



Full length article

Pragmatic randomized controlled trial of a web-based intervention for alcohol use among Brazilian college students: Motivation as a moderating effect



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ARTICLE INFO

Keywords:

Alcohol
Personalized normative feedback
College student
Internet
Motivation
Pragmatic trial

ABSTRACT

Background: Web-based personalized normative feedback (PNF) interventions are less effective than their laboratory versions. Participant motivation may account for this reduced effect, but there is only a limited amount of research into the influence of motivation on PNF effectiveness. We evaluated the effectiveness of a web-based PNF in reducing alcohol use and consequences among college students with different motivation levels.

Methods: Pragmatic randomized controlled trial among Brazilian college drinkers aged 18–30 years (N = 4460). Participants were randomized to a Control or PNF group and followed-up after one (T1), three (T2) and six (T3) months. Outcomes were: AUDIT score (primary outcome), the number of consequences, and the typical number of drinks. Motivation for receiving the intervention was assessed with a visual analog scale (range: 0–10). Generalized mixed models assessed intervention effects via two paradigms: observed cases and attrition models.

Results: PNF reduced the number of typical drinks at T1 (OR = 0.71, p = 0.002), T2 (OR = 0.60, p < 0.001) and T3 (OR = 0.68, p = 0.016), compared to the control. Motivated students (score ≥ 3) receiving PNF also reduced the number of typical drinks at T1 (OR = 0.60, p < 0.001), T2 (OR = 0.55, p < 0.001) and T3 (OR = 0.56, p = 0.001), compared to the control. However, the attrition models were more robust at T1 and T2. In contrast, low-motivated students receiving the PNF increased AUDIT score at T3 (b = 1.49, p < 0.001).

Conclusions: The intervention reduced alcohol use, and motivation for receiving the intervention moderated the intervention effects. Motivated students reduced their typical alcohol use, whereas low-motivated students increased their AUDIT score.

1. Introduction

Alcohol use among college students is related to significant health, academic and social problems (White and Hingson, 2013). In the USA, for example, despite many efforts to reduce alcohol use among this population, trends in use have shown only modest declines over the last three decades (Johnston et al., 2015). Most college students do not access interventions for alcohol use (Caldeira et al., 2009; Wu et al., 2007) and finding ways to reach this target group is still a major challenge for alcohol interventions (Moyer and Finney, 2004). The internet provides an excellent opportunity to broaden access and

motivate change (Cunningham et al., 2006; Koski-Janne and Cunningham, 2001), and is particularly relevant and appealing to young people (Voogt et al., 2012).

One of the most evaluated e-Health interventions for college drinkers is personalized normative feedback (PNF). PNF is a very brief intervention (taking 5–20 min), which provides individualized information on alcohol use (e.g. drinking profiles, negative consequences, risk factors, practical costs of alcohol use, and strategies to limit drinking) accompanied by information on peer alcohol use – normative data (Miller et al., 2012; Riper et al., 2011, 2009). Early studies evaluated PNF delivered by computer in a controlled environment (Lewis et al.,

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<https://doi.org/10.1016/j.drugalcdep.2019.02.021>

Received 24 August 2018; Received in revised form 8 February 2019; Accepted 9 February 2019

Available online 17 April 2019

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2007; Neighbors et al., 2006) with later research assessing PNF effects as web-based interventions, allowing participants more convenient access to the intervention (Neighbors et al., 2010; Rodriguez et al., 2015). Currently, there is substantial evidence showing that PNF has positive effects on reducing alcohol use, both in computer and web-based settings (Dotson et al., 2015; Elliott et al., 2008; Miller et al., 2012; Riper et al., 2009). However, web-based PNF is less effective than its computer-based version (Neighbors et al., 2010; Rodriguez et al., 2015). Research suggests that this reduced effectiveness in web-based PNF might be related to the participant's motivation (Neighbors et al., 2010, 2018).

Interested and curious students may benefit more from PNF interventions (Elliott et al., 2008), and neglecting motivational aspects in informational health risk interventions (such as PNF) may lead to a defensive bias and affect the intervention's efficacy (Leffingwell et al., 2007; Sherman and Cohen, 2002). These assumptions are in accordance with the Self-determination Theory (SDT) (Deci and Ryan, 1985), a widely used theory of human motivation, which offers a comprehensive approach to study the initiation and maintenance of health behaviors while emphasizing the role of social context in promoting or hindering behaviors (Patrick and Williams, 2012). Although PNF interventions share their rationale with SDT (Neighbors et al., 2006), limited attention has been paid to the participant's interest or willingness to engage with the intervention, as studies usually explore the motivation for changing the behavior (Reid and Carey, 2015).

As attrition is a common issue in Internet-based interventions (Eysenbach, 2005), most studies use incentives to achieve acceptable participation and retention rates (Bedendo et al., 2018). However, incentives are powerful motivators and may bias the sample representativeness in terms of motivation and limit proper evaluation of the intervention's effectiveness (Bedendo and Noto, 2016; Geraghty et al., 2013; White et al., 2010). Indeed, a recent study showed that the use of incentives in a remotely delivered alcohol PNF intervention increased recruitment rate, but led to a strong selection bias. Thus, results from PNF trials are not generalizable to conditions where incentives are not offered (Neighbors et al., 2018). Therefore, there is a need for additional research examining the effectiveness of the PNF at the population level, in realistic scenarios and without the use of external incentives (Bedendo and Noto, 2016; Dotson et al., 2015; Neighbors et al., 2018).

In this study, we evaluated the effectiveness of a web-based PNF intervention in reducing alcohol use and alcohol-related consequences after 1, 3 and 6 months among Brazilian college students with different levels of motivation for receiving the intervention and no incentives were used to reduce attrition. We hypothesized that the PNF intervention would reduce alcohol use compared to a control group and that the effect of the intervention would be greater in students with higher levels of motivation.

2. Material and methods

2.1. Design

A parallel-group pragmatic randomized controlled trial with a 1:1 allocation ratio. Participants were college students from all Brazilian regions and data were collected via the internet. Inclusion criteria were college students aged 18–30 reporting alcohol use during the previous 3 months (Fig. 1).

2.2. Intervention

We developed a website called PUB – Pesquisa Universitária sobre Bebidas (Undergraduate Alcohol Research) in partnership with the Centro de Integração Empresa-Escola (CIEE) – Education-Business Integration Centre. The CIEE is a Brazilian national philanthropic institution that provides internship opportunities to students. The CIEE only carried out the construction of the website (website design and

algorithm) without playing a part in any intervention content or research (statistical analysis, manuscript writing).

The intervention was based on personalized normative feedback (PNF) and its main components (Miller et al., 2012): 1) drinking profile (AUDIT risk level, binge drinking frequency, blood alcohol content, and drinks consumed during the last year); 2) gender-specific normative comparisons; 3) practical costs (money spent on alcohol and its monetary equivalents in goods, calories consumed, weight gained and time to burn calories); 4) alcohol-related consequences and possible future consequences; 5) low-risk drinking limits and strategies to avoid at-risk drinking. Based on a pilot study conducted prior to this trial (aiming to refine the intervention functionalities), students took between 5–10 min to complete the full intervention (assessment and reading feedback).

Participants allocated to the intervention group received the PNF immediately after the assessment and at each follow-up, and they were able to have a copy (saved as a pdf, sent by email or printed). After completing the initial questionnaire and being given the PNF, further access to the website was controlled and it was available only during follow-ups.

2.3. Recruitment

First access to the intervention was available between September 2015 and September 2016 with participants being recruited by 1) e-mail invitation, and 2) CIEE's Facebook and institutional website. All students were invited to access a website to "self-evaluate their current alcohol use". E-mail invitations were sent to a random sample of college students from all over the country who had previously registered with the CIEE. Before gaining access to the intervention, all participants had to log in to the CIEE institutional website and agree to participate.

As the website was public, some participants were able to access the intervention directly, so it was not possible to measure the number of students reached through the dissemination strategy. We did not offer any incentives for accessing the website. The study was approved by the University Research Ethics Committee (CEP: 429.170) and registered in Clinical Trials (NCT: 02058355).

2.4. Randomization and blinding

Randomization was carried out through the website algorithm at an individual level. Students meeting the inclusion criteria were randomized to receive the PNF or to a control group (assessment only). Researchers were blinded to the intervention, and the participants were partially blinded, as the control group was informed that they would receive feedback after six months.

2.5. Procedure

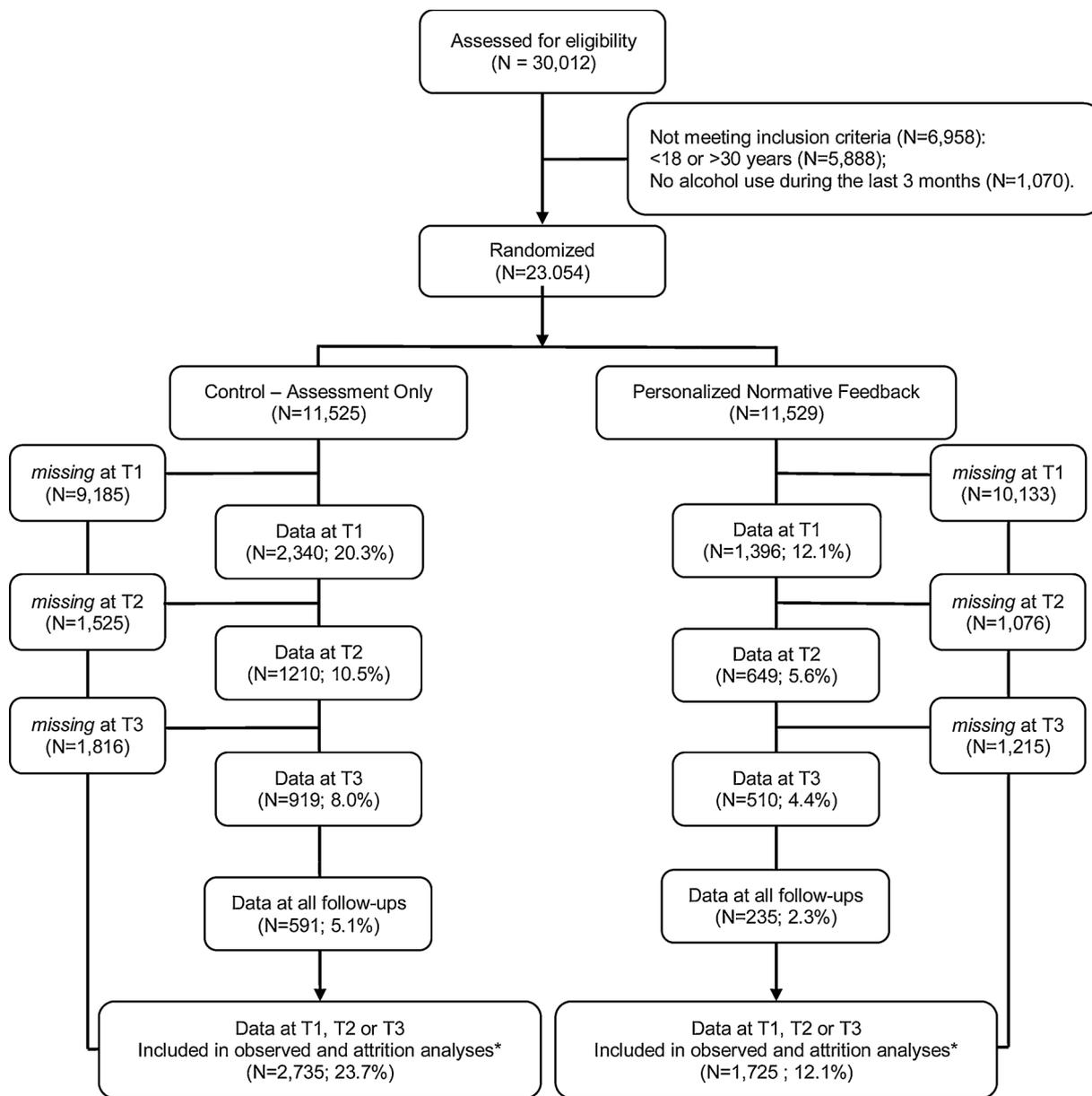
Assessments occurred at T0 (baseline), T1 (1 month), T2 (3 months) and T3 (6 months). Invitations for the first access and reminders for follow-up assessments (up to five times on alternate days) were sent via e-mail. Follow-up assessments included the same questions as in the baseline questionnaire, except for the sociodemographic and individual data.

2.6. Measures and outcomes

Individual data: socio-demographic status (sex, age, region), weight, and height.

Alcohol Use: the Alcohol Use Disorders Identification Test (AUDIT) was used with an additional question about money spent on alcohol. We considered at-risk drinkers to be those students with AUDIT alcohol consumption questions (AUDIT-C) (the first three questions of the AUDIT) scores ≥ 4 for men or ≥ 3 for women (Bradley et al., 2007).

Motivation for receiving the intervention: Student motivation was



*The attrition analyses were performed using Pattern Mixture Model and Multiple Imputation.

Fig. 1. Study Participant Flow and Follow-up Rates. T1: one month; T2: three months; T3: six months.

assessed by the question “How motivated are you to know more about your current alcohol use?” on a visual analog scale ranging from not motivated at all (0) to highly motivated (10). To define motivation subgroups, we conducted a series of decision tree analyses using baseline data (dependent variables: AUDIT score and number of consequences; independent variable: motivation). The analyses were performed using SPSS v.23 software with the CHAID algorithm. The analyses showed a cut-off point of 2.7, which was rounded up to three. Further linear regression analysis showed this cut-off point to have a good fit. Thus, the participants were categorized as being either low-motivated (score < 3) or motivated: (score ≥ 3).

The primary outcome was the AUDIT score. Secondary outcomes were: the number of alcohol consequences (created by summing questions 4–10 from AUDIT, which was re-categorized into binary variables: first category = no (0); all other categories = yes (1); and the typical number of drinks (AUDIT 2nd question). For analyses purposes, the typical number of drinks were further categorized as follows: one or

two (0), three or four (1), five or more (2). All outcomes were related to the previous three months.

2.7. Sample size

Assuming a 5% level of significance, 80% power, and correlation among repeated measures of 0.5, we needed 494 participants at T3 to detect a 10% reduction in the AUDIT score between the groups in favour of the intervention. We conducted a pilot study to estimate follow-up attrition, which showed that among 2147 randomized students, 181 (8.4%) accessed T1, 103 (4.8%) T2 and 58 (2.7%) T3. After adjusting for attrition rates, we estimated a need to randomize 18,297 students.

2.8. Statistical analyses

Pearson’s chi-squared tests and ANOVA were used to evaluate baseline differences between groups. Continuous outcomes were

transformed into deltas (differences between the measures), and intervention effects were analyzed with Generalized Mixed Models with linear or ordered logit distributions. Fixed effects were group, time, group x time interaction and covariates (sex, age, region, AUDIT-C, and outcome baseline data). The participant id was considered as a random effect and the covariance matrix was set as exchangeable. The choice of the covariance matrix was based on the nature of our data, the smaller AIC (Akaike Information Criterion) values and the results of the post-estimation command (`estat vce`).

Analyses assessing intervention effectiveness considered two paradigms: observed cases (available cases at any follow-up – T1, T2 or T3) and attrition models – assessed with the Multiple Imputation (MI) and Pattern-Mixture Models (PMM) (see details below). Attrition models were used to produce a more conservative estimate of treatment effects. The first analysis assessed effectiveness regardless of the motivation level and considered the observed cases (N = 4460). We then included a three-way interaction term (group x time x motivation) to assess the moderating effect of motivation. After this, we conducted subgroup analyses considering student motivation – low-motivated (N = 908) and motivated (N = 3552). All analyses were performed using Stata v.14 (StataCorp, 2015), with a minimum significance level of 5%.

2.9. Attrition analyses

2.9.1. Multiple imputation (MI)

We assumed our missing data to be missing not at random (MNAR) (Enders, 2010; Rubin, 1976). Continuous variables were imputed using predictive mean matching and ordered data was imputed using ordered logistic regression. We imputed 80 datasets ($m = 80$) which were considered adequate for our data (White et al., 2011). The imputation model was performed for each intervention group, and considered motivation, subject, sex, age, region, and all outcomes (baseline and follow-up data). Imputations were performed using the `mi impute chained` command using Stata v.14. Data was imputed for 16.2% of the participants (N = 724) at T1; 58.3% (2601) at T2; and 68.0% (N = 3031) at T3. Table S1 presents descriptive data for the imputed variables.

2.9.2. Pattern-mixture model (PMM)

Multiple imputation can be used under the MNAR assumption, but standard implementations assume a missing at random (MAR) assumption. Thus we also performed a PMM, an approach for MNAR situations (White et al., 2011). We divided the participants into groups according to their missing patterns (0-missing at any follow-up; 1-data at all follow-ups) and then included this variable as a covariate in the models.

3. Results

3.1. Baseline differences

Fig. 1 shows the participant flow chart, follow-up rates and the sample sizes considered in each analysis. We screened 30012 students for eligibility and 23054 (70.1%) were randomized into a control group ($n = 11525$) or PNF ($n = 11529$). Follow-up data was obtained from 4460 (19.4%) students that completed at least one follow-up assessment. Among these, 826 (3.6%) students completed all follow-up assessments.

Attrition rates among the control and PNF groups were different in all follow-up measurements, with the control group being more adherent (Fig. 1). Compared to drop out participants, those taking part in all follow-ups were more likely to be female ($p = 0.017$), in the control group ($p < 0.001$), motivated ($p < 0.001$), at-risk drinkers ($p < 0.001$), report a higher typical number of drinks ($p = 0.002$) and more consequences ($p = 0.004$) (Table S2).

Table 1 presents baseline participant characteristics considering

motivation status and intervention group. Data showed that motivated students receiving the PNF were slightly younger (21.7 vs. 21.9, $p = 0.05$) than motivated students in the control group. There were no other differences between the groups at baseline.

Table 2 presents outcome data by motivation and intervention group at baseline, T1, T2, and T3. When motivation is considered, students with low motivation and receiving the PNF showed an increase in alcohol consumption and in the number of consequences from baseline to follow-up, whereas motivated students in the PNF group tended to have a reduction in their alcohol use and related consequences.

3.2. Intervention effects

3.2.1. Early analyses

Analyses showed an interaction effect with the PNF group significantly reducing their typical number of drinks at T1 (OR = 0.71 95%CI:0.57;0.88, $p = 0.002$), T2 (OR = 0.60 95%CI:0.45;0.80, $p < 0.001$); and T3 (OR = 0.68 95%CI:0.50;0.93, $p = 0.016$), compared to the control group. The PNF group also significantly increased the number of consequences at T2 ($b = 0.11$ 95%CI: 0.001;0.22, $p = 0.05$), compared to the control group (Table 3). Overall contrast tests showed that both effects were significant - typical number of drinks: ($\chi^2(7, N = 4460) = 83.72$, $p < 0.001$); number of consequences: ($\chi^2(7, N = 4460) = 72.78$, $p < 0.001$).

Attrition models replicated these results for typical number of drinks at T1 (PMM: OR = 0.69 95%CI:0.54;0.88, $p = 0.003$; MI: OR = 0.76 95%CI:0.62;0.94, $p = 0.009$) and T2 (PMM: OR = 0.66 95%CI:0.46;0.95, $p = 0.027$; MI: OR = 0.76 95%CI:0.58;1.00, $p = 0.050$). Attrition models were also significant for the number of consequences at T2 (PMM: $b = 0.15$ 95%CI:0.01;0.29, $p = 0.032$; MI: $b = 0.10$ 95%CI:0.01;0.21, $p = 0.043$).

3.2.2. Motivation Moderating Effect

A three-way interaction term (group x time x motivation) showed a moderation effect of motivation on all outcomes: AUDIT score at T3 ($b = -1.85$ 95%CI: -2.60; -1.14, $p < 0.001$); typical number of drinks at T1 (OR = 0.43 95%CI:0.25;0.75, $p = 0.003$) and T3 (OR = 0.36 95%CI:0.16;0.80, $p = 0.012$); and the number of consequences at T3 ($b = -0.48$ 95%CI: -0.79; -0.17, $p = 0.002$).

3.2.3. Subgroup Analyses By Motivation

Table 3 presents the intervention effects for low-motivated and motivated students while considering observed cases, whereas Table 4 shows the results of attrition models. The results showed that motivated students receiving PNF reduced their AUDIT scores at T3 (Fig. 2) and the typical number of drinks at T1, T2, and T3 (Figs. 3B). Attrition models confirmed results for the typical number of drinks (except for PMM at T3 and MI at T2), but not for AUDIT score (Table 4).

On the other hand, low-motivated students receiving PNF showed an increase in AUDIT score at T3 (Fig. 2), which was corroborated in the attrition models (Table 4). PMM three-way interaction terms (group x time x missing) showed that all results occurred independently of the dropout status.

4. Discussion

A web-based PNF intervention for alcohol use was effective in reducing alcohol use, but not alcohol-related consequences among Brazilian college students. The motivation for receiving the feedback (measure by participant's interest) moderated the effects of the PNF on AUDIT scores and typical number of drinks. For low-motivated students, the PNF was significantly associated with an increased AUDIT score after 6 months. In contrast, motivated students who received the PNF reduced their typical number of drinks at 1-, 3-, and 6-month follow-up; however, when taking attrition into account, the 6-month

Table 1
Baseline characteristics of participants considering motivation status and intervention group.

	Low Motivated				Motivated			
	Control n = 543	PNF n = 365	Total n = 908	p value	Control n = 2192	PNF n = 1360	Total n = 3552	p value
Female – n(%)	267(49.2)	192(52.6)	459(50.6)	0.31	1169(53.3)	710(52.2)	1879(52.9)	0.51
Age – mean(SD)	22.1(3.1)	22.2(3.2)	22.2(3.1)	0.67	21.9(3)	21.7(3.0)	21.8(3.0)	0.05
Institution – n(%)								
Private	425(78.3)	298(81.6)	723(79.6)	0.22	1759(80.3)	1077(79.2)	2836(79.8)	0.45
College Year – mean(SD)	2.7(1.5)	2.8(1.5)	2.8(1.5)	0.49	2.8(1.5)	2.7(1.5)	2.7(1.5)	0.56
Age at first alcohol use episode – mean(SD)	16.1(2.6)	16.1(2.5)	16.1(2.6)	0.94	15.8(2.3)	15.8(2.4)	15.8(2.4)	0.66
AUDIT – n(%)								
low risk	450(82.9)	321(88.0)	771(84.9)	0.21	1560(71.2)	985(72.4)	2545(71.7)	0.46
hazardous use	83(15.3)	39(10.7)	122(13.4)		547(25.0)	328(24.1)	875(24.6)	
harmful use	7(1.3)	3(0.8)	10(1.1)		57(2.6)	26(1.9)	83(2.3)	
suggestive of dependence	3(0.6)	2(0.6)	5(0.6)		28(1.3)	21(1.5)	49(1.4)	

PNF: Personalized Normative Feedback; SD: Standard Deviation; AUDIT: Alcohol Use Disorders Identification Test; AUDIT-C: Alcohol Use Disorders Identification Test-Consumption.

Table 2
Outcome data by motivation and intervention group after 1 month, 3 months and 6 months.

		Low Motivated				Motivated			
		Baseline N = 908	1 month N = 729	3 months N = 324	6 months N = 269	Baseline N = 3552	1 month N = 3007	3 months N = 1535	6 months N = 1160
AUDIT Score – mean(SD)	Control	4.3(3.7)	4.1(3.8)	4.2(4.9)	3.7(3.4)	5.9(4.5)	5.6(4.4)	5.4(4.2)	5.3(4.2)
	PNF	3.9(3.3)	3.9(4.3)	4.3(5.3)	4.9(6.4)	5.8(4.5)	5.3(4.7)	5.0(4.5)	4.9(4.4)
Number of Consequences – mean(SD)	Control	0.9(1.4)	0.9(1.6)	0.7(1.5)	0.8(1.4)	1.4(1.7)	1.4(1.7)	1.3(1.7)	1.3(1.7)
	PNF	0.7(1.2)	0.8(1.6)	0.8(1.5)	1.0(1.7)	1.4(1.6)	1.3(1.7)	1.2(1.8)	1.2(1.7)
Typical Drinks – n(%)									
1 or 2	Control	233(42.9)	210(46.9)	89(44.7)	84(51.2)	648(29.6)	564(29.8)	293(29.0)	237(31.4)
	PNF	171(46.9)	128(45.6)	59(47.2)	46(43.8)	403(29.6)	397(35.6)	198(37.8)	156(38.5)
3 or 4	Control	163(30.0)	129(28.8)	55(27.6)	39(23.8)	726(33.1)	622(32.9)	321(31.8)	249(33.0)
	PNF	96(26.3)	80(28.5)	30(24.0)	28(26.7)	444(32.7)	362(32.5)	179(34.2)	126(31.1)
5 or more	Control	147(27.1)	109(24.3)	55(27.6)	41(25.0)	818(37.3)	706(37.3)	397(39.3)	269(35.6)
	PNF	98(26.9)	73(26.0)	36(28.8)	31(29.5)	513(37.7)	356(31.9)	147(28.1)	123(30.4)

PNF: Personalized Normative Feedback; SD: Standard Deviation; AUDIT: Alcohol Use Disorders Identification Test.

effect on typical number of drinks was inconclusive. The PNF did not show significant effects on the number of consequences, independently of the motivation levels. All results were observed without the use of external incentives for motivating participation.

Our intervention was effective in reducing the number of typical drinks, but attrition analyses showed that the effects varied according to the statistical approach. Results were more robust after 1 and 3 months, but the PNF group did not perform significantly better than the control group after 6 months in the PMM analyses. Prior studies showed mixed results for PNF effects on typical number of drinks (Bryant et al., 2013; Kypri et al., 2014; Labrie et al., 2013; Lewis et al., 2014; McCambridge et al., 2013). In particular, one study showed that the PNF reduced the typical number of drinks, but the authors suggested that the result might be vulnerable to attrition bias (Kypri et al., 2014). Such divergences in our study and the prior literature may be related to the small effect sizes observed in PNF interventions (Dotson et al., 2015; Foxcroft et al., 2015). We assessed the typical number of drinks using an ordered variable, which may not have had adequate statistical sensitiveness to address the effectiveness of the intervention. Future real-world pragmatic trials will help to overcome such inconsistencies.

Most of the online alcohol interventions employed incentives, which bias representativeness and reduces the external validity (Bedendo et al., 2018; Neighbors et al., 2018; White et al., 2010). Our study provides evidence on the effectiveness of the PNF in the absence of incentives. As mentioned, PNF interventions have small effect sizes, but these effects are suggested as clinically relevant from a public health perspective (Dotson et al., 2015). However, the effect sizes in our study

appear to be even more modest, suggesting that the absence of incentives may reduce the expected effects for this type of intervention.

In this research, providing the PNF to individuals not interested in knowing more about their drinking also generated a negative effect. This negative result is line with a recent meta-analysis showing that providing computer-delivered alcohol interventions for college students might increase alcohol-related harms at intermediate and long-term follow-ups (Cole et al., 2018). Our results indicated that the negative effect was related to the participant's motivation in receiving the intervention. It is reasonable to expect that low-motivated students may be less attentive during the feedback reading, and attention is suggested as a key factor in the efficacy of remote-delivery interventions (Lewis and Neighbors, 2015; Neighbors et al., 2018). Consequently, the intervention effects should be negative or null.

Prior studies highlighted the importance of motivation on computer-based brief alcohol interventions, indicating that interventions are more efficacious when tailored to participant motivation (Baumann et al., 2017) and those who are more interested in the intervention content seems to benefit more from it (Elliott et al., 2008). According to the Cognitive Dissonance (Festinger, 1957) and Self-determination theories (Deci and Ryan, 1985), when information is dissonant with intrinsic motivation, it may promote avoidant and defensive behaviors (Deci and Ryan, 1985; Festinger, 1957). Thus, the efficacy of health risk interventions (like the PNF) that disregard motivation may be jeopardized by generating a defensive bias (Leffingwell et al., 2007; Sherman and Cohen, 2002).

Considering our results together with the current evidence

Table 3

Intervention effects among the full sample (early analysis), low motivated and motivated students from baseline to 1, 3 and 6 months considering observed cases.

	Full Sample (N = 4460) b(95%CI)	Low Motivated (N = 908) b(95%CI)	Motivated (N = 3552) b(95%CI)
AUDIT Score delta^a			
Group (reference = control)	−0.03(−0.17;0.12)	−0.05(−0.41;0.32)	−0.02(−0.17;0.14)
Time (reference = baseline)			
1 month	−0.30(−0.42;−0.18) ^{***}	−0.23(−0.56;0.10)	−0.32(−0.45;−0.19) ^{***}
3 months	−0.55(−0.70;−0.40) ^{***}	−0.21(−0.65;0.22)	−0.62(−0.78;−0.46) ^{***}
6 months	−0.60(−0.82;−0.47) ^{***}	−0.43(−0.90;0.04)	−0.65(−0.82;−0.47) ^{***}
Group x time			
PNF x 1 month	−0.08(−0.28;0.12)	0.20(−0.33;0.73)	−0.16(−0.37;0.06)
PNF x 3 months	0.08(−0.17;0.34)	0.53(−0.17;1.23)	−0.03(−0.30;0.24)
PNF x 6 months	0.00(−0.28;0.29)	1.49(0.74;2.24) ^{***}	−0.38(−0.68;−0.08) [*]
Number consequences delta^a			
Group (reference = control)	−0.01(−0.07;0.05)	−0.03(−0.17;0.11)	−0.01(−0.08;0.06)
Time (reference = baseline)			
1 month	−0.07(−0.13;−0.02) ^{**}	0.00(−0.12;0.13)	−0.09(−0.15;−0.04) ^{**}
3 months	−0.22(−0.28;−0.15) ^{***}	−0.17(−0.33;−0.01) [*]	−0.23(−0.30;−0.16) ^{***}
6 months	−0.18(−0.25;−0.11) ^{***}	−0.09(−0.26;0.09)	−0.20(−0.29;−0.12) ^{***}
Group x time			
PNF x 1 month	0.02(−0.07;0.11)	0.06(−0.14;0.26)	0.01(−0.09;0.11)
PNF x 3 months	0.11(0.001;0.22) [*]	0.27(0.01;0.53) [*]	0.07(−0.05;0.19)
PNF x 6 months	−0.04(−0.16;−0.08)	0.34(0.06;0.62) [*]	−0.14(−0.28;−0.01) [*]
	OR(95%CI)	OR(95%CI)	OR(95%CI)
Typical drinks^b			
Group (reference = control)	0.99(0.85;1.15)	0.96(0.69;1.33)	0.99(0.84;1.18)
Time (reference = baseline)			
1 month	0.91(0.80;1.04)	0.75(0.56;1.03)	0.95(0.82;1.10)
3 months	0.88(0.74;1.04)	0.81(0.53;1.21)	0.89(0.74;1.07) ^{**}
6 months	0.73(0.60;0.88) ^{***}	0.64(0.40;1.02)	0.74(0.60;0.91) ^{**}
Group x time			
PNF x 1 month	0.71(0.57;0.88) ^{**}	1.38(0.84;2.25)	0.60(0.47;0.76) ^{***}
PNF x 3 months	0.60(0.45;0.80) ^{***}	0.88(0.84;2.24)	0.55(0.40;0.75) ^{***}
PNF x 6 months	0.68(0.50;0.93) ^{**}	1.60(0.78;3.31)	0.56(0.40;0.79) ^{***}

PNF: Personalized Normative Feedback; b: model coefficient; 95%CI: 95% Confidence Interval; AUDIT: Alcohol Use Disorders Identification Test.

^a Linear mixed model.^b Ordered logit mixed model. All results are adjusted for participant id, sex, age, region, AUDIT-C and baseline data.* $p \leq 0.05$.** $p \leq 0.01$.*** $p \leq 0.001$.

highlighting the potential negative effects of the PNF, we do not support web-based PNF as a universal prevention strategy (Dotson et al., 2015). Further studies should evaluate other moderators and groups who would benefit from this type of intervention before the dissemination of the PNF.

We provided feedback during each follow-up, and the repeated exposure to feedback could have played a role as a “booster”. Some authors suggested that multiple feedback enhances the effects of the intervention (Neighbors et al., 2010; Sundstrom et al., 2017), whereas a meta-analysis evidence failed to show any differences between single and multiple-session interventions (Riper et al., 2014). In this study, the potential “booster” effect was not confirmed in additional analysis including the number of times feedback was given as a covariant. The main benefit for participants assessing PNF intervention is the information provided in the feedback, and the use of multiple feedback is more likely to be present during the dissemination of the PNF. Thus, as the current literature is still inconclusive, the impact of multiple feedback should be addressed in future research.

Some characteristics of this study such as the lack of incentives, the requirement to log in to access the intervention, and the control group being aware that they would receive feedback after 6 months may have led to the recruitment of participants with different motivations to engage in this intervention. Individual motivation and persistence in tasks are related to expectations and interest (Hidi and Renninger, 2006; Kettle and Haubl, 2010; Wigfield and Eccles, 2000) and this may have moderated the higher adherence among these participants. At baseline, motivation did not differ among groups; however, we were

not able to evaluate motivation levels at follow-up. Thus, further studies should evaluate intervention characteristics and changes in motivation during follow-up and their potential impact on retention rates among participants.

This is the first study not using incentives assessing the effects of the PNF among Latin American college drinkers. We assessed a large sample of college students from all Brazilian regions, with a diversity of drinking profiles, institutions, undergraduate courses, and cultural aspects. We considered a real-world setting, which favors external validity and provides reasonable inferences about the expected effects at the population level.

However, the presented results must consider some limitations. The one-month follow-up overlaps the baseline measure and may not have properly assessed changes in outcomes. Due to our recruitment strategy using CIEE’s social media and institutional website, our sample might underrepresent students that are not interested in internships, but additional analysis did not show significant effects of the recruitment strategy on the outcomes. We had a high attrition rate in both the control and intervention conditions, as in previous research among a Brazilian adult population (Andrade et al., 2016). Attrition in web-based trials is expected to be far higher than in face-to-face interventions (Eysenbach, 2005), but in contrast to the overall perception, attrition does not necessarily lead to biased results if missing data mechanisms are properly stated and an appropriate analysis is used (Bell et al., 2013). We assumed our missing data to be missing not at random, and the findings supported this assumption. The study used suitable statistical approaches – mixed models (Carpenter and Kenward, 2007;

Table 4

Intervention effects among low motivated and motivated students from baseline to 1, 3 and 6 months considering attrition models (Pattern-Mixture and Multiple Imputation models).

	Low Motivated (N = 908)		Motivated (N = 3552)	
	PMM b(95%CI)	Multiple Imputation b(95%CI)	PMM b(95%CI)	Multiple Imputation b(95%CI)
AUDIT Score delta^a				
Group (reference = control)	-0.06(-0.45;0.34)	-0.05(-0.42;0.31)	-0.01(-0.18;0.16)	-0.02(-0.18;0.14)
Time (reference = baseline)				
1 month	-0.17(-0.53;0.20)	-0.19(-0.50;0.11)	-0.34(-0.49;-0.19) ^{***}	-0.30(-0.43;-0.17) ^{***}
3 months	0.17(-0.39;0.73)	0.04(-0.35;0.44)	-0.78(-0.99;-0.56) ^{***}	-0.52(-0.67;-0.36) ^{***}
6 months	-0.49(-1.15;0.17)	-0.39(-0.81;0.04)	-0.56(-0.85;-0.27) ^{***}	-0.52(-0.68;-0.36) ^{***}
Group x time				
PNF x 1 month	0.12(-0.46;0.69)	0.22(-0.26;0.70)	-0.14(-0.38;0.09)	-0.14(-0.35;0.07)
PNF x 3 months	0.23(-0.62;1.09)	0.33(-0.32;0.98)	0.07(-0.27;0.41)	0.16(-0.09;0.42)
PNF x 6 months	1.13(0.16;2.11) [*]	1.02(0.37;1.66) ^{**}	-0.29(-0.72;0.15)	-0.19(-0.46;0.09)
Number consequences delta^a				
Group (reference = control)	-0.03(-0.18;0.12)	-0.04(-0.19;0.11)	-0.01(-0.08;0.07)	-0.01(-0.09;0.06)
Time (reference = baseline)				
1 month	0.03(-0.10;0.17)	0.01(-0.12;0.13)	-0.10(-0.17;-0.03) ^{**}	-0.09(-0.15;-0.02) ^{**}
3 months	-0.09(-0.30;0.12)	-0.16(-0.33;0.02)	-0.25(-0.35;-0.15) ^{***}	-0.20(-0.27;-0.13) ^{***}
6 months	-0.06(-0.30;0.19)	-0.08(-0.28;0.11)	-0.14(-0.27;-0.01) [*]	-0.19(-0.27;-0.11) ^{***}
Group x time				
PNF x 1 month	0.00(-0.21;0.21)	0.06(-0.14;0.26)	0.02(-0.09;0.12)	0.00(-0.10;0.09)
PNF x 3 months	0.21(-0.11;0.53)	0.18(-0.10;0.46)	0.13(-0.02;0.29)	0.09(-0.03;0.2)
PNF x 6 months	0.17(-0.19;0.54)	0.14(-0.14;0.42)	-0.14(-0.34;0.05)	-0.05(-0.17;0.08)
	OR(95%CI)	OR(95%CI)	OR(95%CI)	OR(95%CI)
Typical drinks^b				
Group (reference = control)	0.95(0.66;1.35)	0.96(0.70;1.32)	1.00(0.83;1.20)	0.99(0.84;1.16)
Time (reference = baseline)				
1 month	0.82(0.59;1.16)	0.84(0.63;1.12)	0.95(0.80;1.13)	0.97(0.85;1.12)
3 months	1.15(0.68;1.95)	1.50(1.00;2.27)	0.74(0.57;0.95) [*]	1.00(0.84;1.19)
6 months	0.53(0.26;1.05)	0.78(0.50;1.23)	0.67(0.48;0.95) [*]	0.91(0.75;1.10)
Group x time				
PNF x 1 month	1.15(0.67;1.98)	1.33(0.84;2.12)	0.60(0.46;0.79) ^{***}	0.66(0.53;0.83) ^{***}
PNF x 3 months	0.70(0.31;1.63)	0.80(0.41;1.57)	0.64(0.43;0.97) [*]	0.75(0.56;1.01)
PNF x 6 months	2.23(0.84;5.92)	1.89(0.89;4.03)	0.70(0.42;1.18)	0.68(0.50;0.92) [*]

PNF: Personalized Normative Feedback; b: model coefficient; 95%CI: 95% Confidence Interval; PMM: Pattern-Mixture Model; AUDIT: Alcohol Use Disorders Identification Test.

^a Linear mixed model.

^b Ordered logit mixed model. All results are adjusted for participant id, sex, age, region, AUDIT-C and baseline data.

* p ≤ 0.05.

** p ≤ 0.01.

*** p ≤ 0.001.

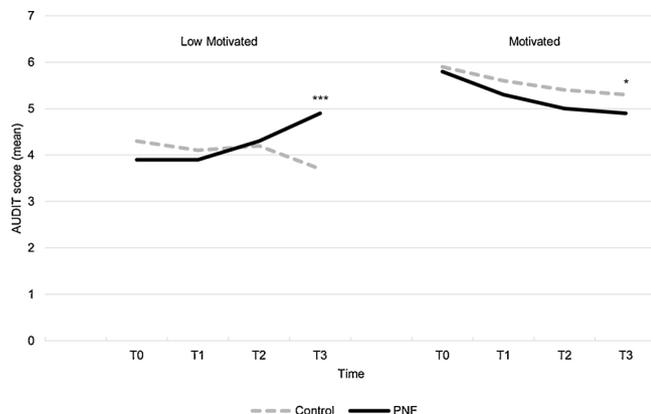


Fig. 2. Group and time interaction effects over mean AUDIT scores for Low Motivated (N = 908) and Motivated (N = 3552) students during baseline (T0), one (T1), three (T2) and six months (T3). *** p ≤ 0.001; * p ≤ 0.05. PNF: Personalized Normative Feedback.

Cheng et al., 2010), PMM (Hedeker and Gibbons, 1997; Little, 1993) and MI (Li et al., 2015; Rubin, 2009; White et al., 2011) – which produced valid estimates with missing data, and only consistent results

across all models were considered. Data imputation occurred for several participants, mainly after 3 and 6 months, but previous studies support this approach (White et al., 2011). However, analyses would benefit from imputations of small amounts of data.

5. Conclusions

A web-based personalized normative feedback intervention for alcohol use among college students resulted in a reduction in the typical number of drinks only among motivated students, whereas low-motivated students showed an increase in AUDIT scores (suggesting a possible boomerang effect). Motivation moderated some effects of the intervention and the findings highlight the importance of considering student motivation (or interest) before offering web-based personalized normative feedback. This has particular importance before the large-scale provision of PNF interventions.

The findings also underline that future studies should consider attrition when evaluating the effectiveness of web-based interventions. Finally, all analyses showed small effect sizes and it should be remembered that web-based PNF intervention is only one of a wider set of prevention, treatment, and environmental approaches that should be integrated to address unhealthy alcohol use among college students.

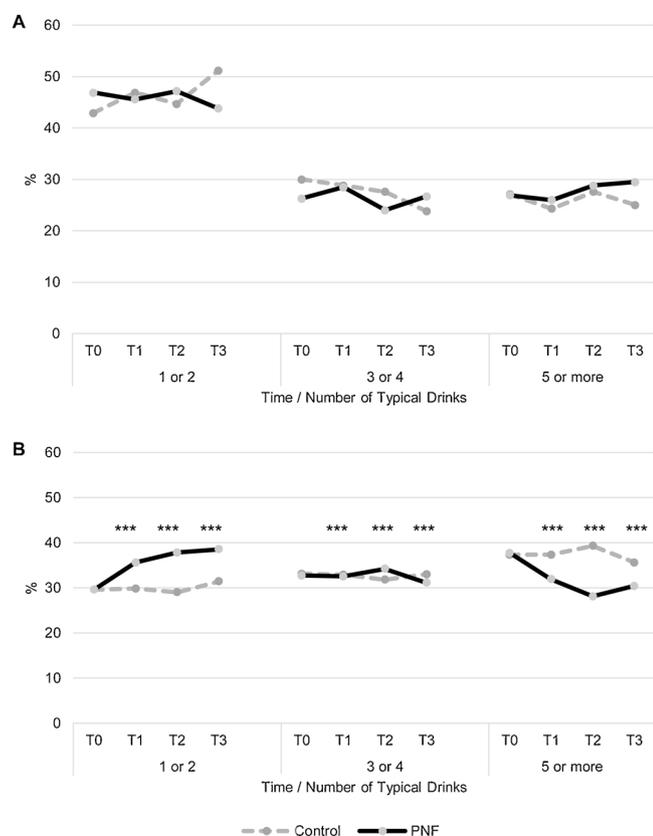


Fig. 3. A: Low-motivated students; B: Motivated students. Group and time interaction effects over the number of typical drinks (categories percentage) for Low Motivated ($N = 908$) and Motivated ($N = 3552$) students during baseline (T0), one (T1), three (T2) and six months (T3). *** $p \leq 0.001$. PNF: Personalized Normative Feedback.

Contributors

AB was responsible for the conceptualization and execution of the study, development of the research question, statistical analysis and drafted the first version of the manuscript. CPF reviewed the manuscript and contributed to the statistical analysis. AALS contributed to the drafting of introduction, statistical analysis, and data discussion. ALMA reviewed and edited the manuscript, and contributed with data interpretation. ARN contributed to the conceptualization and execution of the study, the development of the research question, data interpretation and reviewed the manuscript. All authors have revised and approved the final version of the manuscript.

Role of funding source

Nothing declared.

Conflict of interest

No conflict declared.

Acknowledgements

We would like to thank: the São Paulo Research Foundation (FAPESP – Grants 2013/20341-7; 2015/19472-5) for funding the research and providing a doctoral scholarship to the first author; < GS > the Centro de Integração Empresa-Escola (CIEE) < / GS2 > for the development of the website and provision of e-mails for participant recruitment; the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), the Associação Fundo de Incentivo à

Pesquisa (AFIP) for technical and financial support; and the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) that granted a research productivity grant to the last author

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.drugalcdep.2019.02.021>.

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