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A Text Message Intervention to Reduce 21st Birthday Alcohol Consumption: Evaluation of a Two-Group Randomized Controlled Trial

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Abstract

Twenty-first birthdays are associated with extreme levels of heavy drinking and alcohol-related harm. Effective preventive interventions that are acceptable to young adults are needed. The current study tested the efficacy of a brief text-message intervention for reducing 21st birthday alcohol involvement designed to correct perceived 21st birthday drinking norms and provide protective behavioral strategies (PBS). We also examined potential moderators and mediators. College students (n=200) with an upcoming 21st birthday completed a baseline assessment and were randomized to a text-message intervention or an assessment-only control condition. For

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participants in the intervention group, message 1 (sent day before birthday celebration) focused on personalized normative feedback and message 2 (sent day of birthday celebration) discussed PBS to minimize risk. Primary outcomes were assessed using responses to a follow-up assessment the day after their birthday celebration (93% completion rate). Zero-inflated negative binomial regression analyses did not reveal an overall intervention effect for estimated Blood Alcohol Content (eBAC) or alcohol problems on the 21st birthday celebration. In partial support of our hypothesis, there was an indirect effect of perceived 21st birthday norms on 21st birthday eBAC. The intervention was associated with reduced perceived norms, which was, in turn, related to a lower eBAC. There was a three-way interaction between drinks per week, anticipated eBAC, and intervention condition for the count portion of actual eBAC such that the intervention reduced eBAC among a high-risk subset of the sample. Future research may benefit from further refining the PNF component of 21st birthday interventions.

Keywords

Alcohol; twenty-first birthday; personalized normative feedback; text-message; protective behavioral strategies

Introduction

Most research examining alcohol-related harm considers drinking patterns aggregated over a general time period (e.g. past month or past year). This approach, however, obscures the reality that acute problems typically occur after single occasions of heavy alcohol use. To address this disconnect, a small but emerging body of research focuses on specific events where drinkers are at an elevated risk of alcohol-related harms (Neighbors et al., 2012). These include spring break (Grekin, Sher, & Krull, 2007), bachelorette parties (Buettner & Khurana, 2014), tailgating (Glassman, Werch, Jobli, & Bian, 2007), St. Patrick's Day (Henselee, Bucker, & Irons, 2015), Mardis Gras (Henselee et al., 2015), and of particular relevance to this study, 21st birthdays.

Even among these very high-risk events, 21st birthday drinking stands out as especially risky. Neighbors et al. (2011) observed that average Blood Alcohol Content (BAC) among college drinkers on their 21st birthday was .186, which was 116% higher than St. Patrick's Day, 74% higher than peak consumption over spring break, and 47% higher than New Year's Eve. In another study of 21st birthday celebratory drinking (*N*=2,518), 83% reported some alcohol consumption, with drinkers consuming an average of 12.65 (*SD*=8.5) alcoholic beverages (Rutledge, Park, & Sher, 2008). Nearly half (48%) of those who drank to celebrate consumed more alcohol that day than at *any* previous point in their life. Of particular concern, 34% of men and 24% of women who drank to celebrate consumed 21 or more alcoholic beverages, consistent with the "21run," or "21 for 21" ritual. Most people experience one or more alcohol-related problems as a result of 21st birthday drinking (Neighbors et al., 2014), with 41% blacking out, 45% having a hangover, and 35% vomiting (Brister, Sher, & Fromme, 2011).

21st Birthday Preventive Interventions

Effective preventive interventions focusing on reducing alcohol consumption during 21st birthdays are needed. To date, only a few interventions have been evaluated, with modest results. A recent meta-analysis (Steinka-Fry, Tanner-Smith, & Grant, 2015) of 21st birthday interventions for college students (10 studies total) observed no significant intervention effect for number of drinks consumed (g=.05, 95% CI [−.03, .13]), and a small effect in reducing estimated BAC (g=.20, 95% CI [.07, .33]). However, these findings are due at least in part to the evolving nature of research in this area. The early interventions consisted of nothing more than birthday cards with moderation messages and were not effective (Hembroff, Atkin, Martell, McCue, & Greenamyer, 2007; Neighbors, Spieker, Oster-Aaland, Lewis, & Bergstrom, 2005; Smith, Bogle, Talbott, Grant, & Castillo, 2006). More recent trials, like the Neighbors et al., 2009 study discussed below (also see Neighbors et al., 2012), have included an array of empirically-based intervention approaches, with more promising results.

Two intervention components that could be useful in reducing 21st birthday alcohol consumption are correcting perceived 21st birthday drinking norms and providing harm reduction strategies. A large body of research indicates that personalized normative feedback (PNF) is associated with reductions in alcohol consumption in stand-alone interventions among college students (see Dotson, Dunn, & Bowers, 2015 for a meta-analytic review). Other studies have shown that interventions including protective behavioral strategies (PBS) are effective (Scott-Sheldon, Carey, Elliott, Garey, & Carey, 2014). Neighbors et al. (2009) tested an email intervention which contained a link to a 9-page personalized feedback report that was sent one and two days before college students' 21st birthdays. The intervention provided PNF, PBS, as well as other information often given during a Brief Motivational Interview (Dimeff, Baer, Kivlahan, & Marlatt, 1999). The study participants reported a high level of satisfaction with receiving treatment (e.g. 89% said they "found the information provided interesting.") Relative to the assessment-only control group, this intervention reduced 21st birthday estimated BAC (eBAC), d=. 33. Moderation analyses revealed that the intervention was efficacious for participants with a high *intended* eBAC (d=.42), but not for participants with a low intended eBAC (d=.04). This may be due to personalized feedback creating more self-other drinking discrepancies for students planning to drink very heavily. Mediation analyses showed that the intervention worked as a result of reducing perceived 21st birthday drinking norms. The authors also examined PBS as a potential mediator. No significant indirect effect was observed despite a direct effect suggesting greater PBS use was associated with lower 21st birthday eBAC. Taken together, this suggests there is stronger support for the role of changing perceived norms than increasing use of PBS in terms of 21st birthday intervention efficacy. However, replication is needed, particularly across modalities used more frequently than email.

Text Message Interventions

Text messaging interventions have been successfully used for physical activity (O'Reilly & Spruijtz-Metz, 2013), sexual health (Gold et al., 2011), diabetes management (Cole-Lewis & Kershaw, 2010) weight loss (Bacigalupo et al., 2013), low-density lipoprotein (LDL) cholesterol reduction (Chow et al., 2015), and smoking cessation (Whittaker et al., 2012). In

spite of the general popularity for using TM to manage health behaviors, alcohol researchers are only beginning to utilize the technology as an intervention modality (Mason et al., 2015). In one of the few text-message intervention studies for alcohol, young adults being discharged from an Emergency Department who received TMs that included feedback on willingness to set drinking moderation goals reported less alcohol use and fewer alcohol-related injuries than participants in control groups up to nine-months post-intervention (Suffoletto et al., 2015).

Twenty-first birthday drinking interventions have been delivered with mailed cards (Hembroff et al., 2007; Neighbors et al., 2005; Smith et al., 2006; Lewis, Neighbors, Lee, & Oster-Aaland, 2008), emails (Neighbors et al., 2009), and in-person sessions (Neighbors et al., 2012), but never text-messaging. A 2011 Pew Research study (Smith, 2011) found that 92% of 18–24 year olds use TM and most receive/send 100+ texts per day. TM has advantages over other forms of intervention delivery since they are accessed regularly and quickly. College students spend an astounding 527 minutes on their cell phones per day, with more time devoted to text-messaging (95 minutes) than any other activity (Roberts, Yaya, & Manolis, 2014). This makes text-messaging particularly suitable for event-level preventive interventions, although we are only aware of one study that has utilized TM in this manner (Cardigan et al., under review). In a review of text-messaging as a means of delivering public health interventions, Hall, Cole-Lewis and Bernhardt (2015) argued that “mobile phones have become the most accessible form of mediated communication in world history, and text messaging has become one of the most frequently used forms of mobile communication” (p. 415).

Current Study Overview

The goal of the current study was to provide an extension of the Neighbors et al. (2009) email intervention. Although our intervention was generally based on that of Neighbors and colleagues, we tested the efficacy of a version that was much briefer (focused only on PNF and PBS), and delivered through text-messaging rather than email. In doing so, our hope was to create an effective intervention that could be easily disseminated and widely accessed.

Hypothesis 1 was that a TM intervention for 21st birthday drinking, relative to an assessment-only control group would reduce estimated Blood Alcohol Content (eBAC) and alcohol-related problems for 21st birthdays. Hypothesis 2 was that this main effect would be moderated by 21st birthday drinking intentions, such that the intervention effect would be greater for participants who anticipated a high (versus low) 21st birthday eBAC, consistent with the moderation effect found by Neighbors et al. (2009). Hypothesis 3 was that perceived 21st birthday drinking norms would mediate this association. Specifically, it was hypothesized that (1) the intervention (relative to control) would be associated with a reduction in perceived 21st birthday drinking norms, and (2) lower drinking norms would be related to less alcohol involvement. Two exploratory analyses were also conducted. First, PBS was examined as a potential mediator. No *a priori* hypothesis was established because it did not mediate the effect of treatment condition on eBAC in the Neighbors et al. (2009) study, although it has mediated intervention outcomes in similar work (Barnett, Murphy, Colby, & Monti, 2007; Larimer et al., 2011). Second, we explored typical alcohol use

(drinks per week at baseline) as a potential moderator in a series of two- and three- way interactions with the other independent variables (condition and anticipated eBAC). The three-way interaction was of particular interest because it seemed possible that the intervention might reduce alcohol involvement among low weekly drinkers with a high anticipated eBAC, since light drinkers are perhaps more sensitive to personalized feedback depicting their alcohol use as especially risky

Method

Participants & Recruitment

Participants were recruited between May 2016 and November 2016. In the approximately 7 days prior to their 21st birthday, students (n=1,283) received up to three recruitment emails for a study that ostensibly examined how young adults celebrate their birthday. Those who were interested completed a very brief online questionnaire to verify eligibility (n =280). Students were eligible if they (1) anticipated consuming at least two standard drinks to celebrate their 21st birthday (consistent with the eligibility requirements of Neighbors et al. [2009]), and (2) had a mobile phone from which they could send and receive text messages. Of people who took the eligibility survey, 85.0% were eligible. Sample characteristics at baseline are presented in Table 1, and recruitment is depicted in Figure 1.

Procedure

Upon completing the eligibility survey, eligible participants reviewed an informed consent document. Those who consented were asked to immediately complete a short baseline survey. Next, participants were urn randomized by gender and the number of drinks they planned on consuming during their 21st birthday (strata of standard drinks: 2–5, 6–10, 11–15, 16–20, 21+) to the intervention or control condition (Stout, Wirtz, Carbonari, & Del Boca, 1994). As discussed below, those assigned to the intervention condition were texted at 4pm on the day before, and at 4pm on the day of, their anticipated birthday celebration.[1] Participants assigned to the control condition were not contacted by the research team during this period. At 4 PM the day after their anticipated celebration, participants received a link via email for an online follow-up questionnaire. Non-responders received up to four reminders (one by email, two by text message, and one by phone call, in that order) within the week following their planned celebration date. Participants were entered into a raffle for an iPad mini for completion of the baseline survey, and received $10 in cash or towards an Amazon Gift card for completion of the follow-up survey. All policies and procedures were approved by the University of Rhode Island Institutional Review Board (IRB).

[1]To check accuracy of the anticipated birthday celebration date, which was assessed at baseline, participants were also asked to indicate the date of their birthday celebration at follow-up (henceforth called actual birthday celebration date). Since the date TMs were sent occurred according to the planned birthday celebration, it was possible that participants in the intervention condition would receive the first TM the day of their actual birthday celebration, and receive the second TM the day after their actual birthday celebration (if the actual birthday celebration date was exactly one day before the planned birthday celebration date). It was also possible that participants could receive no TM prior to their actual birthday celebration (if the actual birthday celebration date was two or more days before their planned celebration date). The former scenario occurred for n=5, and the latter occurred for n=1. Other than one participant who was erroneously sent the follow-up too early, no one indicated their birthday celebration occurred after completing the follow-up assessment.

Intervention Development

Focus Groups—To refine the wording and delivery of text messages (described below), six focus groups of 30–60 minutes duration were conducted with drinkers 19–20 years old (n=23). To start, general feedback was solicited about information that may be helpful for students to receive proximal to their 21st birthday. Next, structured questions were asked to elicit answers to specific questions we had while in the process of developing a 21st birthday text-message intervention (e.g. the appropriate length and level of formality, the extent to which messages should differ). In the structured question portion of the focus groups, participants were asked their opinion of receiving two nearly identical text messages presenting PNF. Of n=13 responses (n=10 did not reply directly), 69% thought the texts should be different and 31% liked the redundancy. In the unstructured portion of the focus group, when participants were asked what information might be helpful to receive on a 21st birthday, responses almost exclusively entailed reminders about Protective Behavioral Strategies (PBS; e.g. “drinking slowly” n=3; “drink water” n=5; “eat beforehand” n=5; “arrange a safe ride” n=4).

Intervention—At 4 PM the day before their planned birthday celebration, participants assigned to the intervention group were sent the following (text message one):

> Hi [participant name]. Happy almost birthday from the URI Young Adult Birthday Study! Earlier, you said you would have *W* drinks on your 21st birthday celebration[2]. This is more than what *X*% of URI [males/females] drink on their 21st birthday. If you drink this much over *Y* hours, you will have a blood alcohol content of *Z*. This may result in [effect from Table 2] PLEASE RESPOND “OK” so we know you got our message.

The number of anticipated drinks (W), time spent drinking (Y), and gender were taken from participants’ replies on the baseline survey, and used to calculate Blood Alcohol Content (Z). The normative feedback component (X) was based on gender-specific 21st birthday drinking data collected from 961 undergraduate students 21 years or older in April 2015 at the same study site.

At 4PM the day of their planned birthday celebration, intervention participants were sent the following (text message two):

> Hi [participant name]. Here are some tips to stay safe from the URI Young Adult Birthday Study: Keep track of how many drinks you have and space them out with water, eat beforehand, and have a sober driver ready. Enjoy your time with friends and make it a night to remember! PLEASE RESPOND “OK” so we know you got this.

For both text messages, participants who did not reply received up to two follow-up messages at 5PM and 6PM. The 5PM follow-up to text message one was: “We missed your response. Did you see our earlier message? If so, reply ‘OK’.” The 6PM follow-up to text message one was: “Just checking in again. PLEASE RESPOND ‘OK’ if you got our earlier

[2]The word “celebration” was added after the first 42 participants. This was considered potentially important since some celebrations were planned on days other than their actual birthday.

message.” The 5PM follow-up to text message two was: “We missed your response. Please respond ‘OK’ if you got today’s message.” The 6PM follow-up to text message two was: “Because we did not hear back from you, we assume you did not get our message. PLEASE RESPOND ‘OK’ so we know you got it.” Participants who replied to text message one by 7 PM immediately received: “Thanks! We will check in tomorrow.” Participants who replied to text message two by 7 PM immediately received: “OK thanks! We’ll be emailing you in the next day or two.” Although a reply of “OK” was requested at both time points, any response (e.g. “yes,” “sounds good,” etc.) was treated as indicative of exposure to the message. All text messages were sent from a secure program built for this study at the University of Pittsburgh.

Measures

Eligibility Survey—This survey consisted of two items: 1) “Do you have a mobile phone that you use to send and receive text messages?” 2) “How many standard alcoholic drinks do you intend to consume on your 21st birthday celebration?” Standard drink definitions of 12 oz. of beer, 1.5 oz of liquor and 4–5 oz. of wine were given.

Demographics—At baseline, participants were asked their gender, weight, ethnicity, and race. At baseline, Greek Involvement was also assessed with one item adopted from Capone, Wood, Borsari, and Laird (2007). Participants were asked: “Are you associated with a fraternity or sorority.” Response options included: “Yes, I am a member or pledge;” “No, but I regularly attend fraternity or sorority activities;” and “No, and I DO NOT regularly attend fraternity or sorority activities.”

Intended Birthday Celebration Day—At baseline, participants were shown a calendar and asked to “Indicate the day you intend to celebrate your 21st birthday. If you plan on celebrating two or more days, please choose the day that you anticipate will be the ‘largest’ or ‘primary’ celebration.”

Anticipated/Actual 21st Birthday BAC—At baseline and follow-up, participants were asked: 1) “In total, how many standard drinks do you plan on consuming/did you consume during your 21st birthday celebration?” and 2) “Over how long a period of time do you plan on drinking/were you drinking?” Standard drink estimates were provided. Anticipated/actual 21st birthday eBAC were calculated using these data, as well as gender and weight (from the demographics survey) with the formula provided by Matthews and Miller (1979).

21st Birthday Alcohol Problems—At follow-up, participants completed a 17-item version of the 24-item Brief Young Adult Alcohol Consequences Questionnaire (B-YAACQ; Kahler, Strong, & Read, 2005). Directions were modified to only assess problems the day of or day after their 21st birthday celebration, and items only applicable to drinking over a long time period were deleted (e.g. weight gain). Alpha in this study was 0.76.

Descriptive 21st Birthday Drinking Norms—At baseline and follow-up, we used the following item adapted from Neighbors et al. (2009) “How many drinks do you think a

typical University of Rhode Island student of your gender consumes on his/her 21st birthday?"

Protective Behavioral Strategies—At follow-up, we used a 14-item survey adapted from Neighbors et al. (2009) (also based upon Martens et al., 2005) to assess the number of protective behavioral strategies used on the participant's 21st birthday in a yes/no format (e.g. "use a designated driver"). Scores were calculated as the sum of all items to reflect the total number of strategies endorsed. The survey created by Neighbors et al. (2009) was 15 items, but we erroneously failed to include the item "Avoid drinking shots of liquor." Otherwise, the two questionnaires were identical. We observed a co-efficient alpha of .79.

Intervention Satisfaction—At follow-up, participants in the intervention condition were asked the following questions on a 5-point Likert Scale from 1 (not at all) to 5 (extremely): "The feedback was useful to me," "I thought about this information over the course of my birthday celebration," "I would have preferred receiving this information through other means, such as email."

Analytic Plan

Data Cleaning—For anticipated and actual 21st birthday eBAC, scores greater than .50, which were considered improbable, were recoded to .50 as done in Neighbors et al. (2009). This affected five scores (2.75%) for anticipated eBAC and two scores (1.10%) for actual 21st eBAC. For normative 21st birthday alcohol use, a visual inspection of the distribution revealed six outliers at time 1 (3.00%) and two outliers at time 2 (1.10%), which were recoded to 24.

Preliminary Analyses—A series of comparisons between groups were run to analyze differential participation, eligibility, and attrition. Chi-squared tests were calculated for categorical dependent variables (gender, intervention condition), and independent samples *t*-tests were calculated for continuous dependent variables (eBAC intentions). Descriptive statistics were examined, including for the intervention satisfaction items.

Hypothesis Testing—There was strong negative skew for both actual 21st birthday eBAC and 21st birthday alcohol problems. Consistent with previous research with highly skewed eBAC outcomes, actual 21st birthday eBAC was multiplied by 100 and rounded to the nearest integer and modeled as a count (Neighbors et al., 2011). Using the COUNTFIT command in STATA, we examined goodness of fit indices for these outcomes with Poisson, zero-inflated Poisson, negative binomial, and zero-inflated negative binomial (ZINB) distributions. Zero-inflated negative binomial yielded the lowest Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values (1066 and 1095, respectively) of all four distributions for both outcomes, so our primary analyses were conducted using ZINB. Also of note, a Vuong test indicated that ZINB is superior to negative binomial across four different models with relevant predictor variables and eBAC or consequences as the outcome, Vuong=2.11–3.14, *ps*<.05. A more thorough explanation of applying ZINB to drinking variables is provided by Atkins, Baldwin, Zheng, Gallop and Neighbors (2012) (also see Atkins & Gallop, 2007). A ZINB distribution is a negative

binomial distribution that has an excess number of zeros. Briefly, ZINB models are mixture models which simultaneously evaluates two distributions. The *count* model evaluates the negative binomial distribution including the proportion of zeros that would be expected in a negative binomial distribution with the given mean and dispersion. The *inflation* model consists of a logistic model evaluating the log likelihood of being an excess zero. All of the analyses described below were run in Mplus v. 7.3 using the N=200 who were enrolled (based on intent-to-treat) assuming a ZINB distribution of the outcome.

To examine intervention efficacy, two regression models were run where intervention condition, anticipated 21st birthday eBAC, and baseline drinks per week were all mean-centered and specified as independent variables. All possible two-way interactions were also included, as well as the three-way interaction. Since some of the interaction terms were highly correlated (even after centering), analyses were done in a hierarchical fashion such that the three-way interaction is reported in the full model, the two-way interactions are reported in a model that only includes the main effects and two-way interactions, and the main effects and intercepts are reported in a model that only includes the main effects. Covariances were estimated for correlated terms and we the MPlus default MLR option.

To examine mediation, two path models were tested. These are shown conceptually in Figure 2. In each model, drinking norms at follow-up and protective behavioral strategies were tested as mediators. For the first model (Figure 2A), 21st birthday eBAC was specified as the outcome. For the second model (Figure 2B), alcohol problems was specified as the outcome. Anticipated eBAC was included as a covariate for the outcome and drinking norms at baseline was included as a covariate for drinking norms at follow-up. We purposefully did not estimate the path between PBS and our outcomes for the logistic portion of the model, because this variable was not considered conceptually relevant to the prediction of *any* alcohol involvement versus no alcohol involvement.

In each model, two indirect effects were estimated: Intervention – Norms – Outcome and Intervention – PBS – Outcome on the count portion of the model. Standard errors for indirect effect were estimated with bootstrapping 1000 samples. Significance of indirect effects were determined by bias corrected bootstrapped confidence intervals (BBCI).

We used a Bonferroni correction to adjust for familywise error. For the models examining intervention efficacy, there were two outcomes (eBAC and alcohol problems), each of which included a count and logistic portion. For the indirect effects, there were two potential mediators (norms and PBS) with the same two outcomes. Thus, for these analyses, we corrected for four tests, with outcomes correlated at r=.49 (which represents the relation between eBAC and alcohol problems). This yields an adjusted alpha of 0.25.

Results

Attrition and Comparison Analyses

Among students who received recruitment emails, females (28.0%) were more likely to complete the screening survey than males (15.3%), χ^2 (1, N=1283) = 29.69, p<.001. Among students who took the screening survey, those who were eligible were more likely to be

female than those who were not eligible χ^2 (1, N=242) = 5.561, p = .018 (69.0% female among eligible students; 50.0% female among ineligible students). Among participants retained at baseline, there were no differences between those who completed the follow-up versus those who did not complete the follow-up with respect to gender: χ^2 (1, N=200) = 0.614, p = .433, condition: χ^2 (1, N=200) = 0.526, p = .468, or BAC intentions, t(198) = .94, p = .925.

Descriptive Analyses

At baseline, participants reported a median anticipated 21st birthday eBAC of .0827. At follow-up, participants reported a median actual 21st birthday eBAC of .0830, and a mean of 2.23 (SD=2.40) (range: 0–13) consequences. Among participants retained in the intervention condition, 95.9% (n=94 of 98) responded to the first text message (focusing on PNF), and 95.9% (n=94 of 98) responded to the second text message (focusing on PBS). For both text-messages responders and non-responders did not differ by gender or baseline drinks per week (ps>.15). In the control group, 21st birthday drinking norms were 9.88 (SD=4.84) at baseline and 9.85 (SD=4.74) at follow-up, which was not statistically different $t_{paired}(92)=-.061$, p=.951. In the intervention group, norms were 10.06 (SD=4.98) at baseline and 7.93 (SD=4.54) at follow-up. This reduction was statistically significant $t_{paired}(91)=4.95$, p<.001, d=0.45[3].

Intervention Satisfaction

Mean values for intervention satisfaction, scored on a scale ranging from 1 to 5, were as follows: “Feedback was useful,” M=3.14 (SD=.98); “Thought about information”, M=2.86 (SD=1.18); “Would have preferred receiving feedback through other means”, M=2.19 (SD=1.26).

Regression Results Examining Intervention Efficacy

For both 21st birthday eBAC and 21st birthday problems, results from the count portion of the model suggest that there were no direct intervention effects, nor were the hypothesized Anticipated 21st Birthday eBAC by Condition interactions significant (Table 3). However, for actual 21st birthday eBAC, there was a three-way interaction between Anticipated 21st Birthday eBAC, Drinks per Week, and Condition. This interaction was probed in Figure 3 by graphing the relation between anticipated eBAC and drinks per week on actual eBAC across both conditions. For lighter weekly drinkers in the control group, there was a strong positive relationship between anticipated and actual 21st birthday eBAC with estimated scores ranging widely, as shown by the light blue and red lines on the top panel of Figure 3. For heavy weekly drinkers in the control group, there was a weak (or no) relationship between anticipated and actual 21st birthday eBAC, as shown by the yellow and dark blue lines. By contrast, the difference in the relationship between anticipated and actual 21st Birthday eBAC according to drinks per week was attenuated in the intervention condition. As shown in the bottom panel of Figure 3, regardless of drinks per week among participants receiving

[3]The effect size was calculated according to Morris and DeShon (2002), who recommend accounting for the correlation between Time 1 and Time 2 variables in within-subjects comparisons.

the intervention, there was a modest, positive relationship between anticipated and actual eBAC.

For 21st birthday problems, the only significant interaction was between Anticipated 21st Birthday eBAC and Drinks per Week (Table 3). As shown in Figure 4, there was a positive relationship between anticipated 21st birthday eBAC and the number of alcohol-related problems among light weekly drinkers, but this association was not observed among heavier drinkers. Overall, heavier drinkers experienced more alcohol-related problems than light drinkers. For the logistic portion of both models, there were no significant main effects or interactions.

Mediation

Path models for mediation are represented in Figure 2. Specific results from the path models are presented in Table 4. Of particular interest, the *a* path (independent variable to mediator) was significant for the count portion of both models with Drinking Norms as the putative mediator (*B*= −1.882 and −2.056 for eBAC and problems, respectively). The *b* path (mediator to outcome) with norms as the mediator was also significant for eBAC as the outcome (*B*=.068), but not alcohol problems as the outcome. Also noteworthy is the fact more protective behavioral strategies was associated with fewer alcohol problems (*B*=−.077), but unrelated to eBAC. However, the intervention had no impact on the number of PBS reported.

For the purpose of establishing mediation, it is the indirect effect (*a***b*) that is most important. A significant indirect effect through norms was observed for actual 21st birthday eBAC as the outcome, after controlling for the (non-significant) indirect effect of PBS, −.129(*SE*=.050). We did not find an indirect effect through norms with alcohol problems as the outcome. No indirect effects through Protective Behavioral Strategies were observed for either outcome. These are presented in Table 5.[4]

Discussion

The current study was designed to test the efficacy and mechanisms of a TM intervention, focused on correcting perceived norms and providing protective behavioral strategies, for 21st birthday drinking. To our knowledge, this is the first 21st birthday intervention to use TM as a modality. Study hypotheses were only partially supported.

Counter to our hypothesis that participants receiving the intervention would report lower levels of 21st birthday intoxication than those in a control group, no direct intervention effects were observed for either eBAC or alcohol-related consequences. Unfortunately, these results are consistent with a number of prior 21st birthday interventions that ultimately failed to have a direct effect on drinking (e.g. Hembroff et al., 2007; Lewis et al., 2008; Neighbors

[4]Although this was not the focus of our paper, we also examined serial mediation models. The model reflecting Condition to Norms to PBS to Problems yielded a significant indirect effect of −.029 (*SE*=.017), $p<.01$. Unstandardized coefficients for these three paths are −2.068 ($p<.001$), −.153 ($p<.01$), and −.092 ($p<.01$), respectively. This suggests: 1) the intervention was associated with reduced norms, 2) Lower perceived norms is correlated with more PBS, and 3) more PBS is related to fewer 21st birthday problems. We did not observe a significant indirect effect in the same model with eBAC as the outcome.

et al., 2005; Smith et al., 2006), suggesting that 21st birthday alcohol use may be especially difficult to change. The Neighbors et al. (2009) study, which did successfully intervene upon 21st birthday drinking, included an especially lengthy intervention. Dosage in the current study was much more modest and this could have contributed to the lack of an effect. Also, as discussed below, half of the intervention (the PBS text-message) was broad and generic, which might not have been optimal.

No interaction between eBAC intentions and condition was observed (hypothesis two), failing to replicate findings in Neighbors et al. (2009). However, in partial support of hypothesis three, perceived drinking norms (but not PBS) functioned as a mediator for 21st birthday eBAC. Specifically, at follow-up, participants in the intervention condition (relative to students in the control condition) perceived their peers to drink less during a 21st birthday; lower perceived drinking norms were then associated with lower 21st birthday eBAC. This mediation finding replicates that of Neighbors et al. (2009), using a much shorter intervention delivered through a different modality. Furthermore, the magnitude of this effects was rather large. After accounting for baseline norms, the intervention (relative to control) was associated with a 1.88 unit reduction in the perceived number of 21st birthday drinks consumed by a same-sex University of Rhode Island student. Then, for every one-unit decrease in perceived norms, there was an 7.0% decrease in 21st birthday eBAC. (The *b* path reflects the association between the mediator and the negative binomial distribution of the outcome, which is log-linked. Exponentiation of the coefficient is interpretable as a rate ratio. Thus, e^b for .068=1.070, which indicates, as stated above, that each unit change in follow-up norms is associated with a corresponding 7.0% change in follow-up eBAC). This translates to a 13.2% eBAC reduction for a 1.88 unit change in the mediator.

The existence of an indirect effect through drinking norms on eBAC is promising and consistent with two recent reports. A systematic review by Reid and Carey (2015), which included 61 trials where a mediator was tested for intervention effects in college student samples, identified descriptive norms as the most widely supported mediator. In another review of mediators for technology-delivered psychosocial treatments for substance use, seven studies tested perceptions of peer drinking as a mediator, and it was supported in six (87.5%) trials (Dallery, Jarvis, Marsch, & Xie, 2015). The current study provides further evidence that changing perceptions of drinking norms is a promising tool for preventive interventions, and confirms that this is a mechanisms of change applicable to event-level drinking. We should note that in the present study drinking norms was not a mediator with alcohol problems as the outcome. However, PNF (the active intervention component for changing norms) only targeted drinking behavior, and did not address problems. Although students from our focus group suggested a PBS component to our intervention, it did not function as a mediator, consistent with the findings of Neighbors et al. (2009). It may reflect the fact PBS is an inherently broader concept that, relative to PNF, is more difficult to communicate over a short platform like text-messaging.

There were also some interesting moderation findings. The three-way interaction shown in Figure 3 suggests that habitually heavy drinkers have high 21st birthday eBACs regardless of how much they anticipated drinking. However, being exposed to the intervention mitigated risk for heavy drinkers with a low anticipated eBAC. The intervention was also associated

with a reduction among light drinkers who plan on drinking heavily. This may be an especially important group to intervene upon, because past research shows that acute episodes of drinking more than the typical amount is associated with increased risk of same-day negative outcomes (Neal & Fromme, 2007)

Strengths

The major strength of the present experiment is a high degree of study integrity. Among the 200 participants who were randomized, 92.5% were retained at follow-up, with no evidence of differential attrition. Furthermore, nearly all participants assigned to the intervention group responded to the text messages (96% for TM 1 and 96% for TM 2), which suggests the intended information was successfully conveyed in nearly every case. This finding points to the general promise for using text-messaging as a means of intervening with young adults, consistent with recent reviews (Orr & King, 2015; Suffoletto, 2016). Although no total intervention effect was observed, another strength of the current study is that the text-messages were carefully created based on focus group pilot testing. Based on the descriptive results, participants reported moderate satisfaction with the intervention, similar to a recent report evaluating the acceptability of normative information communicated over text-message (Merrill, Boyle, Barnett, & Carey, in press), although the fact that these scores were around the mid-point of the scale suggests there is still room for improvement. It might reflect the fact participants from our focus group were unrepresentative of the students who ultimately chose to participate. Finally, the intervention tested here was tailored for the date of one's *birthday celebration*, whereas past research has focused only on the actual birthday (which may or may not be the celebration day).

Limitations and Future Directions

Relative to several other studies (e.g. Neighbors et al., 2011; Rutledge et al., 2008), 21st birthday drinking was somewhat low despite the fact more than half of the sample reached legal intoxication. The extent to which these findings generalize to a heavier drinking sample is unknown, although the lack of a Condition x Anticipated 21st Birthday eBAC interaction suggests the intervention would still not have been effective among riskier college students. The sample was also homogenous with respect to race/ethnicity, consistent with the institution from which data were collected; results may not generalize to a more diverse population.

An additional limitation is related to the manner in which eBAC is calculated based on self-report data. The formula used estimated BAC at the **end** of the 21st birthday drinking episode, but consider the following: A 150 pound female who has eight standard drinks between 6:00 pm and 7:00 pm, then one standard drink at 2:00 am will report consuming nine drinks over seven hours with an eBAC of .134. However, at 7:00 pm, her eBAC will be 66% higher at .223. In reality, a greater concern is reducing peak eBAC compared to eBAC at the end of a 21st birthday celebration, and the extent to which these values differ is unknown but could be high in some cases. Future research aimed at describing or preventing event-level alcohol use would benefit from Ecological Momentary Assessment, or even more promising, a wearable bio-sensor (e.g. Kim et al., 2016). This would also negate or minimize issues of inaccurate reporting. Finally, this study only had two assessment points,

and is thus not ideal for establishing mediation. It would have been preferable to assess the putative mediator prior to the dependent variable, rather than simultaneously (Nock, 2007).

The lack of an intervention effect requires revisiting the way we used TM as a preventive intervention for 21st birthday drinking. For example, our intervention may have been too brief to have the desired effect. Dosage could be increased by sending several messages over the course of a night or intervening on friends with whom participants plan to celebrate. Also, it might be beneficial to send initial messages 1–2 weeks prior to an event to capture the period of time when students are likely planning the night's activities in an attempt to intervene upon drinking intentions.

Since perceived norms, but not PBS, mediated the intervention condition −> 21st birthday eBAC path, some options for improvement are suggested. Future studies might include a more intensive exposure to PBS since our intervention did not affect total PBS scores, but PBS was related to one of the two outcomes. Some have recommended a broader operationalization of PBS that includes decisions to avoid drinking all together (Pearson, 2013; the measure in the current study did not capture PBS for abstaining), which could be explored in the context of a 21st birthday intervention. It may also be possible to adapt PNF for PBS (e.g. "X% of students alternate between alcohol and non-alcoholic drinks for their 21st birthday), and preliminary pilot data suggests this would be feasible (Merrill et al., in press). Although this was considered outside the scope of the current study, another recommendation would be to examine whether the intervention affected specific PBS subscales. It is possible that usage of certain types of strategies increased as a result of the text-message, but we observed null findings by using the total score.

One possible future intervention would be correcting both descriptive (quantity of actual behaviors, as addressed in this study) and injunctive (approval of certain behaviors) 21st birthday norms. As discussed by Krieger et al. (2016), injunctive norms are more strongly associated with behavior when the two are closely connected. Perhaps the total intervention effect could be enhanced by including the following feedback: "The average student at your university believes XX drinks is the maximum one should consume on a 21st birthday."

Conclusion

We tested the efficacy of a brief text-message intervention for 21st birthday drinking. The intervention was feasible and acceptable, but did not have a main effect on eBAC or alcohol problems. However, moderation results suggest that the intervention was associated with a reduction in eBAC among certain high-risk groups. A significant indirect effects on eBAC through perceived 21st birthday drinking norms suggests that a brief text-delivered intervention has promise. Future event-level preventive intervention studies could further refine the normative feedback component used here to potentially enhance the overall intervention effect. Interventions to mitigate extreme 21st birthday drinking are needed to reduce the risk of serious physical harms.

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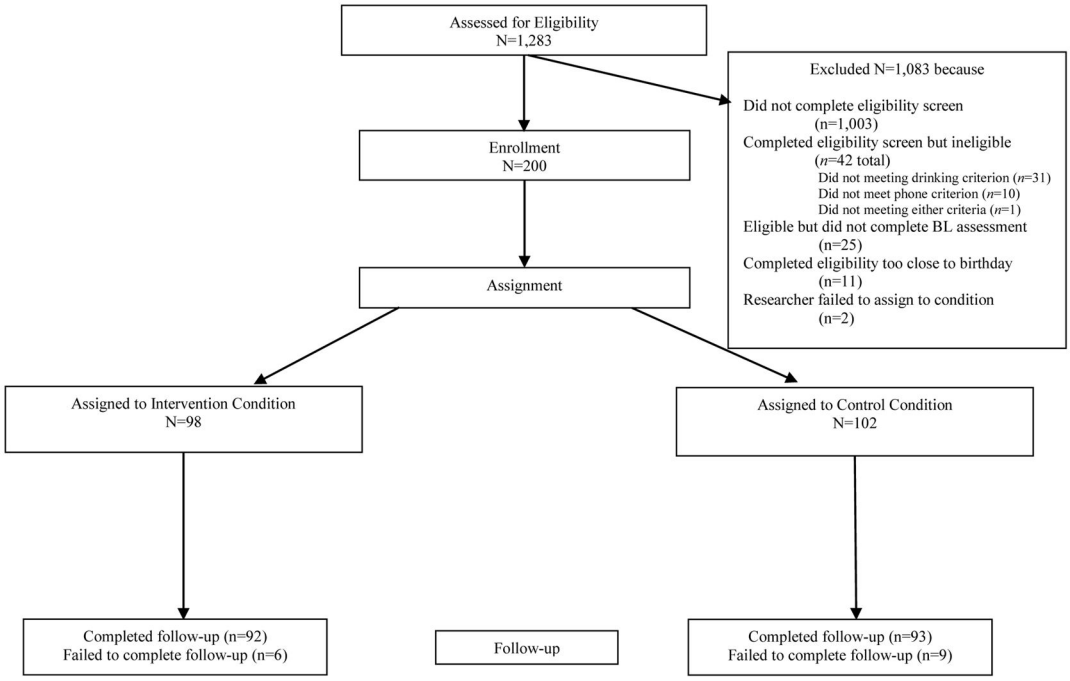

Figure 1.
Procedural Flowchart

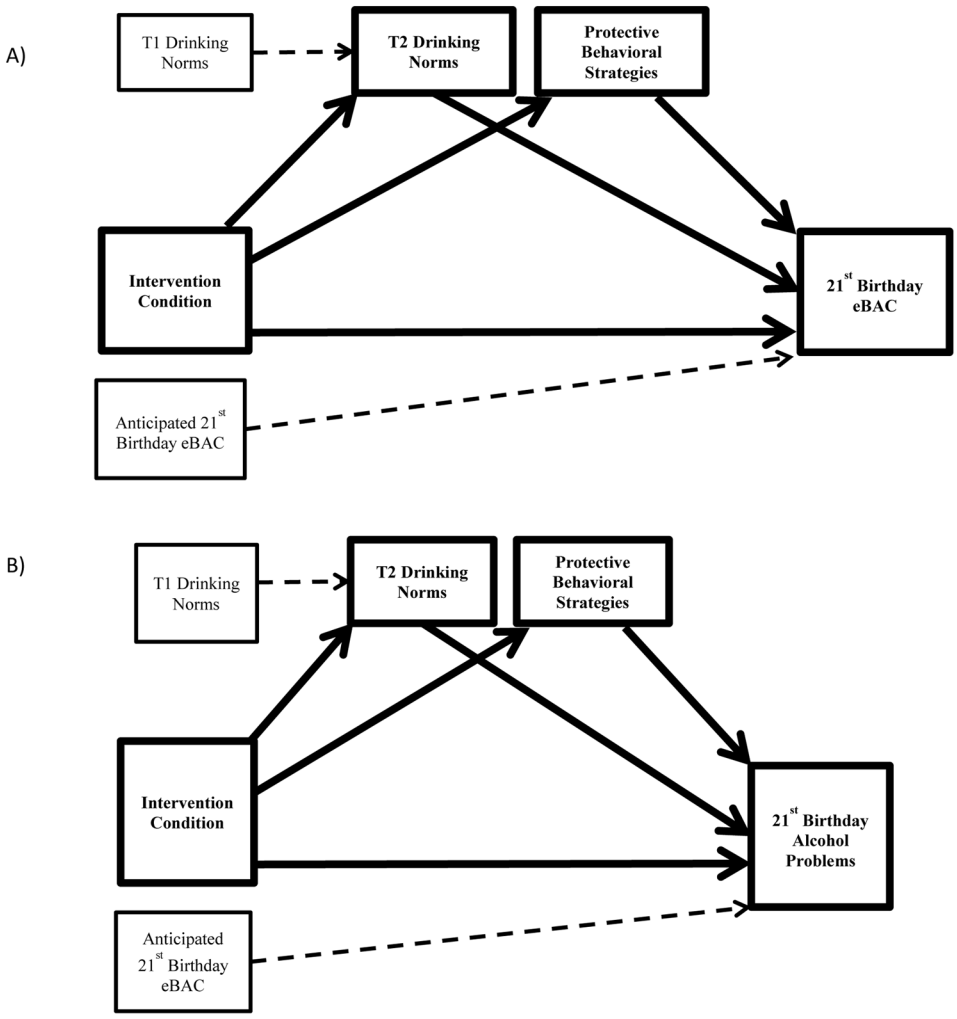

Figure 2. Conceptual Mediation Models

Note. Conceptual models are presented with 21st birthday eBAC as the outcome (Figure 2A) and 21st birthday problems as the outcome (Figure 2B). Empirical results are shown in Table 5. For each mediation model, two mediation paths are hypothesized: one through T2 Drinking norms, and one through Protective Behavioral Strategies. T1=baseline, T2=follow-up. eBAC=estimated Blood Alcohol Content. T1=Time 1 variable. T2=Time 2 variable. eBAC=estimated Blood Alcohol Content

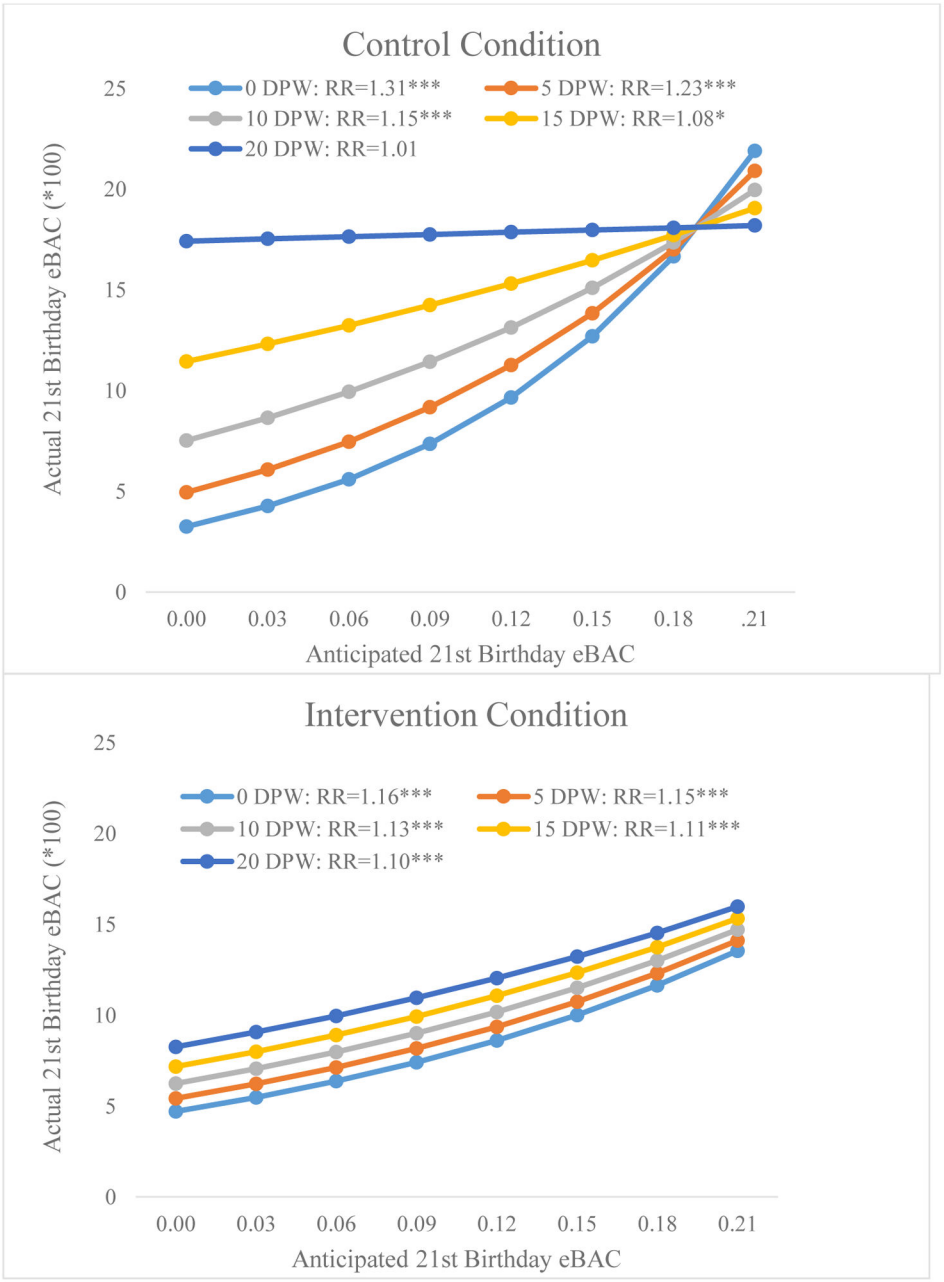

Figure 3. Probe of Three-Way Interaction Between Anticipated 21st Birthday eBAC, Drinks per Week, and Condition on Actual 21st Birthday eBAC

Note. Probe of the three-way interaction shown in the last line of the first segment of Table 3 is depicted. Results reflect the count portion of the model, and values on the y-axis are multiplied by 100 so they satisfy the count requirement of Zero-Inflated Negative Binomial (ZINB) regression. RR=Rate ratio. DPW=Drinks per Week. eBAC=estimated Blood Alcohol Content

* $p<.05$, two-tailed *** $p<.001$ two-tailed

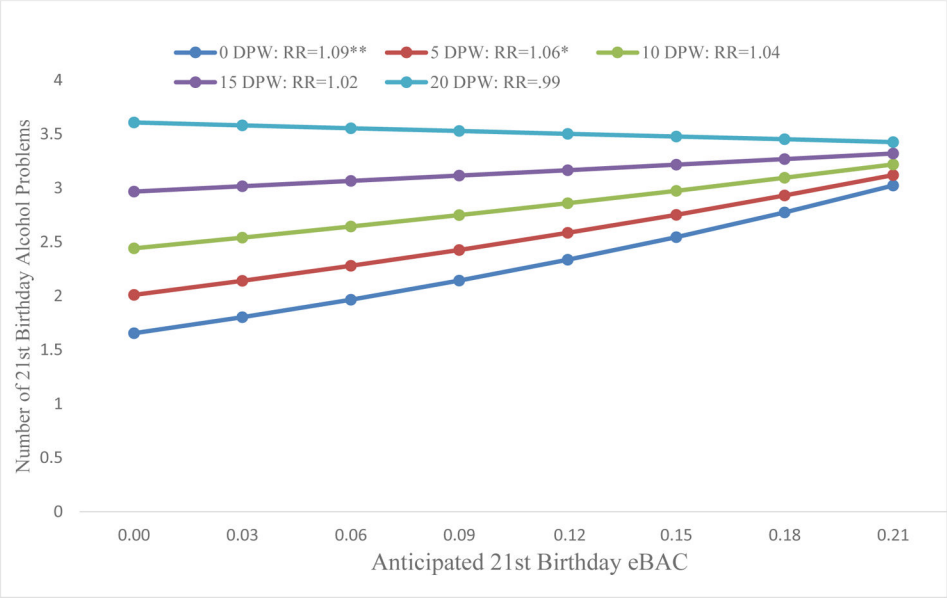

Figure 4. Probe of Two-Way Interaction Between Anticipated 21st Birthday eBAC and Drinks per Week on 21st birthday problems

Note. Probe of the two-way interaction shown in the second segment of Table 3 is depicted. Results reflect the count portion of the model DPW=Drinks per Week. eBAC=estimated Blood Alcohol Content

Table 1

Sample Characteristics at baseline (*N*=200)

Variables	Percent of Sample
Condition	
Intervention	49.0
Control	51.0
Gender	
Female	69.0
Male	31.0
Race	
White/Caucasian	87.5
Black/African American	3.0
Asian	4.5
Native American/American Indian	0.5
Other	4.5
Ethnicity	
Hispanic/Latino	10.5
Not Hispanic/Latino	89.5
Greek Involvement	
Member/Pledge	35.5
Non-member, regularly attend activities	6.0
Non-member, do not regularly attend activities	58.5
Drinks/Week (*M*=9.87, *SD*=10.04)	
0	12.0
1–5	30.9
6–10	21.5
11–15	14.1
16–20	9.9
21+	11.5

Table 2

Effects Reported to Participants in Text-Messages

Expected BAC	Effect
<.06	relaxation and low inhibitions
.06–.09	impaired judgment and decision making
.10–.15	clear deterioration of judgment and coordination
.16–.19	nausea and vomiting
.20–.24	confusion, difficulty walking, and blacking out
.25–.29	becoming very ill, blacking out, and having severe impairments of basic bodily functions
.30–.34	passing out and having difficulty waking up
.35+	going into a coma or even dying from excessive drinking

Note. BAC=Blood Alcohol Content. The effects listed here were based upon ones used by Neighbors et al. (2009).

Table 3

ZINB Primary Model Results: Effect of Anticipated 21st Birthday eBAC, Drinks per Week, and Intervention Condition on 21st Birthday Alcohol Involvement

	Count Portion of Model			*Logistic Portion of Model*		
	Outcome=21st Birthday eBAC					
	B	***SE B***	**Z**	***B***	***SE B***	**Z**
Intercept	2.340	.058	40.604***	−1.718	.282	−6.104***
Main Effects						
Anticipated 21 Birthday eBAC	3.578	.575	6.211***	1.555	2.321	.670
Drinks per Week	.017	.005	3.149**	−.064	.043	−1.482
Intervention Condition[a]	−.180	.111	−.162	−.534	.431	−1.240
Two-Way Interactions						
Anticipated 21st Birthday eBAC by Drinks per Week	−.124	.036	−3.419**	−.426	.561	−.758
Anticipated 21st Birthday eBAC by Condition	.798	1.124	.710	−1.051	4.237	−.248
Drinks per Week by Condition	−.010	.012	−.876	−.003	.094	−.031
Three-Way Interaction						
Anticipated 21st Birthday eBAC by Drinks per Week by Condition	.340	.145	2.341*	−.575	4.797	−.120
	Outcome=21st Birthday Problems					
Intercept	.988	.147	6.708***	−2.380	2.472	−.963
Main Effects						
Anticipated 21 Birthday eBAC	.517	.674	.767	−9.086	22.441	−.405
Drinks per Week	.015	.008	1.965	−.168	.128	−1.312
Intervention Condition[a]	−.193	.207	−.936	−.058	1.287	−.045
Two-Way Interactions						
Anticipated 21st Birthday eBAC by Drinks per Week	−.156	.042	−3.693***	−.312	.490	−.636
Anticipated 21st Birthday eBAC by Condition	.635	1.203	.528	23.820	17.538	1.358
Drinks per Week by Condition	.004	.012	.358	.026	.305	.084
Three-Way Interaction						

	Count Portion of Model			*Logistic Portion of Model*		
	Outcome=21st Birthday eBAC					
	B	***SE B***	**Z**	***B***	***SE B***	**Z**
Anticipated 21st Birthday eBAC by Drinks per Week by Condition	−.070	.116	−.602	−1.394	0.966	−1.444

Note. Results from two separate models are presented, one with 21st birthday eBAC as the outcome (top panel), and one with 21st birthday problems as the outcome (bottom panel). *B* values represent unstandardized coefficients. ZINB=Zero-Inflated Negative Binomial. eBAC=estimated Blood Alcohol Content. Lowest.

*$p<.025$, two-tailed

**$p<.01$, two-tailed

***$p<.001$, two-tailed.

[a]Coded as 0=Control, 1=intervention.

The model with the three-way interaction and AIC and BIC values of 5446 and 5604, respectively. The model with the two-way interaction had AIC and BIC values of 5182 and 5311, respectively. The model with the main effects had AIC and BIC values s3402 and 3468, respectivel

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Table 4

ZINB Mediation Model Results: Effect of PBS and Drinking Norms on 21st Birthday Alcohol Involvement

	Count Portion of Model			Logistic Portion of Model		
	B	***SE B***	**Z**	***B***	***SE B***	**Z**
Model predicting 21st birthday eBAC (Figure 2A)						
Outcome=21st birthday eBAC						
Intervention Condition	.126	.132	.954	−.491	1.635	−.300
Drinking Norms (T2)	.068	.015	4.605***	−3.235	2.187	−1.479
PBS	−.018	.025	−.714			
	.034	.008	4.437***	.326	.191	1.709
Outcome=PBS						
Intervention Condition	.196	.526	.373			
Outcome=Drinking Norms (T2)						
Intervention Condition	−1.882	.594	−3.171**			
	.555	.062	9.024***			
Model predicting 21st birthday problems (Figure 2B)						
Outcome=21st birthday problems						
Intervention Condition	−.085	.150	−.565	−0.461	0.611	−0.754
Drinking Norms (T2)	.011	.016	.690	−0.463	0.269	−1.722
PBS	−.077	.025	−3.053**			
	.007	.007	.973	−.011	.045	−.239
Outcome=PBS						
Intervention Condition	.196	.526	.373			
Outcome=Drinking Norms (T2)						
Intervention Condition	−2.056	.544	−3.781***			
	0.579	.055	10.437***			

Note. Results from two separate mediation models are presented, one with 21st birthday eBAC as the dependent variable (top panel), and one with 21st birthday problems as the dependent variable (bottom panel). Models are shown conceptually in Figures 2A and 2B, respectively. *B* values represent unstandardized coefficients. Gray variables represent covariates. ZINB=Zero-Inflated Negative Binomial. Separate analyses where the outcome or mediators controlled for gender and Drinks per Week yielded similar results PBS=Protective Behavioral Strategies eBAC=estimated Blood Alcohol Content.

*p<.025, two-tailed

** *p*<.01, two-tailed

*** *p*<.001, two-tailed

Table 5

Results of Indirect Effects with Bias-Corrected Bootstrapped Confidence Intervals

	21st Birthday eBAC			21st Birthday Problems		
Mediator	***B***	***SE B***	**Z**	***B***	***SE B***	**Z**
T2 Drinking Norms	−.129	.050	−2.633**	−.023	.036	−.646
PBS	−.003	.015	−.226	−.015	.043	−.352

Note. Unstandardized paths are shown.

** $p<.01$, two-tailed