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# Targeting Perceived Risk Through an Online Personalized Feedback Intervention for Cannabis-Using College Students

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# TARGETING PERCEIVED RISK THROUGH AN ONLINE PERSONALIZED FEEDBACK INTERVENTION FOR CANNABIS-USING COLLEGE STUDENTS

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**Abstract**

Although online personalized feedback interventions (PFIs) that include personalized normative feedback (PNF) have been found to reduce drinking in college populations (for review, see Miller et al., 2013), there is little evidence to support that similar PFIs reduce risky cannabis use in college students (e.g., Elliott, Carey, & Vanable, 2014). The present study sought to examine perceived risk, a leading indicator of cannabis use (Bachman, Johnston, & O'Malley, 1998), as a potential intervention target for online cannabis PFIs. Undergraduate students who reported current (past-month) cannabis use and experiencing at least one past three-month cannabis use-related problem were randomly assigned to receive a feedback control condition ($n$ = 102) or PFI ($n$ = 102). Condition was not related follow-up perceived risk or to any follow-up outcomes (i.e., use frequency, use-related problems, problem-related distress). Follow-up perceived risk or norms did not mediate the relationship between condition and outcomes. Gender moderated the relationship between condition and follow-up problems, such that males in the PFI condition reported greater problems than males in the feedback control condition and females in the PFI condition reported fewer problems than females in the feedback control condition. Baseline problem distress moderated the relationship between condition and follow-up problems, such that those with high distress in the PFI condition reported fewer problems at follow-up than in the feedback control condition. Results suggest that perceived risk of cannabis may not be readily modified via a one-session online intervention. Cannabis PFIs may be efficacious for reducing cannabis use-related problems among females (but not males) and those with high problem distress. Novel PFI components must be considered to increase the efficacy of brief, online interventions for cannabis-using college students, especially among male cannabis users.

## Introduction

Over one-third of college-aged students endorse current (past-year) cannabis use (Schulenberg et al., 2017). Additionally, the likelihood of college students using cannabis has risen over time: the probability of past-year cannabis use for college students rose from 31% in 2013 to 51% in 2015 (Miech, Patrick, O'Malley, & Johnston, 2017). Further, rates of problematic cannabis use in college samples are high, with 90.8% of past-month cannabis users experiencing at least one cannabis-related problem (Pearson, Liese, & Dvorak, 2017) and one-fourth of past-month users meeting DSM-IV criteria for cannabis use disorder (CUD; Caldeira, Arria, O'Grady, Vincent, & Wish, 2008). Particularly pertinent to college students, cannabis users (regardless of frequency of cannabis use) report lower GPA and worse academic outcomes compared to non-users (Phillips, Phillips, Lalonde, & Tormohlen, 2015; Suerken et al., 2016). College students are an at-risk population for problematic cannabis use; therefore, it is important to develop evidence-based cannabis prevention and intervention programs.

### Normative Beliefs

Normative beliefs are one promising target for intervention. There is a large body of research supporting the role of social norms in college substance use: college students' normative beliefs are often inaccurate, such that beliefs regarding substance use are overestimates of actual substance use behaviors and of the acceptability of these behaviors by their peers (for review see Borsari & Carey, 2001). Descriptive norms, defined as an individual's perception of the frequency and quantity of others' substance use, are related to college substance use (Borsari & Carey, 2001, 2003; Lewis & Neighbors, 2006). Although a majority of the descriptive norms research has examined the impact of normative beliefs on alcohol use and related problems (Borsari & Carey, 2003; Lewis & Neighbors, 2006), emerging data support that

normative beliefs are important to cannabis use as well. Lifetime cannabis users report higher descriptive norms and believe that peers use cannabis at higher rates than their own rate of use (Pearson et al., 2017). Greater descriptive norms regarding cannabis use are related to greater frequency of cannabis use (Buckner, 2013; Kilmer et al., 2006; Neighbors, Geisner, & Lee, 2008; Pearson et al., 2017) and more cannabis-related problems (Buckner, 2013; Kilmer et al., 2006; Neighbors et al., 2008). Given that normative beliefs are associated with greater frequency of use and more use-related problems, cannabis descriptive norms may be one important target for intervention.

Cannabis-related problem normative beliefs may be one additional target for cannabis users. In the alcohol literature, students tend to overestimate others' use-related problems which is related to experiencing more problems themselves (Baer, Stacy, & Larimer, 1991; Ecker, Cohen, & Buckner, 2017; Kypri & Langley, 2003) and there is some preliminary evidence that this pattern is true for cannabis-using students as well (Ecker, Richter, & Buckner, 2014). Thus, cannabis use-related problem norms (an individual's perception of the quantity of cannabis-related problems experienced by others) may be a unique target for cannabis users, although we know of no studies testing its utility as an intervention target. Further, as there is often considerable variability in the number of problems experienced by cannabis users (Pearson et al., 2016), it may be useful to determine whether participants perceive a problem as distressing or problematic as it may be that only those problems that cause distress are appropriate targets for intervention.

**Personalized Feedback Interventions (PFIs)**

Although normative beliefs appear to be related to cannabis use, the majority of research on interventions targeting normative beliefs has focused on risky alcohol use. Targeting normative beliefs via online, personalized feedback interventions (PFIs) successfully reduces risky alcohol use in college populations, both generally (for review, see M. B. Miller et al., 2013) and for specific high-risk events, such as 21st birthday celebrations (e.g., Neighbors, Lee, Lewis, Fossos, & Walter, 2009). Alcohol PFIs for college populations contain multiple treatment components, including personalized normative feedback (PNF), protective behavior strategies (PBS), individualized blood alcohol content (BAC), challenges of alcohol expectancies, and risk factors related to drinking.

PNF is a particularly important component of PFIs. PNF provides corrective feedback on normative beliefs by comparing an individual's normative beliefs to actual student norms, which are typically generated from same-campus studies of substance use behaviors. Although PNF may best impact risky college drinking if administered as one piece of a multicomponent PFI (Reid & Carey, 2015), PNF for alcohol use has been shown to work as a stand-alone intervention by correcting descriptive norms and subsequently decreasing alcohol use in college drinkers (for review, see Dotson, Dunn, & Bowers, 2015). PNF that uses typical campus-specific student norms has been shown to be more successful reducing college alcohol use and related problems than other PFI components, such as providing feedback on PBS (Martens, Smith, & Murphy, 2013) and is also successful in brief formats (e.g., only providing information on individual drinking behaviors and campus drinking rates, not perceived norms; Neighbors et al., 2016). Many researchers are trying to tailor PNF to get the largest impact on drinking-related behaviors and problems. For example, gender-specific normative feedback (Lewis & Neighbors, 2007),

and college class-specific and gender-specific normative feedback (Lewis, Neighbors, Oster-Aaland, Kirkeby, & Larimer, 2007) work better than typical student normative feedback. As PFIs (for review, see M. B. Miller et al., 2013) and PNF interventions (for review, see Dotson et al., 2015) have both been shown to decrease risky alcohol use in college drinkers, similar interventions for cannabis-using college students might decrease risky cannabis use.

**PFIs for Cannabis**

Commercially available online PFIs for substance use (e.g., Alcohol e-CHECKUP TO GO, "e-CHUG," Marijuana e-CHECKUP TO GO, "e-TOKE") are widely used by college campuses internationally, with over 600 campuses using e-CHECKUP TO GO interventions (San Diego State Research Foundation). However, online PFIs for cannabis use have been largely understudied and there is little evidence to support that current PFIs reduce risky cannabis use among college students. The e-TOKE intervention provides feedback on cannabis use norms, information about costs, risks and consequences associated with cannabis use, and alternative activities (San Diego State Research Foundation, 2017). Although e-TOKE decreased descriptive norms among past-month cannabis users (Elliott & Carey, 2012; Elliott, Carey, & Vanable, 2014; Palfai et al., 2014), it did not reduce cannabis use frequency and follow-up cannabis use was not significantly different between the E-TOKE and control conditions (Elliott et al., 2014; Palfai et al., 2014). Similarly, a brief web-based PFI targeting past-month cannabis users who were entering their first-year of college did not reduce cannabis use frequency and follow-up cannabis use in the PFI condition was not significantly different from that of the control condition (Lee, Neighbors, Kilmer, & Larimer, 2010).

There is some evidence suggesting that e-TOKE can be more efficacious when administered in certain settings or to certain groups. One study compared whether completing e-

TOKE on-site at a student health center was better than completing it off-site, and found that while the intervention did not decrease cannabis use frequency in either intervention condition, those in the on-site condition showed a decrease in cannabis-related problems (Palfai et al., 2014). A modified version of e-TOKE that included cannabis-related protective behavioral strategies (PBS) found that heavy cannabis-using college students (i.e., used 2 or more times per week at baseline) in the modified e-TOKE intervention condition (compared to a healthy stress management condition) showed reductions in descriptive norms and a number of use cannabis use variables (i.e., self-reported hours high per week, days high per week, weeks high per month, periods high per week) six weeks following the intervention (Riggs et al., 2018). Although, it is unclear how clinically meaningful the reductions were as the authors did not describe the nature of the follow-up use frequency or use periods (Riggs et al., 2018). Further, gender moderated intervention outcomes such that females in the PFI condition reported greater use of PBS than males in the PFI condition (Riggs et al., 2018). Other online cannabis PFIs produced decreases in cannabis use among those who endorsed contemplating changing their cannabis use at baseline, with a family history of drug problems (Lee et al., 2010), or for those who reported higher readiness to change prior to the e-TOKE intervention (Palfai, Tahaney, Winter, & Saitz, 2016), suggesting that online PFIs may be useful for specific cannabis users (e.g., those who are interested in changing their behavior, those with a family history of drug problems) rather than cannabis users in general. Yet the finding that these interventions may only be useful for those already considering changing their cannabis use is problematic given that the majority of college cannabis users are not considering changing their cannabis use, even when experiencing clinically meaningful cannabis-related problems, such as memory problems and missing days of work or class due to use (Buckner, Ecker, & Cohen, 2010).

Although current PFIs do not seem to be successful in reducing cannabis use among college cannabis users in general, they do appear to be successful in reducing cannabis use in treatment-seeking samples (Budney et al., 2011; Copeland, Rooke, Rodriquez, Norberg, & Gibson, 2017; Kay-Lambkin, Baker, Lewin, & Carr, 2009). Copeland et al. (2017) suggest that the intervention effect discrepancy between college and treatment-seeking samples may be due to unique attributes of treatment-seeking samples (e.g., older individuals with a longer history of cannabis use may have higher readiness to change cannabis use). In partial support of this hypothesis, a treatment-seeking sample reported high average motivation to change their cannabis use (Papinczak, Connor, Feeney, Young, & Gullo, 2017), whereas a college sample of students sanctioned for cannabis use treatment following violation of campus drug policies were ambivalent about such change, reporting that, on average, it was neither important or not important to change cannabis use (Buckner, Jeffries, Terlecki, & Ecker, 2016). Thus, it may be that PFIs for risky cannabis use need to be tailored to the unique maladaptive beliefs of college students and/or that strategies must be implemented to increase readiness to change among college students.

**Perceived Risk of Cannabis Use**

Given that PFIs for college samples do not seem to be as effective for decreasing cannabis use as they have been for decreasing alcohol use, it is essential to consider cannabis-specific factors that could help address this discrepancy. One factor that could be considered is perceived risk of cannabis use. In the context of substance use, risk perception is defined as perceptions of the negative effects of using substances (Danseco, Kingery, & Coggeshall, 1999). Historically, perceived risk of cannabis use is a leading indicator of use (Bachman, Johnston, & O'Malley, 1998; Bachman et al., 1988). Importantly, perceived risk also plays a strong role in the

decision to quit using substances – to illustrate, among tobacco users, as perception of risk of smoking increased, so did their intention to quit (Romer & Jamieson, 2001).

Perceived risk of regular cannabis use has decreased markedly since 2002 (Okaneku, Vearrier, McKeever, LaSala, & Greenberg, 2015), and data from the National Survey on Drug Use (NSDUH) and the Monitoring the Future (MTF) study indicate the percentage of young adults who endorse higher perceived risk of regular cannabis use has decreased significantly from 58% in 2006 to 32% in 2015 (Miech, Johnston, O'Malley, Bachman, & Schulenberg, 2016). Some postulate that these reductions may be due in part to the legalization of recreational and medical marijuana at the state level (Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2015).

It is concerning that perceived risk of regular cannabis use is sharply declining, as it has been identified as a strong protective factor against initiating use (Hawkins, Catalano, & Miller, 1992; Kilmer, Hunt, Lee, & Neighbors, 2007; Terry-McElrath, O'Malley, Patrick, & Miech, 2017). Although these recent decreases in risk perception of cannabis use have not been found to increase cannabis use initiation among adolescents (Miech et al., 2016; Substance Abuse and Mental Health Services Administration & Quality, 2013), decreases in risk perception are associated with increased prevalence rates of cannabis use in adults (Compton, Han, Jones, Blanco, & Hughes, 2016). Risk perception is also related to cannabis use frequency. Both non-daily and daily cannabis users perceive regular cannabis use as less risky than non-cannabis users, with daily users perceiving cannabis as less risky than non-daily users (Pacek, Mauro, & Martins, 2015). Change in perceived risk is one of the most important predicators of cannabis use frequency, such that as risk perception increases over time, cannabis use frequency decreases (Bachman et al., 1998). In the limited research on the relationships among risk perception,

cannabis use, and cannabis-related problems, risk perception has been linked to cannabis use in general (Grevenstein, Nagy, & Kroeninger-Jungaberle, 2015; Kilmer et al., 2007; Pacek et al., 2015), greater frequency of use (Lopez-Quintero & Neumark; Pacek et al., 2015), and intentions to use in the future (Lopez-Quintero & Neumark), but has not been linked to more use-related problems (Kilmer et al., 2007).

For some, college may be a time period in which the risk/use relationship changes, as attending college itself is increasingly a risk factor for initiation of cannabis use (Miech et al., 2017). College students rated cannabis among the least risky substances along with alcohol, caffeine, and tobacco, however, ratings of cannabis use risk perception varied more than alcohol or caffeine (Duistman & Colbry, 1995), suggesting that there may be individual differences that influence the perception of risk for cannabis. Furthermore, in one sample of college students, 56% believed that cannabis is less harmful than alcohol and 60.8% believed that cannabis is safer than tobacco (Hazelden Betty Ford Foundation, 2015). College-aged individuals, regardless of level of education, are less likely to report that regular cannabis use carries great risk than younger (12-17) and older (26 and older) individuals (Okaneku et al., 2015). Although there are no significant differences in the perceived risk of weekly cannabis use between full-time college and non-college age peers (Center for Behavioral Health Statistics and Quality, 2015), individuals with a high school education or greater are significantly less likely to perceive great risk in using cannabis compared to same-aged individuals without a high school education (Pacek et al., 2015). Females are also more likely to report greater perceived risk of cannabis use than males (Okaneku et al., 2015; Pacek et al., 2015). For first-year cannabis-using college students, frequency of use and experiencing cannabis-related problems were not related to risk perception (Kilmer et al., 2007). Notably, both frequent and infrequent current users did not view

their use as especially risky, despite experiencing cannabis-related problems. Frequent college cannabis users do perceive some risk associated with use, however, their risk perception is much lower than the risk perception of non-frequent users (O'Callaghan, Reid, & Copeland, 2006).

Most studies on perceived risk of cannabis have focused on four major risk categories, including physical harm (e.g., negative effects of substances on the body, such as addiction or dependence), parental disapproval, peer disapproval, and fear of arrest (e.g., legal problems; Danseco et al., 1999). Risk perception tends to vary across different types of risk, with physical addiction being considered a greater risk than legal problems or acute adverse effects such as anxiety (Copeland et al., 2017). For college students specifically, over half report that regular cannabis use puts the user at great risk for physical dependence (60.0%), finding it hard to stop using (58.1%), and performing worse than otherwise at school or work (53.4%; Copeland et al., 2017). Less than half report that regular cannabis use puts the user at great risk for relationship problems (49.6%), lack of motivation (45.1%), emotional and mood problems (43.6%), having accident while stoned (43.6%), and financial/money problems (39.5%). Compared to non-cannabis users, cannabis users had lower levels of perceived risk for having accidents while stoned, legal consequences, physical health problems, and dependence problems. Risk perception may be an important intervention for all cannabis users, regardless of frequency of use because 1) risk perception is a leading indicator of cannabis use and changes in risk perception are related to changes in use (Bachman et al., 1998) and 2) cannabis users (regardless of frequency of use) perceive cannabis as less risky than non-users (Pacek et al., 2015).

**Interventions Targeting Risk Perception**

Low levels of knowledge about psychological and physical risk of illicit drugs are the strongest predictor of low perception of risk (Grevenstein et al., 2015). However, little empirical work has tested whether interventions that increase knowledge about risks impact risk perception and if so, whether increases in risk perception lead to better outcomes. Polysubstance-using adolescents who received a single, in-person motivational interviewing (MI)-based session focused on increasing risk perception showed greater decreases in specific drug-related risk behaviors (e.g., reducing current drug use) at 3-month follow-up than those in the control condition (McCambridge & Strang, 2004). Although the study did not focus on measuring perceived risk or the change in risk perception, providing risk-related information to participants was helpful in decreasing related substance use behaviors. In the limited literature looking at perceived risk as an active treatment component in substance treatment for college students, one study found that mandated college drinkers who participated in a group MI-based intervention had increased perceived risk at follow-up, however, these increases were not related to changes in drinking (LaChance, Feldstein Ewing, Bryan, & Hutchison, 2009). Further, individuals who perceive that anti-substance use campaigns are more effective have higher perceptions of risk, suggesting that educating people about risk may impact risk perception of substances, and potentially the reduction of risky substance use (Thornton, Baker, Johnson, & Lewin, 2013).

In summary, although PFIs for alcohol use are successful at reducing risky college drinking (for review, see M. B. Miller et al., 2013), similar interventions for risky college cannabis use do not seem to impact cannabis use or related problems (Elliott & Carey, 2012; Elliott et al., 2014; Lee et al., 2010; Palfai et al., 2014). Although some cannabis PFIs do contain some information about risk (San Diego State Research Foundation, 2017), none seem to have

provided corrective feedback on perceived risk or examined whether increasing risk perception leads to better outcomes. Additionally, baseline characteristics, such as family history of substance problems (Lee et al., 2010) and readiness to change or contemplation of change (Lee et al., 2010; Palfai et al., 2016) may influence the effectiveness of cannabis PFIs. Assessing an individual's risk perception and providing corrective feedback on risk may be an important component to include for online PFIs for college students.

**The Current Study**

The current study examined risk perception and its relationship to cannabis use and related problems by testing if risk perception can be modified with a web-based intervention for current (past month) college cannabis users. First, we tested whether providing corrective feedback on perceived risk of regular cannabis use over a number of domains (e.g., physical dependence, health, legal) was related to greater overall perceived risk of cannabis use at follow-up. We hypothesized that there would be a significant effect of condition on follow-up perceived risk such that individuals randomized to the PFI condition would report greater follow-up perceived risk of cannabis than those in the feedback control condition. Second, we tested whether condition was related to follow-up outcomes. We hypothesized that condition would be related to follow-up outcomes such that those in the PFI condition would report less frequent use, fewer use-related problems, and greater problem distress at follow-up than those in the feedback control condition. Third, we tested whether follow-up perceived risk mediated the relationship between condition and follow-up cannabis use outcomes (cannabis use frequency, use-related problems, problem distress). We hypothesized that the PFI condition would be related to better follow-up cannabis outcomes (i.e., less use frequency, fewer use-related problems, greater problem distress) indirectly via its effect on perceived risk. Fourth, given that normative beliefs

are often robustly related to use (Buckner, 2013; Kilmer et al., 2006; Neighbors et al., 2008; Pearson et al., 2017) and have been successfully targeted in prior cannabis PFIs (Elliott & Carey, 2012; Elliott et al., 2014; Palfai et al., 2014), we tested whether providing corrective feedback on norms (i.e., descriptive norms and cannabis-use problem norms) was related to cannabis use outcomes at follow-up (cannabis use frequency, use-related problems, problem distress). We hypothesized that descriptive norms and problem norms would mediate the relationship between condition and outcomes, such that those in the PFI condition (who received problem norms and descriptive norms feedback) would report less frequent use, fewer problems, and greater problem distress at follow-up. Fifth, given that PFIs are more efficacious for specific groups of college cannabis users (e.g., among those who endorsed contemplating changing their cannabis use at baseline and for those who reported a family history of drug problems Lee et al., 2010), we tested whether baseline variables (i.e., frequency of use, perceived risk, use-related problems, family history, readiness to change, gender) moderated the relationship between condition and outcomes such that those in the PFI condition with lower baseline risk, greater baseline frequency, greater problems, and/or family history would evince the best outcomes.

We also tested a secondary hypothesis in the current study. We tested the hypothesis that the relationship between condition and cannabis outcomes would be mediated by the serial impact of perceived risk and use frequency, such that those in the PFI condition would report greater perceived risk, which would be related to less frequent cannabis use, and in turn would be related to fewer cannabis use-related problems at follow-up.

## Method

### Participants

Participants were 204 current undergraduate students who endorsed past-month cannabis use and experienced at least one cannabis use-related problem in the past three-months in an attempt to improve the efficacy of the intervention, as prior work suggests that over 66.5% of college cannabis users report experiencing at least one past three-month cannabis use-related problem and that number of use-related problems is associated with greater interest in treatment (Buckner et al., 2010). Participants were recruited from Louisiana State University (LSU) through the LSU psychology department's online research pool and via flyers on campus. Participants who completed the study through the psychology department research participant pool were compensated with research participation credits for one psychology course for completion of baseline and follow-up surveys. Non-psychology course participants were compensated $10 for completing baseline and $20 for completing follow-up surveys. Originally, non-psychology students were compensated $10 for completing both baseline and follow-up surveys. To improve retention rates, we increased compensation twice during the duration of the study: (1) early on in the study, 35 individuals were compensated $10 for baseline and $10 for follow-up; (2) mid-way through the study, 31 individuals were compensated $10 for baseline and $20 for follow-up. To increase the likelihood of follow-up survey completion, all participants who finished both the baseline and follow-up assessments were entered into a drawing for a chance to win one of 3 cash prizes: 1 $100 prizes and 2 $50 prizes. Given that cannabis is legal for medical but not recreational purposes at the state level in Louisiana, we obtained a Certificate of Confidentiality from the National Institute of Mental Health to further protect participants' confidentiality.

The majority of the participants (93.9%) were recruited from the LSU psychology participant pool. See Figure 1 for a CONSORT flow diagram. Of the 425 individuals who completed the online screening questionnaire between February 2018 and October 2018, 87 were ineligible due to: not being a current undergraduate student at Louisiana State University (*n* = 6), being under 18 years of age (*n* = 1), denying past-month cannabis use (*n* = 55), or not being willing to complete a follow-up survey in one month (*n* = 25). Of the 338 eligible participants who started the baseline assessment, 111 were excluded prior to randomization for: dropping out of the survey prior to randomization (*n* = 66), denying all past three-month cannabis use-related problems (*n* = 35), or not receiving the intervention due to a programming error that was discovered early on in the study period (*n* = 10). Of the 224 participants who completed baseline (PFI *n* = 115, feedback control *n* = 109), 3 were excluded from follow-up due to failing the attention check questions (PFI *n* = 2, feedback control *n* = 1) and 27 participants did not complete the follow-up assessment (PFI *n* = 14, feedback control *n* = 13). Of the 194 who completed baseline and follow-up, 17 participants were excluded from follow-up analyses due to failing the attention check questions at follow-up (PFI *n* = 4, feedback control *n* = 1) or reporting no past-month cannabis use during baseline, despite endorsing past-month cannabis use on the screening survey (PFI *n* = 6, feedback control *n* = 5).[1] Thus, 177 participants (86.8% retention rate) completed the follow-up survey and were included in analyses (Figure 1). Demographic characteristics of the sample are reported in Table 1. The sample was majority female and non-Hispanic White, aged 18-25 years old. Conditions did not differ on demographic variables (Table 1).

[1] Results remained the same when we included the 11 individuals who did not report any past-month during baseline, despite endorsing past-month cannabis use on the screening survey.

Conditions did not significantly differ on retention rates, $\chi^2$ (1, $N$ = 204) = 0.04, $p$ = .836, φ = -0.01. Completers (77.4% female) did not differ from non-completers (74.1% female) on gender, $\chi^2$ (1, $N$ = 204) = 0.15, $p$ = .702, φ = 0.03 or age ($M$ = 19.76, $SD$ = 1.38 vs. $M$ = 20.33, $SD$ = 1.64), $F$(1,203) = 3.89, $p$ = .050, $d$ = 0.41. Completers differed from non-completers on race and ethnicity (70.6% non-Hispanic White vs. 74.1% non-Hispanic White), $\chi^2$ (1, $N$ = 204) = 11.16, $p$ = .025, φ = 0.23. Completers did not differ from non-completers on number of past three-month cannabis use-related problems ($M$ = 8.05, $SD$ = 5.41 vs. $M$ = 7.59, $SD$ = 4.20), $F$(1,203) = 0.18, $p$ = .674, $d$ = 0.09, perceived risk ($M$ = 4.47, $SD$ = 1.79 vs. $M$ = 4.52, $SD$ = 1.55), $F$(1,203) = 0.02, $p$ = .904, $d$ = 0.03, problem distress ($M$ = 10.51, $SD$ = 10.64 vs. $M$ = 10.15, $SD$ = 11.98), $F$(1,203) = 0.03, $p$ = .865, $d$ = 0.04, RTC ($M$ = -5.80, $SD$ = 9.08 vs. $M$ = -8.07, $SD$ = 9.15), $F$(1,203) = 1.46, $p$ = .228, $d$ = 0.25, or family history of substance use problems (63.0% vs. 47.5%), $\chi^2$ (1, $N$ = 204) = 2.25, $p$ = .133, φ = -0.11. Completers ($M$ = 4.10, $SD$ = 3.02) reported greater past-month cannabis use frequently than non-completers ($M$ = 2.81, $SD$ = 2.43), $F$(1,203) = 4.42, $p$ = .037, $d$ = 0.44.

**Procedures**

Participants were screened for eligibility via Qualtrics, an online data collection website, for the following eligibility criteria: being 18 years of age or older, a current LSU undergraduate student, a current (past-month) cannabis user, and endorsing at least one cannabis-use related problem per the *Marijuana Problems Scale* (MPS; Stephens, Roffman, & Curtin, 2000). Ineligible participants were informed that they were not eligible to participate in the study and were directed to the end of the survey. After completing the baseline assessment, eligible

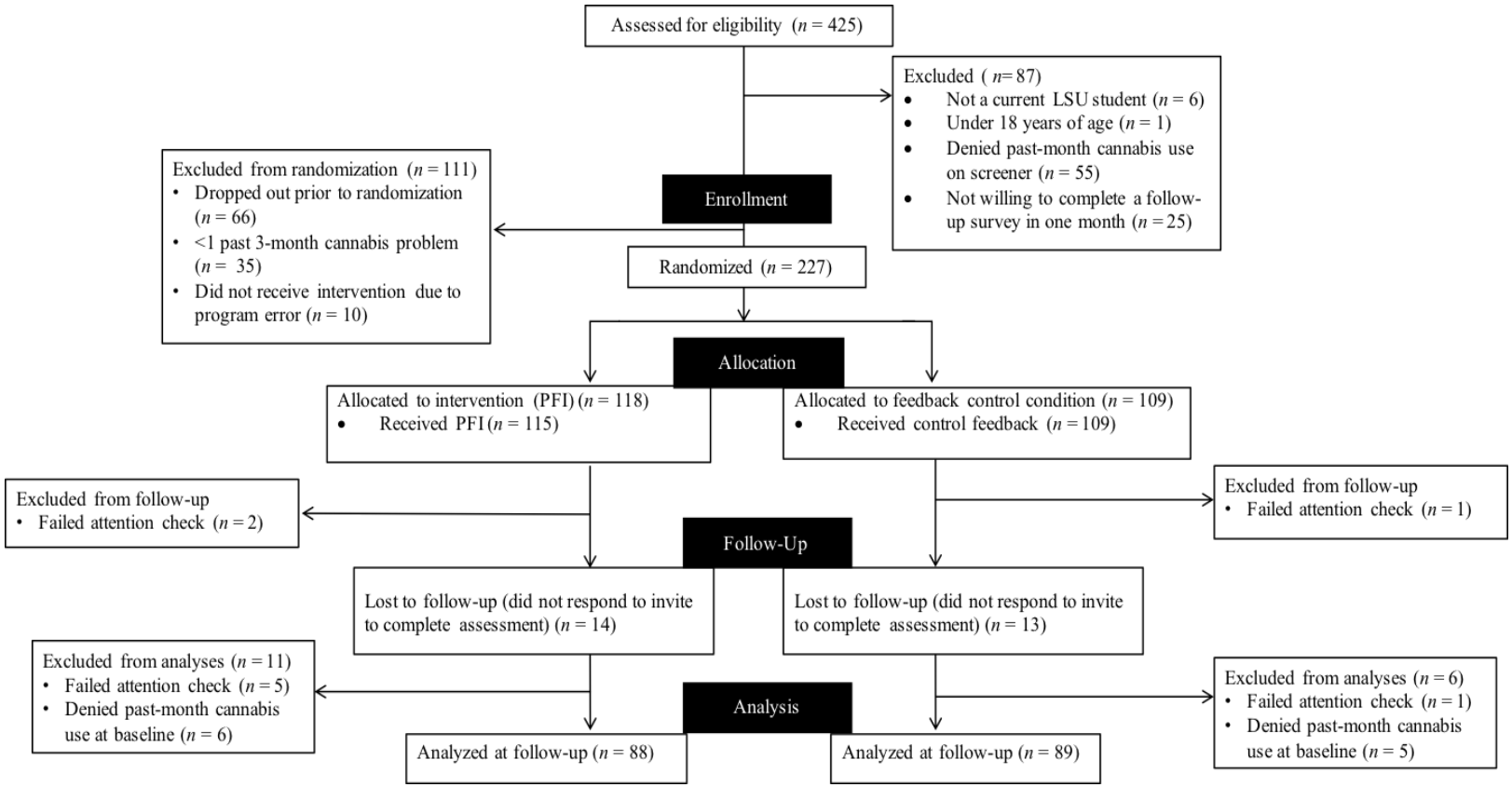


Figure 1. Participant flow chart following Consolidated Standards of Reporting Trials guidelines.

Table 1. Demographic and Baseline Characteristics of Sample by Condition.

| | Total ($N$ = 204) | Feedback Control ($n$ = 102) | PFI ($n$ = 102) | $F$ or $\chi^2$ | $p$ | $d$ or Cramer's V |
|---|---|---|---|---|---|---|
| Age | 19.83 (1.43) | 19.85 (1.53) | 19.81 (1.31) | 0.04 | .845 | 0.03 |
| Gender (% female) | 77.0% | 74.5% | 79.4% | 0.69 | .406 | 0.06 |
| Sexual orientation (% heterosexual) | 84.8% | 84.3% | 85.3% | 0.05 | .997 | 0.02 |
| Gay or Lesbian (%) | 2.9% | 2.9% | 2.9% | | | |
| Bisexual (%) | 10.3% | 10.8% | 9.8% | | | |
| Other (%) | 2.0% | 2.0% | 2.0% | | | |
| Race/Ethnicity (% White/Non-Hispanic) | 71.1% | 69.6% | 72.5% | 0.03 | .871 | 0.02 |
| White/Hispanic (%) | 5.4% | 6.9% | 3.9% | | | |
| African American/Non-Hispanic (%) | 13.2% | 13.7% | 12.7% | | | |
| African American/Hispanic (%) | 0.5% | 0.0% | 1.0% | | | |
| Asian (%) | 2.9% | 2.9% | 2.9% | | | |
| Multiracial/Non-Hispanic (%) | 4.4% | 4.9% | 3.9% | | | |
| Multiracial/Hispanic (%) | 1.5% | 1.0% | 2.0% | | | |
| Other (%) | 1.0% | 1.0% | 1.0% | | | |
| Class standing (% first year) | 28.9% | 28.4% | 29.4% | 7.58 | .104 | 0.19 |
| Second year (%) | 25.0% | 24.5% | 25.5% | | | |
| Third year (%) | 29.4% | 12.7% | 33.3% | | | |
| Fourth year (%) | 13.7% | 15.7% | 11.8% | | | |
| Fifth year (%) | 2.9% | 5.9% | 0.0% | | | |
| % involved in Greek life | 31.4% | 27.5% | 35.3% | 1.46 | .227 | 0.09 |
| % not receiving substance use treatment | 99.5% | 99.0% | 100.0% | 1.01 | .316 | 0.07 |
| % with family substance use history | 49.5% | 48.0% | 51.5% | 0.18 | .674 | 0.03 |
| Average use frequency | 3.93 (2.97) | 3.95 (2.94) | 3.90 (3.02) | 0.01 | .907 | 0.02 |
| Number of past three-month cannabis use-related problems | 7.99 (5.26) | 7.89 (5.27) | 8.09 (5.28) | 0.07 | .791 | 0.04 |
| Perceived risk total score | 4.48 (1.76) | 4.46 (1.76) | 4.50 (1.77) | 0.03 | .874 | 0.02 |
| Readiness to Change total score | -6.10 (9.10) | -6.02 (9.08) | -6.19 (9.17) | 0.02 | .896 | 0.02 |
| Readiness to change ruler score | 4.42 (2.84) | 4.35 (2.73) | 4.49 (2.95) | 0.12 | .731 | 0.05 |
| Importance to change ruler score | 3.24 (3.03) | 3.30 (3.03) | 3.18 (3.05) | 0.09 | .765 | 0.04 |

(table cont'd.)

| | Total ($N$ = 204) | Feedback Control ($n$ = 102) | PFI ($n$ = 102) | $F$ or $\chi^2$ | $p$ | $d$ or Cramer's V |
|---|---|---|---|---|---|---|
| Confidence to change ruler score | 7.99 (2.56) | 8.02 (2.65) | 7.96 (2.48) | 0.03 | .870 | 0.02 |
| Descriptive norms | 5.17 (1.92) | 5.26 (2.18) | 5.07 (1.62) | 0.53 | .466 | 0.10 |
| Problem norms | 15.95 (20.98) | 14.90 (20.67) | 16.99 (21.33) | 0.51 | .479 | 0.10 |
| Problem distress | 10.47 (10.37) | 9.75 (9.02) | 11.19 (11.57) | 0.98 | .322 | 0.01 |

participants were randomized to either the PFI condition or a feedback control condition by Qualtrics, which uses an algorithm to assign participants to condition based on all responses provided and evenly assigns participants to each condition without bias.

Participants completed two surveys -- the baseline survey and the assigned intervention (PFI or feedback control) were completed at baseline and the follow-up survey was completed approximately one month after baseline. This timeframe was used given that prior work demonstrated that cannabis frequency decreased following a cannabis PFI at one month follow-up (Copeland et al., 2017). Participants received the assigned intervention condition immediately after completing baseline assessment measures. Following the intervention, participants completed a question assessing whether they read the intervention materials. Participants were excluded from data analysis if they incorrectly answered 2 or more check questions, the maximum number of attention check questions recommended in prior work (Meade & Craig, 2012).

**Intervention Conditions**

**Feedback control condition:** The feedback control condition included personalized normative feedback (PNF) concerning (per Lee et al., 2010): 1) participants' past-month cannabis use frequency; 2) perceived cannabis use descriptive norms of other LSU students who use cannabis; and 3) information regarding actual norms for LSU students who use cannabis. LSU normative data was obtained from a sample of approximately 230 LSU undergraduate students who endorsed past-month cannabis use (Buckner, Lemke, & Walukevich, 2017).

**Personalized Feedback Intervention (PFI):** The PFI intervention included the PNF given to those in the control condition as well as psychoeducation/personalized feedback pertaining three additional areas: (1) risk related to cannabis use; (2) cannabis-related problem

norms; and (3) risk for cannabis use disorder (CUD) based on number of CUD criteria endorsed. All components were randomized to control for order presentation effects. Details on each of the additional areas is described below.

***Risk related to cannabis use.*** Participants were given risk-related information on eight different risk domains: legal consequences, physical health problems, dependence problems, cognitive impairment, productivity, low energy, procrastination, and education/occupational impairment. These domains were empirically informed through prior work identifying areas of low perceived risk (O'Callaghan et al., 2006) or frequent cannabis use-related problems among college cannabis users (Buckner et al., 2010).

***Cannabis-related problem norms.*** PNF pertaining to cannabis-related problems included: 1) participants' self-reported past 90-day cannabis-related problems, 2) perceived cannabis-related problem norms of other LSU students who use cannabis, and 3) feedback regarding actual problem norms for LSU students who use cannabis. Participants also received personalized problem-specific feedback <u>for each problem</u> endorsed during baseline that included: (1) participants' endorsed problem and self-reported problem severity; (2) perceived cannabis-related problem-specific norms of other LSU students who use cannabis (i.e., the percentage of other marijuana users at LSU who experience that specific problem); and (3) information regarding actual problem-specific norms for LSU students who use cannabis (i.e., the actual percentage of past-month cannabis users at LSU who endorsed experiencing that problem). LSU 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, Lemke, et al., 2017).

***Risk for cannabis use disorder (CUD) based on current CUD symptoms.*** Participants answered a brief questionnaire asking if they had experienced (yes or no) any of the 10 DSM-5 symptoms of CUD in the past year (e.g., using marijuana in larger amounts or for longer periods of time than they meant to). Participants were provided personalized feedback on: (1) the number of CUD symptoms they endorsed experiencing within the past year; (2) psychoeducation on the 10 symptoms of CUD (i.e., people only need to experience 2-3 symptoms in the past year to have CUD); and (3) problems related to frequent cannabis use.

**Measures**

**Marijuana Use Form (MUF; Buckner, Bonn-Miller, Zvolensky, & Schmidt, 2007).** The MUF was used at baseline and follow-up to assess past-month cannabis use frequency. Past-month frequency was assessed using 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 has demonstrated good convergent validity with ecological momentary assessment of cannabis use (Buckner, Crosby, Silgado, Wonderlich, & Schmidt, 2012).

**Cannabis-related problems.** Cannabis use-related problems were assessed using the *Marijuana Problems Scale* (MPS; Stephens et al., 2000), a 19-item self-report questionnaire which asks participants to rate each item from 0 (*no problem*) to 2 (*serious* problem). The MPS was modified for the current study to contain an additional 13 items derived from a self-report questionnaire created from a sample of 300 cannabis users who reported using cannabis at least twice per month and self-reported problems related to their use (Neighbors, unpublished raw data). These items included problems with: appetite/hunger, attention problems/cognitive impairment, anxiety/worry/paranoia, neglecting responsibilities, concentration/focus/disorientation, speech, freaked out/too high, task impairment, dangerous

behavior, negative mood, embarrassing behavior, and impaired decisions. Consistent with prior work (Dean, Ecker, & Buckner, 2017; Lozano, Stephens, & Roffman, 2006), items scored either 1 or 2 were counted to create a sum of number of cannabis-related problems, with higher scores indicating greater problems experienced. For the current study, past 90 day problems were assessed at baseline and past month problems were assessed at follow-up. The original 19-item measure has demonstrated adequate consistency in prior work (e.g., Buckner et al., 2010; Dean et al., 2017). The 30-item modified version used in the current study demonstrated excellent internal consistency (baseline $\alpha$ = .96, follow-up $\alpha$ = .98).

**Cannabis-related problem distress.** We asked participants 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. For the current study, past 90-day problem-related distress was assessed at baseline and past-month problem-related distress was assessed at follow-up.

**Descriptive norms.** Descriptive norms were assessed by asking participants to estimate how often the typical marijuana-using LSU student uses cannabis (8 = *daily*, 7 = *nearly every day*, 6 = *two to three times per week*, 5 = *one time per week*, 4 = *two to three times per month*, 3 = *one time per month*, 2 = *three to six times per year*, 1 = *one to two times per year*, and 0 = *never*). This question was modified from prior work on cannabis descriptive norms (Buckner, 2013; Buckner et al., 2010; Perkins, Meilman, Leichliter, Cashin, & Presley, 1999) by asking participants to estimate use of the "typical cannabis-using LSU student" instead of "typical student," as prior work has demonstrated that more specific norm referent groups (e.g., close friends, gender specific, group specific) are likely to have a stronger influence on substance use behaviors (Lewis & Neighbors, 2006). By using "typical cannabis-using LSU student" as a

norms referent group, we are increasing specificity of our norm referent group in two ways: (1) including cannabis-using student norms (instead of all students, including non-users) and (2) including campus-specific norms (instead of all college students).

**Perception of risk.** Items from the MTF Project (Johnston, O'Malley, & Bachman, 1999) were used to assess overall perception of risk of cannabis use. Participants were asked to rate "How much do you think people risk harming themselves physically or in other ways if they use marijuana 1) once or twice, 2) occasionally (once a month), 3) regularly (once or twice a week)?" on a 1 (*no risk*) to 4 (*great risk*) scale, per prior work (e.g., Bachman et al., 1998; Bachman et al., 1988; Sarvet et al., 2018; Schulenberg et al., 2017). Prior work examining risk perception categorically (i.e., *no risk, some risk, moderate risk, high risk*) found that changes in perceived risk over time have been consistently linked to subsequent changes in use, suggesting strong construct validity (Miech et al., 2016) The current study summed the three responses (i.e., using once or twice, using occasionally, using regularly) to capture an overall and continuous measure of risk perception. Total risk perception scores ranged from 0 to 12, with higher scores indicating greater perceived risk. Overall perception of risk demonstrated adequate internal consistency in the current sample (baseline $\alpha = .82$, follow-up $\alpha = .82$).

**Readiness to Change Questionnaire (RTCQ; Budd & Rollnick, 1996).** The RTCQ is a 12-item measure modified for cannabis use (Stephens, Roffman, Fearer, Williams, & Burke, 2007) that assess a participant's current stage of change. Each of the three subscales (pre-contemplation, contemplation, and action) are made up of four items. To obtain a continuous measure of readiness to change, the Precontemplation score was subtracted from the sum of the Contemplation and Action scores (Budd & Rollnick, 1996). The modified RTCQ has shown adequate internal consistency and test-retest reliability when used as both a continuous measure

of readiness to change and stage of change measure in prior samples (Budd & Rollnick, 1996; Stephens et al., 2007). The RTC demonstrated adequate internal consistency in the current sample (baseline α = .88, follow-up = .85).

**Motivation to Change Rulers.** Three rulers were used to assess the following: 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 (1995) readiness ruler and the importance and confidence rulers were adapted from W. R. Miller and Rollnick (2002), per prior work (Buckner et al., 2016). The readiness ruler showed convergent validity with similar measures in prior work (Boudreaux et al., 2012; Maisto et al., 2011) and RTC in the current sample (Table 3). There is some evidence to support construct validity for importance and confidence rulers, as confidence to change has been shown to increase following an intervention (Buckner & Schmidt, 2009) and increased confidence to change was related to decreased cannabis use (Gates, Norberg, Copeland, & Digiusto, 2012).

**Family history of drug problems.** Per prior work (Lee et al., 2010), family history of drug problems was assessed using one item from the Brief Drinker Profile asking participants to indicate yes or no if any biological family members had a history of drug-related problems.

**Data Analytic Strategy**

We inspected the data for outliers (scores greater than 3.29 standard deviations above the mean; Tabachnick & Fidell, 2013), skew, and kurtosis. Inspection of the data revealed that a majority of baseline and follow-up variables were skewed and all variables were kurtotic (z scores < -1.96, > 1.96; Tabachnick & Fidell, 2013), which is often the case with substance use

related variables (Buckner, Zvolensky, et al., 2017; Dean et al., 2017; Keough, O'Connor, Sherry, & Stewart, 2015). See Table 2 for skew and kurtosis values for baseline and follow-up variables. Outliers were observed on the following variables: baseline use-related problems, baseline and follow-up perceived risk, and follow-up problem norms. For problem norms only, one subject was 13 standard deviations above the mean. Therefore, we replaced the subject's score with a score that was 3.29 standard deviations above the mean.

Table 2. Means, Standard Deviations, Skew, and Kurtosis of Study Variables.

| | *M* | *SD* | Skew | Skew z-score | Kurtosis | Kurtosis z-score |
|---|---|---|---|---|---|---|
| Baseline variables | | | | | | |
| Average use frequency | 3.93 | 2.97 | 0.73 | 4.31 | -0.86 | -2.54 |
| Number of past three-month cannabis use-related problems | 7.99 | 5.26 | 0.92 | 5.43 | 0.87 | 2.58 |
| Perceived risk total score | 4.48 | 1.76 | 1.39 | 8.16 | 1.77 | 5.23 |
| RTC score | -6.10 | 9.10 | 0.00 | 0.00 | -0.85 | -2.50 |
| Readiness ruler score | 4.42 | 2.84 | 0.46 | 2.68 | -0.87 | -2.57 |
| Importance ruler score | 3.24 | 3.03 | 0.59 | 3.50 | -0.78 | -2.31 |
| Confidence ruler score | 7.99 | 2.56 | -1.42 | -8.33 | 1.42 | 4.19 |
| Descriptive norms | 5.17 | 1.91 | 0.65 | 3.81 | 1.13 | 3.34 |
| Problem norms | 15.95 | 20.98 | 2.64 | 15.55 | 7.12 | 21.00 |
| Problem distress | 10.47 | 10.37 | 1.73 | 10.21 | 3.72 | 10.96 |
| Follow-up variables | | | | | | |
| Average use frequency | 3.50 | 3.05 | 0.61 | 3.36 | -0.89 | -2.46 |
| Number of past three-month cannabis use-related problems | 5.15 | 5.13 | 0.95 | 5.21 | -0.03 | -0.08 |
| Perceived risk total score | 4.56 | 1.64 | 0.69 | 3.79 | -0.44 | -1.21 |
| RTC score | -4.75 | 8.82 | -0.22 | -1.23 | -0.67 | -1.85 |
| Readiness ruler score | 4.89 | 2.99 | 0.34 | 1.89 | -1.04 | -2.85 |
| Importance ruler score | 3.56 | 3.07 | 0.48 | 2.61 | -0.93 | -2.57 |
| Confidence ruler score | 8.14 | 2.48 | -1.36 | -7.43 | 1.07 | 2.93 |
| Descriptive norms | 3.87 | 1.86 | -0.22 | -1.19 | 0.23 | 0.63 |
| Problem norms | 16.72 | 49.74 | 6.63 | 36.30 | 49.48 | 135.85 |
| Problem distress | 8.54 | 9.66 | 2.00 | 10.97 | 4.71 | 11.32 |

*Note.* RTC = Readiness to Change Questionnaire

Next, we tested if there were any baseline differences or retention differences between conditions by conducting Pearson's Chi-square for categorical data and one-way analysis of variance (ANOVA) tests for continuous data. Correlations among baseline measures (Table 3) and among follow-up measures (Table 4) were conducted to determine relations among study variables.

Given that initial inspection of our data revealed that a majority of our baseline variables were skewed, kurtotic, and contained outliers, all hypotheses were tested using bias-corrected bootstrapping, which is robust against violations of assumptions of normality (Hayes, 2013). To test our hypotheses that condition would be related to follow-up perceived risk and follow-up outcomes (follow-up cannabis use frequency, use-related problems, problem distress), we conducted three mediation models to examine the relationships among condition (X), follow-up outcomes ($Y_1$ use frequency; $Y_2$ use-related problems; $Y_3$ problem distress), and perceived risk (M) using PROCESS, a conditional process modeling program that uses an ordinary least squares-based path analytical framework to test for both indirect and direct effects (Hayes, 2013). All specific and conditional indirect effects were subjected to follow-up bootstrap analyses with 10,000 resamples using a 95% confidence interval (CI) estimation (Hayes, 2009). Each model tested if risk perception at follow-up mediated the relationship between condition and outcome at follow-up. The simple mediation conceptual path model is presented in Figure 2.

First, we examined the *total effect model,* which represents the proportion of variance in Y that is explained by variance in X. Next, we examined the *full model with the mediator,* which represents the proportion of variance in Y that is explained by variance in X, accounting for the mediator. To test the first hypothesis that that there would be a significant effect of condition on follow-up perceived risk, path a was examined. To test the second hypothesis that condition

would be related to follow-out outcomes (use frequency, use-related problems, problem distress), we examined the *total effect* of X on Y (path c), which can be interpreted as how much two cases that differ by one unit on X are estimated to differ on Y. To test the third hypothesis that follow-up perceived risk mediated the relationship between condition and follow-up outcomes, the *indirect effect* (path a*b) of X on Y through M was examined.

We conducted six additional mediation models to examine the relationships among condition (X), follow-up outcomes ($Y_1$ use frequency; $Y_2$ use-related problems; $Y_3$ problem distress), and norms ($M_1$ descriptive norms, $M_2$ problem norms) using PROCESS and the methods described above. To test our fourth hypothesis that follow-up norms (i.e., descriptive norms, problem norms) would mediate the relationship between condition and follow-up outcomes (use frequency, use-related problems, problem distress, and descriptive norms), the *indirect effect* (path a*b) of X on Y through M was examined.

To test our fifth hypothesis, the moderating effects of baseline variables (i.e., frequency of use, perceived risk, use-related problems, family history, readiness to change, gender) were tested using the PROCESS macro for SPSS (Hayes, 2013). Separate models were constructed for each criterion variable (follow-up use frequency, use-related problems, and perceived risk) with condition as the predictor and baseline variable as the moderator.

Regarding our secondary analysis, to test our hypothesis that perceived risk and use frequency would serially mediate the relationship between condition and follow-up, we conducted serial mediation tests in PROCESS. Serial mediation tests the sequential effect of two mediators in addition to testing the independent indirect effect of each mediator separately (see Figure 3; Hayes, 2013) .

**A priori power analysis and sample size.** The sample size necessary to achieve the recommended power of .80 (Cohen, 1988) was determined using guidelines discussed by Fritz and Mackinnon (2007) for simple mediation models. Fritz and Mackinnon (2007) recommended estimating the size of the indirect effects (path a: condition → perceived risk; path b: perceived risk → cannabis use outcomes). Although few studies have examined the effect of treatment condition on perceived risk (i.e., path a), one study of college drinkers found a small-to-medium effect of intervention on perceived risk (LaChance et al., 2009). There is more research on the relationship between perceived risk and cannabis use frequency – there is a medium-to-large effect of perceived risk on cannabis use frequency (Bachman et al., 1998). Thus, the sample necessary to achieve .80 power for a simple mediation model using bias-corrected bootstrapping and to detect small-to-medium effects in maximum likelihood is 148 participants. Thus, our baseline ($N$ = 202) and follow-up ($n$ = 177) sample sizes should be sufficient to test our primary study hypotheses.

## Results

### Baseline Differences by Condition

At baseline, conditions did not differ significantly on demographic variables, past-month cannabis use frequency, use-related problems, problem distress, descriptive norms, problem norms, RTC, or motivation rulers (Table 1).

### Relationships Among Variables at Baseline

Correlations among baseline variables appear in Table 3. Perceived risk was negatively, significantly associated with use frequency and descriptive norms and positively, significantly associated with use-related problems, readiness to change, and problem distress. Descriptive norms were correlated with use frequency, but were not correlated with use-related problems or any of the motivation to change variables. Problem norms were not related to any variables.

### Relationships Among Baseline RTC, Family History, and Follow-up Variables

Correlations among baseline variables and follow-up variables appear in Table 4. Family history of substance use was not related to any follow-up outcome variables. RTC at baseline was positively associated with number of follow-up problems.

### Impact of Perceived Risk on Outcomes

**Model 1: Impact of condition and perceived risk on follow-up use frequency.** The total effect model did not account for significant variance in follow-up cannabis use frequency, $R^2_{Y1} = .002$, $df = 1, 175$, $F = 0.002$, $p = .547$. The full model with the mediator accounted for significant variance, $R^2_{Y1} = .087$, $df = 2, 174$, $F = 8.320$, $p < .0001$. Inconsistent with our hypothesis, condition was not significantly related to follow-up perceived risk (Table 5, Model 1, path a). Follow-up perceived risk was significantly related to follow-up use frequency (Table 5, Model 1, path b). The total effect of condition on use frequency was also not significant

Table 3. Correlations among Baseline Variables.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Average use frequency | - | | | | | | | | | | |
| 2. Number of cannabis use-related problems | .07 | - | | | | | | | | | |
| 3. Problem distress | .01 | .85*** | - | | | | | | | | |
| 4. Perceived risk | -.28** | .17* | .26*** | - | | | | | | | |
| 5. Descriptive norms | .33*** | .03 | -.01 | -.14* | - | | | | | | |
| 6. Problem Norms | .14 | .15 | .10 | .04 | .09 | - | | | | | |
| 7. Family history | .09 | .22** | .21** | .03 | .02 | -.05 | - | | | | |
| 8. RTC score | .24*** | .45*** | .45*** | .10 | .00 | .07 | .16* | - | | | |
| 9. Readiness ruler score | -.12 | .27*** | .35*** | .10 | -.07 | .09 | .16* | .68*** | - | | |
| 10. Importance ruler score | .05 | .32*** | .41*** | .12 | .04 | .07 | .20** | .69*** | .73*** | - | |
| 11. Confidence ruler score | -.18** | -.14* | -.03 | .02 | -.01 | -.04 | -.01 | -.05 | .20** | 0.10 | - |

*Note.* RTC = Readiness to Change Questionnaire; *$p$ < .05, **$p$<.01, ***$p$<.001

Table 4. Correlations among Family History of Substance Use, Baseline Readiness to Change and Motivation Rulers, and Follow-up Variables.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Average use frequency | - | | | | | | | | | | |
| 2. Number of cannabis use-related problems | .33*** | - | | | | | | | | | |
| 3. Problem distress | .18* | .87*** | - | | | | | | | | |
| 4. Perceived risk | -.29*** | .12 | .21* | - | | | | | | | |
| 5. Descriptive norms | .16* | .07 | .17* | -.07 | - | | | | | | |
| 6. Problem Norms | -.04 | .14 | .33*** | .09 | .01 | - | | | | | |
| 7. Family history | .00 | .11 | -.04 | -.02 | .04 | -.07 | - | | | | |
| 8. RTC score[a] | .14 | .23** | .27** | .04 | .08 | .01 | .16* | - | | | |
| 9. Readiness ruler score[a] | -.18* | .01 | .17 | .15* | .09 | -.01 | .16* | .68*** | - | | |
| 10. Importance ruler score[a] | -.04 | .07 | .21* | .18* | .12 | -.01 | .20** | .69*** | .73*** | - | |
| 11. Confidence ruler score[a] | -.16* | -.06 | .00 | .12 | -.03 | -.05 | -.01 | -.05 | .20** | .10 | - |

*Note.* RTC = Readiness to Change Questionnaire; [a] administered at baseline; *$p < .05$, **$p<.01$, ***$p<.001$

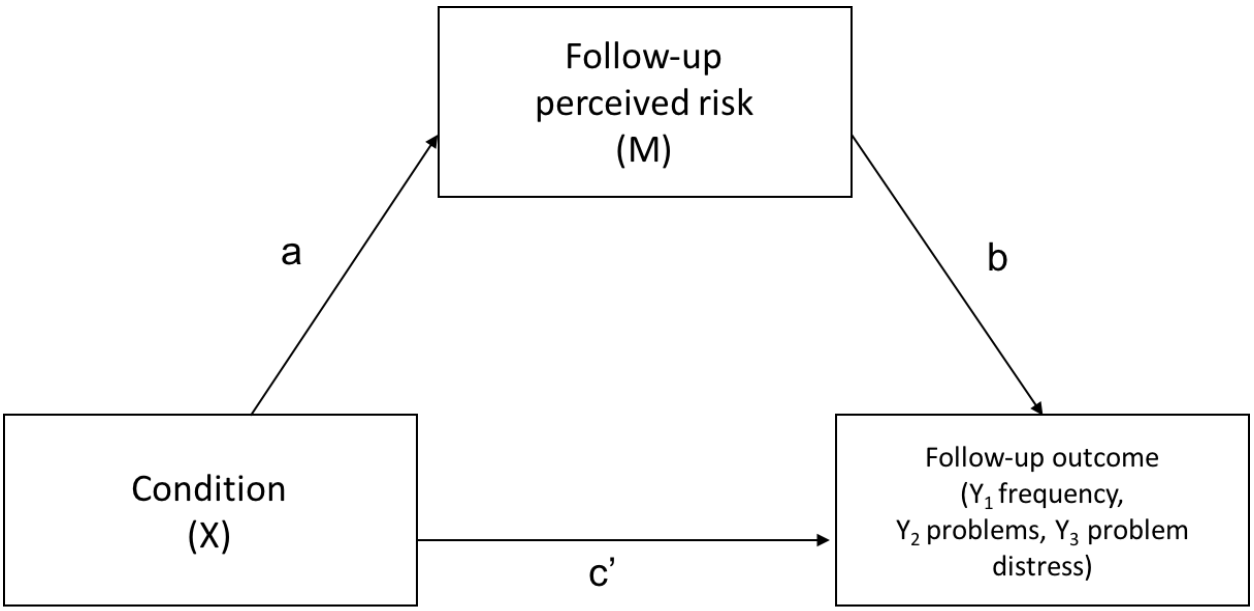


Figure 2. Conceptual path model for Models 1-3. Path c is the *total effect* of X on Y (i.e., a + b + c').

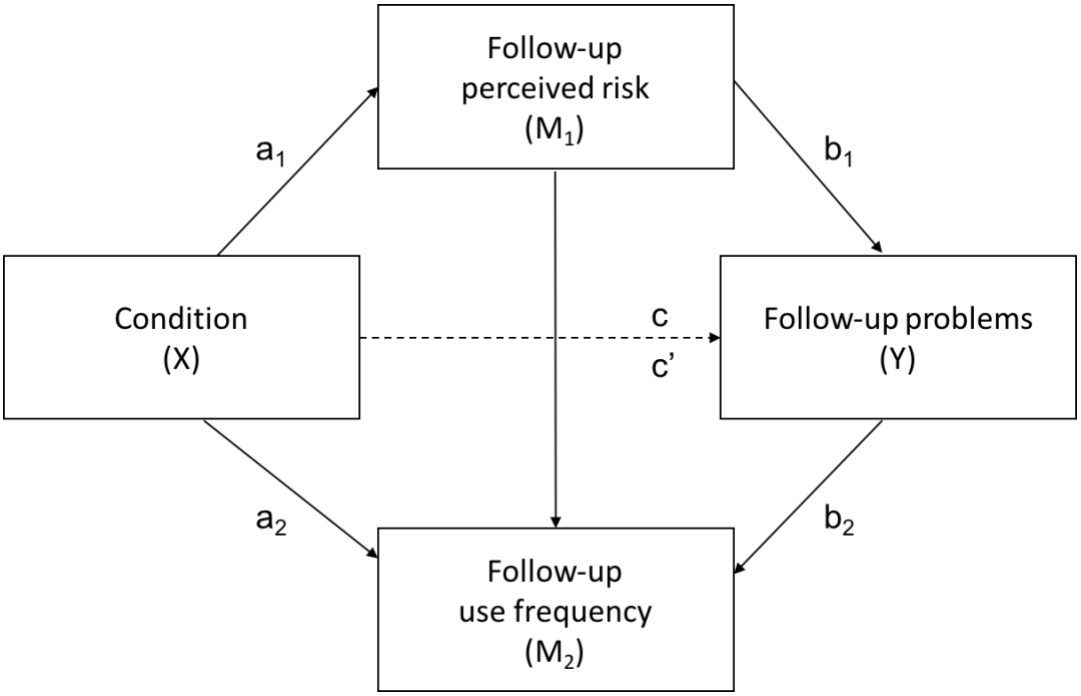


Figure 3. Serial mediation conceptual path model for Model 17.

(see Table 5, Model 1, path c) nor was the direct effect of condition when controlling for follow-up perceived risk (see Table 5, Model 1, path c'). The indirect effect of condition on cannabis use frequency via follow-up perceived risk was not significant, $b$ = -0.139, $SE$ = 0.142, *95% CI* [-0.442, 0.125].

**Model 2: Impact of condition and perceived risk on use-related problems.**

The total effect model did not account for significant variance in follow-up cannabis problems, $R^2_{Y2}$ = .009, $df$ = 2, 174, $F$ = 2.192, $p$ = .215, nor did the full model that included condition and the proposed mediator, $R^2_{Y2}$ = .025, $df$ = 2, 174, $F$ = 2.192, $p$ = .115. Contrary to our hypothesis, condition was not significantly related to perceived risk (Table 5, Model 2, path a). Further, perceived risk was not significantly related to follow-up problems (Table 5, Model 2, path b). Contrary to our hypothesis, condition was not related to follow-up problems (Table 5, Model 2, path c). The direct effect of condition when controlling for follow-up perceived risk was not significant (see Table 5, Model 2, path c'). Condition was not related to follow-up problems indirectly via perceived risk (path a*b), $b$ = -1.059, $SE$ = 0.137, *95% CI* [-0.113, 0.444].

**Model 3: Impact of condition and perceived risk on problem distress.**

The total effect model did not account for significant variance in follow-up problem distress, $R^2_{Y3}$, = .002, $df$ = 1, 132, $F$ = 0.248, $p$ = .619. In contrast, the full model with condition and the proposed mediator accounted for significant variance, $R^2_{Y3}$ = .045, $df$ = 2, 131, $F$ = 3.090, $p$ = .049. Condition was not significantly related to follow-up perceived risk (Table 5, Model 1, path a). Perceived risk was significantly related to follow-up problem distress (Table 5, Model 3, path b). The direct effect of condition when controlling for follow-up perceived risk was not significant (see Table 5, Model 3, path c') and condition was not related to follow-up

problem distress (Table 5, Model 3, path c). Contrary to our hypothesis, condition was not related to follow-up problems indirectly via perceived risk (path a*b), *b* = -0.001, *SE* = 0.391, *95% CI* [-0.776, 0.889].

Table 5. Regression Results for Mediation Models with Perceived Risk as the Mediator.

| Y | Path | *b* | *SE* | *t* | *p-value* |
|---|---|---|---|---|---|
| Model 1: Cannabis use frequency at follow-up | a | 0.255 | 0.247 | 1.034 | .302 |
| | b | -0.544 | 0.135 | -4.030 | <.0001 |
| | c’ | 0.415 | 0.441 | 0.942 | .348 |
| | c | 0.277 | 0.459 | 0.604 | .547 |
| Model 2: Cannabis use-related problems at follow-up | a | 0.255 | 0.247 | 1.034 | .302 |
| | b | -1.059 | 0.769 | -1.379 | .170 |
| Y | Path | *b* | *SE* | *t* | *p-value* |
| | c’ | -0.959 | 0.770 | -1.245 | .215 |
| | c | 0.394 | 0.235 | 1.678 | .095 |
| Model 3: Cannabis use-related problems distress at follow-up | a | 0.000 | 0.271 | -0.002 | .999 |
| | b | 1.283 | 0.527 | 2.434 | .016 |
| | c’ | -0.834 | 1.644 | -0.507 | .613 |
| | c | -0.834 | 1.674 | -0.498 | .619 |

**Impact of Normative Beliefs on Outcomes**

**Model 4: Impact of descriptive norms on follow-up use frequency.**

The total effect model did not account for significant variance in follow-up use frequency, $R^2_{Y4}$, = .002, *df* = 1, 175, *F* = 0.364, *p* = .547, nor did the full model with the mediator, $R^2_{Y4}$ = .025, *df* = 2, 174, *F* = 2.249, *p* = .109. The direct effect of condition when controlling for follow-up normative beliefs was not significant (see Table 6, Model 4, path c’).

Contrary to our hypothesis, condition was not related to follow-up use frequency indirectly via descriptive norms (path a*b), *b* = 0.076, *SE* = 0.085, *95% CI* [-0.072, 0.267].

**Model 5: Impact of descriptive norms on follow-up use-related problems.**

The total effect model did not account for significant variance in follow-up use frequency, $R^2_{Y5}$, = .009, *df* = 1, 175, *F* = 1.550, *p* = .215, nor did the full model with the mediator, $R^2_{Y5}$ = .014, *df* = 2, 174, *F* = 1.265, *p* = .285. The direct effect of condition controlling for follow-up norms was not significant (see Table 6, Model 5, path c'). Inconsistent with our hypothesis, condition was not related to follow-up problems indirectly via follow-up norms (path a*b), *b* = 0.063, *SE* = 0.103, *95% CI* [-0.102, 0.318].

**Model 6: Impact of descriptive norms on follow-up cannabis problem distress.**

The total effect model did not account for significant variance in follow-up use frequency, $R^2_{Y6}$, = .002, *df* = 1, 132, *F* = 0.248, *p* = .619, nor did the full model with the mediator, $R^2_{Y6}$ = .033, *df* = 2, 131, *F* = 2.215, *p* = .113. The direct effect of condition controlling for follow-up descriptive norms was not significant (see Table 6, Model 6, path c'). Regarding the test of indirect effects, condition was not related to follow-up problems via follow-up norms (path a*b), *b* = 0.368, *SE* = 0.352, *95% CI* [-0.186, 1.090].

**Model 7: Impact of problem norms on follow-up use frequency.**

The total effect model did not account for significant variance in follow-up use frequency, $R^2_{Y7}$, = .003, *df* = 1, 174, *F* = 0.480, *p* = .489, nor did the full model with the mediator, $R^2_{Y7}$ = .004, *df* = 2, 173, *F* = 2.000, *p* = .670. The direct effect of condition when controlling for follow-up problem norms was not significant (see Table 6, Model 7, path c'). Condition was not related to follow-up use frequency indirectly via problem norms (path a*b), *b* = 0.019, *SE* = 0.059, *95% CI* [-0.119, 0.139].

**Model 8: Impact of problem norms on follow-up use-related problems.**

The total effect model did not account for significant variance in follow-up problems, $R^2_{Y8}$, = .009, *df* = 1, 174, *F* = 1.593, *p* = .209, nor did the full model with the mediator, $R^2_{Y8}$ = .014, *df* = 2, 174, *F* = 1.265, *p* = .285. The direct effect of condition controlling for follow-up norms was not significant (see Table 6, Model 7, path c'). Regarding the test of indirect effects, condition was not related to follow-up problems via follow-up norms (path a*b), *b* = -0.113, *SE* = 0.152, *95% CI* [-0.349, 0.273].

**Model 9: Impact of problem norms on follow-up problem distress.**

The total effect model did not account for significant variance in follow-up problems, $R^2_{Y9}$, = .002, *df* = 1, 131, *F* = 0.262, *p* = .610. The full model with the mediator accounted for significant variance in follow-up cannabis problems, $R^2_{Y9}$ = .108, *df* = 2, 130, *F* = 7.860, *p* < .001. The direct effect of condition controlling for follow-up norms was not significant (see Table 6, Model 9, path c'). Inconsistent with our hypothesis, condition was not indirectly related to follow-up problems via follow-up norms (path a*b), *b* = -0.218, *SE* = 0.482, *95% CI* [-0.730, 1.266].

Table 6. Regression Results for Mediation Models with Norms as the Mediator.

| Y | Path | *b* | *SE* | *t* | *p-value* |
|---|---|---|---|---|---|
| | | $M_1$ Descriptive Norms | | | |
| Model 4: Cannabis use frequency at follow-up | a | 0.304 | 0.279 | 1.089 | .278 |
| | b | 0.250 | 0.123 | 2.031 | .044 |
| | c' | 0.201 | 0.456 | 0.440 | .660 |
| | c | 0.277 | 0.459 | 0.604 | .547 |

(table cont'd.)

| Y | Path | *b* | *SE* | *t* | *p-value* |
|---|---|---|---|---|---|
| | | *$M_1$* Descriptive Norms | | | |
| Model 5: Cannabis use-related problems at follow-up | a | 0.304 | 0.279 | 1.089 | .278 |
| | b | 0.207 | 0.209 | 0.990 | .234 |
| | c’ | -1.022 | 0.773 | -1.322 | .188 |
| | c | -0.959 | 0.770 | -1.245 | .215 |
| Model 6: Cannabis problem distress at follow-up | a | 0.393 | 0.314 | 1.251 | .213 |
| | b | -0.002 | 0.005 | -0.487 | .628 |
| | c’ | 0.299 | 0.462 | 0.648 | .518 |
| | c | 0.318 | 0.459 | 0.693 | .489 |
| *$M_2$* Problem Norms | | | | | |
| Model 7: Cannabis use frequency at follow-up | a | -8.375 | 7.493 | -1.118 | .265 |
| | b | 0.406 | 2.040 | 0.199 | .842 |
| | c’ | -8.509 | 7.543 | -1.128 | .261 |
| | c | -8.375 | 7.493 | -1.118 | .265 |
| Model 8: Cannabis use-related problems at follow-up | a | -8.375 | 7.493 | -1.118 | .265 |
| | b | 0.014 | 0.008 | 1.737 | .084 |
| | c’ | -0.864 | 0.773 | -1.118 | .265 |
| | c | -0.977 | 0.774 | -1.262 | .209 |
| Model 9: Cannabis problem distress at follow-up | a | -3.046 | 7.679 | -0.400 | .692 |
| | b | 0.072 | 0.018 | 3.928 | <.0001 |
| | c’ | -0.645 | 1.601 | -0.403 | .688 |
| | c | -0.863 | 1.686 | -0.512 | .610 |

**Moderators of Condition and Outcome**

Results from moderation analyses are presented in Tables 7-13. The interaction between condition and gender accounted for significant variance in follow up problems, $\Delta R^2 = 0.048$, $F(1, 173) = 8.900$, $p = .003$. Males in the PFI condition reported greater cannabis use-related problems at follow-up than males in the feedback control condition, $b = 3.261$, $SE = 1.607$, $t(3,173) = 2.029$, $p = .044$, *95% CI* [0.089, 6.433], while females in the PFI condition reported fewer problems than females in the feedback control condition, $b = -2.175$, $SE = 0.859$, $t(3,173) = -2.175$, $p = .012$, *95% CI* [-3.871, -0.480] (Table 12, Model 15.2). This moderation is depicted in Figure 4. Baseline cannabis use-related problems did not differ between males ($M = 8.49$, $SD = 6.16$) and females ($M = 7.84$, $SD = 5.26$). The interaction between condition and baseline problem distress accounted for significant variance in follow-up problems, $\Delta R^2 = 0.039$, $F(1, 173) = 8.100$, $p = .005$. Individuals with high levels of problem distress in the PFI condition reported fewer cannabis use-related problems at follow-up compared to those with high levels of problem distress in the feedback control condition, $b = -3.085$, $SE = 0.970$, $t(1,173) = -3.192$, $p = .007$, *95% CI* [-4.993, -1.177] (Table 13, Model 16.2). This moderation is depicted in Figure 5. No other baseline variable interacted significantly with condition to predict any follow-up outcome.

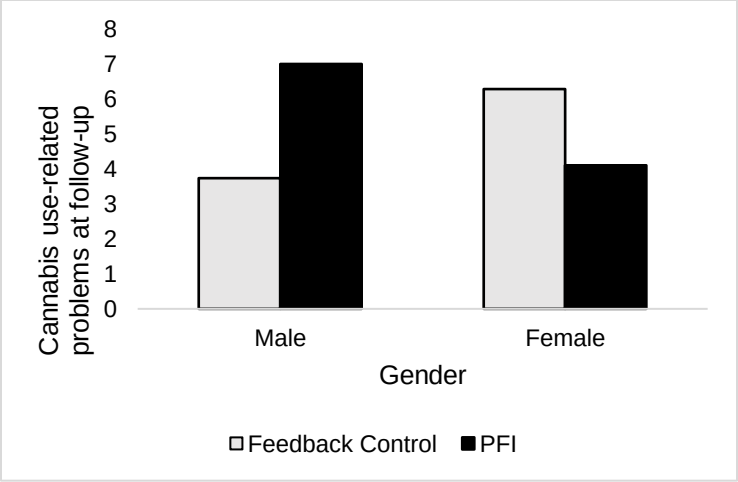


Figure 4. Moderating role of gender on the relationship between condition and use-related problems (Model 15.2).

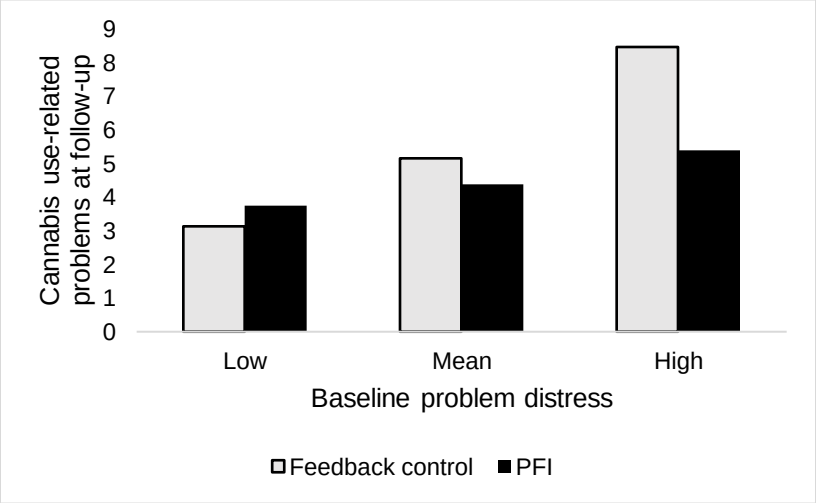


Figure 5. Moderating role of baseline problem distress on the relationship between condition and use-related problems (Model 16.2).

Table 7. Regression Results for Moderation Models with Baseline Frequency as the Moderator.

| | $R^2$ | *F* | *b* | *SE* | *t* | *p-value* | 95% CI (lower) | 95% CI (upper) | $\Delta R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | DV: Follow-up cannabis use frequency | | | | | | |
| Model 10.1 | .693 | 129.899 | - | - | - | <.0001 | - | - | - |
| Condition | - | - | -0.097 | 0.432 | -0.223 | .824 | -0.950 | 0.757 | - |
| Frequency | - | - | 0.788 | 0.060 | 13.020 | <.0001 | 0.668 | 0.907 | - |
| Condition*frequency | - | - | 0.098 | 0.085 | 1.150 | .252 | -0.070 | 0.266 | .002 |
| | | | DV: Follow-up cannabis use problems | | | | | | |
| Model 10.2 | .072 | 4.443 | - | - | - | .005 | - | - | - |
| Condition | - | - | -0.134 | 1.266 | -0.106 | .916 | -2.633 | 2.365 | - |
| Frequency | - | - | 0.514 | 0.177 | 2.904 | .004 | 0.165 | 0.864 | - |
| Condition*frequency | - | 0.632 | -0.198 | 0.249 | -0.795 | .428 | -0.690 | 0.294 | .003 |
| | | | DV: Follow-up perceived risk | | | | | | |
| Model 10.3 | .084 | 5.305 | - | - | - | .002 | - | - | - |
| Condition | - | - | 0.592 | 0.402 | 1.473 | .143 | 0.201 | 1.385 | - |
| Frequency | - | - | -0.104 | 0 .056 | - 1.848 | .066 | -0 .215 | 0 .007 | - |
| Condition*frequency | - | - | -0 .083 | 0 .079 | - 1.055 | .293 | -0 .240 | 0 .073 | .006 |

Table 8. Regression Results for Moderation Models with Baseline Number of Problems as the Moderator.

| | $R^2$ | F | b | SE | t | p-value | 95% CI (lower) | 95% CI (upper) | $\Delta R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | DV: Follow-up cannabis use frequency | | | | | | |
| Model 11.1 | .020 | 1.154 | - | - | - | .329 | - | - | - |
| Condition | - | - | 1.466 | 0.822 | 1.784 | .076 | -0.156 | 3.088 | - |
| Problems | - | - | 0.082 | 0.060 | 1.381 | .169 | -0.035 | 0.200 | - |
| Condition* problems | - | 3.051 | -0.148 | 0.085 | -1.747 | .082 | -0.315 | 0.019 | .017 |
| | | | DV: Follow-up cannabis use problems | | | | | | |
| Model 11.2 | .244 | 18.591 | - | - | - | <.0001 | - | - | - |
| Condition | - | - | 0.567 | 1.216 | 0.466 | .642 | -1.833 | 2.967 | - |
| Problems | - | - | 0.550 | 0.088 | 6.237 | <.0001 | 0.376 | 0.724 | - |
| Condition* problems | - | 2.710 | -0.206 | 0.125 | -1.646 | .102 | -0.454 | 0.041 | .012 |
| | | | DV: Follow-up perceived risk | | | | | | |
| Model 11.3 | .043 | 2.576 | - | - | - | .055 | - | - | - |
| Condition | - | - | 0.527 | 0.437 | 1.206 | .230 | -0.336 | 1.390 | - |
| Problems | - | - | 0.073 | 0.032 | 2.300 | .023 | 0.010 | 0.136 | - |
| Condition* problems | - | 0.633 | -0.036 | 0.045 | -0.796 | .427 | -0.125 | 0.053 | .004 |

Table 9. Regression Results for Moderation Models with Baseline Perceived Risk as the Moderator.

| | $R^2$ | F | b | SE | t | p-value | 95% CI (lower) | 95% CI (upper) | $\Delta R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | DV: Follow-up cannabis use frequency | | | | | | |
| Model 12.1 | .127 | 8.419 | - | - | - | <.0001 | - | - | - |
| Condition | - | - | 2.402 | 1.163 | 2.065 | .040 | 0.106 | 4.697 | - |
| Risk | - | - | -0.310 | 0.174 | -1.783 | .076 | -0.654 | 0.033 | - |
| Condition* risk | - | 3.770 | -0.469 | 0.241 | -1.942 | .054 | -0.945 | 0.008 | .019 |
| | | | DV: Follow-up cannabis use problems | | | | | | |
| Model 12.2 | .019 | 1.126 | - | - | - | .340 | - | - | - |
| Condition | - | - | 1.636 | 2.077 | 0.787 | .432 | -2.464 | 5.735 | - |
| Risk | - | - | 0.330 | 0.311 | 1.063 | .289 | -0.283 | 0.944 | - |
| Condition* risk | - | 1.811 | -0.580 | 0.431 | -1.346 | .180 | -1.431 | 0.271 | .010 |
| | | | DV: Follow-up perceived risk | | | | | | |
| Model 12.3 | .282 | 22.657 | - | - | - | <.0001 | - | - | - |
| Condition | - | - | 0.255 | 0.568 | 0.449 | 0.654 | -0.866 | 1.376 | - |
| Risk | - | - | 0 .483 | 0 .085 | 5.687 | <.0001 | 0.316 | 0.651 | - |
| Condition* risk | - | 0.002 | -0.005 | 0.118 | -0.046 | .963 | -0.238 | 0.227 | .000 |

Table 10. Regression Results for Moderation Models with Baseline RTC as the Moderator.

| | $R^2$ | F | b | SE | t | p-value | 95% CI (lower) | 95% CI (upper) | $\Delta R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | DV: Follow-up cannabis use frequency | | | | | | |
| Model 13.1 | .023 | 1.385 | - | - | - | .249 | - | - | - |
| Condition | - | - | 0.117 | 0.542 | 0.216 | .830 | -0.953 | 1.187 | - |
| RTC | - | - | 0.062 | 0.037 | 1.687 | .093 | -0.011 | 0.135 | - |
| Condition* RTC | - | 0.320 | -0.029 | 0.050 | -0.566 | .572 | -0.128 | 0.071 | .002 |
| | | | DV: Follow-up cannabis use problems | | | | | | |
| Model 13.2 | .060 | 3.670 | - | - | - | .013 | - | - | - |
| Condition | - | - | -1.071 | 0.896 | -1.195 | .234 | -2.840 | 0.698 | - |
| RTC | - | - | 0.139 | 0.061 | 2.283 | .024 | 0.019 | 0.259 | - |
| Condition* RTC | - | 0.070 | -0.022 | 0.083 | -0.264 | .792 | -0.187 | 0.143 | .000 |
| | | | DV: Follow-up perceived risk | | | | | | |
| Model 13.3 | .023 | 1.386 | - | - | - | .249 | - | - | - |
| Condition | - | - | -0.005 | 0.292 | -0.017 | .987 | -0.581 | 0.571 | - |
| RTC | - | - | 0.032 | 0.020 | 1.608 | .110 | -0.007 | 0.071 | - |
| Condition* RTC | - | 2.739 | -0.045 | 0.027 | -1.655 | .100 | -0.099 | 0.009 | .015 |

Table 11. Regression Results for Moderation Models with Family Substance Use History as the Moderator.

| | $R^2$ | F | b | SE | t | p-value | 95% CI (lower) | 95% CI (upper) | $\Delta R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | DV: Follow-up cannabis use frequency | | | | | | |
| Model 14.1 | 0.003 | 0.181 | - | - | - | .909 | - | - | - |
| Condition | - | - | 0.462 | 0.636 | 0.726 | .469 | -0.793 | 1.718 | - |
| Family | - | - | 0.221 | 0.651 | 0.339 | .735 | -1.064 | 1.506 | - |
| Condition* Family | - | 0.179 | -0.391 | 0.923 | -0.423 | .673 | -2.213 | 1.432 | .001 |
| | | | DV: Follow-up cannabis use problems | | | | | | |
| Model 14.2 | 0.021 | 1.251 | - | - | - | .293 | - | - | - |
| Condition | - | - | -0.912 | 1.062 | -0.859 | .392 | -3.007 | 1.084 | - |
| Family | - | - | 1.198 | 1.087 | 1.102 | .272 | -0.948 | 3.344 | - |
| Condition* Family | - | 0.005 | -0.112 | 1.541 | -0.073 | .942 | -3.154 | 2.930 | .000 |
| | | | DV: Follow-up perceived risk | | | | | | |
| Model 14.3 | 0.008 | 0.481 | - | - | - | .696 | - | - | - |
| Condition | - | - | 0.120 | 0.342 | 0.352 | .725 | -0.554 | 0.795 | - |
| Family | - | - | -0.199 | 0.350 | -0.568 | .571 | -0.889 | 0.492 | - |
| Condition* Family | - | 0.329 | 0.285 | 0.496 | 0.574 | .567 | -0.694 | 1.263 | .002 |

Note. Family history of substance use was coded as (0 = no family history, 1 = any family history)

Table 12. Regression Results for Moderation Models with Gender as the Moderator.

| | $R^2$ | F | b | SE | t | p-value | 95% CI (lower) | 95% CI (upper) | $\Delta R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | | DV: Follow-up cannabis use frequency | | | | | |
| Model 15.1 | 0.002 | 0.130 | - | - | - | .942 | - | - | - |
| Condition | - | - | 0.271 | 0.981 | 0.276 | .783 | -1.666 | 2.208 | |
| Gender | - | - | -0.101 | 0.743 | -0.137 | .892 | -1.568 | 1.365 | |
| Condition* Gender | - | 0.000 | 0.015 | 1.113 | 0.014 | .989 | -2.181 | 2.212 | .000 |
| | | | | DV: Follow-up cannabis use problems | | | | | |
| Model 15.2 | 0.057 | 3.510 | - | - | - | .017 | - | - | - |
| Condition | - | - | 3.261 | 1.607 | 2.029 | .044 | 0.089 | 6.433 | - |
| Gender | - | - | 2.549 | 1.217 | 2.095 | .038 | 0.148 | 4.950 | - |
| Condition* Gender | - | 8.900 | -5.436 | 1.822 | -2.983 | .003 | -9.033 | -1.839 | .048 |
| | | | | DV: Follow-up perceived risk | | | | | |
| Model 15.3 | 0.010 | 0.566 | - | - | - | .638 | - | - | - |
| Condition | - | - | 0.621 | 0.527 | 1.180 | .240 | -0.418 | 1.661 | - |
| Gender | - | - | 0.239 | 0.399 | 0.600 | .240 | -0.418 | 1.661 | - |
| Condition* Gender | - | 0.629 | -0.474 | 0.597 | -0.793 | .429 | -1.652 | 0.705 | .004 |

Note. Gender was coded as male = 0, female = 1.

Table 13. Regression Results for Moderation Models with Baseline Problem Distress as the Moderator

| | $R^2$ | F | b | SE | t | p-value | 95% CI (lower) | 95% CI (upper) | $\Delta R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | | DV: Follow-up cannabis use frequency | | | | | |
| Model 16.1 | 0.014 | 0.809 | - | - | - | .490 | - | - | - |
| Condition | - | - | 0.829 | 0.653 | 1.269 | .206 | -0.461 | 2.119 | - |
| Distress | - | - | 0.013 | 0.036 | 0.349 | .727 | -0.059 | 0.084 | - |
| Condition* Distress | - | 1.247 | -0.050 | 0.451 | -1.117 | .266 | -0.140 | 0.039 | .007 |
| | | | | DV: Follow-up cannabis use problems | | | | | |
| Model 16.2 | 0.398 | 10.844 | - | - | - | <.0001 | - | - | - |
| Condition | - | - | 0.818 | 1.017 | 0.804 | .422 | -1.189 | 2.825 | - |
| Distress | - | - | 0.288 | 0.056 | 5.134 | <.0001 | 0.177 | 0.399 | - |
| Condition* Distress | - | 8.100 | -0.200 | 0.070 | -2.846 | .005 | -0.339 | -0.061 | .039 |
| | | | | DV: Follow-up perceived risk | | | | | |
| Model 16.3 | 0.043 | 1.963 | - | - | - | .123 | - | - | - |
| Condition | - | - | 0.053 | 0.358 | 0.149 | .882 | -0.654 | 0.761 | - |
| Distress | - | - | 0.035 | 0.019 | 1.825 | .070 | -0.003 | 0.073 | - |
| Condition* Distress | - | 0.012 | -0.003 | 0.028 | -0.108 | .914 | -0.058 | 0.052 | .000 |

## Secondary Analyses

### Model 17: Impact of condition, perceived risk, and use frequency on problems.

We tested the serial impact of perceived risk and use frequency on the relationship between condition and follow-up problems. The total effects model did not account for significant variance, $R^2_{Y17} = .009$, $df = 1, 175$, $F = 1.550$, $p = .215$. The full model with the mediators accounted for significant variance, $R^2_{Y17} = .175$, $df = 3, 173$, $F = 12.214$, $p < .0001$. The direct effect of condition when controlling for follow-up perceived risk was not significant (see Table 14, path c'). Condition was not significantly related to perceived risk (Table 14, path $a_1$) or to frequency of use (Table 14, path $a_2$). However, perceived risk was significantly related to follow-up frequency of use (Table 14, path $a_3$) and follow-up problems (Table 14, path $b_1$), and follow-up frequency of use was also related to follow-up problems (Table 14, path $b_2$). Tests of indirect effects are presented in Table 15. Condition was not related to follow-up problems via the sequential effect of perceived risk and use frequency (path $a_1$*$a_3$*$b_2$)

Table 14. Model 17: Regression Results for the Serial Mediation Model with Perceived Risk and Use Frequency as Mediators.

| Y | Path | b | SE | t | p-value |
|---|---|---|---|---|---|
| Model 17: # of follow-up cannabis-related problems | $a_1$ | 0.255 | 0.247 | 1.034 | .302 |
| | $a_2$ | 0.415 | 0.441 | 0.942 | .348 |
| | $a_3$ | -0.544 | 0.135 | -4.030 | <.0001 |
| | $b_1$ | 0.766 | 0.227 | 3.380 | .001 |
| | $b_2$ | 0.683 | 0.122 | 5.612 | <.0001 |
| | c' | -1.343 | 0.711 | -1.890 | .060 |
| | c | -0.959 | 0.770 | -1.245 | .215 |

Table 15. Model 17: Bootstrap Estimates of the SEs and 95% CIs for the Indirect Effects of Serial Mediation Analyses.

| Indirect effects | B | SE | 95% Confidence interval |
|---|---|---|---|
| COND → FPR → PROB ($a_1$*$b_1$) | 0.195 | 0.210 | [-0.184, 0.652] |
| COND → FREQ → PROB ($a_2$*$b_2$) | 0.284 | 0.308 | [-0.324, 0.896] |
| COND → FPR → FREQ → PROB ($a_1$*$d_{21}$*$b_2$) | -0.095 | 0.101 | [-0.321, 0.081] |

Note. COND is the independent variable (X), FPR (follow-up perceived risk, $M_1$) and FREQ (follow-up cannabis use frequency, $M_2$) are the mediators, PROB (follow-up cannabis use-related problems, Y) is the outcome. The 95% confidence intervals for indirect effects were obtained by bootstrapping with 10,000 resamples. → = effects. All indirect effect 95% confidence intervals were nonsignificant (i.e., contained zero).

## Discussion

The current study tested whether providing corrective feedback on perceived risk (versus a feedback control condition) via a web-based intervention was related to greater perceived risk and was related to follow-up outcomes (i.e., decreased use frequency, fewer use-related problems, and increased problem distress) among current (past-month) college cannabis users. The current study also tested whether follow-up perceived risk, descriptive norms, and problem norms mediated the relationship between condition and outcomes. Informed by prior research suggesting that online PFI interventions may be efficacious for certain groups (Lee et al., 2010; Palfai et al., 2016), we also tested whether baseline variables (e.g., frequency of use) moderated the relationship between condition and outcomes.

Inconsistent with our hypotheses, condition was not related to follow-up perceived risk, which suggests that a brief, online intervention does not increase perceived risk of cannabis, regardless of whether participants received feedback on perceived risk. Further, condition was not related to follow-up use frequency, related problems, or problem distress, suggesting that PFI outcomes were not superior to those of the feedback control condition. However, follow-up risk was related to follow-up use frequency, problem distress, and problems, suggesting that perceived risk remains an important construct to understand and target in future research. Inconsistent with our hypotheses, neither follow-up descriptive norms nor problem norms mediated the relationship between condition and outcomes. For our moderation analyses, only gender and baseline problem distress moderated the relationship between condition and outcomes.

Gender moderated the relationship between condition and follow-up problems such that males in the PFI condition (compared to males in the feedback control condition) reported

*greater* problems at follow-up while females in the PFI condition (compared to females in the feedback control condition) reported *fewer* problems at follow-up. Importantly, males and females did not differ on number of cannabis-use related problems at baseline. Some gender differences have been found in the limited online cannabis PFI literature. Similar to the results of the current study, males in the PFI condition reported more cannabis abuse symptoms at follow-up than males in an assessment-only control condition while females in the PFI condition reported fewer abuse symptoms at follow-up compared to females in the control condition (Elliott et al., 2014). Females may also be more likely to benefit from online PFIs that include strategies to reduce or prevent substance use (i.e., protective behavior strategies; PBS), as females in the PFI condition increased their use of PBS following the intervention compared to males (Riggs et al., 2018). Differences in PFI efficacy between males and females may be explained in part by gender differences in cannabis use and related problems. Historically, there are greater prevalence rates of cannabis use (Center for Behavioral Health Statistics and Quality, 2017; Schulenberg et al., 2018) and CUD (Hasin et al., 2016; Khan et al., 2013) among males compared to females. College-age males tend to report greater cannabis use-related problems than females (Ecker & Buckner, 2014). Taken together, findings from the current study suggest that the PFI condition was suitable for reducing cannabis-use related problems for females but was related to worse outcomes among males. Future work should investigate the role of gender in online PFIs for cannabis use and particular attention should be paid to targeting use-related problems among males.

Baseline problem distress moderated the relationship between condition and follow-up problems, such that those with high levels of problem distress in the PFI condition reported fewer use-related problems than those with high levels of problem distress in the control

condition. Surprisingly, it was high problem distress, not actual number of problems experienced or RTC, that led to better outcomes in the PFI condition, which suggests that problem distress may be an important target for future intervention work for cannabis users. However, condition was not related to follow-up problem distress and thus, problem distress was likely not changed due to the intervention.

Perceived risk did not significantly differ between baseline and follow-up for either condition, which suggests that perceived risk remained stable from baseline to follow-up and was not impacted by the content of either condition. Although changes in perceived risk have been identified as one of the most important predicators of cannabis use frequency (Bachman et al., 1998), limited research exists on whether risk perception can be modified through treatment. The current study is the first to our knowledge to test whether providing corrective feedback on risk via a web-based intervention changes risk perception. Results from the current study do not support the efficaciousness of a one-session online intervention to modify risk perception. While there is evidence that perceived risk of cannabis does change over time and tends to increase with age (Grevenstein et al., 2015; Terry-McElrath et al., 2017), it does not appear that a single-session online intervention is sufficient as changing perceptions of risk. However, the finding that follow-up perceived risk was related to use frequency at follow-up suggests that it is still an important target for interventions aimed at decreasing cannabis use frequency and perceived risk may require more intensive or longer-term intervention programs to change.

Follow-up descriptive norms were positively associated with cannabis use frequency at follow-up but did not mediate the relationship between condition and outcomes. Prior cannabis PFIs for college students successfully reduced descriptive norms but did not reduce use or problems (Elliott & Carey, 2012; Elliott et al., 2014; Lee et al., 2010; Riggs et al., 2018).

Findings from the current study suggest that increased specificity of descriptive norms feedback may be important to include when providing feedback to cannabis-using students. Gender-specific norms may be especially important to include in future cannabis PFI interventions, given that gender was identified as a moderator of PFI efficacy on follow-up problems. Further, we also examined problem norms, or a participant's estimate of the number of use-related problems that the typical marijuana-using LSU student experiences. Problem norms were not associated with any variables at baseline. Follow-up problem norms were significantly and positively associated with follow-up problems, which is consistent with prior work finding that cannabis-using students tend to overestimate the number of use-related problems that their friends experience and that greater problem norms are positively associated with one's own problems (Ecker et al., 2014). Unfortunately, problem norms at follow-up did not mediate the relationship between condition and outcomes, thus, providing corrective feedback on problem norms in the PFI did not change problem norms. It should be noted that participants in the current study were allowed submit problem normative beliefs as a free-text entry, which may have led to a wide range in responses (0-420 problems).

The results from the current study should be interpreted in light of some limitations that suggest a few potential areas for research in PFIs for cannabis-using college students. First, the majority of the sample was comprised of non-Hispanic White female students recruited from the LSU psychology pool. Future work may benefit from recruitment of a more diverse sample of students. Second, this study relied exclusively on self-report and future work should incorporate other methodologies (e.g., ecological momentary assessment, biological verification of use). Third, this study used questions from the MTF study to measure perceived risk, as these questions have been used to measure the relationship between risk and substance use for over 40

years. However, the language used to ask individuals about perceived risk of cannabis use varies greatly across studies. To illustrate, some studies asked participants to rate the danger of a substance: “How dangerous do you think is the consumption of this substance for people in general?” on a 1 (*harmless*) to 6 (*very dangerous*) scale (Grevenstein et al., 2015), "Of the drugs listed below, how dangerous do you think the drug is to the user?" on a 1 (*not dangerous*) to 5 (*very dangerous*) scale (Duistman & Colbry, 1995). Other studies ask participants to rate interference of using a substance on schoolwork or social life on a 1 (will definitely not interfere) to 4 (will definitely interfere) scale . Other than the MTF survey perceived risk questions, few studies provided psychometrics of their risk-related questions. Further research should examine psychometrics of measures of perceived risk and cannabis use to determine which language best measures the construct of perceived risk.

Although the study hypotheses related to perceived risk were not supported, findings from this study highlight the importance of continuing to investigate constructs that may serve as unique treatment targets for cannabis using college students. Cannabis PFIs for college students may serve as a useful tool to target cannabis use-related problems among females or those with higher levels of distress related to their use-related problems. While perceived risk did not change as a function of condition, follow-up perceived risk was related to cannabis outcomes. Thus, future research is necessary to test whether additional novel treatment components or longer-term, more intensive online interventions change risk perception or improve PFI outcomes among cannabis-using college students.

# Appendix. IRB Approval

**ACTION ON PROTOCOL APPROVAL REQUEST**

Institutional Review Board
Dr. Dennis Landin, Chair
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**TO:** Julia Buckner
Psychology

**FROM:** Dennis Landin
Chair, Institutional Review Board

**DATE:** January 4, 2018

**RE:** **IRB#** 3991

**TITLE:** Targeting Perceived Risk Through and Online Personalized Feedback Intervention

**New Protocol/Modification/Continuation:** New Protocol

**Review type:** Full ___ Expedited X **Review date:** 12/21/2017

**Risk Factor:** Minimal ___X___ Uncertain _____ Greater Than Minimal_____

**Approved**_____X_____ **Disapproved**_____

**Approval Date:** 1/3/2018 **Approval Expiration Date:** 1/2/2019

**Re-review frequency:** (annual unless otherwise stated)

**Number of subjects approved:** 200

**Protocol Matches Scope of Work in Grant proposal:** (if applicable)

**By**: Dennis Landin, Chairman _____

**PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –**
**Continuing approval is CONDITIONAL on:**

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. **SPECIAL NOTE: When emailing more than one recipient, make sure you use bcc.**

**All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb*

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## Vita

Katherine Walukevich-Dienst received a dual Bachelor of Arts Degree in Psychology and Public Relations from Syracuse University in 2014. Following graduation, she was a full-time post-baccalaureate research coordinator at the University of Miami. In 2016, Katherine entered the clinical psychology graduate program at Louisiana State University to work with Dr. Julia Buckner in her Anxiety and Addictive Behaviors Research Laboratory and Clinic (AABC). Katherine's primary research interests include identifying malleable psychosocial factors related to substance use, with an emphasis on cognitive, social, and context-specific differences in use, and applying this knowledge to developing personalized, evidence-based treatments.