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Level of Response to Alcohol as a Factor for Targeted Prevention in College Students

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Background: Heavy alcohol consumption and alcohol problems among college students are widespread and associated with negative outcomes for individuals and communities. Although current methods for prevention and intervention programming have some demonstrated efficacy, heavy drinking remains a problem. A previous pilot study and a recent large-scale evaluation (Schuckit et al., 2012, 2015) found that a tailored prevention program based on a risk factor for heavy drinking, low level of response (low LR) to alcohol, was more effective at reducing heavy drinking than a state-of-the-art (SOTA) standard prevention program for individuals with the low LR risk factor.

Methods: This study enrolled 231 first-semester college freshmen with either high or low LR into the same level of response-based (LRB) or SOTA online prevention programs as in the previous reports (consisting of 4 weeks of video modules), as well as a group of matched controls not receiving alcohol prevention, and compared changes in alcohol use between these groups across a 6-month period.

Results: Individuals in alcohol prevention programs had a greater reduction in maximum drinks per occasion and alcohol use disorder symptoms than controls. There was limited evidence for interactions between LR and prevention group in predicting change in alcohol use behaviors; only among participants with strict adherence to the program was there an interaction between LR and program in predicting maximum drinks per occasion. However, overall, low LR individuals showed greater decreases in drinking behaviors, especially risky behaviors (e.g., maximum drinks, frequency of heavy drinking) than high LR individuals.

Conclusions: These results indicate that prevention programs, including brief and relatively inexpensive web-based programs, may be effective for persons at highest risk for heavier drinking, such as those with a low LR. Tailored programs may provide incremental benefits under some conditions. Long-term follow-ups and further investigations of tailored prevention programs based on other risk factors are needed.

Key Words: Alcohol, Level of Response, College Students, Prevention, Web-Based.

ALCOHOL USE AND misuse are common and potentially dangerous aspects of the college experience. Nearly all college students (78%) have tried alcohol, and 63% of students drank alcohol within the past month (Johnston et al., 2013). Alcohol use disorders (AUDs) are also prevalent: In a 2013 national survey, 13.5% of college students met DSM-IV criteria for alcohol dependence or abuse (Substance Abuse and Mental Health Services Administration, 2014). These high rates of drinking contribute to a host of negative outcomes for students in areas such as academic performance, physical and emotional health, legal problems, and interactions with peers. The risk of harm or injury is significantly elevated for individuals who engage in "binge" drinking, defined as 4 or more drinks per occasion for women and 5 or more for men (Wechsler and Nelson, 2008). In a survey of U.S. college students, about 35% of students reported an occasion of binge drinking (5 or more drinks) in the previous 2 weeks (Johnston et al., 2013). In light of concerning numbers such as these, the National Institute on Alcohol Abuse and Alcoholism delivered a call to action in 2002 for universities to address alcohol concerns on campus; however, problems related to heavy alcohol use continue to threaten the success of college students.

Despite the prevalence of heavy drinking and alcohol problems on college campuses, only 41% of universities mandate alcohol education for their students (Nelson et al., 2012). The transition to college represents a time of heightened behavioral change, due in part to greater independence and increased access to alcohol and other substances; thus,

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early intervention is key (Fromme et al., 2008; Schulenberg and Maggs, 2002). Many programs that aim to curb these changes employ empirically supported techniques such as motivational interviewing and cognitive behavioral therapy to communicate socially normative rates of consumption and dangers of heavy drinking, as well as teaching skills to identify and cope with stress, manage peer influences, and avoid risky drinking (Borsari and Carey, 2001; Larimer and Cronce, 2007; Nation et al., 2003; Schuckit et al., 2012). Evidence suggests that alcohol prevention programs that are personalized to give individual-level feedback (based on an participants' drinking behaviors, alcohol expectancies, or other factors) are more effective for reducing risky drinking among college students than those lacking such components (Cronce and Larimer, 2009; Scott-Sheldon et al., 2014). However, many colleges still rely on "one-size-fits-all" programs to educate students on safer drinking practices, providing the same content for all participants.

Even with individualized efforts to fit the message to the participant's needs, there is much room for additional improvement (Malloy et al., 2002; Paschall et al., 2011). As heavy drinking and AUDs have substantial genetic components (50 to 60% heritability; Kendler et al., 1992), some individuals are more vulnerable to developing problems than others, particularly in some contexts. Biologically influenced factors that increase the risk for heavy drinking include impulsivity, negative affect, coping-related drinking motivations, and a low level of response (low LR) to alcohol (Schuckit, 2009). Identifying these factors in students could provide opportunities to specifically target prevention programming based on individualized risk profiles for developing alcohol problems (Conrod et al., 2013; Schuckit et al., 2012).

Among these risk factors, one of the most well-studied is the low LR to alcohol, where an individual needs to consume more alcohol than the average person to feel the same intoxicating effects. In addition to requiring a greater amount of alcohol, Piasecki and colleagues (2012) found that individuals with low LR are also less likely to experience the negative effects of alcohol associated with a hangover. Low LR is strongly genetically influenced and impacts risk for alcohol problems both directly, through increased alcohol consumption and binge drinking, and indirectly, through a number of environmental mediators (Schuckit, 2009; Schuckit et al., 2012). A theoretical model of the relationship between low LR, peer drinking influences, alcohol expectancies, stress coping strategies, and long-term alcohol outcomes is detailed by Schuckit and colleagues (2011, 2012). Because of its strong associations with heavy alcohol consumption and alcohol problems, as well as its potential to be influenced by modifiable environmental factors, LR presents a viable target for personalized prevention and intervention efforts.

In a small pilot project, Schuckit and colleagues (2012) developed a web-based alcohol prevention program tailored toward the low LR to alcohol for a group of 64 freshman college students at the University of California at San Diego. Their study assigned individuals to 1 of 2 alcohol prevention programs: one focusing on low LR as a risk factor for binge drinking and alcohol problems; and the other a nontailored, standard alcohol prevention program. Both programs comprised 4 sessions of online modules (50-minute videos) that focused on increasing awareness of risks associated with heavy drinking, correcting myths about social norms, and teaching skills to avoid risky drinking behaviors. However, the level of response-based (LRB) program was structured around the low LR model (Schuckit et al., 2012). Results indicated an interaction between LR and the prevention program received: Individuals with a low LR reported a greater reduction in drinking quantities when enrolled in the program tailored to address low LR than in the standard prevention program. A larger replication (N = 500) at the same university found a similar LR by program interaction in reducing drinking quantity (Schuckit et al., 2015). This suggests that tailoring prevention programming to an individual's biologically predisposed low LR may be more effective than standard one-size-fits-all programs in reducing risky drinking among college students.

The current study aimed to replicate and extend the findings of Schuckit and colleagues (2012, 2015) in a population of first-year college students at a large public university in the southeast United States. We built upon the previous studies by replicating the protocol in a large sample from a university with different demographic, regional, and cultural influences, examining longer term effects and measuring the effectiveness of the prevention programs by assessing drinking behaviors across time in a group of control students from the same population. We hypothesized that low LR individuals in the tailored prevention program would experience a greater reduction in drinking frequency and quantity than those in the standard prevention program and that individuals in the prevention programs would have lower levels of alcohol use than controls at follow-up.

MATERIALS AND METHODS

Participants

Participant Selection and Matching. Following approval from the university's Institutional Review Board and incorporating informed consent procedures, participants were selected from a larger university-wide study of substance use and emotional health among college students ("Spit for Science"; Dick et al., 2014), an online survey offered to all incoming students aged 18 or older early in the fall of their freshman year. The participation rate for the parent study was 59% of those invited (N = 2,022). As part of this initial survey, participants who reported having used alcohol 5 or more times in their lives (57.7%) responded to the Self-Rating of the Effects of Alcohol (SRE) scale (Schuckit et al., 1997). This scale consists of 4 questions that ask students to think back to the first 5 times they consumed alcohol and report how many standard drinks it took for them to feel tipsy/have a buzz, feel dizzy/slur their speech, stumble/find it hard to walk, and fall asleep without intending to. A SRE score, representing the average number of drinks needed to feel these intoxicating effects, was calculated. The higher the SRE score, the lower the effect per drink and the lower the LR (Schuckit, 2009). Drawing from the participants who completed the initial Spit for

Science survey within the first 4 weeks of the study (83% of the 2,022 individuals), those with SRE scores greater or <0.25 standard deviations from the mean were considered eligible for the study, to compare individuals who clearly had a low versus high LR. Schuckit and colleagues (2012) used the same criterion for distinguishing low LR and high LR individuals; however, the overall mean SRE score (5.3, SD = 2.12) in that study was lower than that of this study (seen in Table 1). Enrollment was capped approximately 4 weeks after the initial survey to facilitate the timeline of the prevention programs; during this time, 323 of the invited 572 students expressed interest in participating (56.5%) and 231 were enrolled in the study. Participants included 165 females (71.4%), and the self-reported race/ethnicity was 0.4% American Indian/Native American, 6.9% Asian, 11.3% Black/African American, 5.6% Hispanic/Latino, and 75.8% White. Females and whites were overrepresented in this prevention subset compared to the university sample.

Participants were entered into a matching program to be paired with another participant with similar demographic characteristics (sex, ethnicity, height, and weight) as well as similar alcohol use (typical quantity and frequency of alcohol use) but opposite LR to alcohol (high vs. low) to ensure that individuals in each group were similar on other variables impacting alcohol use that might confound the analyses. Matched pairs of participants were then randomly assigned to 1 of 2 alcohol prevention modules: a nontargeted, state-of-the-art (SOTA) prevention program, or a similar program that focused on LR as a risk factor for heavy alcohol use and problems (LRB), resulting in 4 total groups: high LR–LRB, high LR–SOTA, low LR–LRB, and low LR–SOTA. For 27 individuals, a suitable pair member could not be assigned, resulting in 52 pairs and 12 singletons in the LRB group and 50 pairs and 15 singletons in the SOTA group.

Selection of Control Participants. The university-wide Spit for Science survey was conducted early in the fall semester, with a follow-up survey approximately 6 months later in the spring semester (for all students who completed the initial survey, including the prevention program participants). To determine whether changes in alcohol use across time could be attributed to the prevention programs, we selected a set of control individuals from this parent Spit for Science study who did not participate in the prevention programs. Following completion of the spring follow-up, we retrospectively selected control participants who had completed both the fall and spring Spit for Science surveys and matched them to the prevention study participants using the protocol described above (i.e., based on ethnicity, and drinking behaviors, etc.). We then compared the controls' changes in alcohol use across time to that of participants enrolled in the prevention programs.

Protocol

Data Collection. Study data were collected and managed using Research Electronic Data Capture (REDCap; Harris et al., 2009) tools hosted at Virginia Commonwealth University. REDCap is a secure, web-based application designed to support data capture for research studies.

Alcohol Prevention Programs. After being assigned to a prevention program, participants completed 1 Internet-based 50-minute video per week for 4 consecutive weeks, after each of which they filled out a short comprehension quiz. For both groups, the videos consisted of providing general alcohol information such as the definition of a standard drink and the dangers of heavy drinking, debunking myths related to social norms about drinking, providing real statistics about alcohol use, and teaching skills for healthy ways of coping and refusing drinks. However, the information provided in the LRB modules was framed around low LR as a risk factor for heavier/problematic alcohol use and stressed the relationship between LR and other risk factors, such as peer substance use, alcohol expectancies, and coping mechanisms. LRB participants were also provided with instructions for how to calculate their own SRE score. These videos were designed by Marc Schuckit; see Schuckit and colleagues (2012) for more details about the prevention programs and the material covered in each video.

Assessment of Alcohol Use Behaviors. As part of the prevention programs, alcohol use behaviors were assessed via self-report at the time of the first and final video modules ("Week 1" and "Week 4") and in a follow-up questionnaire 30 days after completing the programs ("Week 8"). These assessments measured 4 past-month alcohol use behaviors: number of days drinking alcohol, usual number of drinks per drinking occasion, maximum number of drinks in 24 hours, and number of days drinking 4 or more alcoholic drinks.

Table 1. Demographic Characteristics and Baseline Alcohol Use Patterns of 231 College Students Enrolled in Alcohol Prevention Programs

Measure *n*	Full sample 231	Low LR-LRB 53	Low LR-SOTA 51	High LR-LRB 63	High LR–SOTA 64	F/χ^2 (*p*)
Age (mean [SD])	18.51 (0.39)	18.54 (0.57)	18.5 (0.3)	18.49 (0.29)	18.5 (0.35)	0.48 (0.70)
Female (*n* [%])	165 (71.43)	38 (71.70)	35 (68.63)	47 (74.60)	45 (70.31)	0.55 (0.91)
Ethnicity (*n* [%])						5.20 (0.95)
Native American	1 (0.43)	0 (0.00)	0 (0.00)	1 (1.59)	0 (0.00)	–
Asian	16 (6.93)	3 (5.66)	2 (3.92)	5 (7.94)	6 (9.38)	
African American	26 (11.26)	6 (11.32)	5 (9.80)	8 (12.7)	7 (10.94)	–
Hispanic/Latino	13 (5.63)	3 (5.66)	2 (3.92)	4 (6.35)	4 (6.25)	–
White	175 (75.76)	41 (77.36)	42 (82.35)	45 (71.43)	47 (73.44)	–
SRE score (mean [SD])	5.69 (2.8)	8.04 (2.13)	8.34 (2.28)	3.58 (1.02)	3.7 (1.00)	144.25 (<0.01)
Alcohol use						
Number of days drinking (mean [SD])	3.12 (3.38)	3.79 (3.7)	4.24 (4.19)	2.41 (2.47)	2.38 (2.83)	4.72 (<0.01)
Number of drinks per day (mean [SD])	3.74 (2.04)	4.77 (2.24)	4.72 (2.07)	2.95 (1.34)	2.81 (1.59)	19.46 (<0.01)
Module comprehension questions (% correct)	0.92 (0.09)	0.88 (0.12)	0.95 (0.08)	0.90 (0.10)	0.96 (0.06)	7.69 (<0.01)
Average time spent watching each video (minutes)	44.69 (8.84)	45.28 (6.36)	42.79 (8.72)	44.02 (10.45)	46.39 (8.43)	1.50 (0.22)
Average level of interest in each video	3.02 (0.89)	3.05 (1.01)	3.02 (0.90)	2.98 (0.79)	3.03 (0.91)	0.05 (0.98)

LR, level of response to alcohol; LRB, level of response-based prevention program; SOTA, state-of-the-art prevention program; SRE, Self-Rating of the Effects of Alcohol scale (higher scores indicate more drinks needed to achieve intoxicating effects).

Alcohol use variables were measured in the Baseline/Fall semester Spit for Science survey used for recruitment. Level of interest was a 5-point ordinal variable averaged across videos.

The time frame for these behaviors was 30 days prior to assessment, such that Week 1 measures reflected alcohol use in the month prior to the prevention programs, Week 4 measures reflected alcohol use during the month-long programs, and Week 8 measures reflected behaviors in the month after completing the programs.

In addition, in the parent Spit for Science survey, alcohol use behaviors were assessed for both the prevention program participants and their matched controls in the initial fall survey approximately a month before Week 1 of the programs ("Baseline/Fall") and in a follow-up survey in the spring semester approximately 6 months after the initial fall survey and 22 weeks from the beginning of the prevention programs ("Week 22/Spring"). Seventy-five percent of the prevention study participants completed the Week 22 follow-up. Alcohol use behaviors assessed in these surveys included typical number of days drinking per month (ordinal, recoded as pseudo-continuous), usual number of drinks per occasion (ordinal, recoded as pseudo-continuous), maximum drinks in 24 hours (MAX24) (fall: lifetime maximum; spring: maximum since beginning college), and DSM-V AUD symptoms (fall: lifetime symptoms; spring: symptoms since beginning college) (American Psychiatric Association, 2013). An overview of the study timeline and measures is displayed in Fig. 1.

Participants in the prevention study received a total possible compensation of $100 for completing each of the 4 video modules and associated questionnaires. In total, 131 participants (56.7%) completed all 4 modules, and 34 (14.7%) did not complete any of the modules after enrolling in the study. Participants who did not complete any modules were more likely to have a low LR ($n = 25$; $\chi^2[1] = 13.09$, $p < 0.01$) and to be male ($n = 15$; $\chi^2[1] = 4.72$, $p = 0.03$), but did not differ by ethnicity or the prevention program to which they were assigned.

Data Analysis

Comparison of LRB and SOTA Alcohol Prevention Programs. Our primary analyses consisted of comparing alcohol use across time between the LR and prevention program groups. Because participants were allowed to miss individual modules/questionnaires without being dropped from the study, many individuals had missing data at 1 or more time points; thus, we employed a linear mixed model design rather than the repeated-measures analysis of variance used by Schuckit and colleagues (2012). Analyses were conducted in SPSS version 21 using the GENLINMIXED command (IBM Corp., Armonk, NY), with an unstructured covariance matrix to account for the unequal spacing between the repeated measurement occasions and a robust sandwich estimator to improve estimation of the standard errors. These models estimated the effects of LR (low; high), program (LRB; SOTA), and their interaction across time to predict change in alcohol use across the prevention program and follow-up assessments (weeks 4, 8, and 22). Sex, ethnicity, and baseline alcohol use (from the Baseline/Fall survey) were included as covariates to account for residual confounding after participant matching. To follow up these analyses, we also included other factors in the models, including percentage of postmodule quiz questions answered correctly, average level of reported interest in the videos, and average length of time spent watching the videos, to determine whether these variables or their interaction with the prevention programs influenced alcohol use outcomes.

Comparison of Alcohol Prevention Programming Participants Versus Controls. Control participants were assessed at Baseline/Fall and Week 22/Spring. To compare the prevention study participants with the control participants, we used a linear mixed model with LR and Prevention status (Prevention; Control) and their interaction predicting the change in alcohol use behaviors across time. Sex and ethnicity were included as covariates.

RESULTS

Participant Characteristics

Demographic characteristics and baseline substance use patterns for participants in the SOTA and LRB prevention groups at baseline ($n = 231$) are shown in Table 1. There were no group differences in gender or ethnicity, but, by design, there were significant differences on SRE scores across the groups. Despite our matching process, there were also significant differences on alcohol use, although post hoc analyses showed that these differences were only between the low versus high LR groups and not between prevention programs (LRB vs. SOTA). We therefore included Baseline/Fall alcohol use (days drinking and drinks per day) in the analytic models to control for baseline group differences in alcohol use.

Comparison of LRB and SOTA Alcohol Prevention Programs

Mean levels of alcohol use behaviors for the LR and prevention program groups from Week 1 to Week 22 are shown in Table 2, and the results of the mixed model analyses for these alcohol use outcomes are summarized in Table 3. The following sections provide specific details of the results for each alcohol use behavior, and a visual example is presented for one of the outcomes, MAX24, to illustrate the results (Fig. 2).

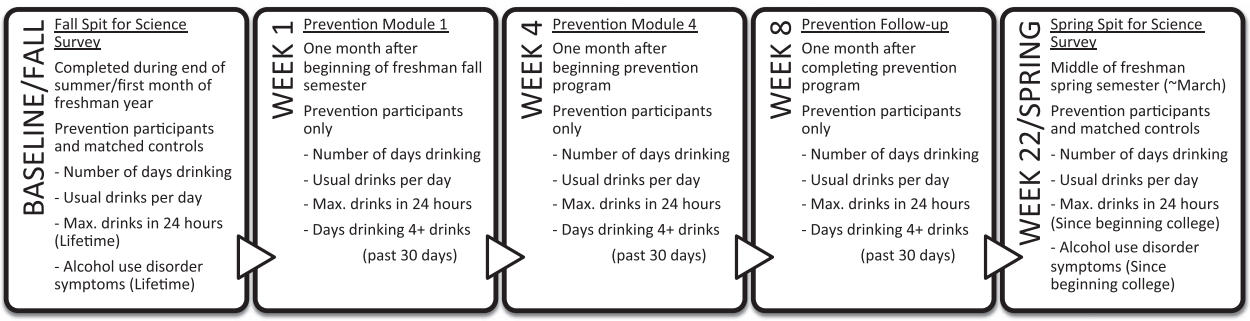

Fig. 1. Timeline and content of assessments from the prevention programs and parent Spit for Science survey.

Table 2. Mean Alcohol Use Behaviors Across Time for College Students Enrolled in Alcohol Prevention Programs

	High LR–LRB Mean (SD)	High LR–SOTA Mean (SD)	Low LR–LRB Mean (SD)	Low LR–SOTA Mean (SD)
Number of drinking days per month				
Week 1	3.20 (2.97)	3.45 (3.35)	5.88 (4.34)	5.30 (4.45)
Week 4	1.25 (1.77)	3.78 (3.43)	2.94 (3.86)	4.41 (3.57)
Week 8	3.55 (3.46)	3.58 (3.63)	3.53 (3.57)	3.97 (4.18)
Week 22	3.04 (2.87)	3.71 (3.48)	4.45 (4.34)	4.09 (3.37)
Usual number of drinks per occasion				
Week 1	2.80 (2.15)	2.71 (1.84)	4.73 (3.44)	5.03 (3.04)
Week 4	2.92 (2.65)	2.73 (1.57)	4.87 (5.57)	4.65 (3.29)
Week 8	2.88 (2.31)	2.57 (1.76)	3.71 (2.83)	3.89 (3.04)
Week 22	3.67 (1.88)	3.26 (1.39)	4.72 (2.01)	4.63 (2.30)
Maximum drinks in 24 hours				
Week 1	4.49 (3.65)	4.00 (3.19)	7.15 (5.03)	7.58 (5.30)
Week 4	2.82 (2.27)	4.40 (3.04)	4.39 (3.03)	7.56 (5.46)
Week 8	4.21 (3.52)	3.98 (3.42)	5.44 (4.67)	5.81 (5.04)
Number of days per month drinking 4+ drinks				
Week 1	1.65 (2.45)	1.38 (1.71)	3.67 (4.03)	3.60 (3.77)
Week 4	4.06 (3.64)	1.49 (1.91)	6.48 (4.94)	3.32 (3.60)
Week 8	1.57 (2.66)	1.58 (1.96)	2.35 (3.40)	2.81 (3.98)
DSM-V alcohol use disorder symptoms				
Week 1	1.77 (1.90)	1.60 (1.77)	2.89 (2.15)	2.58 (2.35)
Week 22	2.16 (2.18)	2.02 (2.17)	2.05 (1.87)	2.70 (2.02)

LR, level of response to alcohol; LRB, level of response-based prevention program; SOTA, state-of-the-art prevention program.

Number of Days Drinking Alcohol. As shown in Tables 2 and 3, there were significant effects of Time and significant Time*LR and Time*Program interactions on the number of days drinking alcohol per month, with an overall decrease in drinking days across time that was greater for the low LR than the high LR group. Averaging across LR, those in the LRB program had a sharp decrease from Week 1 to Week 4 followed by a return toward the baseline levels, while those in the SOTA program had little change across time. Pairwise contrasts indicated that at the Week 4 assessment, both low LR and high LR individuals in the SOTA program drank more often than those in the LRB program (difference = 1.68 to 2.42, $p = 0.02$ to <0.001), although this difference did not persist beyond Week 4. Interactions between LR and Program were not significant.

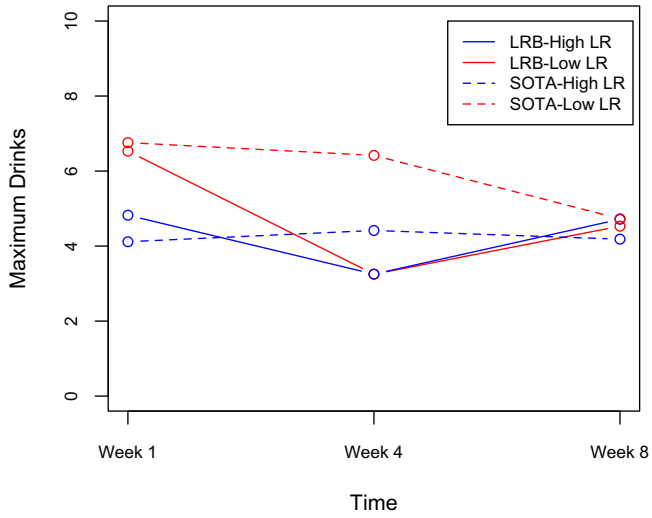

Fig. 2. Change across time in maximum drinks in 24 hours in the past 30 days for students with high or low level of response (LR) enrolled in either a level of response-based (LRB) or state-of-the-art (SOTA) alcohol prevention program. Points represent estimated marginal means from the mixed model analyses (Table 3), controlling for the effects of sex, ethnicity, and Baseline/Fall alcohol frequency and quantity.

Usual Drinks per Drinking Day. Average drinks per drinking occasion decreased across the prevention study period with a slight overall increase at the Week 22 follow-up. Only Time and LR had significant effects on this outcome. Individuals with a low LR drank more than those with high LR, even after controlling for baseline differences in alcohol use frequency and quantity between groups.

Maximum Drinks in 24 Hours. Time and LR had significant main effects on MAX24, with significant interactions between Time*LR and Time*Program (Fig. 2). There was an overall decrease of approximately 2 drinks for low LR individuals from Week 1 to Week 8, while there was little change, on average, for high LR individuals. Averaging across LR groups, there was a greater decrease for

Table 3. Summary of Results from Linear Mixed Model Analyses Predicting Change in Alcohol Use Behaviors Across Time (Weeks 1, 4, 8, and 22) for College Students Enrolled in Alcohol Prevention Programs

	Number of drinking days per month		Usual number of drinks per occasion		Maximum drinks in 24 hours		Number of days per month drinking 4+ drinks		DSM-V alcohol use disorder system	
	F	*p*	*F*	*p*	*F*	*p*	*F*	*p*	*F*	*p*
LR	0.07	0.792	**6.46**	**0.013**	**5.13**	**0.026**	2.16	0.144	3.62	0.059
Program	2.16	0.144	0.61	0.436	1.67	0.200	**8.03**	**0.006**	0.08	0.776
Time	**11.37**	**<0.001**	**4.97**	**0.005**	**10.32**	**<0.001**	**20.26**	**<0.001**	0.02	0.891
LR*Program	0.26	0.612	0.62	0.434	1.88	0.174	0.13	0.724	0.73	0.394
Time*LR	**6.83**	**<0.001**	2.78	0.052	**4.51**	**0.014**	**4.14**	**0.020**	3.37	0.068
Time*Program	**9.41**	**<0.001**	0.45	0.718	**12.77**	**<0.001**	**17.82**	**<0.001**	0.72	0.398
Time*LR*Program	0.44	0.725	0.08	0.970	0.77	0.467	0.18	0.837	0.90	0.344

LR, level of response to alcohol.
Bolded values are significant, $p < 0.05$.

individuals in the LRB program than in the SOTA program during the prevention program period (Week 4 pairwise contrasts: difference = 1.16 to 3.17, $p = 0.02$ to 0.001), but these differences did not persist past Week 4.

Number of Days Drinking 4 or More Alcoholic Drinks. There were significant main effects of Time and Program on frequency of heavy drinking, and significant Time*LR and Time*Program interactions. The LRB group had an increase from Week 1 to Week 4, followed by a return to baseline (for the high LR group) or a decrease from the baseline (for the low LR group), while the SOTA group had little change over time. Low LR individuals decreased more, on average, than high LR individuals.

AUD Symptoms. Examining the means (Table 2) indicated that the low LR/LRB was the only group that decreased AUD symptoms from fall to spring. However, none of the effects of LR, program, or their interaction were significant.

Effects of Protocol Adherence. The previous sections represent results among all program participants, including those who missed or skipped modules; however, this may represent a lower bound of potential efficacy of the program. To test the programs' maximal effectiveness (and for consistency with the protocol of Schuckit and colleagues [2012]), we conducted the same analyses as above using data only from individuals who completed all modules ($n = 131$). Results were largely unchanged; however, there was a significant LR*Program interaction in predicting MAX24 ($F = 4.34$, $p = 0.041$). Low LR individuals in the LRB program drank, on average, approximately 2.5 fewer drinks than low LR individuals in the SOTA program (4.26 vs. 6.71), while high LR individuals in both programs drank similar amounts on average (LRB: 4.24; SOTA: 4.52).

Incorporation of Moderating Factors

We investigated potential moderation of program and Program*Time effects by postmodule quiz accuracy, average level of interest, and average length of time spent watching the videos. These variables demonstrated no significant effects on the change in any of the 4 measured drinking behaviors and did not moderate the effects of the prevention programs (results available upon request).

Comparison of Alcohol Prevention Programming Participants Versus Controls

Finally, to determine whether these changes in alcohol use behaviors reflected effects of the prevention programs rather than normative changes across time, we compared the Baseline/Fall and Week 22/Spring alcohol use variables between the SOTA and LRB participants and a group of matched controls not enrolled in any prevention program. Although there were some differences between programs in their patterns of alcohol use across time, our results from the above analyses did not indicate substantial differences in main effects between the LRB and SOTA programs, and we did not expect such differences in efficacy to exist between the similar programs (except as an interaction when participants and programs were matched). Therefore, we combined these 2 groups to compare prevention versus no prevention conditions.

Mean levels of alcohol use behaviors between prevention participants and controls are shown in Table 4, and the results from the mixed model analyses are shown in Table 5. Across all alcohol use outcomes, there were significant effects of the prevention program and of LR, with additional significant or near-significant Time*LR interactions, and, for maximum drinks and AUD symptoms, Time*Prevention interactions. Illustrative results for these 2 outcomes are presented in Fig. 3. Across all outcomes, Week 22/Spring alcohol use was lower in prevention participants than controls

Table 4. Mean Alcohol Use Behaviors Across Time for College Students Enrolled in Alcohol Prevention Programs and Their Matched No Prevention Controls

	High LR–LRB Mean (SD)	High LR–SOTA Mean (SD)	High LR–controls Mean (SD)	Low LR–LRB Mean (SD)	Low LR–SOTA Mean (SD)	Low LR–controls Mean (SD)
Number of drinking days per month						
Fall	2.39 (2.46)	2.38 (2.81)	2.77 (3.29)	3.79 (3.7)	4.11 (4.16)	4.90 (4.70)
Spring	3.04 (2.87)	3.71 (3.48)	4.08 (4.10)	4.45 (4.34)	4.09 (3.37)	4.96 (4.56)
Usual number of drinks per occasion						
Fall	2.96 (1.33)	2.82 (1.58)	3.46 (2.01)	4.77 (2.24)	4.75 (2.20)	5.24 (2.27)
Spring	3.67 (1.88)	3.26 (1.39)	3.77 (1.99)	4.72 (2.01)	4.63 (2.30)	5.06 (2.26)
Maximum drinks in 24 hours						
Fall	7.03 (3.54)	6.66 (3.61)	7.74 (4.19)	12.55 (5.63)	13.47 (6.25)	12.76 (5.59)
Spring	7.16 (5.62)	7.48 (4.70)	9.37 (6.17)	9.64 (4.82)	11.08 (6.53)	11.01 (6.16)
DSM-V alcohol use disorder symptoms						
Fall	1.77 (1.91)	1.61 (1.77)	2.08 (2.35)	2.89 (2.15)	2.58 (2.35)	3.31 (2.75)
Spring	2.16 (2.19)	2.03 (2.18)	2.83 (2.69)	2.06 (1.87)	2.71 (2.02)	3.75 (2.79)

LR, level of response to alcohol; LRB, level of response-based prevention program; SOTA, state-of-the-art prevention program.

Baseline differences in alcohol use behaviors at the Fall assessment did not significantly differ between participants in the control versus prevention conditions ($p > 0.05$).

Table 5. Summary of Results from Linear Mixed Model Analyses Predicting Change in Alcohol Use Behaviors Across Time (Baseline/Fall Semester to Week 22/Spring Semester) for College Students Enrolled in Alcohol Prevention Programs and Their Matched Controls not Participating in a Prevention Program

	Number of drinking days per month		Usual number of drinks per occasion		Maximum drinks in 24 hours		DSM-V alcohol use disorder symptoms	
	F	*p*	*F*	*p*	*F*	*p*	*F*	*p*
LR	**14.06**	**<0.001**	**85.62**	**<0.001**	**80.71**	**<0.001**	**10.67**	**0.001**
Prevention	**6.34**	**0.012**	**4.24**	**0.040**	**4.58**	**0.033**	**12.98**	**<0.001**
Time	**14.59**	**<0.001**	**6.58**	**0.011**	2.89	0.090	**17.39**	**<0.001**
LR*Prevention	0.01	0.935	0.02	0.901	2.05	0.153	0.00	0.991
Time*LR	**5.53**	**0.020**	3.57	0.060	**37.14**	**<0.001**	3.76	0.053
Time*Prevention	1.54	0.216	0.15	0.701	**6.15**	**0.014**	**15.78**	**<0.001**
Time*LR*Prevention	0.86	0.354	0.81	0.368	0.02	0.880	1.11	0.292

LR, level of response to alcohol.
Bolded values are significant, $p < 0.05$.

and low LR individuals had a greater decrease (lesser increase) than high LR individuals. For both maximum drinks and AUD symptoms, those in the prevention programs showed a greater decrease (lesser increase) from fall to spring as compared to controls. Participants with low LR enrolled in the prevention programs experienced a decrease in AUD symptoms across their freshman year of college, while the high LR prevention participants and all of the controls experienced an increase.

DISCUSSION

The current study examined the effectiveness of a set of brief, web-based alcohol prevention programs for reducing risky drinking behaviors in a college freshman sample, focusing on whether an individually tailored program based on the LR to alcohol had a greater impact on alcohol use behaviors than a nontargeted "state-of-the-art" program. Our first hypothesis was that individuals with low LR would experience greater reductions in alcohol use when enrolled in the tailored LRB program, as was previously reported by Schuckit and colleagues (2012, 2015). The evidence of an interaction between program and LR in predicting changes in alcohol use was limited, with a significant interaction observed only for maximum drinks per day among participants who completed all program modules. Thus, our overall results did not support robust effects associated with matching individuals to a targeted program based on LR to alcohol, but these LR-tailored prevention programs may have incremental effects over standard programs when protocol adherence—and exposure to the educational content—is high. However, our results do support the effectiveness of prevention programs for individuals at high risk for alcohol problems based on low LR to alcohol. In both prevention programs, individuals with a low LR showed a greater decrease over time than those with a high LR, particularly in high-risk behaviors such as heavy episodic drinking (MAX24 and days drinking 4 or more drinks). As high LR individuals did not experience as great a benefit as low LR individuals from either program, it may be that any kind of prevention program is advantageous to high-risk individuals, with programs tailored toward specific risk factors potentially providing incremental benefits if protocol adherence is high.

Our second hypothesis was that the prevention programs would have an effect on decreasing alcohol use. We found that participating in either prevention program was associated with lower postprogram levels of all alcohol use behaviors and particularly strongly associated with a decrease in risky outcomes (maximum drinks and AUD symptoms), as compared with students who received no alcohol prevention. As this study only covered a 6-month period, longer term follow-ups will be necessary to determine whether these kinds of prevention programs have persistent effects. The Spit for Science sample will continue to be assessed throughout their college years, providing an opportunity to examine the longer term impact of these prevention programs.

A number of differences in sample and study design between the present study and that of Schuckit and colleagues (2012) may explain our failure to fully replicate their results. The 2 samples had very different compositions in terms of ethnicity and gender, which may have been correlated with differences in both genetic factors contributing to the LR to alcohol, and social and environmental factors influencing alcohol use and response to the programs. The study by Schuckit and colleagues (2012) also required participants to complete all modules, which may have contributed a stronger effect of their prevention programs on changes in alcohol use. Therefore, it may be that maximizing participant involvement or adding booster modules to reinforce the prevention principles could increase the effectiveness of tailored programs. In addition, their sample was of second-semester freshmen and excluded anyone with no drinking over the previous 6 months, so the overall levels of alcohol use were higher in their sample, particularly for the high LR group. However, we note that we did not find differences in the results when using data only from heavy baseline drinkers (results not shown).

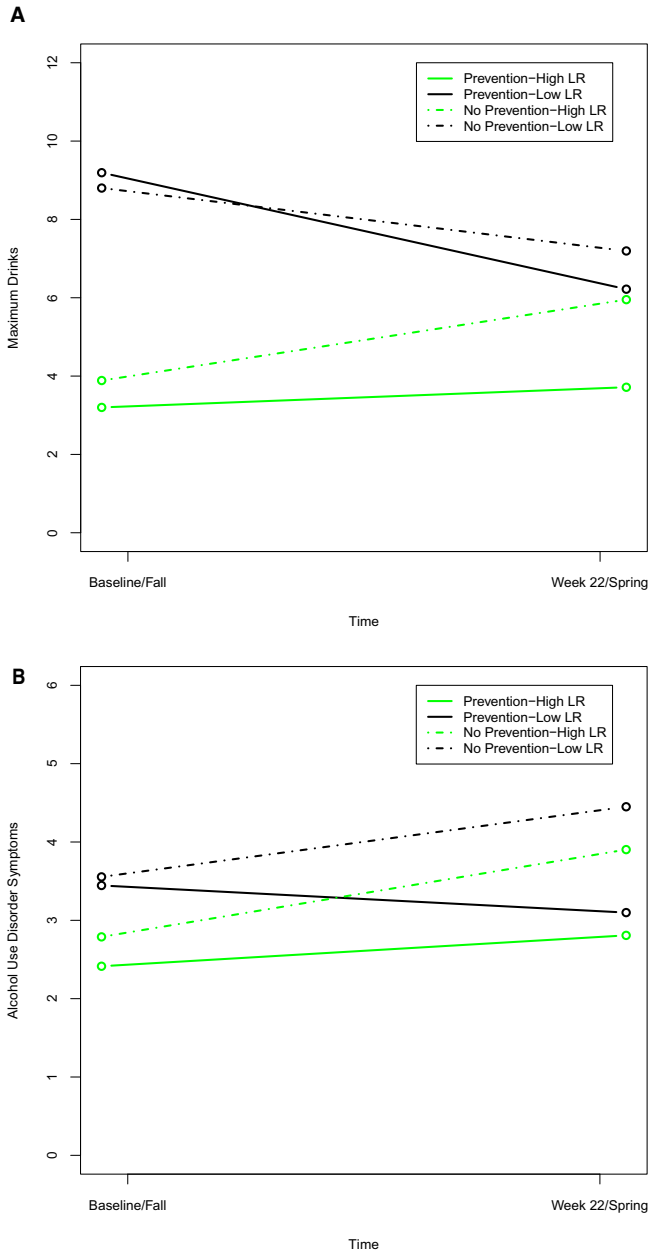

Fig. 3. Change in (**A**) maximum drinks in 24 hours and (**B**) alcohol use disorder symptoms from Baseline/Fall to Week 22/Spring in college students with low and high levels of response (LR) to alcohol, enrolled in either a state-of-the-art or level of response-based alcohol prevention program (prevention), and their matched controls who did not participate in an prevention program (no prevention). Points represent estimated marginal means from the mixed model analyses (Table 5), controlling for the effects of sex and ethnicity.

Some limitations of this study include an inability to fully match low and high LR participant pairs on levels of alcohol use (which might have obscured LR*Program interaction effects, although baseline alcohol use was controlled for), and control participants being selected from a parent study with somewhat different measures and assessment periods rather than being assessed as part of the prevention study. It is also possible that sampling bias influenced our results, as there were some differences between participants who volunteered for the prevention study compared to the larger university study in terms of demographics (more likely to be female and Caucasian) and alcohol use (participants drank slightly less and were less likely to meet criteria for alcohol dependence).

Overall our findings support previous studies demonstrating that simple and inexpensive online interventions have the potential to reduce risky drinking behaviors and their associated costs on a short-term basis (Carey et al., 2009; Hustad et al., 2010; Kypri et al., 2009; Neighbors et al., 2009). Importantly, we found these prevention programs to be most effective at reducing risky alcohol use among individuals that are most at risk for heavy alcohol use, in this case, as measured by a low LR to alcohol. Such programs may be even more effective with designs to make them more engaging and interactive (increasing participants' motivation to adhere to the protocol) and to incorporate new technologies such as utilizing cell phones to provide brief, ongoing interventions (e.g., Mason et al., 2014), which could reduce participant attrition and provide long-term reinforcement of prevention principles. Further efforts are still required to test the efficacy of prevention/intervention programs targeting other genetically influenced risk factors for heavy drinking and alcohol problems, such as impulsivity, disinhibition, negative affect, and coping-related drinking motivations, and to assess the overall effectiveness of receiving personalized information (regardless of what domain it is tailored to) versus one-size-fits-all programs. Further, as the epidemiological sample of college students here and in the pilot study had low levels of alcohol use and thus a limited ability to decrease their use, targeted interventions should also be tested among heavy or problem drinkers. Risky drinking behaviors have a strong genetic basis, and while genes are difficult to modify, cognitive and behavioral prevention programs that provide education about risks, recalibrate social norms, and teach skills to cope with stress and manage peer influences have the potential to overcome preexisting genetic vulnerabilities. Creating effective and cost-efficient targeted programs is an essential step in reducing the enormous health and financial burden associated with heavy drinking among college students.

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