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Injunctive and Descriptive Normative Feedback for College Drinking Prevention: Is the Whole Greater than the Sum of its Parts?

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Abstract

Objectives.—Single-component personalized normative feedback (PNF) interventions and multi-component personalized feedback interventions (PFI) have been shown to reduce alcohol consumption among college students. The current study compared the efficacy of PNF interventions targeting descriptive norms alone (Descriptive PNF), injunctive norms alone (Injunctive PNF), or their combination (Combined PNF), against a multi-component PFI and an attention control condition.

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De-identified data and analytic code used in this manuscript is available upon request from the first author.

Portions of these findings in a preliminary form were presented at the Annual Meeting of the Research Society on Alcoholism in 2013, at NIAAA Council in 2021, and at the Association for Behavioral and Cognitive Therapies Special Interest Group meeting in 2021. Data collection and analyses were sponsored by the National Institute on Alcohol Abuse and Alcoholism (R37AA012547; T32AA07455). Secondary analyses of data stemming from this project have been published to address other, ancillary research questions, but no previous publication has examined the effects of intervention that were central to this data collection. Sample size was determined on the basis of a priori power analysis prior to recruitment. All intervention outcome measures are reported; additional measures included only to address secondary research questions are not reported. All participant exclusions are reported. This trial was not preregistered.

Method.—Undergraduates (N = 1,137) across two universities who reported a minimum of one past-month episode of heavy episodic drinking (i.e., 4+/5+ drinks on a single occasion for females/males) completed assessments at baseline and 3-, 6-, and 12-months post-intervention.

Results.—Relative to the attention control, participants in each of the four intervention conditions showed greater reductions in perceived descriptive/injunctive norms, total drinks per week, and alcohol-related consequences. Peak estimated blood alcohol concentration was also reduced in the Injunctive PNF, Combined PNF, and Multi-component PFI conditions, with the latter two conditions showing an advantage for duration of effects. The Multi-component PFI condition also evidenced greater reductions than the Injunctive PNF in descriptive norms at 3-month and injunctive norms at 6- and 12-month follow-ups. No other group comparisons on any outcome were significant.

Conclusions.—Each intervention has merit for use in college student harm-reduction efforts. Single-component or combined PNF could be considered a potential starting point, as PNF is less burdensome than a multi-component PFI when considering ease and length of delivery. Results can inform optimization of norms-based interventions and guide recommendations on efficacious components for reducing alcohol use and harms on college campuses.

Keywords

Alcohol; descriptive norms; injunctive norms; personalized feedback; young adults

College student drinking is an important public health concern due to its prevalence and associated risk for acute and long-term consequences (White & Hingson, 2013). Social norms are implicit or explicit expectations regarding behavior and are often described as *descriptive* (i.e., perceived frequency or amount of peer behavior) or *injunctive* (i.e., how acceptable peers are perceived to view behavior) (Cialdini et al., 1990). Overall, the perception that others drink more or experience more consequences (descriptive norms) and/or are more approving of drinking or experiencing consequences (injunctive norms) is associated with increased alcohol use and consequences (e.g., Graupensperger et al., 2020). However, some studies have shown descriptive norms to be more strongly associated with alcohol use than injunctive norms (Lac & Donaldson, 2018; Neighbors et al., 2008), making the former the more common focus of personalized normative feedback (PNF) interventions. Despite concerns about potential reactance to feedback on injunctive norms (e.g., Pavey et al., 2018), injunctive PNF may hold value in shaping alcohol use, either as an alternative to or in combination with descriptive PNF (e.g., Merrill et al., 2016, 2018); although, the addition of injunctive to descriptive norms feedback has not been shown to universally impact subsequent drinking (e.g., Steers et al., 2016). Thus, research is needed to elucidate the conditions under which descriptive or injunctive norms PNF, or their combination, evince optimal efficacy for reducing alcohol use and consequences.

In addition, research is needed to determine amount of intervention content necessary or optimal to reduce alcohol use and consequences. Ray et al. (2014) found more intervention content or components is better for reducing alcohol use and consequences but only if content is highly personalized; otherwise, interventions with fewer components may produce better outcomes. Research is needed to examine whether imbedding descriptive and

injunctive PNF interventions as components within more comprehensive, multi-component personalized feedback interventions (PFIs; e.g., LaBrie et al., 2013) maximizes efficacy relative to PNF alone.

Present Study

The current study compared efficacy of web-based PNF interventions using descriptive norms alone (Descriptive PNF), injunctive norms alone (Injunctive PNF), or combined descriptive and injunctive norms (Combined PNF) to a web-based Multi-component PFI and an attention control condition in which participants received non-alcohol-related normative feedback. We hypothesized all four interventions (Descriptive PNF, Injunctive PNF, Combined PNF, Multi-component PFI) would be more efficacious than attention control in reducing perceptions of descriptive and injunctive drinking norms, total drinks per week, peak estimated blood alcohol concentration (eBAC), and alcohol-related negative consequences (Hypothesis 1); that Multi-component PFI would further enhance magnitude and duration of efficacy compared to individual and combined PNF interventions (Hypothesis 2); that Combined PNF would outperform single component Injunctive and Descriptive PNF (Hypothesis 3); that Descriptive PNF would be more efficacious than Injunctive PNF, given stronger concurrent relationships with alcohol use for descriptive norms (Hypothesis 4); and, finally, that changes in perceived descriptive and injunctive drinking norms from baseline to 3-month follow-up would mediate effects of all four interventions on alcohol use and consequences at 6- and 12-month follow-ups (Hypothesis 5). We also explored whether intervention effects were moderated by sex.

Method

Participants and Procedures

Invitations to participate in a study of alcohol use and perceptions of drinking in college were mailed and emailed to a random sample of 5,998 undergraduate students in 2010–2011 selected from the rosters maintained by the Registrar's Office at two west coast universities. Invitations included a hyperlink to a 20-min web-based screening survey. Of those invited, 2,767 (46.1%) responded and completed the screening survey (62.8% identified their sex assigned at birth as female). Campus 1 (n_1 = 1,521), a large, public university, has enrollment of approximately 30,000 undergraduates. Campus 2 (n_2 = 1,246) is a mid-sized private university with enrollment of approximately 6,000 undergraduates. Of students completing screening, 1,494 (54%) reported at least one occasion of heavy episodic drinking in the past month (i.e., 4+/5+ drinks on a single occasion for females/males), meeting inclusion criteria for the current study.

Following the screening survey, students who met inclusion criteria were stratified by total drinks consumed per week (10 or less, 11 or more) within each campus and randomized within strata to a minimal assessment control group,[1] an attention control group, or one

[1]Participants in the minimal assessment control condition completed only an abbreviated survey at baseline and the full survey at 12-month follow-up and were therefore not included in the present analyses. A preliminary study compared the repeated assessment and minimal assessment control conditions and found no evidence of assessment reactivity among the repeated assessment control condition analyzed in the present (Graupensperger et al., 2022).

of the four interventions conditions using urn randomization.[2] Participants were then immediately invited to participate in the longitudinal trial via a hyperlink to a web-based baseline survey. Of those who met inclusion criteria, 1,367 (91.50%) completed the baseline survey. Of these, 1,137 were randomized to one of the five conditions used to test hypotheses in the current study.

Immediately after completing baseline, participants were provided with web-based feedback based on condition and given the option to print and/or return to view their feedback online any time over the next 4 weeks. Participants who did not click the hyperlink to view the feedback received automated reminders via email, text, and phone. Participants received invitations and up to six emails, two telephone calls, and one mailed postcard reminder to complete web-based follow-up surveys at 3, 6, and 12 months following baseline (see Figure 1). Sample size was determined prior to recruitment based on a priori power analysis and anticipated attrition. Participants received $15, $25, $25, $30, and $35 for screening, baseline, and 3-, 6-, and 12-month follow-up surveys, respectively, plus a $25 bonus for completing all assessments.

Participants in the analytic sample were 18 to 24 years old (M = 20.13, SD = 1.36; 63.2% female). Racial and ethnic composition was 12.5% Hispanic/Latinx (across all races), 62.6% non-Hispanic White, 12.1% non-Hispanic Asian, 7.5% non-Hispanic multiracial, 2.2% non-Hispanic Black/African American, 1.6% non-Hispanic Hawaiian/Pacific Islander, and 0.3% non-Hispanic American Indian/Alaskan Native; 1.2% provided their own response. Class standing was 14.6% 1st year, 20.2% 2nd year, 25.6% 3rd year, and 39.6% 4th year or higher. Follow-up rates were 1,056 (92.89%), 1,042 (91.64%), and 1,011 (88.92%) at 3-, 6-, and 12-months follow-up, respectively. The study was approved by the Institutional Review Boards of both universities and a Federal Certificate of Confidentiality was obtained. The trial was not pre-registered; we do report how we determined sample size, all data exclusions (if any), all manipulations, and all study outcome measures.

Intervention Conditions

Attention Control—Similar to LaBrie et al. (2013), generic non-alcohol-related feedback was presented in the attention control condition. Control feedback comprised three pages with text and bar graphs presenting information on number of hours spent texting, downloading music, and playing video games in a typical week with one bar each per graph representing (a) participant's own behavior and (b) actual behavior for a typical student on their campus. Participants were also shown their percentile rank compared to other students on their campus (e.g., "Your percentile rank is 60%. This means you text as much or more than 60% of other [campus name] college students").

Descriptive PNF—The web-based Descriptive PNF comprised four pages with text and bar graphs presenting information on number of drinking days per week, average drinks per occasion, peak drinks per occasion, and total average drinks per week with one bar each per graph representing (a) participant's own drinking behavior, (b) their reported perceptions

[2]Randomization occurred after screening, rather than baseline, because the minimal assessment condition received an abbreviated baseline survey.

of a typical student's drinking behavior, and (c) actual drinking norms for a typical student from their campus. Actual norms were gender neutral and derived from screening data collected on each campus, with the behavior of a typical student defined as the average on a given outcome. Participants were also shown their percentile rank compared to other students on their respective campus (e.g., "Your percentile rank is 99%. This means you drink as much or more than 99% of other [campus name] college students"). The choice of a "typical student" reference group was based on prior research (LaBrie et al., 2013) suggesting typical student feedback is associated with similar or larger impacts on alcohol use as more specific reference groups and may be easier to scale.

Injunctive PNF—The web-based Injunctive PNF similarly comprised four pages of text and bar graphs presenting information on acceptability of number of drinking days per week, average drinks per occasion, peak drinks per occasion, and total average drinks per week with one bar each per graph representing (a) level of drinking quantity and frequency the participant viewed as acceptable, (b) participants' reported perceptions of the amount of consumption a typical student on their campus would view as acceptable, and (c) actual norms for the amount of consumption a typical student on their campus found to be acceptable. Actual norms were gender-neutral and derived from screening data collected on each campus, with attitudes of a typical student defined as the average on a given outcome.

Combined PNF—The web-based Combined PNF, which included both descriptive and injunctive drinking norms feedback, comprised the four pages of descriptive normative feedback and four pages of injunctive normative feedback as previously described.

Multi-component PFI—The web-based Multi-component PFI contained 27 pages of interactive information based on assessment results, modeled from previous trials (e.g., LaBrie et al., 2013). Pages 2 and 3 included gender-neutral descriptive and injunctive PNF identical in content to the Combined PNF condition but displayed on a single page for each type of norm. Additionally, Multi-component PFI included information on participants' typical quantity and frequency of alcohol use, peak amount of alcohol consumed on a single occasion, and typical and peak eBAC. It also provided information regarding standard drink size, average rate of alcohol oxidation, how sex differences are correlated with BAC levels, effects of alcohol at different BAC levels, participants' reported alcohol-related negative consequences, estimated calories and financial costs based on total drinks per week, estimated level of alcohol tolerance, risks for alcohol use disorder based on family history and current reported drinking behavior, and tips for reducing risks while drinking (i.e., protective behavioral strategies; PBS). Participants could click hyperlinks throughout the PFI to obtain additional information on calculating standard drink size, sex differences and alcohol use, alcohol oxidation, biphasic effects of alcohol, hangovers, alcohol costs, tolerance, and PBS, as well as provided with a hyperlink to a BAC calculator; hyperlinked content was included in the overall 27 pages of feedback for this condition.

Measures

Baseline and follow-up surveys comprised the same measures and defined a standard drink as 12 oz beer, 10 oz wine cooler, 4 oz wine, 1 oz 100 proof (1¼ oz 80 proof) liquor.

Perceived Descriptive Drinking Norms—The Drinking Norms Rating Form (DNRF; Baer et al., 1991) assessed participants' perception of number of drinks consumed on each day of the week by a typical student on their campus. Responses were summed across each of the 7 days to form a perceived quantity-based descriptive drinking norm composite variable.

Perceived Injunctive Drinking Norms—The DNRF (Baer et al., 1991) was adapted to assess participants' perception of the number of drinks a typical student on their campus would view as acceptable to consume on each day of the week (Krieger et al., 2016). Responses were summed across each of the 7 days to form a perceived quantity-based injunctive drinking norm composite variable.

Typical Weekly Alcohol Quantity—The Daily Drinking Questionnaire (DDQ; Collins et al., 1985) assessed alcohol quantity, defined as total number of standard drink per week. Students were asked to consider a typical week in the past month and indicate number of standard drinks they typically consumed on each day of the week. Responses were summed across each of the 7 days to form a composite score.

Peak Estimated Blood Alcohol Concentration—The Quantity Frequency Peak index (QFP; Marlatt et al., 1998) was used to measure participants' past-month peak eBAC. Participants were asked about the occasion when they drank the most during the past month and how many standard drinks they consumed over how many hours on that occasion. The formula by Matthews and Miller (1979), wherein sex constant equaled 9.0 for females and 7.5 for males, was used to calculate peak eBAC: ([number of standard drinks / 2] × [sex constant / body weight in lbs.]) — (.016 × hours since first sip of alcohol). Scores above 0.40 were recoded to 0.40 (e.g., Martens et al., 2010).

Alcohol-Related Negative Consequences—A 25-item adapted Rutgers Alcohol Problem Index (RAPI) assessed frequency of alcohol-related consequences. Responses ranged from 0 (*never*) to 4 (*10 or more times*). The original RAPI (White & Labouvie, 1989) was 23 items, but two additional items are commonly added (e.g., Geisner et al., 2018): "Drove shortly after having two or more drinks" and "Drove shortly after having four or more drinks." Responses were summed to create a composite index of negative consequences. Internal reliability was strong across all time points (α = .90–.94).

Data Analyses

As interventions were web-based, preliminary analyses evaluated descriptively whether and how many times participants accessed feedback and how long feedback was open on participants' computers; these indicators of participation were then compared across conditions. Primary hypotheses focused on identifying differences in intervention effects at 3, 6, and 12 months post-baseline (Hypotheses 1–4). Thus, time was dummy-coded[3] (i.e.,

[3]We also examined continuous representations of time, such as log-transformation and quadratic. However, the change in outcome variables (among intervention conditions) is notably discontinuous across time points and not always similar across outcomes; thus, given the relatively few time points, a dummy-coding approach provides the best fit and allows precise estimate of intervention comparisons over time.

baseline = 0) and entered into mixed effects models as a main effect (i.e., average effect of time across all conditions) and as a condition × time interaction. Interaction coefficients represent differences between two conditions at a given follow-up, relative to differences between conditions at baseline. Main effect of conditions represents differences between groups at baseline. All models controlled for participants' age, sex assigned at birth, and campus (Public = 0, Private =1).

Outcome variables other than peak eBAC are positively skewed non-negative variables with large variability, ill-suited for statistical methods assuming normality of residuals.[4] Thus, we explored best ways to fit each model to appropriately handle characteristics of these count variables. Models with perceived norms as outcomes were fit using negative binomial regression, while models for total drinks per week and consequences had overdispersed distributions best suited to a zero-inflated negative binomial hurdle model, comprising a logistic portion predicting odds of any drinks/consequences (vs. zero) and a truncated negative binomial portion predicting the count for non-zero responses. In count regression, predictors are connected to outcomes through a natural logarithm link function and coefficients are exponentiated to yield count ratios (CR). A CR of 1 indicates no effect; CRs smaller or larger than 1 indicate percentage reductions or increases in the outcome, respectively. Models were fit in *R* using the 'glmmTMB' package.

To assess if changes from baseline to 3-month follow-up in perceived descriptive and injunctive norms acted as a mechanism of intervention effects on alcohol use and consequences at 6- and 12-month follow-ups (Hypothesis 5), we fit complete case mediation models using the *mediate_zi()* function in the 'maczic' R package. Models appropriately handled negative binomial and zero-inflated distributions in the mediation and outcome pathways, respectively, and estimates/confidence intervals were derived from 1,000 Monte Carlo simulations under a quasi-Bayesian approximation. Mediation analyses entailed decomposing the total effect of each intervention condition (against the attention control) into direct and indirect effects (i.e., causal mediated effects) and interpreting proportion of the total effect explained by the indirect effect as the measure of mediation. For zero-inflated outcome models, estimates of direct, indirect, and total effects are derived from both zero-logistic and zero-truncated count parts of the model.

Results

Feedback Access

Across all conditions, 94.9% of participants clicked the hyperlink to access their feedback at least once (range 1–8 views) over the 4-week access period. The average number of times participants accessed their feedback was similar across conditions (attention control [1.29 views, SD = 0.48], Descriptive PNF [1.38 views, $SD = 0.56$], Injunctive PNF [1.37 views, $SD = 0.73$], Combined PNF [1.35 views, $SD = 0.57$], Multi-component PFI [1.64 views, $SD = 0.83$]). However, participants in Multi-component PFI opened the feedback online significantly more times than all other conditions, $F(4,1112) = 9.63$, $p = .001$, supported by

[4]As used in this study, the RAPI scores are not inherently a count variable, but the distribution of scores entailed a positive skew and large variability, thus requiring negative binomial regression.

post-hoc analyses, *p*s < .001. The first occasion participants accessed their feedback, it was open from 5 s to 51 min with an overall average of 1.77 min (*SD* = 4.75). The average time feedback was open on the first occasion was similar across conditions (attention control [0.58 min, *SD* = 1.82], Descriptive PNF [1.44 min, *SD* = 5.15], Injunctive PNF [1.41 min *SD* = 5.21], Combined PNF [1.04 min, *SD* = 1.96], Multi-component PFI [4.41 min, SD = 6.57]). As might be expected, participants in Multi-component PFI spent significantly more time viewing feedback when first opened than those in all other conditions, $F(4,1051) = 22.95$, $p = .001$, supported by post-hoc analyses, *p*s < .001.

Missingness and Correlates of Attrition

We examined missingness patterns across each condition and potential correlates of attrition at each follow-up. Using logistic regressions, with experimental condition as a categorical independent variable, using the Benjamini-Hochberg adjustment for multiple comparisons, there were no significant differences between any groups on missingness/attrition at the 3-month (*p*s = .14 to .61), 6-month (*p*s = .13 to .96), or 12-month (*p*s = .31 to .93) follow-ups, indicating missingness at each follow-up wave was unrelated to condition. Missingness was uncorrelated with baseline reports of typical drinks per week (*p*s = from .41 to .83), peak eBAC (*p*s = from .34 to .92), and negative consequences (*p*s = from .63 to .98). As such, models were estimated under the assumption that data are missing at random.

Descriptive Pattern of Results

Several descriptive observations are apparent in Figure 2, which presents means for each outcome at all assessment time points (detailed numerical summary shown in Table 1). First, plotting these values with corresponding 95% confidence intervals shows demonstrable raw effects for all intervention conditions relevant to attention control. Most notably, participants in attention control reported relatively stable values for total drinks per week across time points, while all intervention conditions demonstrated stark decreases in total drinks per week at 3-month follow-up. Second, the most noticeable intervention effects generally occurred between baseline and 3-month follow-up, with the exception of negative consequences, which decreased more gradually or did not decrease until 6-month follow-up for intervention conditions. After 3-month follow-up, for the intervention conditions, perceptions of descriptive and injunctive drinking norms began to increase slightly while total drinks per week largely plateaued. Across several conditions, but most notably the attention control, alcohol use and consequence outcomes showed a slight increase at 6-month follow-up relative to 3- and 12-month follow-ups, potentially reflecting the impact of spring break. Finally, mean scores across time in the intervention conditions were generally similar across perceived descriptive and injunctive norms, total drinks per week, peak eBAC, and negative consequences, with minor differences in patterns across time points.

Intervention Conditions Compared to the Attention Control (Hypothesis 1)

To test the first hypothesis, models contrasted each of the intervention conditions to the attention control.[5] Main effects of intervention condition showed no significant differences

[5]We explored whether adding a random intercept and/or slope for ‘campus’ would improve the models by accounting for participants being nested in the two campuses. Adding these intercept and slope parameters (tested separately and in conjunction) had nearly no

at baseline in either descriptive or injunctive norms nor in total drinks per week, peak eBAC, and negative consequences between the intervention conditions and attention control, suggesting successful randomization. Results from the mixed effect models estimating condition effects on perceptions of descriptive and injunctive drinking norms are shown in Table 2.[6] Mixed effects models displaying estimated intervention effects for total drinks per week and peak eBAC are shown in Table 3, and effects for alcohol-related negative consequences are shown in Table 4.

Significant condition × time interactions indicated that, relative to attention control, all four intervention groups showed significantly lower perceived descriptive and injunctive norms at 3-, 6-, and 12-month follow-ups (CRs < 1) with the exception of the Injunctive PNF condition, which was not different than attention control at12-month follow-up for perceived descriptive norms. For total drinks per week, models were disaggregated into logistic and count portions using a zero-inflated hurdle approach. The condition × time interactions indicated no significant effects in the logistic portion of the models (i.e., no effect on abstaining), but the count portion revealed favorable effects of each intervention condition at all three follow-ups compared to control (i.e., ranging from 8–15% fewer drinks per week, on average). With respect to peak eBAC, Combined PNF showed significant relative reductions, almost .02 greater reduction in peak eBAC (on average) compared to attention control, at each follow-up, while greater than .02 reductions in peak eBAC relative to attention control (on average) were evident for Multi-component PFI at 6- and 12-month follow-ups. The effect of Injunctive PNF on peak eBAC was only significantly different than attention control at 6-month follow-up, and Descriptive PNF was non-significantly different from attention control on this outcome at any follow-up.

Similar to total drinks per week, models were disaggregated into logistic and count portions using a zero-inflated hurdle approach for alcohol-related consequences. No significant effects were detected in the logistic portion of the model (i.e., zero consequences vs. any consequences), but condition × time interactions in the count portion showed significant favorable effects for each intervention relative to attention control at 6-month follow-up, ranging from 19–28% relative reduction in consequences (on average). There were no significant effects on consequences at 3 or 12 months for any intervention condition relative to attention control.

Comparing Multi-component PFI to PNF-Only Conditions (Hypothesis 2)

The second series of analyses tested whether outcomes for participants in Multi-component PFI differed from PNF-only conditions. Multi-component PFI was associated with lower perceived *descriptive* norms than Injunctive PNF at 3-month follow-up and lower perceived *injunctive* norms at 6- and 12-month follow-ups (Table 2). However, there were no significant differences between Multi-component PFI and the three PNF conditions in total

effect on the coefficients and upon examining the random effects we found that the variance components for both the random intercept and slope were very near to zero.

[6]Sensitivity analyses controlled for participants' social desirability scores, which had no effect on interpretation of the models. Social desirability scores did not significantly differ between any of the conditions.

drinks per week, peak eBAC, or alcohol-related consequences at any follow-up (Tables 3 and 4).

Comparing Descriptive PNF and Injunctive PNF to the Combined PNF (Hypothesis 3)

The third series of models contrasted Descriptive PNF and Injunctive PNF to Combined PNF. There were no significant differences between Combined PNF and either single-PNF condition on perceived descriptive or injunctive norms (Table 2) nor any alcohol use or consequence outcome (Tables 3 and 4) at any follow-up.

Comparing Descriptive PNF and Injunctive PNF (Hypothesis 4)

The fourth series of models contrasted Descriptive PNF with Injunctive PNF. Descriptive and Injunctive PNF conditions did not differ on perceptions of descriptive or injunctive norms (Table 2), total drinks per week, peak eBAC, or consequences at any follow-up (Tables 3 and 4).

Changes in Perceived Descriptive and Injunctive Norms as Mediators of Intervention Efficacy (Hypothesis 5)

In a final analytic step, we examined the extent to which changes in participants' perceptions of descriptive and injunctive norms from baseline to 3-months follow-up mediated intervention effects at 6- and 12-month follow-ups (see Table 5). Magnitude of indirect effects is estimated as proportion of the total effect explained by the indirect effect of changes in perceived descriptive and injunctive norms, respectively.

Mediation through changes in perceived descriptive norms—Relative to attention control, effects of the Descriptive PNF, Combined PNF, and Multi-Component PFI on total drinks per week at 6-month follow-up were all mediated by reductions in perceived descriptive norms, which explained between 30.4% and 56% of the total effect. Similarly, relative to attention control, effects of Descriptive PNF and Multi-Component PFI on total drinks per week at 12-month follow-up were significantly mediated by reductions in perceived descriptive norms, which explained approximately 50% of the total effect. Although effect of Combined PNF on total drinks per week at 12-month follow-up via reductions in descriptive norms was also significant, overall proportion mediated was non-significant, indicating non-significant mediation overall. No significant mediation via perceived descriptive norms was detected for Injunctive PNF on total drinks per week at 6- or 12-month follow-ups.

Compared with attention control, Injunctive PNF was the only condition in which mediation effects of reduced perceived descriptive norms on peak eBAC at 6-months follow-up were detected, though the proportion mediated was relatively small (i.e., 6.1%). Injunctive PNF was also the only condition to show mediation effects on peak eBAC at 12-month follow-up via reductions in descriptive norms, which explained 14.4% of the total effect. Relative to attention control, no effects on alcohol-related consequences at either 6- or 12-month follow-up for any of the interventions were mediated by reductions in perceived descriptive norms.

Mediation through changes in perceived injunctive norms—Relative to attention control, effects of Injunctive PNF, Combined PNF, and Multi-Component PFI on total drinks per week at 6 months were significantly mediated by reductions in perceived injunctive norms, which explained between 24% and 51.4% of the total effect. Compared to control, effects of all interventions on total drinks per week at 12 months were mediated by reductions in injunctive norms, explaining 37.1%-57.6% of the total effect.

Compared to control, only the effect of Injunctive PNF on peak eBAC at 6-month follow-up was mediated by reductions in perceived injunctive norms, explaining 14.1% of the total effect. At 12-months, the effect of Combined PNF on peak eBAC was mediated by reductions in perceived injunctive norms, explaining 39.3% of the total effect. Relative to attention control, none of the effects on alcohol-related consequences at either 6- or 12-month follow-up for any of the interventions were mediated by reductions in perceived injunctive norms.

Moderation of Treatment Efficacy by Sex Assigned at Birth

In a final exploratory step, we examined whether treatment efficacy was moderated by sex assigned at birth. These models are an extension of the models shown in Tables 3 and 4 but add a 3-way interaction term (i.e., Condition × Time × Sex). Sex assigned at birth did not significantly moderate any effect within models examining perceived descriptive and injunctive norms or peak eBAC as outcomes. For total drinks per week, sex assigned at birth moderated several effects in the logistic portion of the model: Descriptive PNF at 6 and 12 months, Combined PNF at 12 months, and Multi-Component PFI at 3 and 12 months (all relative to attention control). These significant 3-way interactions, shown in Supplemental Table 1, indicate females (relative to males) were more likely to abstain from alcohol in response to the given intervention condition. Only one significant 3-way interaction was detected in the count portion of the model; Combined PNF at 12 months (vs. attention control) was significantly more efficacious for females relative to males. Finally, sex assigned at birth significantly moderated several effects on negative consequences in the logistic portion of the model, but only for Injunctive PNF (at all three time points versus attention control; see Supplemental Table 2). These interactions indicated females, relative to males, were more likely to report zero consequences in response to Injunctive PNF. In the count model for consequences, Combined PNF at 12 months (vs. attention control) was more efficacious for females relative to males.

Discussion

The purpose of the present study was to evaluate efficacy of four interventions containing descriptive and/or injunctive normative feedback against an attention control condition that received non-alcohol-focused normative feedback. Results indicated all four active intervention conditions (Descriptive PNF, Injunctive PNF, Combined PNF, and Multi-component PFI) were associated with reductions in perceived descriptive and injunctive norms relative to attention control. Reductions held across 3-, 6-, and 12-month follow-ups for all groups except Injunctive PNF, which did not differ from attention control at 12 months in perceived descriptive norms. In contrast to some prior research suggesting

short-term effects of norms-based interventions may diminish over time without additional boosters or re-administration of feedback (Neighbors et al., 2010), but consistent with a handful of studies demonstrating online PNF interventions and PFI can have lasting, albeit relatively small, effects (Cole et al., 2018), impacts on total drinks per week were evident by 3-month follow-up and maintained across 12-month follow-up for all four interventions. Impacts on eBAC were more mixed, with significant effects relative to attention control at one or more follow-us for Injunctive PNF, Combined PNF, and Multi-Component PFI, but not Descriptive PNF. Effects of Combined PNF and Multi-component PFI on eBAC persisted to 12-month follow-up relative to attention control. Significant effects of all interventions on alcohol-related consequences at 6-month follow-up are partially consistent with prior research suggesting impacts on alcohol-related consequences generally follow reductions in alcohol use and appear at later follow-ups (Carey et al., 2018). Absence of significant effects on consequences at 12-month follow-up may show a protective effect of the interventions relative to attention control during a high-risk drinking period (i.e., Spring break) occurring during the 6-month follow-up window and/or reflect emerging maturational reductions in alcohol-related consequences among attention control participants by the 12-month follow-up period.

While all intervention conditions were associated with reductions in both perceived descriptive and injunctive norms and alcohol use and consequences relative to attention control, results add to growing support for providing injunctive norms feedback as part of the intervention content. Specifically, presenting feedback on injunctive norms alone or in combination with descriptive norms (Combined PNF and Multi-component PFI) was associated with reduction in all intervention outcomes at one or more follow-ups, whereas feedback on descriptive norms alone did not produce significant reductions in peak eBAC at any follow-up relative to attention control. Thus, although a majority of PNF studies have focused on correcting descriptive norms, current findings show effects of correcting injunctive norms are not significantly different than the other interventions and may have a slight advantage over Descriptive PNF alone with respect to reducing peak intoxication levels.

Findings also suggest participants may generalize feedback about descriptive norms toward their perceptions of injunctive norms, and vice versa. Participants exposed to single component PNFs reduced perceptions of *both* types of norms, which was particularly true of those receiving Descriptive PNF. It would appear that, once one knows other people drink less than previously perceived, one might logically infer other people approve of drinking less than previously perceived as well. The inverse may be somewhat less true; people may approve of more (or less) alcohol consumption than they typically engage in (e.g., an individual limiting their own consumption may still view it as acceptable for someone else to drink more; a person unsuccessful at limiting their own consumption may still view their own and others' drinking with disapproval). Although it may not be as intuitive for participants to infer perceived descriptive norms from perceived injunctive norms, nonetheless current findings suggest correcting either type of norm may hold benefits for correcting misperceptions of both.

Although comparison of individual intervention conditions to attention control suggests some advantages of including injunctive norms as well as some duration advantages of more complex (i.e., combined PNF and Multicomponent PFI) conditions for reducing peak eBAC at 6- and 12-month follow-ups, directly comparing active conditions to each other showed few significant differences on any outcome at any follow-up; only Multicomponent PFI was shown to be related to lower injunctive norms relative to Injunctive PNF at 3-month follow-up and lower descriptive norms than Injunctive PNF at 6- and 12-month follow-ups. These findings suggest overall any of these interventions have utility for reducing alcohol use and consequences, with potentially enduring effects on at least some outcomes.

Regarding mechanisms underlying intervention efficacy, mediation analyses generally supported hypotheses that changes in alcohol use would be driven by changes in perceptions of descriptive and injunctive norms. More specifically, changes in descriptive norms at 3-month follow-up mediated effects of intervention conditions containing descriptive norms feedback (Descriptive PNF, Combined PNF, Multicomponent PFI) on drinks per week at later follow-ups, with the exception of combined PNF at 12 months which was not significantly mediated by descriptive norms. Similarly, effects of intervention conditions containing injunctive norms feedback (Injunctive PNF, Combined PNF, and Multicomponent PFI) on drinks per week at 6- and 12-month follow-ups were mediated by changes in injunctive norms at 3-months. This finding is not in itself novel, as changes in perceived norms have long been thought to be the central mechanism for norm-correcting feedback interventions (e.g., LaBrie et al., 2013). However, the specificity of injunctive and descriptive norms reductions as mediators of conditions containing relevant feedback components on drinks per week provides further support for both descriptive and injunctive norms components and their combination.

Interestingly, effects on peak eBAC were largely not mediated by changes in descriptive or injunctive norms; the only exceptions were for the effect of Injunctive PNF on peak eBAC, which was mediated by changes in both descriptive and injunctive norms at 6-months and descriptive norms at 12-months, and Combined PNF which was mediated by changes in injunctive norms at 12-month follow-up. However, total effects on peak eBAC were fairly small and the proportion mediated by reductions in perceived norms was not as substantial as the drinks per week mediation models, potentially indicating that reducing norms has a more salient indirect effect on total drinking than on peak intoxication. This may suggest a need for outcome-specific normative feedback, such as feedback highlighting that the reference group typically avoids intoxication when they drink. Neither changes in injunctive nor descriptive norms at 3-month follow-up mediated any intervention condition effects on negative consequences at 6- or 12-month follow-ups relative to attention control; these findings may reflect that initial changes in perceived norms mediate changes in drinking behavior, which could in turn produce changes in negative consequences over longer periods of time (Carey et al., 2018). However, serial mediation is beyond the scope of the current study.

With respect to moderators of efficacy, we explored whether impacts of active intervention conditions relative to attention control were moderated by participants' sex assigned at birth. Several significant interaction effects were detected, demonstrating that, relative to

males, females who received descriptive norms PNF alone or in combination with other components (i.e., Descriptive PNF, Combined PNF, Multicomponent PFI) were more likely to report no drinks per week at one or more follow-ups relative to males. Females who did drink also experienced greater reductions in drinks per week in Combined PNF at 12 months relative to males. There were no significant moderation effects by sex in any condition on peak eBAC. With respect to negative consequences, females who received Injunctive PNF were more likely to report experiencing no consequences in the past month at all follow-ups relative to men, and females in Combined PNF reported greater reductions in negative consequences at12-month follow-up relative to men. Taken together, findings suggest interventions are similarly efficacious for both males and females with respect to count outcomes and peak intoxication. However, interventions containing descriptive norms feedback may be particularly useful for females in producing abstinence from alcohol, Injunctive PNF may be particularly useful for females in avoiding all negative consequences of drinking, and Combined PNF may be particularly helpful for females in reducing both drinks per week and negative consequences at long-term follow-up. Because analyses were exploratory, research is needed to replicate findings and further understand mechanisms through which PNF/PFI interventions may differentially impact females versus males, and how findings extend to those with diverse gender identities.

Clinical Implications and Future Directions

Results underscore the value of including descriptive norms PNF in preventive interventions and further support inclusion of injunctive norms PNF into interventions to reduce college student drinking, as both descriptive and injunctive norms mediated alcohol use outcomes. While results comparing each condition to attention control suggested some potential advantages of combining descriptive and injunctive norms PNF (alone or with other PFI components) for some outcomes, direct comparisons of active intervention conditions yielded almost no significant differences between Multi-component PFI and single-component PNF, and no differences relative to Combined PNF, suggesting a need to further consider whether and when it makes sense to imbed PNF components into more comprehensive PFI as compared to relying on simpler single-component or combined PNF. In addition to normative feedback, a number of common components of multi-component PFIs have been shown to be efficacious on their own (e.g., protective behavioral strategies [Martens et al., 2005]; decisional balance [LaBrie et al., 2006]); however, questions remain about how different components interact with each other when implemented together to either enhance or detract from overall impact. Moreover, beyond sex differences, additional research is needed to evaluate how participant characteristics might modify effects of different combinations of intervention components and how best to personalize and optimize interventions to produce the largest effects for the most people.

Collectively, findings suggest a need to further examine factors influencing duration as well as magnitude of PNF/PFI effects. One potential factor is the extent to which attention and/or comprehension may impact the relative lack of additional benefit of the more comprehensive Multi-component PFI relative to Combined PNF or single-component PNF. These factors may be particularly relevant for online or mobile PFI, in contrast to facilitated brief motivational interventions that include feedback, such as BASICS (Dimeff et al., 1999),

as facilitated interventions may benefit from the ability to elaborate on comprehensive content during discussion and ensure participant comprehension. Although the web-based multi-component PFI in the current study was relatively highly personalized (Ray et al., 2014) and included some interactive components and hyperlinks, it did not include elements of gamification or other highly interactive features that might enhance attention and concentration. Prior studies have suggested level of engagement with normative feedback material can be bolstered through gamification of the normative information (e.g., Boyle et al., 2017); though other studies have suggested gamification alone may not produce results that are significantly different than standard PNF and viewing rich profile information regarding peers who were stated as having also competed in the game may be necessary (Boyle et al., 2021; LaBrie et al., 2019). Thus, additional research is needed to evaluate relative merits of more highly interactive feedback compared to simpler feedback designs with respect to engagement, attention, comprehension, efficacy, and scalability. Alternatively, a stepped care approach (e.g., Borsari et al., 2012) that layers a facilitated brief motivational intervention on top of PNF or PFI for students who do not respond to PNF or PFI alone may be necessary to achieve optimal effects.

These questions notwithstanding, the current study suggests campuses could be confident in implementing any of the currently tested interventions, and the simpler Combined PNF, which showed effects on total drinks per week at all three follow-ups relative to attention control, showed effects on negative consequences at 6-month follow-up, and was no different than the Multi-component PFI on any outcome, may have advantages for bringing the interventions to scale. To the extent additional components may be beneficial for different individuals or when addressing specific outcomes, it may be advantageous to consider sequencing these components rather than aggregating them into a single intervention in order to maintain attention, comprehension, and immediate impact of PNF interventions while potentially enhancing duration of effects on drinking outcomes. However, this remains to be empirically tested.

Limitations

The sample was drawn from two west coast campuses and enrolled female students slightly out of proportion with university enrollment estimates; thus, findings may not generalize to all college students or to young adults not enrolled in college. Further, given modest response rates, it is possible response bias may have influenced results in ways that are difficult to verify (e.g., heavier drinkers may have been less likely to participate in the screening survey). At the same time, prior research has suggested non-response to web-based surveys is common and may have minimal impact on parameter estimates, as the most frequently cited reason young adults have for lack of survey response is failing to see the email (Fosnacht et al., 2017). Moreover, retention rates were generally good to excellent across conditions, and analyses suggested randomization produced equivalent groups at baseline, increasing confidence in validity of the intervention findings. All data were collected via self-report, which can be subject to various sources of bias, including recall bias or deliberate under- or over-reporting of studied phenomena. However, self-report of alcohol use and related outcomes is both reliable and valid when appropriate protections are provided for confidentiality and standardized measures are used (Del Boca & Darkes,

2003; Simons et al., 2015), such as in the current study. Though the present analyses were the most parsimonious option for addressing the current study's research questions, more complex longitudinal analyses over longer timespans or with more frequent follow-ups might identify alternative trajectories/slopes in effects of the interventions. Given the number of statistical comparisons, traditional adjustments would be overly conservative and drastically increase likelihood of Type-II error. Although we note that the numerous tests may inflate likelihood of Type-I error, this concern is lessened through a priori theory-driven hypotheses. Lastly, whereas we generally found no significant effects when comparing active intervention conditions, this is not sufficient evidence to conclude equivalent efficacy (i.e., non-inferiority analyses are needed to make such conclusions).

Conclusions

Despite evidence of general efficacy of norms-based interventions, various norms-based strategies have rarely been compared directly. Although results of the current study suggest all the interventions tested have merit for use in college student alcohol-related prevention efforts, specific comparisons of various intervention components revealed limited advantage of the comprehensive Multi-component PFI relative to the Injunctive PNF and lasting effects of the more minimal Combined PNF. Results also provided novel evidence college students may generalize different types of normative feedback; for example, feedback regarding peers' alcohol use behavior (descriptive norms) reduced perceptions of peers' attitudes/approval toward alcohol use (injunctive norms), and changes in both descriptive and injunctive norms are important mechanisms of intervention effects. Taken together, these results can inform optimization of norms-based interventions for reducing alcohol use and related harms on college campuses.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Public Health Significance Statement

This study examined relative efficacy of four web-based interventions for college student drinking containing normative feedback, all of which showed evidence of efficacy compared to an attention control condition. The three personalized normative feedback interventions (focused individually on descriptive and injunctive norms and their combination) showed relatively comparable efficacy to a comprehensive multi-component personalized feedback intervention (inclusive of both types of normative feedback and other elements) and may be easier to scale.

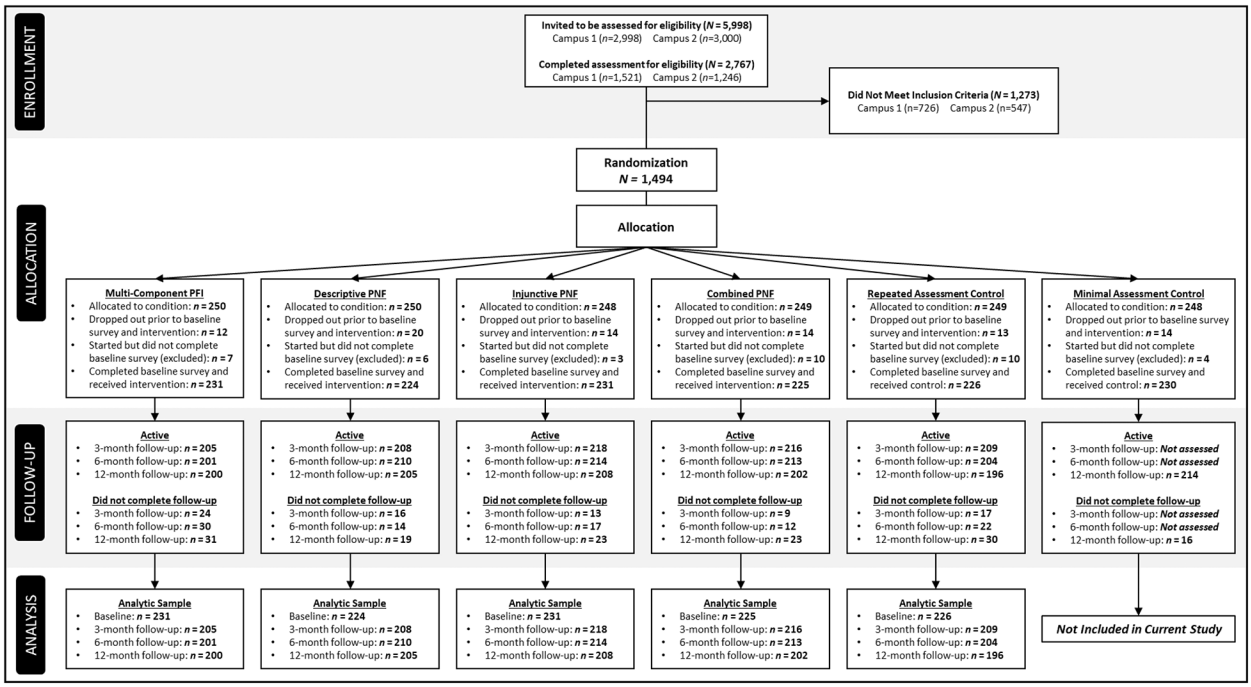

Figure 1.
Consort Diagram

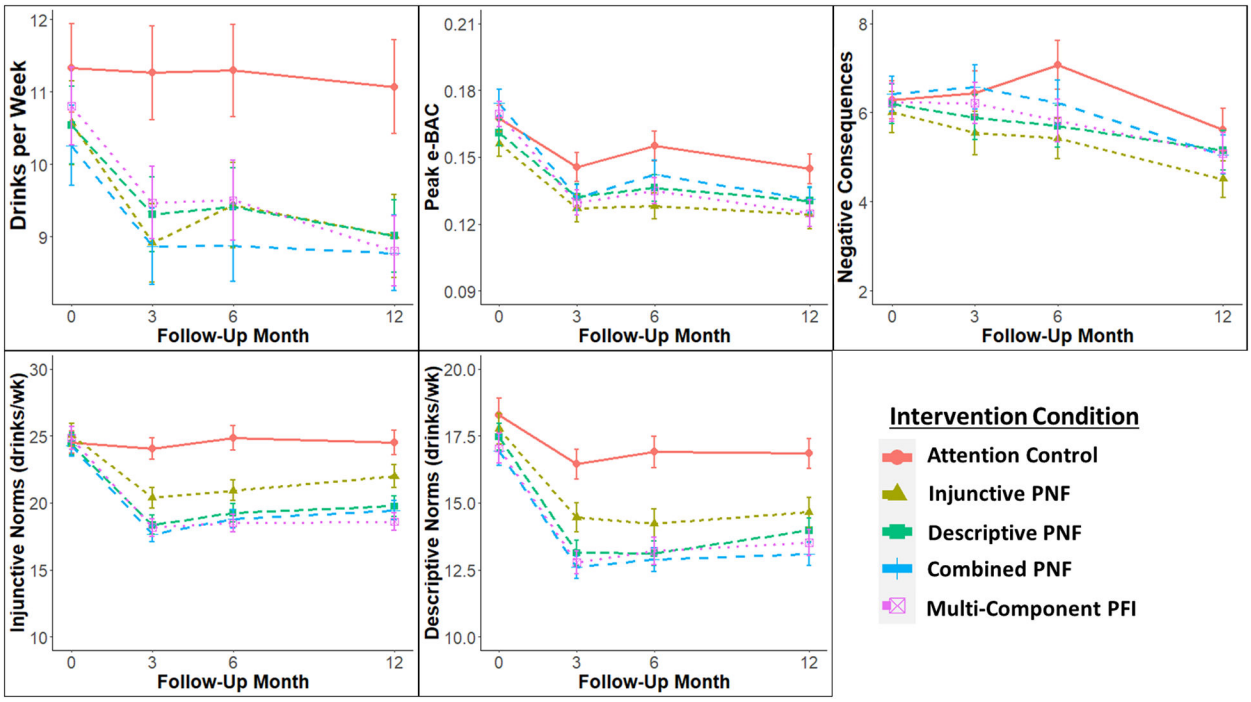

Figure 2.

Mean Values for Outcome Variables at Each Assessment, Stratified by Condition.

Note. Time 0 is baseline. Error bars represent 95% Confidence Intervals

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Table 1.

Mean Outcomes by Experimental Condition at Each Assessment.

	Proportion of Zeros	Control	Injunctive PNF		Descriptive PNF		Combined PNF		Multi-Component PFI	
		Mean (SD)	Mean (SD)	*d*	Mean (SD)	*d*	Mean (SD)	*d*	Mean (SD)	*d*
Perceived Descriptive Norms										
Baseline	0.1%	18.6 (10.4)	18.1 (10.1)		17.3 (7.6)		16.9 (8.7)		17.3 (9.2)	
3 months	0.5%	16.7 (9.7)	14.7 (9.5)	*0.21*	13.2 (7.5)	*0.40*	12.6 (6.4)	*0.50*	12.9 (7.3)	*0.44*
6 months	0.7%	17.3 (10.7)	14.4 (8.9)	*0.30*	13.1 (6.9)	*0.47*	12.9 (6.6)	*0.49*	13.3 (8.1)	*0.42*
12 months	0.6%	16.9 (8.7)	15.2 (11.5)	*0.17*	14.0 (6.8)	*0.37*	13.1 (6.5)	*0.49*	13.6 (7.6)	*0.40*
Perceived Injunctive Norms										
Baseline	0.1%	24.4 (13.3)	25.5 (14.7)		24.5 (13.3)		24.5 (13.6)		25.0 (14.3)	
3 months	0.4%	24.9 (15.5)	20.8 (13.4)	*0.28*	18.4 (10.5)	*0.49*	17.7 (9.1)	*0.57*	18.4 (11.4)	*0.48*
6 months	0.4%	25.5 (16.3)	21.2 (13.2)	*0.29*	19.3 (10.4)	*0.45*	18.9 (10.8)	*0.48*	18.8 (11.5)	*0.47*
12 months	0.8%	25.3 (17.2)	22.3 (14.5)	*0.19*	19.8 (12.1)	*0.37*	19.4 (10.7)	*0.41*	18.8 (11.8)	*0.44*
Total Drinks per Week										
Baseline	4.6%	12.0 (12.3)	10.7 (9.1)		10.8 (9.0)		10.8 (10.7)		10.7 (8.4)	
3 months	8.6%	11.8 (12.0)	9.0 (8.7)	*0.27*	9.4 (8.1)	*0.23*	9.1 (9.4)	*0.25*	9.5 (7.7)	*0.23*
6 months	9.8%	11.9 (12.1)	9.5 (9.2)	*0.22*	9.5 (8.7)	*0.23*	8.9 (7.7)	*0.30*	9.6 (8.7)	*0.22*
12 months	8.9%	11.7 (12.6)	9.1 (9.0)	*0.24*	9.1 (8.0)	*0.25*	8.9 (8.4)	*0.26*	8.9 (7.9)	*0.27*
Peak eBAC										
Baseline	0.4%	.167 (.093)	.161 (.087)		.156 (.086)		.174 (.091)		.169 (.087)	
3 months	5.6%	.145 (.101)	.132 (.090)	*0.13*	.127 (.094)	*0.18*	.132 (.086)	*0.13*	.130 (.085)	*0.15*
6 months	5.6%	.155 (.104)	.136 (.091)	*0.18*	.128 (.089)	*0.26*	.142 (.098)	*0.13*	.135 (.091)	*0.19*
12 months	6.2%	.145 (.102)	.131 (.088)	*0.14*	.124 (.097)	*0.21*	.131 (.087)	*0.14*	.125 (.091)	*0.20*
Alcohol-Related Negative Consequences										
Baseline	14.9%	6.7 (8.1)	6.3 (9.0)		6.6 (8.7)		6.6 (6.4)		6.4 (7.5)	
3 months	20.2%	6.8 (9.5)	5.9 (9.0)	*0.10*	6.2 (9.1)	*0.06*	6.9 (9.2)	*−0.01*	6.6 (8.9)	*0.02*
6 months	20.7%	7.6 (10.5)	5.5 (7.2)	*0.23*	5.9 (8.1)	*0.18*	6.5 (8.6)	*0.12*	6.4 (9.9)	*0.12*
12 months	24.3%	6.3 (10.2)	4.7 (7.4)	*0.18*	5.4 (7.8)	*0.10*	5.3 (8.1)	*0.11*	5.6 (9.1)	*0.07*

Note. Effect size estimates (*Cohen's d*) should only be interpreted descriptively, as more rigorous models accounting for covariates and change from baseline are shown in Tables 2, 3, & 4.

Table 2.

Mixed Effects Negative Binomial Models Estimating Intervention Effects on Perceived Descriptive and Injunctive Norms via Condition × Time Interactions.

	Perceived Descriptive Norms	Perceived Injunctive Norms
	CR [95% CI]	CR [95% CI]
Age	0.98 [0.96, 0.99] *	1.00 [0.98, 1.02]
Sex Assigned at Birth (M = 0; F = 1)	0.98 [0.93, 1.04]	0.86 [0.82, 0.91] ***
Campus (Public = 0, Private = 1)	1.15 [1.09, 1.21] ***	0.98 [0.93, 1.04]
Main Effect of Time (Ref = Baseline)		
3-months Follow-Up	0.894 [0.84, 0.95] ***	1.00 [0.93, 1.07]
6-months Follow-Up	0.93 [0.89, 0.99] *	1.03 [0.96, 1.10]
12-months Follow-Up	0.90 [0.85, 0.96] **	0.99 [0.92, 1.07]
Intervention Condition at Baseline (Ref = Control)		
Injunctive PNF	0.98 [0.89, 1.08]	1.05 [0.95, 1.16]
Descriptive PNF	0.98 [0.89, 1.07]	1.03 [0.93, 1.13]
Combined PNF	0.94 [0.86, 1.04]	1.05 [0.95, 1.16]
Multi-Component PFI	0.94 [0.86, 1.03]	1.04 [0.95, 1.15]
Condition × Time Interactions		
Models Comparing PNF and Multi-Component PFI to the Attention Control (Ref = Control × Time)		
Injunctive PNF × 3-months	0.91 [0.83, 0.98] *	0.80 [0.72, 0.88] ***
Injunctive PNF × 6-months	0.86 [0.79, 0.94] ***	0.80 [0.72, 0.88] **
Injunctive PNF × 12-months	0.92 [0.84, 1.01]	0.85 [0.77, 0.95] ***
Descriptive PNF × 3-months	0.84 [0.77, 0.92] ***	0.74 [0.67, 0.82] ***
Descriptive PNF × 6-months	0.80 [0.74, 0.88] ***	0.76 [0.69, 0.85] ***
Descriptive PNF × 12-months	0.89 [0.82, 0.98] *	0.81 [0.73, 0.89] ***
Combined PNF × 3-months	0.84 [0.77, 0.91] ***	0.71 [0.64, 0.79] ***
Combined PNF × 6-months	0.82 [0.75, 0.89] ***	0.73 [0.66, 0.81] ***
Combined PNF × 12-months	0.87 [0.79, 0.95] **	0.80 [0.72, 0.88] ***
Multi-Component PFI × 3-months	0.82 [0.75, 0.90] ***	0.73 [0.66, 0.81] ***
Multi-Component PFI × 6-months	0.80 [0.73, 0.88] ***	0.71 [0.64, 0.79] ***
Multi-Component PFI × 12-months	0.86 [0.78, 0.94] ***	0.75 [0.67, 0.83] ***
Models Comparing PNF to the Multi-Component PFI (Ref = Multi-Component PFI × Time)		
Injunctive PNF × 3-months	1.10 [1.01, 1.20] *	1.09 [0.99, 1.21]
Injunctive PNF × 6-months	1.07 [0.97, 1.17]	1.12 [1.01, 1.24] *
Injunctive PNF × 12-months	1.07 [0.98, 1.18]	1.15 [1.03, 1.27] *
Descriptive PNF × 3-months	1.02 [0.93, 1.12]	1.02 [0.92, 1.13]
Descriptive PNF × 6-months	1.00 [0.91, 1.10]	1.08 [0.97, 1.19]
Descriptive PNF × 12-months	1.04 [0.95, 1.14]	1.08 [0.97, 1.20]

	Perceived Descriptive Norms	Perceived Injunctive Norms
	CR [95% CI]	CR [95% CI]
Combined PNF × 3-months	1.02 [0.93, 1.11]	0.99 [0.89, 1.10]
Combined PNF × 6-months	1.02 [0.93, 1.12]	1.03 [0.93, 1.14]
Combined PNF × 12-months	1.01 [0.92, 1.11]	1.08 [0.97, 1.19]
Models Comparing Descriptive PNF and Injunctive PNF to the Combined PNF (Ref = Combined PNF × Time)		
Injunctive PNF × 3-months	1.08 [0.99, 1.17]	1.11 [1.00, 1.23]
Injunctive PNF × 6-months	1.04 [0.95, 1.14]	1.09 [0.98, 1.20]
Injunctive PNF × 12-months	1.05 [0.96, 1.14]	1.06 [0.96, 1.18]
Descriptive PNF × 3-months	1.00 [0.91, 1.09]	1.03 [0.93, 1.15]
Descriptive PNF × 6-months	0.98 [0.89, 1.07]	1.04 [0.94, 1.16]
Descriptive PNF × 12-months	1.03 [0.94, 1.12]	1.00 [0.90, 1.11]
Models Comparing Injunctive PNF to Descriptive PNF (Ref = Descriptive Norms PNF × Time)		
Injunctive PNF × 3-months	1.08 [0.99, 1.18]	1.07 [0.97, 1.19]
Injunctive PNF × 6-months	1.07 [0.98, 1.17]	1.04 [0.94, 1.15]
Injunctive PNF × 12-months	1.02 [0.93, 1.12]	1.06 [0.96, 1.17]

Note: Time was dummy coded and treated as categorical. CR = Rate Ratios.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 3.

Mixed Effects Models Estimating Intervention Effects on Alcohol Use via Condition × Time Interactions

	Total Drinks per Week (DDQ)		Peak eBAC (%)
	Logistic Model	*Truncated Count Model*	
	AOR [95% CI]	**CR [95% CI]**	***b* (SE)**
Age	0.89 [0.71, 1.11]	0.94 [0.91, 0.97]***	−1.23 (0.16)***
Birth Sex (M = 0; F = 1)	1.21 [0.65, 2.25]	0.64 [0.59, 0.69]***	0.66 (0.43)
Campus (Public = 0, Private = 1)	0.74 [0.40, 1.37]	1.10 [1.02, 1.20]*	0.81 (0.43)
Main Effect of Time (Ref = Baseline)			
3month Follow-Up	1.42 [0.46, 4.35]	0.98 [0.92, 1.03]	−2.50 (0.62)***
6month Follow-Up	1.69 [0.55, 5.23]	1.02 [0.97, 1.08]	−1.15 (0.63)
12month Follow-Up	2.01 [0.66, 6.17]	0.99 [0.93, 1.04]	−2.36 (0.64)***
Intervention Condition at Baseline (Ref = Control)			
Injunctive Norms PNF	0.93 [0.23, 3.75]	0.92 [0.81, 1.05]	−0.98 (0.83)
Descriptive Norms PNF	0.59 [0.13, 2.64]	0.96 [0.84, 1.09]	−0.73 (0.83)
Combined PNF	0.46 [0.10, 2.09]	0.94 [0.83, 1.08]	0.63 (0.83)
Multi-Component PFI	0.52 [0.12, 2.34]	0.94 [0.83, 1.07]	0.05 (0.82)
Condition × Time Interactions			
Models Comparing PNF and Multi-Component PFI to the Attention Control (Ref = Control × Time)			
Injunctive PNF × 3-months	2.80 [0.65, 12.05]	0.90 [0.83, 0.98]*	−0.40 (0.88)
Injunctive PNF × 6-months	3.31 [0.77, 14.26]	0.91 [0.84, 0.99]*	−1.76 (0.89)*
Injunctive PNF × 12-months	2.79 [0.65, 11.96]	0.92 [0.84, 1.00]*	−0.91 (0.90)
Descriptive PNF × 3-months	2.00 [0.40, 9.91]	0.92 [0.85, 1.00]*	−0.42 (0.88)
Descriptive PNF × 6-months	2.62 [0.53, 12.87]	0.91 [0.84, 0.99]*	−1.28 (0.89)
Descriptive PNF × 12-months	1.41 [0.29, 6.98]	0.89 [0.82, 0.97]**	−0.78 (0.90)
Combined PNF × 3-months	4.04 [0.83, 19.73]	0.89 [0.82, 0.97]**	−1.80 (0.88)*
Combined PNF × 6-months	4.25 [0.86, 20.92]	0.88 [0.81, 0.95]**	−1.93 (0.88)*
Combined PNF × 12-months	2.92 [0.60, 14.34]	0.90 [0.83, 0.98]*	−1.80 (0.90)*
Multi-Component PFI × 3-months	3.12 [0.63, 15.32]	0.92 [0.85, 1.00]*	−1.53 (0.89)
Multi-Component PFI × 6-months	3.71 [0.75, 18.28]	0.89 [0.82, 0.97]**	−2.44 (0.89)**
Multi-Component PFI × 12-months	2.85 [0.58, 14.07]	0.85 [0.78, 0.92]***	−2.25 (0.90)**
Models Comparing PNF to the Multi-Component PFI (Ref = Multi-Component PFI × Time)			
Injunctive PNF × 3-months	0.90 [0.21, 3.81]	0.97 [0.86, 1.09]	−0.39 (0.61)
Injunctive PNF × 6-months	0.90 [0.21, 3.77]	1.03 [0.91, 1.16]	0.09 (0.62)
Injunctive PNF × 12-months	0.98 [0.23, 4.18]	1.08 [0.96, 1.22]	0.38 (0.62)
Descriptive PNF × 3-months	0.65 [0.13, 3.14]	1.00 [0.89, 1.13]	−0.05 (0.62)
Descriptive PNF × 6-months	0.71 [0.15, 3.38]	1.02 [0.91, 1.15]	0.24 (0.62)
Descriptive PNF × 12-months	0.51 [0.10, 2.48]	1.06 [0.94, 1.19]	0.48 (0.62)
Combined PNF × 3-months	1.29 [0.27, 6.16]	0.98 [0.87, 1.10]	−0.38 (0.61)

	Total Drinks per Week (DDQ)		Peak eBAC (%)
	Logistic Model	*Truncated Count Model*	
	AOR [95% CI]	**CR [95% CI]**	***b* (SE)**
Combined PNF × 6-months	1.15 [0.24, 5.47]	1.00 [0.89, 1.13]	−0.14 (0.62)
Combined PNF × 12-months	1.03 [0.21, 5.01]	1.08 [0.96, 1.22]	0.43 (0.63)
Models Comparing Descriptive PNF and Injunctive PNF to the Combined PNF (Ref = Combined PNF × Time)			
Injunctive PNF × 3-months	0.70 [0.17, 2.92]	0.99 [0.88, 1.12]	1.40 (0.86)
Injunctive PNF × 6-months	0.79 [0.19, 3.26]	1.03 [0.91, 1.16]	0.16 (0.86)
Injunctive PNF × 12-months	0.95 [0.23, 3.99]	1.00 [0.89, 1.14]	0.89 (0.87)
Descriptive PNF × 3-months	0.51 [0.11, 2.41]	1.03 [0.91, 1.16]	1.38 (0.86)
Descriptive PNF × 6-months	0.62 [0.13, 2.92]	1.02 [0.91, 1.15]	0.64 (0.86)
Descriptive PNF × 12-months	0.49 [0.10, 2.38]	0.98 [0.87, 1.11]	1.02 (0.88)
Models Comparing Injunctive PNF to Descriptive PNF (Ref = Descriptive PNF × Time)			
Injunctive PNF × 3-months	1.40 [0.32, 6.05]	0.97 [0.86, 1.09]	0.02 (0.86)
Injunctive PNF × 6-months	1.26 [0.30, 5.35]	1.01 [0.90, 1.13]	−0.48 (0.86)
Injunctive PNF × 12-months	1.96 [0.45, 8.52]	1.02 [0.91, 1.15]	−0.13 (0.87)

Note: Time was dummy coded and treated as categorical. CR = Count Ratios.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 4.

Mixed Effects Models Estimating Intervention Effects on Negative Alcohol-Related Consequences via Condition × Time Interactions

	Negative Consequences	
	Logistic Model	***Truncated Count Model***
	AOR [95% CI]	**CR [95% CI]**
Age	1.30 [1.13, 1.49]	0.98 [0.94, 1.02]
Birth Sex (M = 0; F = 1)	0.98 [0.68, 1.42]	0.83 [0.74, 0.94]**
Campus (Public = 0, Private = 1)	0.90 [0.62, 1.30]	1.12 [0.99, 1.26]
Main Effect of Time (Ref = Baseline)		
3month Follow-Up	1.52 [0.78, 2.98]	1.00 [0.87, 1.16]
6month Follow-Up	2.29 [1.19, 4.40]*	1.19 [1.03, 1.38]*
12month Follow-Up	2.64 [1.37, 5.08]**	0.95 [0.82, 1.11]
Intervention Condition at Baseline (Ref = Control)		
Injunctive Norms PNF	2.42 [1.10, 5.30]*	1.04 [0.84, 1.29]
Descriptive Norms PNF	1.09 [0.48, 2.47]	1.02 [0.82, 1.26]
Combined PNF	0.89 [0.39, 2.05]	1.08 [0.87, 1.33]
Multi-Component PFI	1.24 [0.55, 2.77]	1.00 [0.81, 1.24]
Condition × Time Interactions		
Models Comparing PNF and Multi-Component PFI to the Attention Control (Ref = Control × Time)		
Injunctive PNF × 3-months	1.17 [0.48, 2.85]	0.90 [0.74, 1.11]
Injunctive PNF × 6-months	0.66 [0.27, 1.59]	0.72 [0.58, 0.88]**
Injunctive PNF × 12-months	1.14 [0.48, 2.73]	0.86 [0.69, 1.07]
Descriptive PNF × 3-months	1.27 [0.50, 3.26]	0.91 [0.75, 1.12]
Descriptive PNF × 6-months	0.72 [0.29, 1.84]	0.75 [0.61, 0.91]**
Descriptive PNF × 12-months	1.11 [0.44, 2.79]	0.86 [0.70, 1.06]
Combined PNF × 3-months	1.32 [0.51, 3.42]	1.01 [0.83, 1.24]
Combined PNF × 6-months	0.88 [0.34, 2.23]	0.76 [0.62, 0.93]**
Combined PNF × 12-months	1.52 [0.60, 3.83]	0.89 [0.72, 1.10]
Multi-Component PFI × 3-months	1.31 [0.52, 3.32]	1.00 [0.82, 1.23]
Multi-Component PFI × 6-months	1.06 [0.43, 2.65]	0.81 [0.66, 0.99]*
Multi-Component PFI × 12-months	1.32 [0.53, 3.27]	0.95 [0.77, 1.18]
Models Comparing PNF to the Multi-Component PFI (Ref = Multi-Component PFI × Time)		
Injunctive PNF × 3-months	0.90 [0.38, 2.11]	0.91 [0.74, 1.11]
Injunctive PNF × 6-months	0.62 [0.26, 1.48]	0.93 [0.76, 1.14]
Injunctive PNF × 12-months	0.87 [0.37, 2.03]	0.93 [0.75, 1.15]
Descriptive PNF × 3-months	0.97 [0.39, 2.41]	0.91 [0.75, 1.11]
Descriptive PNF × 6-months	0.68 [0.27, 1.70]	0.95 [0.78, 1.16]
Descriptive PNF × 12-months	0.84 [0.34, 2.07]	0.93 [0.75, 1.14]
Combined PNF × 3-months	1.01 [0.40, 2.54]	1.00 [0.82, 1.21]
Combined PNF × 6-months	0.82 [0.33, 2.07]	0.96 [0.79, 1.17]

	Negative Consequences	
	Logistic Model	***Truncated Count Model***
	AOR [95% CI]	**CR [95% CI]**
Combined PNF × 12-months	1.15 [0.47, 2.84]	0.95 [0.77, 1.16]
Models Comparing Descriptive PNF and Injunctive PNF to the Combined PNF (Ref = Combined PNF × Time)		
Injunctive PNF × 3-months	0.89 [0.37, 2.14]	0.91 [0.75, 1.11]
Injunctive PNF × 6-months	0.76 [0.31, 1.83]	0.97 [0.80, 1.19]
Injunctive PNF × 12-months	0.76 [0.32, 1.80]	0.98 [0.79, 1.22]
Descriptive PNF × 3-months	0.96 [0.38, 2.43]	0.91 [0.75, 1.11]
Descriptive PNF × 6-months	0.83 [0.33, 2.10]	0.99 [0.81, 1.20]
Descriptive PNF × 12-months	0.73 [0.29, 1.83]	0.98 [0.79, 1.20]
Models Comparing Injunctive PNF to Descriptive PNF (Ref = Descriptive PNF × Time)		
Injunctive PNF × 3-months	0.92 [0.39, 2.20]	1.00 [0.81, 1.22]
Injunctive PNF × 6-months	0.91 [0.38, 2.19]	0.99 [0.80, 1.21]
Injunctive PNF × 12-months	1.03 [0.43, 2.45]	1.01 [0.81, 1.25]

Note: Time was dummy coded and treated as categorical. CR = Count Ratios.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 5.

Indirect Effects of the Interventions (in Comparison to Attention Control) on Alcohol Use and Alcohol-Related Negative Consequences at 6- and 12-Month Follow-Ups via Changes in Perceived Norms (from Baseline to 3-Month Follow-Up)

	Total Drinks per Week				Peak eBAC (%)				Alcohol-Related Negative Consequences			
	Causal Mediated Effect	**Direct Effect**	**Total Effect**	**Proportion Mediated (%)**	**Causal Mediated Effect**	**Direct Effect**	**Total Effect**	**Proportion Mediated (%)**	**Causal Mediated Effect**	**Direct Effect**	**Total Effect**	**Proportion Mediated (%)**
Mediator = Change in Perceived Descriptive Norms												
6-Month Follow-Up												
Descriptive PNF	−0.78**	−1.70	−2.48**	**30.4%****	−0.03	−1.78*	−1.81*	**1.9%**	−0.03	−1.54	−1.57	**2.1%**
Injunctive PNF	−0.60	−2.09	−2.69*	**21.3%**	−0.19**	−2.72***	−2.91***	**6.1%****	−0.02	−1.77*	−1.79*	**0.9%**
Combined PNF	−1.32***	−0.88	−2.20*	**58.7%***	−0.18	−1.92*	−2.10*	**9.0%**	−0.11	−1.21	−1.32	**7.0%**
Multi-Component PFI	−1.51***	−1.16	−2.67**	**56.0%****	0.05	−2.76**	−2.71**	**−1.8%**	−0.64**	−0.85	−1.49	**37.6%**
12-Month Follow-Up												
Descriptive PNF	−0.94***	−0.96	−1.90*	**47.9%***	−0.45***	−0.62	−1.07	**34.1%**	−0.33	−1.19	−1.52	**17.2%**
Injunctive PNF	−0.53	−2.01*	−2.54**	**21.1%**	−0.26***	−1.45	−1.71*	**14.4%***	−0.05	−0.91	−0.96	**2.4%**
Combined PNF	−0.96***	−0.56	−1.52	**56.8%**	−0.65***	−0.91	−1.60*	**39.9%**	−0.38***	−0.17	−0.55	**59.2%** (†)
Multi-Component PFI	−1.51***	−1.18	−2.69**	**56.2%****	−0.39	−1.80	−2.19*	**17.6%**	−0.56**	0.48	−0.08	**24.5%**
Mediator = Change in Perceived Injunctive Norms												
6-Month Follow-Up												
Descriptive PNF	−0.59	−2.30*	−2.89**	**19.2%**	−0.19	−1.35	−1.54	**10.4%**	−0.04	−1.56	−1.60	**1.7%**
Injunctive PNF	−0.63**	−1.93*	−2.56**	**24.0%****	−0.42*	−2.63***	−3.05***	**14.1%***	−0.01	−1.85*	−1.86*	**0.5%**
Combined PNF	−1.58***	−1.47	−3.05**	**51.4%****	−0.51	−1.60	−2.12*	**24.4%**	−0.13	−1.13	−1.26	**9.0%**
Multi-Component PFI	−1.34***	−1.69	−3.03**	**43.7%****	0.03	−2.60**	−2.57**	**0.0%**	−0.73**	−0.71	−1.44	**44.4%**
12-Month Follow-Up												
Descriptive PNF	−1.42***	−1.35	−2.78**	**51.2%****	−0.39	−0.65	−1.03	**28.8%**	−0.31	−1.80	−2.11	**12.6%**
Injunctive PNF	−1.30***	−2.18*	−3.49***	**37.1%*****	−0.33	−1.64	−1.97*	**16.1%**	0.02	−1.07	−1.05	**−1.5%**
Combined PNF	−1.39***	−1.00	−2.39*	**57.6%***	−0.70*	−1.05	−1.75*	**39.3%***	−0.46***	−0.28	−0.74	**60.3%** (†)

	Total Drinks per Week				Peak eBAC (%)				Alcohol-Related Negative Consequences			
	Causal Mediated Effect	**Direct Effect**	**Total Effect**	**Proportion Mediated (%)**	**Causal Mediated Effect**	**Direct Effect**	**Total Effect**	**Proportion Mediated (%)**	**Causal Mediated Effect**	**Direct Effect**	**Total Effect**	**Proportion Mediated (%)**
Multi-Component PFI	−1.82***	−1.69	−3.50***	**51.4%*** **	−0.14	−2.16*	−2.29*	**6.2%**	−0.56*	0.24	−0.32	**38.1%**

Note: Models controlled for age, sex assigned at birth, campus, and baseline score of the given alcohol outcome variable. Effect estimates for models of total drinks per week and alcohol-related consequences are reported in their non-exponentiated form to enable interpretation of the indirect effect and the percentage of the total effect that is explained by the indirect effect.

†Zero-inflated negative binomial model would not converge, so this model was run using zero-inflated Poisson model.

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