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Development and Evaluation of a Mobile Intervention for Heavy Drinking and Smoking among College Students

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Abstract

Nearly all college student smokers also drink alcohol, and smoking and heavy-episodic drinking (HED) commonly co-occur. However, few studies have examined the factors that *concurrently* influence smoking and HED among college students and, to date, no interventions have been developed that target both HED and smoking in this population. The objective of the current study was to develop and evaluate a mobile feedback intervention that targeted HED and smoking. Participants (n = 94) were non-treatment seeking college students (mean age = 20.5, SD=1.7) who engaged in at least one HED episode in the past two weeks and reported concurrent smoking and drinking at least once a week. Participants were randomized to either receive the mobile intervention for 14 days, complete mobile assessments (without intervention) for 14 days, or complete minimal assessments (without intervention or mobile assessments). At a 1-month follow-up, in comparison to the minimal assessment condition we observed significant reductions in the number of cigarettes per smoking day in both the mobile intervention (d=0.55) and mobile assessment conditions (d=0.45). Among those randomized to the mobile intervention, receiving more modules of the intervention was significantly associated with a lower likelihood of any drinking during the 14-day assessment period and significant reductions in smoking at 1-month follow-up. The mobile intervention did not result in significant reductions in HED or concurrent smoking and drinking. Future research should continue to examine ways of using technology and the real-time environment to improve interventions for HED and smoking.

Keywords

heavy drinking; smoking; college students; ecological momentary assessment; mobile intervention; Brief Alcohol Screening and Intervention for College Students (BASICS)

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More than 80% of college students report consuming alcohol annually, with 44% reporting heavy episodic drinking (HED; 5/4 drinks per occasion for men/women) at least once in the past 2 weeks (Henry Wechsler et al., 2002). Excessive drinking is associated with damaged property, academic problems, hangovers, trouble with authorities, injuries, fatalities, risky sexual behavior, sexual assault, depression, and eating disorders (Hingson, Zha, & Weitzman, 2009; Larimer & Cronce, 2007). The prevalence of smoking among college students is also high. One national US survey found 46% of college students had used tobacco in the past year and approximately 28% were current smokers (Rigotti, Lee, & Wechsler, 2000). Although these data were reported over a decade ago, more recent research suggests tobacco use prevalence rates among young adults have remained fairly consistent (e.g. Welte, Barnes, Tidwell, & Hoffman, 2011). Moreover, individuals who never smoked prior to college are likely to experiment with smoking during college, and those who smoked occasionally in high school often became heavier smokers in college (Wechsler, Rigotti, Gledhill-Hoyt, & Lee, 1998). One study found 87% of daily smokers and 50% of occasional smokers reported continued tobacco use after four years of college (Wetter et al., 2004). Wetter and colleagues (2004) also found substantial individual variability in rates of smoking across the college years with many college students transitioning between varying levels of smoking more readily than adults, suggesting that college students “may be particularly receptive to interventions.” (p. 176).

The co-occurrence of smoking and drinking among college students has been demonstrated in several studies (Dierker et al., 2006; Reed, Wang, Shillington, Clapp, & Lange, 2007; Weitzman & Chen, 2005). Weitzman and Chen (2005) found 98% of student smokers drank alcohol and 44–59% of drinkers smoked cigarettes, with co-occurrence risk highest among students who reported greater alcohol consumption, having a drinking problem, or using drinking to cope with their problems. Among drinkers, the odds of “drinking to get drunk” were more than 2.7 times greater for smokers vs. nonsmokers (Weitzman & Chen, 2005). College student smokers drink significantly more per occasion, more frequently, and have significantly more alcohol-related problems than non-smoking college student drinkers (Reed et al., 2007; Wetter et al., 2004). In addition, frequent drinking (40+ times in the past year) among non-smoking college students is a significant risk factor for becoming a smoker within a year (Reed et al., 2007). Thus, the combination of college student HED and tobacco use presents a significant public health problem. Furthermore, research suggests that current heavy drinkers are less likely to attempt to quit smoking and less successful if they do attempt to quit (Duffy et al., 2006). Consequently, there is a need to address these problems simultaneously; yet, to our knowledge, no interventions have been developed that specifically target both smoking and HED among college students.

Interventions for Harmful Alcohol Use and Smoking in College Students

Alcohol programs.

Prevention and treatment interventions for college student drinking incorporating motivational interviewing, cognitive-behavioral skills (e.g., alcohol related skills training), and personalized normative feedback have received considerable empirical support for efficacy among college students and are more efficacious than purely educational

interventions or no intervention (Carey, Scott-Sheldon, Carey, & DeMartini, 2007; Larimer & Cronce, 2007; Walters & Neighbors, 2005). Brief Alcohol Screening and Intervention for College Students (BASICS; (Dimeff, Baer, Kivlahan, & Marlatt, 1999; Marlatt et al., 1998), a widely implemented and empirically-supported intervention for college student HED (see meta-analysis by Fachini, Aliane, Martinez, & Furtado, 2012), is a brief intervention incorporating personalized feedback about drinking behavior with components of cognitive behavioral treatment, including education regarding the effects of alcohol on the brain and behavior, skills training, risk awareness, expectancy information, and suggestions for less risky drinking habits, as well as brainstorming alternatives to heavy drinking (Marlatt et al., 1998). The BASICS program has been shown to reduce alcohol consumption and negative consequences associated with drinking (Baer, Kivlahan, Blume, McKnight, & Marlatt, 2001; Larimer et al., 2001; Marlatt et al., 1998).

Smoking Programs.

Approximately 70–80% of college student smokers report a desire to quit smoking (Everett et al., 1999), yet few effective programs have been developed to target college student smoking. A study (n=35) evaluating “Kick It!,” a web-based intervention including graphics, quizzes and other features (Escoffery, McCormick, & Bateman, 2004) provided initial support for its acceptability and feasibility. While 6-month follow-up quit rate was 25.7%, nearly equal to the self-quit rate of 24.8%, 94.1% reported they would consider future participation in web-based programs, supporting feasibility of this modality of intervention. Obermayer and colleagues (Obermayer, Riley, Asif, & Jean-Mary, 2004) developed a smoking cessation program combining web assessment with individually tailored smoking cessation messages delivered via text messaging to the participant’s cell phone. Among those who completed the study (n=29) the 6-week quit rate was 28%, and there was a significant reduction in cigarettes smoked per week among those who did not quit. Bowen and Marlatt (2009) examined the effects of a brief (11 minute) mindfulness-based intervention to manage cravings among non-treatment-seeking college student smokers. Participants in the treatment condition reported significantly lower point-prevalence smoking rates one week following the intervention.

While results of these interventions are somewhat encouraging, none of the college student smoking cessation intervention studies described above addressed the issue of HED and smoking in combination. Considering that nearly all college student smokers drink alcohol (Wechsler et al., 2002), it could be helpful to develop an intervention that targets health behavior more broadly, perhaps as part of an intervention program for college student drinking.

The Promise of Mobile Interventions

With advances in computing technology, a number of researchers have developed interventions that can be administered on electronic devices (Rizvi, Dimeff, Skutch, Carroll, & Linehan, 2011; Stoner & Hendershot, 2012; Watts et al., 2013). There are many advantages of computerized interventions, including 24-hour availability, anonymity, portability, increased compliance, and accurate data recording (Heron & Smyth, 2010).

Computer-delivered and web-based interventions have been found to be efficacious for reducing quantity and frequency of drinking among college students (Carey, Scott-Sheldon, Elliott, Bolles, & Carey, 2009; Walters & Neighbors, 2011). The anonymity of computerized intervention may be particularly suited for providing assessment and feedback about excessive alcohol use and other risky and/or illegal behavior. For example, 74% of participants in a computerized alcohol screening and feedback study reported a preference for the computer printout instead of personalized feedback from staff (Karlsson & Bendtsen, 2005). Additionally, electronically delivered interventions have demonstrated comparable efficacy to other intervention modalities such as printed feedback (Elliott, Carey, & Bolles, 2008). Attempts to target multiple risk behaviors using individualized interventions have had some success (Prochaska et al., 2004), although to our knowledge no studies have attempted to target both high risk drinking and smoking among college students.

To date, only one locatable study has used a daily intervention in combination with ecological momentary assessment (EMA) to target alcohol use in college student drinkers (Weitzel, Bernhardt, Usdan, Mays, & Glanz, 2007). College students (n=40) who reported drinking at least weekly were randomized to receive either EMA-only or EMA with text messaging during a two-week reporting period. The EMA+text group received one text message per day tailored to drinking and consequences. The EMA+text group reported greater reductions in drinks per drinking day as compared to the EMA-only group during the reporting period. The study was limited by a small sample size and experimenter/technical error resulting in some students failing to receive messages daily. Despite these limitations, the authors demonstrated the feasibility of this type of intervention with college students and initial support of its efficacy for reducing drinking in a college student population. More recently, Suffoletto and colleagues (2012) found weekly text-messaging-based feedback interventions delivered over a 12-week period was associated with significant reductions in frequency of heavy drinking and quantity of drinks per drinking day in a sample of young adults (aged 18 to 24) recruited from emergency departments (82% were enrolled in college).

Riley and colleagues (Riley, Obermayer, & Jean-Mary, 2008) recently developed and implemented an intervention program combining internet and text-message smoking cessation for college students who wanted to quit smoking (n = 31). Participants received personalized text-messages 1 to 3 times per day. At a six-week follow-up, the authors found significant decreases in smoking rates and dependence, as well as significant increases in the number of days abstinent from smoking. These findings provide further support for the use of daily mobile interventions for changing college student health behavior.

Current Study

The current study was designed to develop and implement a mobile intervention that incorporated components from a brief alcohol intervention and a brief smoking intervention. The alcohol intervention components were largely derived from the Brief Alcohol Screening and Intervention for College Students program (BASICS; Dimeff et al., 1999), a widely implemented and empirically-supported intervention for college student HED that incorporates personalized feedback about drinking behavior with components of cognitive

behavioral treatment (Marlatt et al., 1998). The complete BASICS curriculum was not adapted to be a mobile intervention; rather alcohol intervention components included in the mobile intervention were based on BASICS feedback materials. The smoking intervention consisted of feedback about smoking and "urge-surfing," a mindfulness-based approach to help people recognize and allow urges to occur and pass without needing to reactively engage in smoking or drinking, drawn from relapse prevention (Marlatt & Gordon, 1985) and mindfulness-based relapse prevention (Bowen, Chawla, & Marlatt, 2010). Urge-surfing has been shown to effectively reduce smoking rates among non-treatment seeking college student smokers (Bowen & Marlatt, 2009).

Interventions incorporating computerized BASICS have demonstrated efficacy in reducing drinking and related consequences in college student samples (Butler & Correia, 2009). The primary goal of this research was to integrate components of BASICS with smoking feedback and urge-surfing elements using assessment and intervention delivered via mobile phone in real-time. The intervention, called the Brief Alcohol and Smoking Intervention for College Students (BASICS-Mobile), was embedded within the web-based assessment. We hypothesized that providing a personalized, real-time intervention would result in significant reductions in the frequency of smoking and heavy drinking relative to mobile assessment-only and a minimal assessment control group.

Methods

Participants and Procedures

Participants (n = 94) were non-treatment seeking college students enrolled at a large public university who engaged in at least one episode of heavy drinking (5/4 drinks per occasion for men/women) in the past two weeks and reported concurrent smoking and drinking at least once a week. Participants were recruited through flyers posted on campus (in dormitories, cafeterias, student centers, etc.) as well as print and online advertisements in student newspapers and on Craigslist and Facebook. Ads included basic information about the study as well as study contact information. After contacting the study office, interested individuals were emailed a link to a 10–15 minute online screening survey, which assessed demographics and alcohol and cigarette use. Students who completed the survey were entered into a drawing for one of four $50 gift certificates.

Individuals who met the screening criteria were immediately linked to a 40–45 minute online baseline survey, which included measures of drinking and smoking norms, expectancies, motives, consequences, family history and protective behavioral strategies. Students received $20 for participating in the baseline survey. After completing the baseline survey, participants were randomized to one of three conditions (see Figure 1): BASICS-Mobile (n=32), daily monitoring only via mobile assessment (n=33), or minimal assessment control (n=29). Individuals in the BASICS-Mobile and daily monitoring only conditions each completed 14 days of EMA via web-enabled phone, a brief online assessment immediately following the monitoring period, and an online follow-up assessment 1-month after the monitoring period. Individuals in the minimal assessment condition completed only the initial screening and baseline assessments and the 1-month follow-up. All participants received $30 for completing the 1-month follow-up assessment.

The EMA portion of the study consisted of three randomly prompted mobile assessments per day and instruction to complete a user-initiated mobile assessment at the beginning and end of each drinking occasion for 14 days. The 14-day time frame was chosen to capture data from two weekends (when more drinking occurs), and because the in-person BASICS program often consists of two sessions over a two-week period. Those participating in EMA were asked to attend a 30-minute in-person training session with a research assistant to learn how to complete the random and user-initiated assessments via a web-enabled phone. Participants with web-enabled phones were allowed to use their own phones, and participants who did not have web-enabled phones were provided with a Blackberry® smart phone (Model #s 8330, 8700, 8900) with a data-only plan (i.e., no voice plan was included with the phone). The majority of participants used either a Blackberry® (approximately 46%), an iPhone® (approximately 31%), or an Android® phone (approximately 23%).

Random prompts were sent daily via text messages during 3 different blocks of time. A morning prompt was sent between 10am and 1pm, an afternoon prompt was sent between 2pm and 5pm, and an evening prompt was sent between 6pm and 9pm. Each mobile assessment was 3–5 minutes long. Participants were allowed up to 2 hours from the time of the prompt to log in and complete the survey. Students received $3 for each random assessment plus a $21 bonus for every week they completed at least two of three random assessments per day, for a possible total of $168. Participants were not provided with any incentive for the user-initiated (i.e., event contingent) assessments during drinking occasions.

Individuals in the BASICS-Mobile condition also received an intervention module after completing each mobile assessment (including randomly prompted assessments and event-contingent assessments). We administered up to 31 different modules during the intervention. Each module was 1 to 3 pages (sized for a mobile phone screen) and targeted one of the following topics: normative feedback (13.7% of modules delivered), general or health information about drinking and smoking (26.4% of modules delivered), protective behavioral strategies for drinking and smoking (28.9% of modules delivered), alternative activities to drinking and smoking (6% of modules delivered), urge-surfing (16.5% of modules delivered), or decisional balance for drinking and smoking (8.5% of modules delivered). Two example modules (the Smoking Assumptions & Actual Smoking Module and Standard Drinks Module), each with two pages, are provided in Figure 2. To assess participant interaction with the module we required a participant response for each module. For example, on page 1 of the Standard Drinks Module (Figure 2) we asked participants to respond to “How many standard drinks do you think are in each of their drinks?” The intervention modules were personalized in two ways. First, participant answers from the baseline assessment were incorporated into the intervention in real-time to make the intervention more personalized to the individual user. Second, BASICS-Mobile was programmed to administer urge-surfing interventions if an individual reported an urge to smoke at the time of the current assessment.

Baseline Measures

Daily Drinking Questionnaire (DDQ).—Participants' alcohol consumption for each day of a typical drinking week in the past month was assessed via the Daily Drinking Questionnaire (DDQ; Collins, Parks, & Marlatt, 1985). The DDQ measures typical alcohol quantity (i.e. number of standard drinks per drinking day), frequency (i.e. the number of drinking days per week), and total consumption. Participants were provided with a standard drink definition for reference. The internal consistency reliability of the DDQ was $\alpha = 0.83$ in the current sample, and the DDQ has demonstrated high reliability in previous research (Baer et al., 1992).

Daily Smoking Questionnaire (DSQ).—Participants' smoking for each day was assessed via an adapted version of the DDQ that inquired about cigarettes smoked per day. The internal consistency reliability of the DSQ was $\alpha = 0.97$ in the current sample.

Young Adult Alcohol Problems Screening Test (YAAPST).—Alcohol-related problems were measured via the 14-item Young Adult Alcohol Problem Screening Test (YAAPST; Hurlbut & Sher, 1992), assessing the frequency of occurrence of drinking consequences over the past year. The YAAPST has demonstrated good test-retest reliability and good internal consistency (Hulbut & Sher, 1992). In the current sample, the internal consistency reliability of the YAAPST was $\alpha = 0.79$.

Ecological Momentary Assessment (EMA) Measures.

Questions adapted from prior EMA studies (Muraven, Collins, Shiffman, & Paty, 2005) and existing questionnaires of smoking urges, (Cox, Tiffany, & Christen, 2001), affective states (Clark & Watson, 1991), and contextual questions (Witkiewitz et al., 2012) were used to collect real time data at three randomly-prompted time points during each of the 14-days of the study. At each momentary assessment, the students were asked to record the number of drinking occasions since the prior assessment (date/time of prior assessment was shown to the student), how many standard drinks they consumed per occasion (with number of drinks per occasion since prior report assessed for each individual occasion), how many cigarettes they smoked since the prior assessment, and whether they smoked cigarettes while drinking. Participants were provided with a standard drink definition for reference when answering questions about alcohol use. Measures of smoking urge, affect, self-regulation, and context were also included in each assessment. Sample EMA items from each domain include: urges - "I have a strong urge for a cigarette right now" (rated on a scale from 0 = "not at all" to 4 = "very much"); affect - "How tense/anxious are you right now?" (rated on a scale from 0 = "not at all" to 4 = "very much"); self-regulation – "How much do you feel you need to control or fix your mood" (rated on a scale from 0 = "not at all" to 4 = "very much"); and contextual – "Where are you right now?" (with response options "at home," "at a bar," "at a party," etc.). For the event-contingent EMA, participants were instructed to complete one EMA at the beginning and end of each drinking occasion. The urge, affect, self-regulation, and contextual questions from the random assessments were included, as well as items about current drinking and smoking (e.g., "How many drinks did you consume prior to starting this interview?"). We constructed the data such that randomly prompted and event-contingent assessments were not double-counted, in other words, the same drinking episode

(reported first at an event contingent assessment and again at the next random prompt) was not counted as two distinct drinking episodes.

Statistical Analyses

Drinking and smoking during EMA.—Generalized linear mixed models with fixed effects of intervention condition and random effects of time were used to examine differences in drinking, smoking, and occasions of concurrent drinking and smoking between daily monitoring and BASICS-Mobile over the course of the 14-day EMA monitoring period. Given that number of drinks per occasion and number of cigarettes smoked since last prompt were both count outcomes with a zero count as the modal outcome we used a negative binomial hurdle model[1] (Atkins, Baldwin, Zheng, Gallop, & Neighbors, 2012). The hurdle model simultaneously estimates the count outcome as a logistic (e.g., drinking vs. not drinking and smoking vs. not smoking, with the logistic portion predicting "no drinking" and "no smoking") and as a truncated count regression (e.g., # of drinks among those who drank and # of cigarettes among those who smoked). For the concurrent smoking and drinking outcome (which was characterized as 0=no occasions, 1=concurrent smoking and drinking), we used a logistic model.

For each outcome measure (drinks per occasion since prior prompt, cigarettes smoked since prior prompt, and concurrent drinking and smoking since prior prompt), we included drinking/smoking, weekend (Friday to Sunday), and time as level 1 covariates (group-mean centered) and treatment condition, gender, baseline cigarettes per smoking day, baseline drinks per drinking day, and average drinking/smoking during the EMA period as level 2 covariates (grand-mean centered). Weekend was included as a covariate because prior studies have found that college students drink more alcohol on weekend days (e.g., Witkiewitz et al., 2012), and preliminary analyses showed that individuals in the current study drank twice as much on weekend days, compared to weekdays. Drinking/smoking were included on both level 1 and level 2, which allowed us to partition the effects of drinking and smoking into a within-person effect (e.g., effect of an individual's drinking on number of cigarettes) and a between-person effect (e.g., effect of an individual's average level of drinking across the 14 days on number of cigarettes). Thus, when predicting number of drinks at each assessment, we controlled for the concurrent number of cigarettes reported at the same assessment (within-person effect) and average level of smoking and drinking across the EMA period (between-person effect). Likewise, when predicting number of cigarettes smoked at each assessment, we controlled for the concurrent number of drinks reported at the same assessment (within-person effect) and average level of smoking and drinking across the EMA period (between-person effect). Baseline cigarettes per smoking day and drinks per drinking day were also included as level 2 covariates. The associations between baseline smoking/drinking and average levels of smoking/drinking across the EMA period were r = 0.73 ($p < 0.001$) for smoking and r = 0.49 ($p < 0.001$) for drinking, thus there was strong correspondence between the baseline retrospective reports and actual

[1] Alternative model specifications were also tested, including a zero inflated negative binomial, negative binomial without zero inflation, and Poisson models. Results indicated that the hurdle model provided the best fit to the data, yielded the least amount of dispersion, and smallest standard errors. See Atkins, Baldwin, Zheng, Gallop, & Neighbors (in press) for a detailed description of these different model specifications for longitudinal substance use data.

smoking/drinking during EMA, particularly for smoking. Finally, we also examined cross-level interactions for the association between drinking and smoking, regressed on treatment condition and the other level 2 covariates.

To evaluate the effectiveness of modules within the BASICS-Mobile condition, we also tested generalized linear mixed models with a fixed effect for the total number of modules received. The level 1 covariates included drinking/smoking, weekend, and time (group-mean centered), and we included number of modules received over the 14-day intervention, gender, baseline cigarettes per smoking day, baseline drinks per drinking day, and average drinking/smoking during the EMA period as level 2 covariates (grand-mean centered).

Drinking and smoking at 1-month follow-up.—The general linear model was used for the analysis of mean differences in outcomes across groups at the 1-month follow-up using an intent-to-treat approach. For count outcomes (e.g., number of cigarettes smoked, days of heavy drinking) we used negative binomial models with a log link function. For ordered categorical outcomes (e.g., "How often do you typically drink alcohol and smoke at the same time") we used a multinomial distribution with a cumulative logit link function. For binary outcomes (e.g., occasions of concurrent drinking and smoking) we used the binomial distribution with a logit link function. Finally, for continuous outcomes (e.g., cigarettes per smoking day, drinks per drinking day, and drinking consequences on the YAAPST) we used the normal distribution with the identity link function. Cigarettes per smoking day was square root transformed prior to analyses to reduce positive skew. Covariates for all analyses included the baseline levels of all outcomes, gender, age, and treatment condition. Continuous covariates were mean-centered and categorical covariates were coded using effect coding (−0.5 and 0.5) to facilitate interpretation (Kraemer & Blasey, 2004).

Missing data.—Across all conditions, 89.4% completed the 1-month follow-up assessment (see Figure 1). Individuals who did not complete the 1-month follow-up assessment smoked significantly more cigarettes per smoking day at baseline ($t(92) = -4.13$, $p < 0.001$), as compared to those who completed the 1-month follow-up assessment. There was an interaction between attrition from the study and treatment assignment in the prediction of baseline smoking ($F(2,88) = 8.38$, $p < 0.001$), such that individuals who did not complete the follow-up assessments smoked significantly more cigarettes per smoking day at baseline if they were assigned to daily monitoring (Mean = 13.11, SD = 6.64) or BASICS-Mobile (Mean = 9.79, SD = 8.18), as compared to those assigned to minimal assessment (Mean = 2.91, SD = 1.81). Given these differences, we ran all analyses with cigarettes per smoking day at baseline as a covariate. We also conducted analyses with the baseline values of cigarettes per smoking day imputed as the follow-up cigarettes per smoking day for those with missing data at follow-up. There were no other significant differences between those who completed the 1-month assessment and those who did not complete the assessment on any other measures at baseline.

Results

Descriptive Findings

The mean age of the sample was 20.5 (SD=1.7) and 27.7% were female. The sample was 71.3% White, 21.3% Asian, 3.2% American Indian/Alaskan Native, 3.2% African American, 1% Native Hawaiian/Pacific Islander, and 2.1% of the sample identified as Hispanic or Latino. The rates of concurrent drinking and smoking were consistent with the screening criteria, with 7.4% (n=7) engaging in concurrent drinking and smoking every day, 61.7% (n=58) at least a few times per week, and 30.9% (n=29) at least once per week. At baseline, the average drinks per drinking day was 6.16 (SD = 3.01) with an average of 4.05 (SD = 1.62) drinking days per week, average cigarettes per smoking day was 4.52 (3.69), and 39.4% of the participants were daily smokers. The means and standard deviations of primary outcome measures by treatment group, as well as within-group effect sizes from baseline to the 1-month follow-up are provided in Table 1.

Feedback from Daily Monitoring and BASICS-Mobile Conditions

At the end of the 14-day EMA monitoring period, we administered a satisfaction questionnaire to participants in the BASICS-Mobile and daily monitoring conditions to assess acceptability, feasibility, perceived utility, and overall satisfaction. There were no significant differences between groups on any of the satisfaction questionnaire items. The majority of participants in both conditions found the EMA “very easy” (66.1%) or “easy” (20.3%) to navigate, felt that completing the daily assessments was “very easy” (40.7%) or “easy” (32.2%), found the overall length of the assessments to be “about right” (77.1%), and felt that completing the EMA had little to no interference in their daily lives (86.2%). Participants also endorsed learning new information about smoking (20.0% in daily monitoring and 43.3% in BASICS-Mobile) and alcohol (24.1% in daily monitoring and 43.3% in BASICS-Mobile).

Participants in both conditions reported that, after completing the study, they “developed a goal to change my smoking habits” (χ (1) = 0.15, p = 0.70; 51.6% in daily monitoring and 46.6% in BASICS-Mobile) and “drinking habits” (χ (1) = 0.01, p = 0.94; 24.1% in daily monitoring and 23.3% in BASICS-Mobile). They also reported “learning new information about smoking” (χ (1) = 3.46, p = 0.06; 20.7% in daily monitoring and 43.3% in BASICS-Mobile) and alcohol (χ (1) = 2.43, p = 0.12; 24.1% in daily monitoring and 43.3% in BASICS-Mobile). Individuals in the BASICS-Mobile condition indicated that the tips they received from the mobile phones “motivated me to change my smoking” (36.7%) and “alcohol use” (20.1%). Over 65% of participants across both conditions provided qualitative feedback that participating in the study was beneficial in increasing awareness of their drinking and/or smoking. Likewise, over 90% of participants in both conditions stated they would recommend participation in the research study to a friend, with 60.5% endorsing that they would recommend it to a friend because the study provided greater awareness and/or could help a friend reduce their drinking and/or smoking. Conversely, four individuals in the BASICS-Mobile condition (13.3%) and two individuals in the daily monitoring condition (6.8%) reported participating in the study and completing the surveys made them want to drink or smoke more.

Drinking and Smoking during EMA

Daily Monitoring and BASICS-Mobile.—Over the 14 days of EMA for the daily monitoring and BASICS-Mobile conditions, 83.5% of random assessments (2105 out of 2520) were obtained and 40 participants (66.7% of the sample; n=22 of those in Daily Monitoring and n=18 of those in BASICS-Mobile) also completed 236 participant-initiated assessments at times of drinking only (120 assessments) or drinking and smoking (116 assessments). Preliminary analyses revealed no significant differences in drinking/smoking rates or other variables of interest across random and event (i.e., participant initiated) assessments, thus data from random and event assessments were combined for all analyses. Also, the effects of prompt-type (random or event assessment) and the prompt-type by intervention group interaction were not significant predictors of drinking and/or smoking during EMA. The total number of assessments was 2341, including 664 occasions of drinking (28.4% of assessments), 1199 occasions of smoking (51.2% of assessments), and 365 occasions of concurrent drinking and smoking (15.6% of assessments). Across participants, the average number of drinks when drinking-only was 2.79 (SD = 2.88) and the average number of cigarettes when smoking-only was 2.49 (SD = 2.02). During occasions of concurrent drinking and smoking, the average number of drinks increased to 4.99 (SD = 3.79) and average number of cigarettes increased to 3.67 (SD = 3.16).

As seen in Table 2, intervention condition was not a significant predictor of drinking or smoking outcomes during the EMA period, and the cross-level interactions between level 1 drinking and smoking regressed on intervention condition were also not significant. However, results from the mixed models indicate that level 1 smoking significantly predicted level 1 drinking (and vice versa), but that average level of smoking (on level 2) over the 14 days did not predict level 1 drinking (and vice versa). In other words, an individual's drinking and smoking on each occasion (level 1) was significantly associated with smoking and drinking, respectively, at each occasion (level 1), whereas the average amount that each individual drank or smoke over the 14-day EMA period (level 2) did not predict how much an individual smoke or drank, respectively, at each occasion (level 1). The average amount that each individual drank or smoked over the 14 days (estimated on level 2) did significantly predict occasions of concurrent drinking and smoking (estimated at level 1). Odds ratios for these predictors indicated that at the average level of the other covariates, for each additional drink an individual had over the 14 days that same individual had nearly twice the odds (odds ratio = 1.99) of engaging in concurrent drinking and smoking at a given occasion. For each additional cigarette that was smoked over the 14 days, the odds were 1.32 times greater that the same individual would engage in concurrent drinking and smoking at a given occasion.

BASICS-Mobile.—Next we examined the association between number of modules received and each of the drinking and smoking outcomes described above using generalized linear mixed models. The average number of modules received was 23.05 (SD = 6.78), with a range of 0 to 35 and a mode of 27 modules per person. Only one person in the BASICS-Mobile condition received 0 modules. The results from the analysis of the number of modules received in the BASICS-Mobile condition indicated that receiving more modules across the 14 days significantly reduced the probability of any drinking on a given occasion

(B (SE) = −0.04 (0.01), $p = 0.001$), with each additional module received associated with a 4% decrease in the probability of any drinking. Number of modules received was not related to any smoking or number of cigarettes smoked (all $p > 0.50$) and did not predict the probability of concurrent drinking and smoking (B (SE) = 0.01 (0.02), $p = 0.63$).

Drinking and Smoking at 1-Month Follow-Up

Drinking (drinks per drinking day, days of heavy drinking), concurrent drinking and smoking, and drinking-related problems at the 1-month follow-up did not significantly differ across conditions (results shown in Table 3). There was one significant effect of condition in the prediction of outcomes: individuals assigned to minimal assessment were smoking significantly more cigarettes per smoking day at the 1-month follow-up than individuals assigned to either BASICS-Mobile or daily monitoring (partial $\eta^2 = 0.09$). These results were consistent when controlling for baseline levels of cigarettes per smoking day (Wald $\chi^2(2) = 8.34$, $p = 0.015$), and when we imputed the baseline cigarettes per smoking day for those with missing data at the follow-up (Wald $\chi^2(2) = 9.09$, $p = 0.011$). Specifically, using the original untransformed scale of cigarettes per smoking day at the average level of the other predictors, being in the minimal assessment condition was associated with an average increase of 2.04 cigarettes per smoking day as compared to BASICS-Mobile (B (SE) =2.04 (0.66), $p = 0.002$; d = 0.55) and an average increase of 1.59 cigarettes per smoking day as compared to daily monitoring (B (SE) = 1.59 (0.66), $p = 0.02$; d = 0.45). An inspection of smoking quit rates at baseline and the 1-month follow-up indicated that among those who had no quit attempts at baseline (total N=40), 5 individuals in the BASICS-Mobile condition (38.5% of the 13 people with no quit attempts at baseline), 1 individual in daily monitoring (7.7% of the 13 people with no quit attempts at baseline), and 2 individuals in the minimal assessment condition (14.3% of 14 people with no quit attempts) had at least one quit attempt by the 1-month follow-up. Overall, including those with quit attempts at baseline, the differences in quit attempt rates across groups at follow-up were not statistically significant ($\chi 2$ (2) = 5.38, $p = 0.07$); however, the odds of attempting to quit were 2.55 times greater in BASICS-Mobile (66.7% had attempted to quit) as compared to minimal assessment (44% attempted to quit) and 3.28 times greater in BASICS-Mobile than in the daily monitoring condition (37.9% attempted to quit).

Likewise, for those who received BASICS-Mobile, the number of modules received during the 14-day EMA period significantly predicted cigarettes per smoking day at the 1-month follow-up (Wald $\chi^2(1) = 7.88$; B (SE) = −0.04 (0.02), $p = 0.005$). Again, using the original untransformed scale of cigarettes per smoking day at the average level of the other predictors, there was an 8% decrease in cigarettes per smoking day for each additional module received. On average, individuals (n=19) who received fewer than 24 modules, which was the median number of modules received, were smoking an average of 4.30 cigarettes per smoking day (SD = 3.58), and those who received more than 24 modules (n=9) were smoking an average of 1.25 cigarettes per smoking day (SD=1.69). Individuals who received more than 24 modules also had significantly fewer cigarettes per smoking day than individuals in the minimal assessment (Mean (SD) = 4.55 (4.07)) and daily monitoring conditions (Mean (SD) = 2.71 (2.86; Wald $\chi^2(1) = 8.47$; B (SE) = −0.94 (0.32), $p = 0.004$). Furthermore, looking at the frequency of smoking, receiving more modules was associated

with significantly fewer days of smoking over the past 14 days (Wald $\chi^2(1) = 9.20$; B (SE) = −0.31 (0.10), $p = 0.002$). Of those who received fewer than 24 modules, the average days of smoking over the past 14 days was 10.26 (SD = 4.99). Of those who received more than 24 modules, the average days of smoking over the past 14 days was 4.33 days (SD = 6.08). The average days of smoking over the past 14 days in the minimal assessment condition was 7.38 (SD = 4.91) and in the daily monitoring condition was 7.10 (SD = 5.20). Finally, number of modules received predicted any smoking (Wald $\chi^2(1) = 10.12$; B (SE) = −2.66 (0.83), $p = 0.001$). Of those who received more than 24 modules, 55.6% of individuals had no smoking days, whereas among those in BASICS-Mobile who had fewer than 24 modules only 5.3% of individuals had zero smoking days. In the minimal assessment condition, 11.5% had zero smoking days and in the daily monitoring condition 10.3% had zero smoking days.

Discussion

In this study, we developed and empirically evaluated a brief mobile intervention designed to target alcohol use and smoking among non-treatment seeking heavy drinking college student smokers. Results provided initial evidence that mobile assessment and intervention could be an effective strategy for reducing smoking among college students. There were significant reductions in cigarettes per smoking day among those who were randomized to complete the mobile assessments or mobile assessments with mobile intervention, as compared to a minimal assessment control group. Furthermore, a greater “dose” of the intervention (defined as the number of feedback modules received) was associated with significantly greater reductions in smoking. These findings are consistent with the recent study by Riley and colleagues (2008), who found that mobile text messaging up to 3 times per day predicted significant decreases in smoking rates and increases in abstinent days among college student smokers who were interested in quitting smoking.

Compared to the minimal assessment condition, individuals in the mobile assessment and BASICS-Mobile intervention did not report significant reductions in drinks per drinking day, days of heavy episodic drinking (HED), alcohol related problems, or rates of concurrent drinking and smoking. Likewise, the dose of the BASICS-Mobile intervention did not predict greater reductions in drinking, HED, or rates of concurrent drinking and smoking. As compared to the average levels of drinking and smoking at the baseline assessment, all three conditions reported reductions in drinking, HED, and drinking related problems (see effect sizes in Table 1), but there were no time-by-condition interactions for any of these outcomes. Given the rapid development of intervention applications for mobile devices, it is imperative that future research continue to examine whether these applications are actually effective in reducing HED and related problems (Cohn, Hunter-Reel, Hagman, & Mitchell, 2011).

The current study also provides initial data supporting the feasibility and acceptability of the BASICS-Mobile intervention. Overall, the majority of participants in both the daily monitoring mobile assessment and BASICS-Mobile conditions reported that participation in the study and completing the mobile assessments was “easy” to “very easy.” Likewise, over 90% of individuals would recommend participating in this type of study to their friends. Many participants reported that they learned something new about alcohol or smoking, especially in the BASICS-Mobile condition, and one-quarter to one-half of participants

reported that participation in the study helped them develop a goal to change their smoking and/or drinking habits.

It should also be noted that a small percentage of participants (13.3% of BASICS-Mobile and 6.8% of daily monitoring) reported in their qualitative feedback that participation in the study made them want to smoke or drink more than usual. For example, one participant reported, “I feel that I actually smoked more often. Usually, I don’t buy packs of cigarettes very often and this limits my smoking. I felt the need to have a pack on hand at all times during the study.” Two other participants reported, “I think that filling out a survey about smoking three times a day made me want to smoke more often,” and “Sometimes when the survey would pop up, I would read about smoking cigarettes and start to think I want a cigarette.” These qualitative reports suggest that reactivity to repeated assessment may be an issue for mobile interventions. Yet analysis of the smoking and drinking behavior of the individuals (n=5) who reported in the qualitative feedback that the surveys caused increased desire or tendency to smoke or drink indicated that these individuals reported similar reductions in drinking and smoking as those who did not provide this feedback. These results are consistent with prior research that has found minimal evidence of EMA reactivity (Shiffman, 2009).

There were several limitations of the current study. First, the small sample size limited our ability to detect the small effects of the BASICS-Mobile intervention on drinks per drinking day (d = 0.07) and days of concurrent drinking and smoking (d = 0.27). Second, the intervention length (14 days) may have been too brief to elicit change in drinking among the heavy episodic drinkers enrolled in our study. The finding that the dose of the intervention predicted better outcomes would suggest that receiving more of the modules may have been associated with greater changes in smoking and potentially an effect on drinking, suggesting that a longer intervention period may be beneficial. For example, Suffoleto and colleagues (2012) found significant reductions in frequency of heavy drinking and drinks per drinking day after 12 weeks of a text-based intervention.

A related limitation is that we do not have an objective measure of the degree to which participants engaged with the intervention content. As noted above, participants were asked to respond to the module content by answering questions to proceed to the next screen. However, there was no measure of whether they paid attention to the intervention content or answered the questions embedded within the intervention modules randomly. Future research may consider additional ways of measuring engagement with intervention content. For example, including a quiz following each intervention could provide a way of approximating engagement with the intervention content. We did not explicitly incentivize module completion, and future studies might consider providing bonuses for receiving more modules. It is also important to note that individuals in the current study were not seeking any form of treatment and therefore might have lacked motivation to read the intervention content as a means for changing their drinking or smoking behavior.

The assessments used in the current study were also a limiting factor. All assessment was self-report, and it is unclear to what extent the self-reported drinking and smoking matched the actual drinking and smoking among participants. Interestingly, the rates of smoking and

drinking during the EMA period were somewhat lower than the rates reported at baseline, which could be explained by a number of factors, including the effect of self-monitoring. Second, the compliance with event-contingent participant-initiated assessments was quite low and numerous occasions of drinking that were not reported at the time of drinking were reported at random prompts. One explanation for poor compliance was the fact that we did not incentivize for completing participant-initiated assessments.

Another major limitation was that the 1-month follow-up period was possibly too brief to evaluate whether the BASICS-Mobile intervention and daily monitoring would have lasting effects on smoking behavior. Additionally, we did not include a measure of social desirability. Thus, it is unclear to what extent the reports of drinking and smoking were due to a social desirability bias, which has been shown to predict greater changes in college student drinking (Carey, Borsari, Carey, & Maisto, 2006). It may also be the case that regression to the mean was an issue in the current study (Cunningham, 2006). We explicitly recruited participants with above average heavy episodic drinking, and even the minimal assessment condition showed small-to-medium effect sizes decreases in drinking behavior from baseline to the 1-month follow-up.

A final limitation was in the development of the intervention itself. We had hoped to develop a fully dynamic and individualized mobile intervention that would respond to multiple factors in an individual's environment (as reported at the random or event assessment), such that the intervention would be highly tailored to each individual's experience in real-time. All modules were personalized based on the participant's baseline data and the urge-surfing module was provided when an individual endorsed an urge to smoke in real-time, but the intervention did not respond to multiple interacting factors in the environment. A more specific and thorough tailoring could have been more effective.

Given the success of BASICS in reducing college student drinking (see Larimer & Cronce, 2007), it is unclear why the BASICS-Mobile intervention was not more successful at changing drinking behavior than daily monitoring or minimal assessment. First, BASICS-Mobile was not the full BASICS program (Dimeff et al 1999) adapted to be a mobile intervention; rather, we incorporated aspects of BASICS into a mobile platform. Future research should attempt to more closely adapt the BASICS program into a mobile format that targets heavy alcohol use and alcohol-related problems. We anticipate that a mobile intervention that exclusively targeted alcohol use would be more effective than the current BASICS-Mobile intervention, which targeted both drinking and smoking. It would also be interesting to compare a closely adapted BASICS program to the BASICS-Mobile intervention developed for the current study.

It is also important to examine whether interventions that target multiple risk behaviors (i.e., smoking and heavy drinking) are less efficacious or more efficacious than interventions that target only one risk behavior. Numerous recent studies have found that multiple component brief interventions that target more than one behavior are not as effective as single component brief interventions targeting a single behavior (e.g., Dermen & Thomas, 2011; Kypri & McAnally, 2005; Lostutter, 2010). For example, Kypri and colleagues (2004) found a brief intervention targeting alcohol was efficacious in reducing alcohol consumption and

related consequences, but the same investigators found the same brief feedback alcohol intervention with components added to address smoking and exercise had no effects on alcohol, smoking, or exercise behavior (Kypri & McAnally, 2005).

Despite these limitations, the robust effects of 14 days of daily monitoring via a mobile device on smoking behavior among non-treatment seeking college students is worthy of further study. It may be the case that daily monitoring and the BASICS-Mobile intervention were more effective in reducing smoking behavior because smoking behavior among college students may be more mutable (Wetter et al., 2004). Within the context of the current study, it will be important to assess the mechanisms of these behavioral changes. According to the qualitative feedback, it appears that participating in daily monitoring and the BASICS-Mobile intervention increased awareness of behavior and provided more information about alcohol use and smoking. Greater awareness of behavior and knowledge about its potential harms could explain both the increased desire to change the behaviors and subsequent behavior change.

Numerous questions remain about whether certain modules of the BASICS-Mobile intervention were more or less effective and whether the timing and sequencing of modules is important. Further analyses of the individual modules received and the subsequent drinking and smoking after receiving each module may elucidate the active ingredients of the BASICS-Mobile intervention and could help to further refine the intervention. Finally, given the significant effects on smoking behavior, it is important to extend this research to non-college student smokers and to individuals who are seeking smoking cessation treatment.

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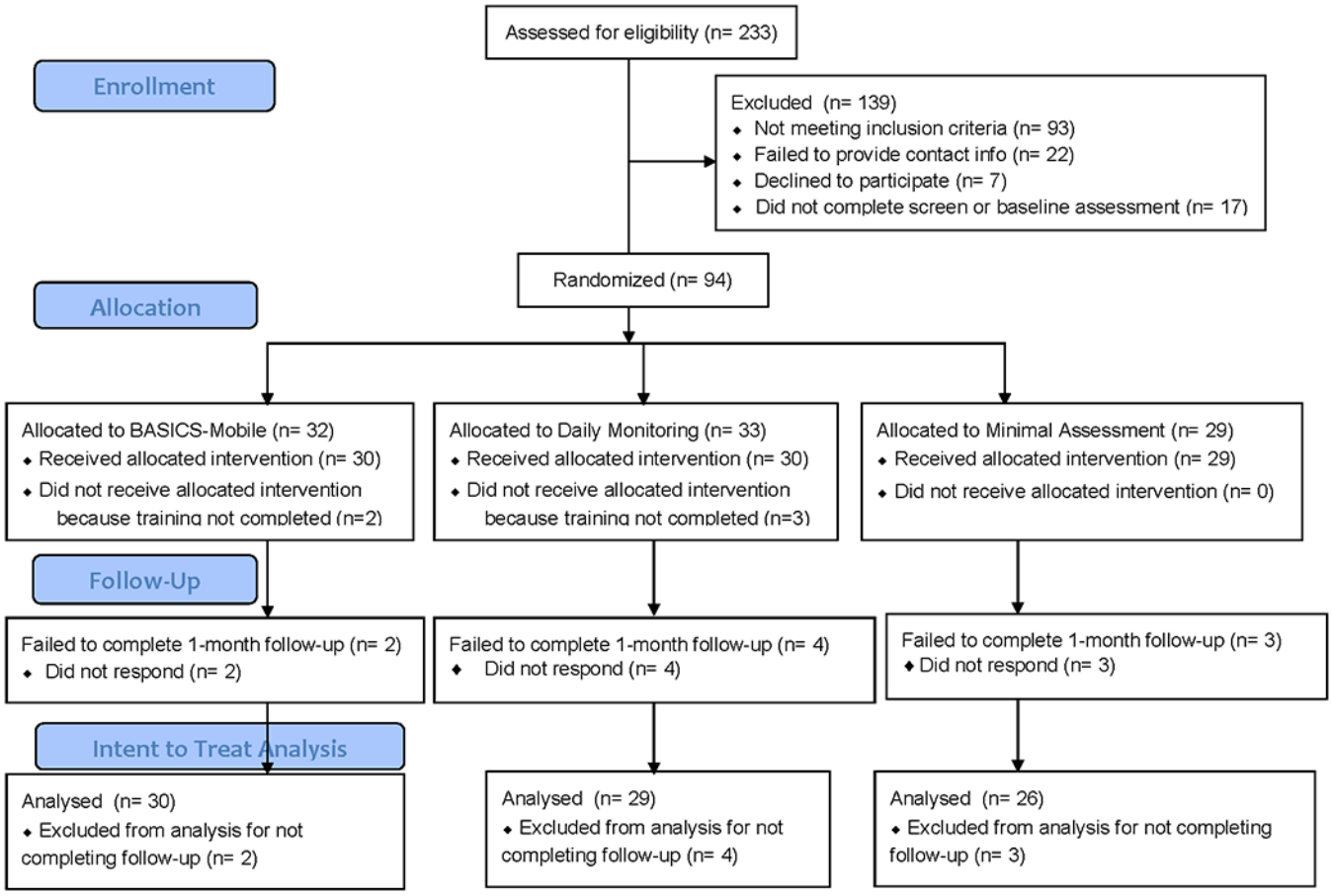

Figure 1.
CONSORT diagram of participant flow into the study.

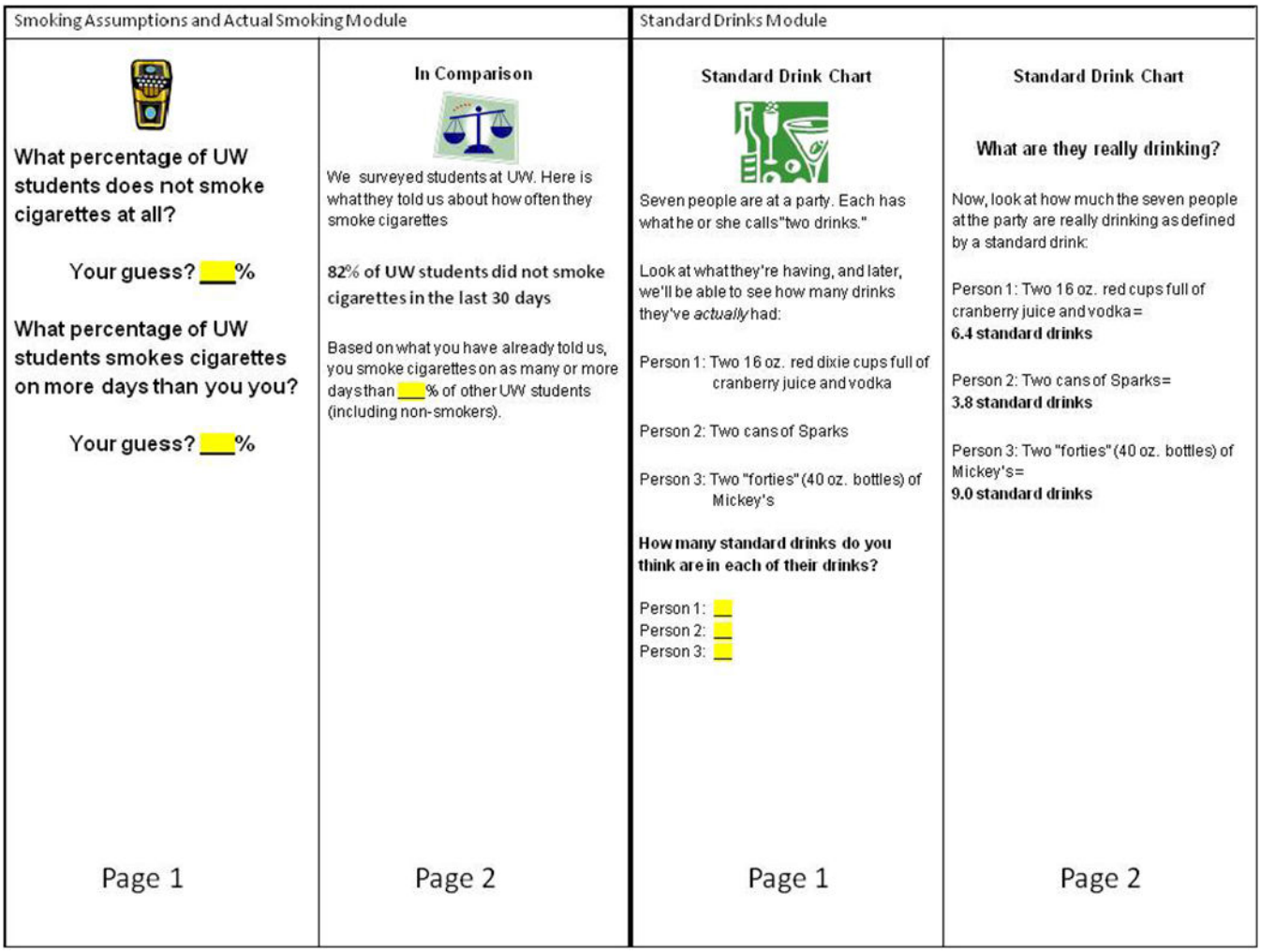

Figure 2.

Sample intervention modules for smoking normative feedback (left two panels) and standard drink calculation (right two panels). The shaded boxes indicate participant input or individualized information based on prior assessment.

Table 1.

Means for Primary Outcomes from Baseline to Follow-Up by Treatment Group.

				Pre-Post Within Group Difference (Cohen's d)		
Outcome	**Minimal assessment**	**Daily Monitoring**	**BASICS-Mobile**	**Minimal assessment**	**Daily Monitoring**	**BASICS-Mobile**
DDD baseline	7.46 (3.46)	5.58 (2.45)	5.57 (2.81)	0.44	0.41	0.27
DDD follow-up	6.05 (2.88)	4.56 (2.65)	4.83 (2.59)			
Heavy days baseline	2.86 (1.41)	2.45 (1.44)	2.31 (1.53)	0.40	0.50	0.15
Heavy days follow-up	2.31 (1.35)	1.76 (1.33)	2.07 (1.70)			
YAAPST baseline	1.36 (0.46)	1.38 (0.84)	1.27 (0.53)	0.20	0.53	0.13
YAAPST follow-up	1.25 (0.62)	0.99 (0.63)	1.19 (0.71)			
CSD Baseline	3.76 (2.15)	4.78 (4.83)	4.93 (3.43)	0.24	0.51	0.49
CSD Follow-up	4.55 (4.07)	2.71 (2.86)	3.28 (3.35)			
Drink+smoke baseline	2.66 (0.48)	2.82 (0.64)	2.81 (0.59)	0.64	0.98	0.96
Drink+smoke follow-up	1.76 (0.83)	2.07 (0.88)	1.97 (1.09)			

Note. DDD = drinks per drinking day, YAAPST = Young Adult Alcohol Problem Screening Test, CSD = Cigarettes per smoking day; Drink+Smoke = days of drinking and smoking per week.

Table 2

Unstandardized Estimates (Standard Errors) from Mixed Models predicting Drinking and Smoking Behavior during EMA.

Predictors	No drinking	# of drinks	No smoking	# of cigarettes	Concurrent drinking and smoking
Level 1					
Time	0.009 (0.005)	0.002 (0.002)	0.006 (0.005)	0.004 (0.002)	−0.01 (0.01)
Any drinking	--	--	−0.22 (0.28)	0.15 (0.12)	--
Number of drinks	--	--	−0.27 (0.06) *	0.10 (0.01) *	--
Any smoking	−0.87 (0.24) *	0.16 (0.09)	--	--	--
Number of cigarettes	−0.32 (0.08) *	0.14 (0.02) *	--	--	--
Weekday/weekend	−0.63 (0.11) *	0.17 (0.06) *	0.09 (0.13)	−0.03 (0.05)	0.67 (0.14) *
Cross-Level - Slope of drinking/smoking, concurrent drinking and smoking on smoking/drinking					
Treatment Condition	0.15 (0.11)	0.02 (0.02)	0.06 (0.09)	0.004 (0.02)	−0.29 (0.22) on drinking −0.27 (0.31) on smoking
Level 2					
Treatment Condition	−0.15 (0.37)	−0.02 (0.09)	−0.05 (0.19)	0.02 (0.09)	−0.08 (0.17)
Gender (Female =+0.5)	−0.17 (0.15)	−0.09 (0.11)	−0.03 (0.21)	−0.20 (0.10)	0.12 (0.19)
Baseline DDD	0.15 (0.04) *	0.09 (0.03) *	0.04 (0.04)	−0.01 (0.02)	−0.06 (0.05)
Baseline CSD	−0.03 (0.03)	0.00 (0.02)	−0.03 (0.03)	−0.002 (0.01)	−0.01 (0.03)
Average # of drinks	−0.96 (0.14) *	0.21 (0.08) *	0.07 (0.16)	−0.02 (0.06)	0.69 (0.13) *
Average # of cigarettes	0.17 (0.09)	−0.04 (0.08)	−1.36 (0.19) *	0.40 (0.05) *	0.28 (0.11) *

Note.

* $p < 0.01$; CSD = Cigarettes per smoking day; DDD = drinks per drinking day. Condition – BASICS-Mobile coded +0.5.

Table 3.

Adjusted Means* for Primary Outcomes from Baseline to Follow-Up.

		Follow-up Means (SD) by group			
Outcome	**Total baseline M (SD)**	**Minimal assessment**	**Daily Monitoring**	**BASICS-Mobile**	**Wald χ^2 (df), p-value**
Drinks/drinking days	6.16 (3.01)	5.22 (2.88)	5.04 (2.65)	5.09 (2.59)	χ^2 (2,76) = 0.12 (p = 0.94)
Heavy drinking days	2.53 (1.46)	1.78 (1.35)	1.65 (1.33)	1.86 (1.70)	χ^2 (2,76) = 0.09 (p = 0.91)
Raw cigarettes/smoking day	4.62 (3.67)	4.74 (4.06)	3.14 (2.97)	2.69 (3.35)	χ^2 (2,74) = 10.40 (p = 0.006)
YAAPST binary sum	18.54 (8.86)	17.54 (8.63)	13.31 (8.62)	16.41 (10.05)	χ^2 (2,75) = 4.05 (p = 0.13)
Days of drink+smoke	1.23 (0.57)	2.24 (0.93)	1.93 (0.88)	2.03 (1.10)	χ^2 (2,75) = 1.96 (p = 0.38)

Note.

*Follow-up means are marginal means covarying gender, race, age, baseline drinks per drinking day, and baseline cigarettes per smoking day.