Increasing Chance-Based Uncertainty Reduces Heavy Drinkers' Cognitive Reactance to Web-Based Personalized Normative Feedback

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ABSTRACT. Objective: Despite its prominence in the health communication literature, psychological reactance has rarely been considered as a factor that may undermine web-based Personalized Normative Feedback (PNF) alcohol interventions for college students. This study built on recent gamification work to examine how chance-based uncertainty, a popular game mechanic associated with motivation and attention in digital games for learning, might be leveraged to reduce the psychological reactance experienced by heavy drinking students receiving alcohol PNF, thereby leading to larger reductions in their alcohol consumption. **Method:** Psychological reactance, perceptions of norms, and drinking behaviors were assessed during a 3-week period following random assignment of binge drinking students ($N = 141$, 51% female) into one of four web-based PNF conditions. These conditions asked the same questions about drinking and delivered identical PNF on alcohol use but differed in whether animated slot-machine spinners appeared to select participants' question and feedback topics as well as the number of ad-

ditional topics (beyond alcohol) on which questions were asked and PNF was delivered. **Results:** All conditions similarly reduced drinking norms but differed in the degree to which they aroused cognitive reactance and reduced drinking. Relative to a no-spinner alcohol-only condition, increasing chance-based uncertainty by giving question and feedback topics the appearance of being selected by gamelike spinners substantially reduced cognitive reactance, which, in turn, reduced drinking 20 days later. Overall, participants experienced the least cognitive reactance when spinners first selected three question topics and later selected two of these topics to deliver feedback on. **Conclusions:** Findings suggest that introducing chance-based uncertainty through gamelike spinners, asking questions about multiple topics, and delivering feedback on additional topics unrelated to alcohol together work to reduce the degree to which the task feels like an alcohol intervention overtly aimed at reducing consumption, thereby making the alcohol PNF more effective among heavy drinking students. (*J. Stud. Alcohol Drugs*, 79, 601–610, 2018)

BECAUSE PERCEPTIONS OF PEER DRINKING norms have been found to reliably predict future alcohol consumption (Neighbors et al., 2007; Perkins, 2003; Perkins & Berkowitz, 1986), and students reliably overestimate these norms, interventions designed to combat heavy drinking and consequences among undergraduates by correcting misperceptions of peer drinking behavior have become near-ubiquitous. Personalized Normative Feedback (PNF), one popular norms-based intervention strategy, involves presenting students with individualized reports designed to correct norms using a graphical display comparing national or campus-wide drinking statistics both to participants' estimates of peer drinking and to their own self-reported drinking. To date, however, PNF interventions have consistently demonstrated only modest effects (Dotson et al., 2015; LaBrie et al., 2013; Lewis & Neighbors, 2007; Martens et al., 2013; Neighbors et al., 2010). The current study examines psychological reactance as a force that may hinder the effectiveness of PNF among heavy drinking students. Building on recent work that has explored gamification in the alcohol intervention context, we investigated the ability of specific

game mechanics to reduce psychological reactance, thereby increasing the effectiveness of PNF.

Psychological reactance theory

Psychological reactance is an aversive emotion experienced when one's freedom and autonomy are thwarted or usurped (Brehm, 1966; Brehm & Brehm, 1981). Reactance theory contends that, when a certain behavior is forbidden, individuals interpret this as a threat to their personal freedom and experience emotions and cognitions that motivate them to reestablish that freedom. This can be accomplished directly, by engaging in the forbidden behavior, or indirectly, by either increasing positive attitudes toward the threatened behavior (Hammock & Brehm, 1966) or derogating the source of the threat (Kohn & Barnes, 1977). Although a universal phenomenon, reactance theory addresses human needs for autonomy, which are particularly strong during adolescence and emerging adulthood (Heilman & Toffler, 1976; Miller et al., 2006). Furthermore, previous work has found that reactance is especially likely to be aroused when the threat to freedom occurs in a domain self-relevant to the individual (e.g., alcohol use for a heavy drinking college student; Cornelis et al., 2014; Jung et al., 2010). Thus, it is not surprising that alcohol prevention messages that use forceful and moralistic language have been found to increase alcohol use among heavy drinking college students (Foxcroft et al., 1997; Perkins et al., 2005;

Received: July 26, 2017. Revision: February 19, 2018.

Manuscript preparation was supported by National Institute on Alcohol Abuse and Alcoholism Grant R21AA024853-01.

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Rains & Turner, 2007; Wechsler et al., 2003; Werch et al., 2000).

Reactance in the personalized normative feedback context

In contrast to alcohol interventions that instruct heavy drinkers to drink less or attempt to arouse fear, PNF interventions are designed to simply show the heavy drinker that peers are drinking much less than they assumed and that their own drinking exceeds the actual norm of their peer group (Miller & Prentice, 2016; Perkins, 2003; Perkins & Berkowitz, 1986). Because PNF is designed to be free of controlling language, allowing heavy drinkers to confront their own nonnormative consumption (Nye et al., 1999), it may seem as though psychological reactance is unlikely to be experienced. Research suggests, however, that even the mere awareness that the goal of a program is to modify behavior may be enough to trigger psychological reactance, undermining the intervention (Brehm & Brehm, 1981). In most PNF interventions for college students both questions and feedback are overtly focused on alcohol, making students aware, at minimum, that researchers/administrators are interested in their drinking if not seeking to modify their consumption. Thus, psychological reactance may still be experienced in these interventions.

Although reactance has yet to be examined in the PNF context, several studies evaluating social norms marketing campaigns have attributed their ineffectiveness to this aversive emotional experience (Campo & Cameron, 2006; Jung et al., 2010; Werch et al., 2000). In one such study, Jung and colleagues (2010) assessed reactance in response to a campus-wide social norms marketing campaign among students who regularly engaged in heavy episodic drinking (HED). For these students, the reactance experienced in response to the normative statistics mediated the relationship between campaign exposure and subsequent alcohol consumption intentions. Specifically, greater exposure to the campaign increased reactance, which in turn made students less likely to intend to decrease their consumption. The current research was designed to examine the extent to which alcohol PNF similarly arouses reactance among heavy drinking students. Importantly, we also investigated how chance-based uncertainty might be incorporated in PNF interventions to diminish reactance and increase effectiveness.

Incorporating chance-based uncertainty to decrease reactance

Chance-based uncertainty, commonly achieved through animated spinners or die rolls, is a popular game mechanic associated with increased user motivation, attention, and enjoyment in digital games for learning (Costikyan, 2014; Howard-Jones & Demetriou, 2009; Ozcelik et al., 2013; Whitton, 2014). Recognizing that uncertainty might also

be used to disguise the intention of an alcohol intervention, Boyle and colleagues (2017) incorporated animated spinners into a novel gamified alcohol PNF intervention for college students. The intervention was framed as a Facebook-connected game about college life in which students competed for points by trying to accurately estimate peer norms for various campus behaviors. Animated spinners, styled to look like slot machines, selected both the college life topics on which the user would answer questions and, later, one topic on which the user would receive feedback (i.e., PNF on alcohol). The initial study compared the effectiveness of alcohol questions and PNF delivered by the game against identical alcohol questions and PNF delivered by a standard online survey. Two weeks following PNF delivery, students randomized to the game condition demonstrated significantly decreased norms and reduced alcohol use relative to students randomized to the standard survey condition. The researchers theorized that the animated spinners, which implied chance selection of question and feedback topics, may have diminished psychological reactance among heavy drinkers, explaining the increased effectiveness of the game condition. However, reactance was not assessed in that study, and the game condition also featured additional game mechanics not present in the survey condition that may have also explained conditional differences. The current study narrows the focus to the heavy drinking students most likely to experience reactance in PNF interventions to systematically examine the behavioral and psychological impacts of chance-based uncertainty in a gamified PNF intervention.

Current study

The current study held constant all game mechanics (i.e., points, Facebook photos, etc.) introduced in Boyle and colleagues' gamified PNF condition but manipulated chance-based uncertainty through the presence of animated topic and feedback selection spinners. Psychological reactance, perceptions of norms, and drinking behaviors were assessed during a 3-week period following random assignment of students recently engaging in HED into one of four conditions described in Table 1. We expected that all conditions would similarly reduce peer drinking norms (Hypothesis 1) but anticipated that the presence of animated spinners would decrease the psychological reactance experienced by participants (Hypothesis 2), thereby leading to larger reductions in alcohol consumption at follow-up (Hypothesis 3). Furthermore, we predicted that arousing chance-based uncertainty at two points in the game (Conditions 2 and 3), relative to one (Condition 1), would lead to larger reductions in both reactance (Hypothesis 2a) and alcohol consumption (Hypothesis 3a). Last, as an exploratory research question, we investigated whether having the second spinner select and deliver PNF on an additional topic (Condition 3) would further reduce reactance and alcohol consumption.

TABLE 1. Descriptions of study conditions

Condition	Description
Condition 0	<i>No spinner; single personalized normative feedback (PNF):</i> Standard questions about alcohol, followed by alcohol PNF
Condition 1	<i>Single spinner; single PNF:</i> Questions about alcohol use selected from 10 topics by an initial spinner, followed by alcohol PNF
Condition 2	<i>Double spinner; single PNF:</i> Questions about 3 topics selected by an initial spinner, followed by PNF on alcohol selected from these topics by a second spinner
Condition 3	<i>Double spinner; double PNF:</i> Questions about 3 topics selected by an animated spinner, followed by PNF on both social media and alcohol use selected from these topics by a second spinner

Method

Participants

Participants were undergraduate students recruited via the Psychology Department's Human Subject Pool ($N = 121$) and the campus Judicial Affairs Office ($N = 103$) at a private mid-sized university. Students recruited through the subject pool received partial course credit for participation, whereas adjudicated students received partial credit toward completing their sanctions. All participants reported demographic characteristics, and only those who reported engaging in HED (4+ drinks on an occasion for females or 5+ drinks for males) at least once during the previous 2 weeks were invited to participate further. A total of 141 participants completed the baseline assessment (Time 1), with 138 (98%) also completing both the 10-day (Time 2) and 20-day (Time 3) follow-ups. Figure 1 further details participant randomization and retention by study condition. Of the 138 followed participants, 86% were in their first or second year of college; 51% were female; and 55% were White, 8% Asian, 12% African American, 22% Hispanic, and 3% other. All study procedures and measures were approved by the university's institutional review board.

Procedure

After being screened into the study and providing consent, participants were redirected to the Social Perception Test, where they logged in using their Facebook credentials and read a description of the test as a competition to make accurate guesses about other students at their university. Participants were told that 132 of their same-sex peers had also recently played and that during the game they would win points based on the accuracy of their guesses about the behaviors reported by same-sex peers. Consistent with the gamified PNF intervention tested by Boyle et al. (2017), an animated loading screen displayed 132 Facebook thumb-

nail photos, ostensibly belonging to the other students who participated previously. To avoid potential confounds to study condition, all male students were presented the same set of 132 stock images of male college students and all female students were presented the same set of 132 stock images of female students. The sets of stock images selected were those rated by our undergraduate research assistants to look most similar to the Facebook profile photos of typical college students. Next, participants were automatically randomized to one of four conditions (Table 1). The key manipulations in this study were the presence of animated spinners, first in the selection of question topics and later in the selection of feedback topics. Because these animated spinners and the feelings they create are not easily captured in still images, a demonstration version of the game can be found at <http://tinyurl.com/SocialPerceptionDemo>, allowing readers to fully experience each of the four study conditions.

All conditions prompted participants to answer the same six questions about peers' alcohol use and their own corresponding drinking behaviors. In Conditions 2 and 3 participants also answered parallel questions about social media use (six questions) and television watching (six questions). After answering all questions, participants received identical PNF slides on alcohol use, with participants in Condition 3 also receiving PNF slides on social media use. Feedback for each question consisted of a screen revealing the number of points won, an animated graph comparing participants' perceptions to the actual average, and an infographic-style chart comparing participants' own self-reported behavior to the actual average. Immediately after viewing their PNF, participants responded to survey questions about the thoughts and feelings they experienced while viewing their feedback. Links to complete follow-ups were emailed to participants 10 days and 20 days post-intervention. After completing the final follow-up, participants were debriefed regarding the study's research questions and deceptive elements (i.e., Facebook photos, nonrandom spinners).

FIGURE 1. Flow diagram for participants incentivized by partial human subject pool or judicial sanction credit. No differences in retention were observed between student groups. C = Condition.

Measures

Drinking norms. Drinking norms were assessed at baseline (Time 1) and at the 10-day follow-up (Time 2). Three questions assessed perceptions of the quantity of alcohol consumed by a typical student of the participant's same sex and class year during the previous 2 weeks. Consistent with the norms assessed by Boyle et al. (2017), items assessed perceptions of (a) the maximum number of drinks consumed on a single occasion, (b) the average number of drinks consumed per occasion, and (c) the frequency of binge drinking (define as 4+ drinks on an occasion for females or 5+ drinks for males) during the previous 2 weeks. The three items were highly correlated and internally consistent at each time point ($r_s > .61$, $\alpha = .76$ at baseline; $r_s > .70$, $\alpha = .82$ at follow-up). To create a composite measure of drinking norms at Time 1,

z scores for each item were computed and then the three z scores were averaged. To examine pre-to-post PNF change in norms, pseudo- z scores for norm items at Time 2 were computed based on each item's mean and standard deviation at Time 1. Then, these z scores were averaged to create a composite measure of drinking norms at Time 2.

Alcohol consumption. Drinking was assessed at baseline (Time 1) and at the 20-day follow-up (Time 3). Participants reported their own alcohol consumption during the previous 2 weeks using three items that paralleled the norms items (e.g., maximum, average, and binge). At both time points these items were highly correlated ($r_s > .65$ at baseline; $> .80$ at follow-up) and demonstrated high internal consistency ($\alpha = .83$ baseline; $\alpha = .90$ at follow-up). As such, composite alcohol consumption variables at Time 1 and Time 2 were computed following the same procedures

TABLE 2. Descriptive statistics for normative perception, psychological reactance, and alcohol use variables overall and by study condition

Variable	Overall <i>M (SD)</i>	C0 no spinner; single PNF <i>M (SD)</i>	C1 single spinner; single PNF <i>M (SD)</i>	C2 double spinner; single PNF <i>M (SD)</i>	C3 double spinner; double PNF <i>M (SD)</i>
Time 1 drinking norms					
Average occasion	4.48 (1.74)	4.68 (1.93)	4.18 (1.53)	4.67 (1.67)	4.40 (1.80)
Maximum occasion	7.20 (2.26)	7.40 (2.52)	6.59 (1.98)	7.69 (2.48)	7.06 (1.86)
Binge episodes	2.31 (1.34)	2.29 (1.42)	2.21 (1.29)	2.28 (1.43)	2.47 (1.39)
Drinking norms, <i>z</i>	0.00 (0.83)	0.05 (0.89)	-0.16 (0.74)	0.08 (0.84)	0.02 (0.83)
Time 1 alcohol consumption					
Average occasion	4.96 (2.11)	5.00 (2.15)	4.91 (2.18)	5.06 (2.10)	4.87 (2.09)
Maximum occasion	7.52 (2.70)	7.14 (2.94)	7.81 (2.66)	7.81 (2.66)	8.03 (2.60)
Binge episodes	2.31 (1.34)	2.09 (1.12)	2.34 (1.33)	2.33 (1.47)	2.51 (1.44)
Alcohol use, <i>z</i>	0.00 (0.90)	-0.09 (0.90)	-0.04 (0.89)	0.06 (0.89)	0.09 (0.90)
Time 1 post-PNF reactance					
Cognitive reactance	3.25 (1.13)**	4.04 (1.10) ^a	3.26 (0.92) ^b	3.10 (0.96) ^b	2.61 (1.10) ^c
Emotional reactance	2.30 (1.58)	2.61 (1.48)	2.49 (1.55)	2.00 (1.48)	2.14 (1.61)
Time 2 drinking norms					
Average occasion	3.28 (1.71)	3.59 (2.13)	3.12 (1.05)	3.03 (1.40)	3.41 (2.06)
Maximum occasion	5.14 (2.33)	5.15 (2.78)	5.00 (1.79)	5.17 (2.38)	5.24 (2.33)
Binge episodes	1.53 (1.40)	1.74 (1.58)	1.53 (1.16)	1.36 (1.15)	1.71 (1.40)
Drinking norms, <i>z</i>	-0.71 (0.87)	-.61 (1.03)	-0.78 (0.62)	-0.81 (0.79)	-0.64 (0.98)
Time 3 alcohol use					
Average occasion	3.57 (2.24)	4.18 (2.86)	3.97 (1.99)	3.06 (2.07)	3.09 (1.76)
Maximum occasion	5.30 (3.20)	5.71 (3.90)	5.82 (2.99)	5.19 (3.15)	4.50 (2.51)
Binge episodes	1.53 (1.40)	2.03 (1.73)	1.62 (1.35)	1.28 (1.14)	1.20 (1.22)
Alcohol use, <i>z</i>	-0.69 (1.04)	-0.42 (1.32)	-0.53 (0.96)	-0.85 (0.92)	-0.94 (0.83)

Notes: Variables with significant between-condition differences in unadjusted means are marked with asterisks in the "overall" column. C = Condition; PNF = personalized normative feedback.

** $p < .01$; unadjusted means not sharing a common superscript differ from each other at the $p < .05$ level after applying the Holm-Bonferroni sequential correction.

described for drinking norms (averaged *z* scores at Time 1; averaged *z* scores based on the Time 1 means and standard deviations at Time 2).

Psychological reactance. Both cognitive and affective components of psychological reactance were assessed at Time 1, immediately after participants viewed their feedback. Emotional reactance was assessed by three items adapted for the PNF context: "To what extent did the results you received make you feel irritated/angry/annoyed?" (1 = *not at all* to 7 = *very much so*; Dillard & Shen, 2005; Gardner & Leshner, 2016). The scale exhibited high internal consistency ($\alpha = .89$). Cognitive reactance was measured by three items adapted from Silva (2005) and Gardner & Leshner (2016), which asked participants to report (a) how believable they found the statistics, (b) how skeptical they felt about the results they received, and (c) the degree to which they criticized the information while reviewing it. Items were assessed on a 7-point scale (1 = *not at all* to 7 = *very much so*; $\alpha = .86$).

Data analytic plan

As norm, consumption, and reactance outcomes were normally distributed (e.g., for all outcomes skew ranged from $-.7$ to $.10$ and kurtosis ranged from $-.98$ to 1.6 ; see Table 2 for means and standard deviations), hypotheses were

evaluated by one-way analyses of covariance (ANCOVAs). Respective models for norms and consumption outcomes featured the intervention condition (0, 1, 2, or 3) as the between-subjects' factor and participants' sex, class year, origin (subject pool or judicial), and the baseline measure of the outcome variable as covariates. In the presence of significant omnibus *F* tests, pairwise comparisons between the four conditions were evaluated. *P* values for multiple comparisons were corrected by Holm's Sequential Bonferroni procedure (Abdi, 2010; Gaetano, 2013; Holm, 1979).

Upon establishing through ANCOVA that cognitive reactance significantly differed by condition, but emotional reactance did not, a mediation model focused on cognitive reactance as the mediator of the relationship between condition assignment and alcohol consumption at follow-up. Mediation analyses were performed by the PROCESS bootstrap test in SPSS (Preacher et al., 2008) following recommended guidelines (e.g., 5,000 bootstrap samples and bias-corrected confidence intervals) (Hayes, 2009; Preacher & Hayes, 2004; Zhao et al., 2010). The model specified a multi-categorical, indicator-coded predictor (study condition), which estimated individual *M* and *Y* paths for each spinner condition (coded 1) relative to the no-spinner control condition (coded 0). The model also controlled for participants' sex, class year, origin (judicial vs. subject pool), and baseline alcohol consumption in *M* and *Y* paths.

TABLE 3. Analysis of covariance models testing the effect of condition on drinking norms, alcohol use, and psychological reactance among heavy drinkers ($n = 138$)

Dependent variable	Omnibus test for condition				Pairwise comparisons of adjusted M (SE)			
	df	F	p	η^2	Condition 0 No spinner; single PNF ($n = 34$)	Condition 1 Single spinner; single PNF ($n = 34$)	Condition 2 Double spinner; single PNF ($n = 36$)	Condition 3 Double spinner; double PNF ($n = 34$)
T1 cognitive reactance	3, 130	13.19***	<.001	.23	4.17 (0.18) ^a	3.20 (0.18) ^b	3.06 (0.17) ^{b,c}	2.57 (0.18) ^c
T1 emotional reactance	3, 130	1.25	.29	.03	2.63 (0.28)	2.50 (0.26)	2.01 (0.26)	2.09 (0.27)
T2 drinking norms, z	3, 130	0.54	.65	.01	-0.71 (0.12)	-0.68 (0.11)	-0.82 (0.11)	-0.63 (0.11)
T3 alcohol use, z	3, 130	6.01**	.001	.12	-0.30 (0.14) ^a	-0.50 (0.13) ^{a,b}	-0.88 (0.13) ^{b,c}	-1.04 (0.13) ^c

Notes: Analysis of covariance models for drinking norms and alcohol use controlled for the baseline measure of the outcome variable in addition to participants' sex, class year, and group (human subject pool or judicial). Reactance models controlled for baseline alcohol use in addition to participants' sex, class year, and group. T = Time.

** $p < .01$; *** $p < .001$; adjusted means not sharing a common superscript differ from each other at the $p < .05$ level after applying the Holm-Bonferroni sequential correction for multiplicity.

Results

Preliminary results

A few anticipated baseline differences and unexpected similarities between the binge-drinking students recruited through the Human Subject Pool and Judicial Affairs were observed. The human subject pool students (67%) were more likely than the adjudicated students to be female (39%), $\chi^2(137) = 11.02$, $p < .001$. Likely because of this gender imbalance, the judicially sanctioned students perceived the typical same-sex student to consume significantly greater quantities of alcohol ($t = -2.39$, $p = .02$) and reported themselves consuming greater quantities of alcohol ($t = -2.62$, $p = .01$) than the subject pool students. However, across conditions, there were no differences in cognitive ($t = 0.99$, $p = .32$) or emotional reactance ($t = -0.49$, $p = .62$) experienced by subject pool and adjudicated students following PNF delivery. Furthermore, random assignment resulted in both participant groups being evenly represented across study conditions (Figure 1), and there were no conditional differences at baseline in drinking norms or alcohol consumption (Table 2). As planned, we elected to control both participant sex and origin (subject pool vs. judicial) across tests of hypotheses.

Effect of condition on perceived drinking norms (Hypothesis 1)

ANCOVA results revealed a nonsignificant effect for condition on perceived norms at Time 2, $F(3, 130) = 0.51$, $p = .68$, $\eta^2 = .01$, supporting Hypothesis 1.

Effect of condition on cognitive reactance (Hypothesis 2) and alcohol consumption (Hypothesis 3)

The model for the emotional reactance indicated no differences between conditions, $F(3, 130) = 1.25$, $p = .29$, η^2

$= .03$, whereas the model for the cognitive measure revealed robust differences, $F(3, 130) = 13.19$, $p < .001$, $\eta^2 = .23$. Consistent with Hypothesis 2a, pairwise comparisons (Table 3) revealed that participants in all three spinner conditions reported significantly less cognitive reactance than those in the no-spinner condition. Furthermore, Double Spinner/Double PNF Condition 3 was associated with significantly less reactance than Single Spinner/Single PNF Condition 1. However, there were no significant differences in cognitive reactance between Double Spinner/Single PNF Condition 2 and Single Spinner/Single PNF Condition 1. Further, addressing our exploratory question, although Double Spinner/Double PNF Condition 3 was associated with the least cognitive reactance of all the conditions, the difference between this condition and Double Spinner/Single PNF Condition 2 was not statistically significant.

The ANCOVA model predicting alcohol consumption at Time 3 also indicated significant differences between conditions, $F(3, 130) = 6.01$, $p = .001$, $\eta^2 = .12$. In support of Hypothesis 3b, pairwise comparisons (Table 2) revealed that Double Spinner/Double PNF Condition 3 better reduced drinking than did both Single Spinner/Single PNF Condition 1 and No-Spinner/Single PNF Condition 0. Although Double Spinner/Single PNF Condition 2 better reduced drinking than No-Spinner Condition 0, alcohol consumption in this condition did not differ significantly from that in Single Spinner/Single PNF Condition 1. Addressing our exploratory question, although the least cognitive reactance and largest reductions in drinking were observed in Double Spinner/Double PNF Condition 3, the difference in alcohol consumption between this condition and Double Spinner/Single PNF Condition 2 did not reach significance.

The model presented in Figure 2 and indirect effects detailed in Table 4 provide further support for Hypothesis 2 and Hypothesis 3. Cognitive reactance mediated the overall relationship between study condition and alcohol use at follow-up as well as the relationship between each individual spinner condition (contrasted with the no-spinner condi-

FIGURE 2. Bootstrap Mediation model with study condition specified as a multi-categorical predictor. All paths controlled for Time 1 alcohol consumption, participants' sex, class year, and group (human subject pool or judicial). The parenthesized coefficients on Y paths indicate the total effect on alcohol consumption associated with each spinner condition relative to the no spinner control condition (C0). Above these, the nonparenthesized Y coefficients represent the direct effect of the study condition on alcohol consumption after accounting for the significant indirect effect (detailed in Table 4) from spinner condition to alcohol consumption via cognitive reactance. PNF = personalized normative feedback; ns = not significant.

* $p < .05$; ** $p < .01$; *** $p < .001$.

tion) and alcohol use at follow-up. Relative to No-Spinner Condition 0, each spinner condition significantly reduced the degree of cognitive reactance experienced, which in turn subsequently reduced alcohol consumption at Time 3. Furthermore, providing additional support for Hypothesis 3b, although Single Spinner/Single PNF Condition 1 significantly reduced cognitive reactance relative to No-Spinner/Single PNF Condition 0, the size of the reduction was not large enough to meaningfully influence alcohol consumption as was observed in Double Spinner Conditions 2 and 3. Also notable is that, after we accounted for the larger indirect effects for double-spinner conditions via cognitive reactance, there remained a diminished but still significant direct effect associated with Double Spinner/Double Feedback Condition 3 but not Double-Spinner/Single Feedback Condition 2.

Discussion

Findings from this study suggest that cognitive reactance is likely experienced by heavy drinking college students participating in traditional web-based PNF interventions, and problematically this reactance is likely diminishing the degree to which alcohol PNF leads to reductions in drinking. Fortunately, this study introduces chance-based uncertainty, an established game mechanic, as a novel and cost-effective means of reducing this reactance. Results revealed that, relative to a no-spinner condition, the inclusion of animated

spinners that appeared to determine both the questions asked and the PNF delivered significantly decreased the cognitive reactance experienced by heavy drinking college students, thereby better reducing their alcohol consumption 3 weeks later. Furthermore, although the differences in cognitive reactance and alcohol consumption reported by participants assigned to Double Spinner Conditions 2 and 3, which diverged only in their delivery of PNF of one topic versus two, did not reach statistical significance in the ANCOVA models, the mediation results suggest that there may be advantages to delivering PNF on a second topic. After accounting for the substantial indirect effect through cognitive reactance, a significant relationship persisted between the double PNF condition and drinking at follow-up. Thus, beyond diminishing reactance, delivering heavy drinking students PNF on an additional topic may increase the degree to which alcohol PNF reduces drinking through other mechanisms (e.g., increased attention). In sum, findings suggest that introducing chance-based uncertainty through gamelike spinners, asking questions about multiple topics, and delivering feedback on additional topics unrelated to alcohol work together to reduce the degree to which the task feels like an alcohol intervention overtly aimed at reducing consumption, thereby making the alcohol PNF more effective among heavy drinking students.

Despite between-condition differences in the presence of animated spinners and subsequent numbers of both question and feedback topics, all four conditions similarly reduced

TABLE 4. Indirect effects for cognitive reactance both overall and by study condition (relative to the no-spinner control condition)

Variable	Estimate	SE (boot)	LLCI	ULCI
Overall	.04*	.01	.01	.08
C1 Single spinner; single feedback	-.16*	.06	-.31	-.05
C2 Double spinner; single feedback	-.19*	.08	-.37	-.05
C3 Double spinner; double feedback	-.26*	.10	-.49	-.06

Notes: C = condition; LLCI = lower limit of the confidence interval; ULCI = upper limit of the confidence interval.

* $p < .05$.

peer drinking norms. This finding suggests that PNF's ability to correct drinking norms is not diminished by the additions of chance spinners, questions about multiple topics, or the delivery of feedback on an additional topic. Thus, in the gamified PNF context at least, the cognitive component of reactance does not appear to decrease heavy drinkers' attention to the feedback or act as a barrier to the encoding of true drinking norms. Instead, it appears that reactance determines the extent to which corrected drinking norms lead heavy drinking students to decrease their consumption.

Implications

Psychological reactance theory explains that, because heavy drinkers are likely to identify with their alcohol use, they may interpret questions and PNF about their alcohol use from a researcher, campus health educator, or mandatory on-line program as a threat to their personal freedom. Thus, these at-risk students may resist decreasing their drinking and, in some cases, increase their consumption, even as their perceptions of peers' drinking are corrected. Findings from this study suggest that using animated spinners to induce chance-based uncertainty, multiple question topics, and multiple feedback topics in PNF interventions may be a simple and cost-effective solution to both problems of reactance among heavy drinkers and modest effect sizes in these interventions.

One natural, nonthreatening disguise for a PNF intervention is a Facebook-based game that tests social perceptions of classmates (Boyle et al., 2017). Studies suggest that the ever-increasing popularity of social media sites on college campuses (Kim et al., 2016) may be at least partially explained by young adults' desire for peer knowledge and social comparison (Fardouly et al., 2015; Gerson et al., 2016; Vogel et al., 2014), which also contributes to the power of social norms interventions (Litt et al., 2012). Thus, providing PNF within a social media-connected game is likely to reach college students for whom PNF is likely to be most effective. Furthermore, this context also provides a face-valid reason to ask questions about multiple topics, incorporate gamelike spinners suggestive of chance, and borrow additional mechanics from the gamification literature to further increase engagement and motivation. Importantly, the social media-based "disguised PNF" intervention format would also provide an evidence-based answer to recent calls for the

development of social media-based interventions to combat the potential normative influence of peers' alcohol and other drug-related posts on social media (Ridout, 2016). For an example of how an ongoing gamified PNF intervention might be packaged to appeal to students and sustain play in the absence of incentives, please see Earle et al. (2018).

Limitations and directions for future research

This study is not without limitations. First, because this study was designed to build on our previous gamified PNF work, we did not test conditions that lacked chance-based uncertainty but included multiple question and/or feedback topics. The degree to which these variables alone might reduce reactance and thereby increase the effectiveness of alcohol PNF remains an important question to be addressed in future research.

Second, although results from this study suggest that spinners designed to imply chance selection of question and feedback topics better reduced reactance among heavy drinkers, it also remains unknown whether these elements would be similarly beneficial among nondrinking and light-drinking students likely to experience less reactance in response to PNF. Thus, future research should examine the impact of multiple topics and the apparent selection of question and feedback topics by gamelike spinners on students with less alcohol experience.

Last, the inconsistent conditional effects for cognitive and affective reactance observed in this study were surprising, but the current design did not allow us to fully understand the reason for the low emotional reactance observed across conditions. It could be that alcohol PNF interventions simply arouse little emotional reactance. Alternatively, the Facebook connection, photos of other students, the point-based reward system, and the game framing held may have mitigated negative emotions that might have been experienced otherwise. Future research might compare the emotional reactance experienced by heavy drinking students taking part in both gamified and traditional web-based PNF interventions.

Conclusion

Web-based PNF interventions for college students have consistently produced small to moderate effects, yet the

potential role of psychological reactance has rarely been considered in this domain. The current study examined the abilities of chance-based uncertainty, an established game mechanic, and delivery PNF on a second topic (unrelated to drinking) to reduce the reactance experienced by heavy drinking students, thereby increasing the drinking reduction effects associated with a brief, gamified, web-based PNF intervention. Results revealed that increasing chance-based uncertainty by giving question and feedback topics the appearance of being selected by animated slot-machine-like spinners substantially reduced cognitive reactance, which, in turn, reduced drinking 20 days later. Furthermore, participants experienced the least cognitive reactance when spinners first selected three question topics and later selected two of these topics to deliver feedback on (drinking and social media use). In sum, findings suggest that pairing animated spinners with questions and feedback about both alcohol-related and non-alcohol-related topics may be a simple and cost-effective solution to both problems of reactance among heavy drinkers and modest effect sizes in web-based PNF interventions.

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