cannabis-related problems, the main effect of time showed a statistically significant decrease in cannabis-related problems, $F(1, 175) = 50.87$, $p < .0001$. The Condition × Cannabis-Related Problems interaction was not significant, $F(1, 175) = 2.41$, $p = .122$.

Baseline Problem Distress as a Moderator of the Relation Between Condition and Cannabis Outcomes

The overall model including the main effects of condition and problem distress and the Condition × Problem Distress interaction did not account for significant variance in cannabis use frequency, $R^2 = 0.015$, $F(3, 173) = 0.894$, $p = .445$. The main effects of condition, $b = 0.308$, $SE = 0.218$, $t(173) = 1.417$, $p = .158$, 95% confidence interval (CI) [−0.121, 0.739] and problem distress, $b = 0.001$, $SE = 0.012$, $t(173) = 0.096$, $p = .924$, 95% CI [−0.023, 0.025] were not significant, nor was the Condition × Problem Distress interaction, $\Delta R^2 = 0.003$, $F(1, 173) = 0.567$, $p = .453$, $b = −0.011$, $SE = 0.015$, $t(173) = −0.753$, 95% CI [−0.041, 0.018].

The overall model including the main effects of condition and problem distress and the Condition × Problem Distress interaction accounted for significant variance in cannabis-related problems, $R^2 = 0.051$, $F(3, 173) = 3.082$, $p = .029$. The nonsignificant main effects of condition, $b = 0.101$, $SE = 0.210$, $t(173) = 0.479$, $p = .632$, 95% CI [−0.313, 0.513] and problem distress, $b = 0.011$, $SE = 0.012$, $t(173) = 0.961$, $p = .338$, 95% CI [−0.012, 0.034], were qualified by a significant Condition × Problem Distress interaction, $\Delta R^2 = 0.026$, $F(1, 173) = 4.810$, $p = .030$,

Table 3

Hierarchical Linear Regression Model Testing the Robustness of Problem Distress in the Prediction of Motivation to Change Variables at Baseline

Variable	ΔR^2	ΔF	β	t	p	sr^2
Readiness to change						
Step 1	0.09	10.04			<.0001	
Cannabis use frequency			−0.14	−2.05	.041	0.02
Number of problems			0.28	4.12	<.0001	0.08
Step 2	0.05	10.81	−	−	<.0001	—
Problem distress			0.412	3.29	.001	0.05
Importance to change						
Step 1	0.10	11.56			<.0001	
Cannabis use frequency			0.02	0.33	.744	0.001
Number of problems			0.32	4.76	<.0001	0.10
Step 2	0.07	17.29			<.0001	
Problem distress			0.51	4.16	<.0001	0.08
Confidence to change						
Step 1	0.05	5.32			.006	
Cannabis use frequency			−0.17	−2.52	.012	0.03
Number of problems			−0.13	−1.88	.062	0.02
Step 2	0.03	5.80			.001	
Problem distress			0.31	2.41	.017	0.03

$b = -0.032$, $SE = 0.015$, $t(173) = -2.193$, 95% CI $[-0.060, -0.003]$, such that those in the PFI condition with high levels of baseline problem distress reported a greater decrease in problems than those in the PNF-only condition, $b = -0.572$, $SE = 0.216$, $t(173) = -2.647$, $p = .009$, 95% CI $[-0.998, -0.145]$ (see Figure 2). Those with low ($b = 0.101$, $SE = 0.210$, $t(173) = 0.479$, $p = .632$, 95% CI $[-0.313, 0.514]$) and moderate ($b = -0.234$, $SE = 0.148$, $t(173) = -1.581$, $p = .116$, 95% CI $[-0.525, 0.058]$) levels of problem distress did not significantly differ by condition (see Figure 2).

Baseline Number of Cannabis-Related Problems as a Moderator of the Relation Between Condition and Cannabis Outcomes

The overall model including the main effects of condition and number of cannabis-related problems and the Condition × Problems interaction did not account for significant variance in cannabis use frequency, $R^2 = 0.019$, $F(3, 173) = 1.090$, $p = .355$. The main effects of condition, $b = 0.473$, $SE = 0.274$, $t(173) = 1.726$, $p = .086$, 95% CI $[-0.068, 1.014]$ and number of problems, $b = .011$, $SE = 0.020$, $t(173) = 0.547$, $p = .585$, 95% CI $[-0.028, 0.050]$ were not significant, nor was the Condition × Problem interaction, $\Delta R^2 = 0.009$, $F(1, 173) = 1.616$, $p = .205$, $b = -0.036$, $SE = 0.028$, $t(173) = -1.271$, 95% CI $[-0.092, 0.020]$. The overall model did not account for significant variance in cannabis related problems, $R^2 = 0.030$, $F(3, 173) = 1.806$, $p = .148$. The main effects of condition, $b = 0.125$, $SE = 0.267$, $t(173) = 0.466$, $p = .642$, 95% CI $[-0.403, 0.652]$ and number of problems, $b = 0.019$, $SE = 0.019$, $t(173) = 0.982$, $p = .328$, 95% CI $[-0.019, 0.057]$ were not significant, nor was the Condition × Problem interaction, $\Delta R^2 = 0.015$, $F(1, 173) = 2.710$, $p = .102$, $b = -0.045$, $SE = 0.028$, $t(173) = -1.646$, 95% CI $[-0.100, 0.009]$.

Discussion

The current study examined problem distress as a novel variable associated with motivation to change cannabis use and tested whether baseline problem distress moderated the impact of an online, problem-focused PFI (compared to a PNF-only condition). Consistent with our hypothesis, baseline problem distress was robustly and positively associated with baseline readiness to change, importance, and confidence to change cannabis use, above and beyond baseline cannabis use frequency and number of cannabis-related problems. Cannabis users who perceived their problems as more distressing appeared to benefit from a problem-focused intervention relative to a PNF-only intervention, as those with higher levels of problem distress (not lower levels) in the PFI condition reported a greater decrease in cannabis-related problems than those in the PNF-only condition. Given that it appears that both conditions reduced cannabis use frequency and use-related problems, individuals with greater problem distress may be more likely to benefit from a problem-focused PFI relative to a more traditional PNF-only intervention.

Results highlight problem distress, the extent to which an individual perceives cannabis-related problems as distressing, as a novel construct robustly related to motivation to change (i.e., readiness, importance, and confidence to change). Participants who endorsed experiencing problems were most distressed by experiencing psychological (e.g., anxiety/worry/paranoia, memory loss) and physical problems (e.g., medical problems, blackouts) related to their cannabis use. Few participants endorsed experiencing some problems (e.g., legal problems, medical problems, blackouts); however, the participants who did report experiencing these problems endorsed high levels of problem distress associated with these problems. The PFI used in the current study provided personalized feedback on some of these problems, including physical health, memory, and legal consequences. Taken together, individ-
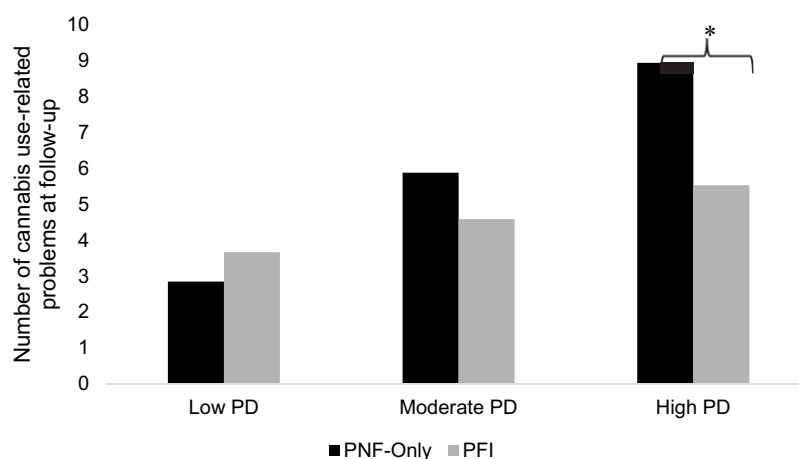

Figure 2. Baseline problem distress (PD) moderated the relationship between condition and number of cannabis-related problems at follow-up. Low, moderate, and high levels of PD were determined using 1 *SD* below the mean, the mean, and 1 *SD* above the mean, respectively. Those with high levels of PD in the personalized feedback intervention (PFI) condition reported fewer problems at follow-up than those in the personalized normative feedback (PNF)-only condition. Those with low and moderate levels of PD did not significantly differ by condition. * $p < .05$.

uals who perceive their cannabis-related problems as distressing were more motivated to change their cannabis use at baseline and more likely to benefit from an intervention geared toward decreasing risky cannabis use. Further, these findings highlight the importance of improving personalization in PFIs—including personalized components geared toward specific problems that an individual finds distressing may improve intervention outcomes. Moreover, cannabis users vary in the extent to which they find specific cannabis-related experiences problematic. Interventions which identify experiences that are seen as most problematic for each individual are likely to be more effective because they are congruent with individuals existing motivations. Interventions which fail to consider which problems are most distressing to intervention recipients are likely to include a high proportion of content targeting behaviors and experiences that recipients have no interest in changing.

These findings further our understanding about who may benefit from problem-focused PFIs. Consistent with prior work, the current study supports the notion that specific subgroups of cannabis-using undergraduates may respond differently to certain PFI content. To illustrate, women are more likely to increase their use of cannabis-related protective behavior strategies (PBS) than men following a PBS-focused PFI (Riggs et al., 2018), and women who received an online problem-focused PFI reported fewer cannabis-related problems at follow-up than women receiving PNF-only (Walukevich-Dienst et al., 2019). Moreover, problem distress, not number of cannabis-related problems (i.e., recognition of problems), moderated intervention outcomes. Results from the current study suggest that to maximize the impact of the intervention and decrease cannabis-related problems, it may be helpful to assess problem distress before administering an online PFI to determine whether individuals may benefit from a PFI focused on problems or if other content (e.g., PBS) may be more helpful. Future work may benefit from examining other potential moderators of PFI outcomes. For example, certain types of anxiety (e.g., social anxiety) and anxiety-related constructs (e.g., fear of physical or cognitive symptoms of anxiety) have been differentially related to cannabis-related problems by gender (Buckner, Zvolensky, & Schmidt, 2012; Guillot, Blumenthal, Zvolensky, & Schmidt, 2018), suggesting that observed differences in cannabis-related problems may be partially influenced by demographic factors (e.g., gender) and psychological factors such as anxiety and anxiety-related constructs.

Results should be interpreted in light of limitations. First, the majority of the sample was comprised of young adult college cannabis users who were majority non-Hispanic/Latinx White females. Future work may benefit from testing whether results generalize to a more diverse sample of cannabis-using undergraduates. Second, future work would benefit from including other methodologies (e.g., ecological momentary assessment) to determine proximal predictors of cannabis use and cannabis-related problems following online PFIs. Third, the 1-month follow-up period in the current study was relatively brief; thus, including longer follow-up periods may help long-term efficacy of the intervention. Fourth, future work should consider including an assessment-only control group. Fifth, the current study operationalized cannabis use as cannabis use frequency. Given the unique challenges of measuring and quantifying cannabis use consumption (Cuttler & Spradlin, 2017; Prince, Conner, & Pearson, 2018),

future work could benefit from incorporating other cannabis consumption outcomes (e.g., number of grams used per occasion, subjective intoxication per occasion). Sixth, the current study is the first known investigation of a novel measure of cannabis-related problem distress; thus, future work could benefit from examining problem distress variability and its relation to risky cannabis use patterns, other psychosocial factors, and treatment outcomes.

Despite these limitations, the current study provided initial support that problem distress is robustly associated with motivation to change among high-risk college cannabis users before receiving an intervention. Problem-focused cannabis PFIs for college students may serve as a useful tool to target cannabis use-related problems among those with greater levels of distress related to their cannabis problems. This study also provides novel insight into the types of problems that undergraduate cannabis users find distressing, which may be useful targets for prevention and treatment efforts.

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