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A Randomized Pilot Trial of a Mobile-Delivered Alcohol-Impaired Driving Brief Intervention with College Students

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A RANDOMIZED PILOT TRIAL OF A MOBILE-DELIVERED ALCOHOL-IMPAIRED DRIVING BRIEF INTERVENTION WITH COLLEGE STUDENTS

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Abstract

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Alcohol-Impaired Driving (AI-driving) among college students remains a significant public health concern. Counselor delivered and web based Brief Alcohol Interventions (BAIs) have been shown to reduce AI-driving among college students, but to date no study has selected students on the basis of recent AI-driving and evaluated the efficacy of a mobile-based BAI specific to AI-driving. The present study examined whether a mobile-based, AI-driving specific BAI would significantly decrease AI-driving among college students compared to an informational control. Participants were 82 college students who endorsed driving after drinking two or more drinks at least twice in the past three months. After completing baseline measures, participants were randomly assigned to receive either: a) alcohol information or b) an AI-driving specific personalized feedback intervention. Participants in the personalized feedback condition received a personalized feedback document via text containing personalized feedback related to alcohol use and AI-driving. Students randomized to the information condition received standard information about alcohol and AI-driving via a link to a secure website included in text message and/or email. Participants completed outcome measures at three-month follow-up. Repeated measures mixed modeling analyses revealed that students receiving the Al-driving intervention reported significantly greater reductions in driving after drinking than students in the information condition at three-month follow-up. However, differential group differences were not found for estimated BAC prior to driving and alcohol use as both groups reduced on these outcomes at three-month follow-up. The findings of this study provide preliminary support for the efficacy of a mobile-based brief intervention for reducing alcohol-impaired driving among college students.

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Alcohol-impaired driving (AI-driving) is a national public health concern. Each year, over 10,000 people die as a result of AI-driving crashes and costs of alcohol-related traffic accidents total around $59 billion (National Highway Traffic Safety Administration, 2014). Despite widespread prevention efforts, college students are more likely than any other age group to report driving under the influence of alcohol, and alcohol-related traffic accidents remain the leading cause of alcohol-related death among college students (Hingson, Zha, & Weitzman, 2009). Approximately 3.4 million college students (30% of all US college students) report driving after drinking alcohol (Hingson et al., 2009), with rates increasing significantly after the 21st birthday (Beck et al., 2010; Fromme, Weatherill, & Neal, 2010). Among college drinkers, 41% report past-month driving after drinking, 17% report driving after consuming five or more drinks, and 43% report believing they can drive safely after consuming 2-4 drinks in one hr (Hingson, Heeren, Levenson, Jamanka, & Voas, 2002). Consequences of AI-driving can be fatal; 74% of alcohol-related student deaths result from alcohol-impaired traffic accidents. College students are more likely to drive after drinking than their same-aged peers who do not attend college; 34.2% of full-time college students report past year driving after drinking compared to 27.9% of nonstudents (Paschall, 2003).

Recent research indicates that polydrug use among college students is on the rise (Brady & Li, 2013). Approximately a quarter of drivers injured in car accidents test positive for multiple substances, the most common combination being alcohol and marijuana. Combined use of drugs and alcohol is associated with greater psychomotor impairment (Kelly, Darke, & Ross, 2004; Lamers & Ramaekers, 2001); those who drive after the combined use of drugs and alcohol are 23

times more likely to be involved in a fatal car accident (Brady & Li., 2013). The combined effects of alcohol and other substances have been shown to significantly impair driving performance, even at relatively low levels of blood alcohol concentration (Sewell, Poling, & Sofuoglu 2009). Though other studies have examined rates and predictors of drug and alcohol-impaired driving among college students (Arria, Caldeira, Vincent, Garnier-Dykstra, & O'Grady, 2011, Arterberry et al., 2012; McCarthy, Lynch, & Pedersen, 2007; Teeters & Murphy, 2015), to our knowledge no intervention studies have explicitly targeted this particularly dangerous combination.

Predictors of AI-Driving

Predictably, heavy episodic drinking (i.e., 4/5 drinks or more per occasion for females/males) is a strong predictor of drinking and driving, accounting for over 80% of all driving occurrences (Flowers et al., 2008). Compared to students who did not engage in heavy episodic drinking (HED) over a two-week period, students who engaged in 3-4 HED episodes were eight times more likely to drive after drinking (Paschall, 2003). Moreover, the number of drinks students estimate they can consume and still be able to drive safely and legally within an hr is predictive of AI-driving (Hingson, 2002). In addition, researchers have identified several individual difference factors associated with AI-driving. Consistent findings throughout the literature reveal that young white males are more likely than others to drive after drinking (for review see Kelly et al., 2004). Fraternity or sorority membership (LaBrie, Napper, & Ghaidarov, 2012), living off-campus (Weschler, Lee, Nelson, & Lee, 2003), family history of alcohol problems (LaBrie, Kenney, Mizra, & Lac, 2011), and younger age of drinking onset (Hingson 2002, 2004) are associated with more frequent AI-driving. Additionally, stronger self and perceived peer approval of AI-driving and decreased perceptions of risks and legal consequences

associated with AI-driving are associated with a higher likelihood of driving after drinking (LaBrie et al., 2012; McCarthy et al., 2007). Sensation seeking has also been shown to be associated with AI-driving in both the general population and among young adults (for review see Jonah, 1997).

Recently, several studies have examined factors that lead to AI-driving at the *event-level*. Quinn and Fromme (2012) conducted a longitudinal analysis in a sample of 1,350 college students over four years to examine the interaction of subjective intoxication with actual intoxication (estimated blood alcohol concentration). Students reported their alcohol consumption, subjective intoxication, and whether or not they drove after drinking each day for up to 30 days via an electronic daily diary. Findings revealed that students with higher estimated blood alcohol concentrations that perceived themselves as less intoxicated were most likely to drive after drinking. These findings did not change over time, suggesting that perceived intoxication is a steady risk factor for AI-driving throughout college and a potential intervention target. The authors concluded that risk for AI-driving is highest when students are intoxicated but unaware of their actual intoxication level (Quinn & Fromme, 2012).

Though studies have examined alcohol-use in the drinking environment at the event-level (Brown & Vanable, 2007; LaBrie & Peterson, 2008; Thombs et al., 2010), few studies have examined risk factors for AI-driving immediately after leaving the drinking environment (e.g., bar, restaurant, on-campus party, etc.). Rossheim and colleagues (2015) examined risk factors for driving after leaving a college bar by collecting data from 512 bar patrons exiting college bars. They found that the situational variables of perceived intoxication and self-estimated blood alcohol concentration were more strongly associated with self-efficacy for AI-driving (confidence in driving safely after drinking) than demographic and individual difference factors

such as gender, risk-proneness, and past year drinking history. These findings led the authors to conclude that bar patrons' confidence to drive safely after drinking alcohol is strongly affected by perceptions about intoxication level and impairment rather than objective intoxication (blood alcohol concentration). Thus, modifying misperceptions about intoxication and impairment are important intervention targets.

Laboratory Studies on AI-Driving

Findings from event-level studies examining AI-driving echo findings from laboratory studies. Marczinski, Harrison, and Fillmore (2008) found that binge drinkers reported lower perceived intoxication and greater perceived ability to drive safely after drinking than nonbinge drinkers after receiving a moderate dose of alcohol (.065 g/kg). Extending their previous study, Marczinski and Fillmore (2009) examined whether acute tolerance to alcohol's effects contribute to decisions to drive after drinking among binge drinkers. Acute tolerance refers to experiencing tolerance to alcohol's effects within a single drinking session, thus explaining why the effects of alcohol are greater when measured on the ascending limb rather than the descending limb despite equivalent BACs. No differences in perceived intoxication or willingness to drive between binge drinkers and nonbinge drinkers were found on the ascending limb of the blood alcohol curve. Notably, binge drinkers reported less intoxication and greater willingness to drive than non-binge drinkers on the descending limb of the blood alcohol curve, indicating acute tolerance. More recently, Morris and colleagues (2014) found that perceived danger of driving after consuming alcohol was reduced on the descending limb. Additionally, they found that perceived danger following alcohol administration was associated with both willingness to drive and self-reported driving behavior. As an extension of this research, Amlung, Morris, and McCarthy (2014) directly tested whether increased willingness to drive after alcohol consumption can be attributed

to perceived danger, finding that willingness to drive increased significantly on the descending limb due to a decrease in perceived dangerousness across limbs.

Taken together, results of these laboratory studies suggest that perceived intoxication following alcohol consumption is uniquely associated with decisions to drive after drinking. Furthermore, these results suggest that risk of driving after drinking may be especially heightened on the descending limb of the blood alcohol curve due in part to lower perceptions of intoxication and dangerousness of driving after drinking. These findings suggest that correcting misperceptions of intoxication level and dangerousness of driving after drinking at various levels of intoxication should be important intervention targets.

Interventions for AI-driving

Although a variety of policy-based public health interventions (i.e., raising the legal drinking age, lowering the legal BAC driving limit, sobriety checkpoints, zero tolerance laws, server training, etc.) have been implemented to decrease AI-driving, the frequency of driving after drinking remains high, particularly among college students (Hingson, Assailly, &Williams, 2004). In addition, a number of media campaigns, school-based instructional programs, and peer organizations have been designed specifically to target driving after drinking among college students, but there is insufficient evidence that these approaches reduce AI-driving (Elder et al., 2005). Elder and colleagues (2005) conducted a systematic review of the literature in order to determine the efficacy of school-based programs (school-based instructional programs, peer organizations, and social-norming campaigns) for reducing AI-driving. The authors determined that interactive instructional programs (primarily small-group based) that incorporate skill training are most likely to be effective at reducing AI-driving related behaviors. However, the authors concluded that there is insufficient evidence that school-based instructional programs,

peer organization programs, and social norming programs significantly reduce AI-driving. Additionally, a number of designated driver programs have been implemented in order to reduce AI-driving, such as nationwide programs that encourage designated driver use and programs in drinking establishments that provide incentives to act as the designated driver (Ditter et al., 2005). However, results of a systematic review indicate that there is insufficient evidence to suggest that these programs actually reduce AI-driving behavior and crashes. Conversely, there is evidence to suggest that college students may in fact be more likely to increase alcohol consumption when relying on a designated driver (DeJong & Winsten, 1999; Ditter et al., 2005).

In an effort to determine the impact of various alcohol interventions on reducing driving after drinking among adolescents and young adults, Steinka-Fry, Tanner-Smith, and Hennessy (2015) conducted a meta-analysis to summarize the effects of brief alcohol interventions (under 5 hrs of contact) on drinking and driving. Their analyses included the following alcohol interventions: M-PASS (four 10-15-mins) online sessions focusing on alcohol-related risks, norms, alcohol-related consequences, and goal setting), DARE (police-officer led drug and alcohol education sessions), Skills Training (group meetings focusing on moderation strategies and outcome expectancies), Alcohol Curriculum Infusion (a single session harm prevention curriculum), Lifestyle Management Class (2-hr peer or professional-led group meetings focusing on alcohol education, moderation strategies, peer norms and drinking myths, legal charges, and personal goal setting), Driving Simulator (consists of a driving console connected to computer to create a virtual driving simulation), Virtual Interactive Party (computer-based simulation of a house party), Alcohol Edu (a 2-3 hr online course of generic alcohol education), and Behavior Image Models (brief tailored consultation session and fitness goal plan provided by a “fitness specialist”), and brief motivational interventions (typically consist of 50-min individual

therapeutic meetings delivered in motivational interviewing style and include *personalized feedback*). Results indicated that overall, the alcohol interventions were associated with significant reduction in drinking and driving behaviors compared to control conditions. Notably, effect sizes for the included interventions ranged from -0.48 to 1.02 and only five of the effect sizes included were significantly different from zero. The interventions included in this study varied widely in terms of intervention content and sample (e.g., adolescents in the ER vs. high school students vs. college students) making it difficult to conclude which intervention packages and components were most effective. Additionally, this meta-analysis included both brief motivational interventions, which have been widely shown to reduce alcohol use and overall alcohol related problems (discussed at length below) and standard alcohol prevention and education programs, many of which are typically used as control groups in studies examining the effects of brief interventions on alcohol use and problems. The brief motivational interventions included in the study exhibited varying effect sizes at follow-ups (Schaus, Sole, McCoy, Mullett, & O'Brien, 2009: effect size at 3M =.33, 6M =.15, 9M =.17, 12M =.18; Spirito et al., 2004: effect size at 3M = .78, 6M = .27, and 12M = .17). These effect sizes were similar to those found in other BAIs included in this meta-analysis, indicating that previously developed brief motivational interventions targeting alcohol use have performed similarly to other brief alcohol interventions delivered in different frameworks in terms of reducing driving after drinking

Brief Alcohol Interventions

Brief Alcohol Interventions (BAIs) attempt to identify and correct faulty normative beliefs and highlight consequences of alcohol use (such as driving after drinking) in order to increase motivation to change. Recent meta-analyses and integrated analyses indicate that BAIs succeed in reducing alcohol use (frequency, quantity, level of intoxication) and a variety of

alcohol-related problems (see Cronce, Larimer, White, & Rabiner, 2012 and Mun et al., 2014, for review), although effect sizes are typically small (Foxcroft, Coombes, Wood, & Allen, 2016; Huh et al., 2015).

BAIs based on The Brief Alcohol Screening and Intervention for College Students (BASICS; Dimeff, Baer, Kivlahan, & Marlatt, 1999) model have been widely studied and disseminated. BAIs typically consist of one or two individual therapeutic meetings (approximately 50 mins per session; Carey, Scott-Sheldon, Carey, & DeMartini, 2007) delivered in motivational interviewing (MI; Miller & Rollnick, 2012 style and include *personalized feedback*. Personalized feedback is created based on a series of questionnaires completed by the student prior to their BAI session, and though specific feedback components differ by study, a personalized drinking profile, information on social norms, prior alcohol-related consequences experienced by the student (including drinking and driving if endorsed), practical costs (e.g. money spent on alcohol and caloric intake from alcohol), and information on strategies to limit alcohol-related risk are typically included (see Miller et al., 2012). The feedback component is meant to highlight the student's risky drinking habits, correct faulty social norms, and explore ambivalence around changing drinking patterns. Although few studies have examined the relative impact of specific feedback components, recent research suggests that providing normative information and information on protective strategies to limit risk may be especially potent feedback elements (Martens, Smith, & Murphy, 2013; Miller et al., 2013). Additionally, research has revealed that when the BAI is highly personalized to the participant, having more BAI components generally improves drinking outcomes (Ray et al., 2014). BAIs typically promote harm-reduction strategies, often referred to as Protective Behavioral Strategies (PBS), as a way to minimize or eliminate alcohol-related problems, such as reducing drinking quantity, spacing drinks to lower

peak blood alcohol levels, avoiding specific high-risk situations, and planning ahead to arrange a designated driver or alternate transportation. Providing drinkers with personalized feedback on PBS may be particularly helpful in preventing AI-driving. In addition, multiple studies have found significant drinking reductions utilizing solely a descriptive normative component (Lewis, Neighbors, Oster-Aaland, Kirkeby, & Larimer, 2007; Martens et al., 2013; Neighbors et al., 2010), suggesting that BAIs focusing specifically on social norms information may be enough to produce reliable changes in drinking. Given that heavy drinking is the most robust predictor of AI-driving, and BAIs are efficacious for reducing heavy drinking, AI-driving interventions should include some standard BAI content (e.g., normative feedback) as well as AI-specific content.

Brief Interventions for AI-driving in the Emergency Room

Several RCTs (randomized controlled trials) involving BAIs have been conducted among traffic accident victims and emergency room patients with mixed results. Utilizing a sample of alcohol positive motor vehicle crash victims at a trauma center, Schermer and colleagues (2006) randomly assigned 126 patients to receive standard care or a 30-minute BAI delivered in MI style. Those in the BAI condition showed significantly lower rates of arrest for DUI 3-years post hospital discharge than those receiving standard care; Seven out of 62 patients (11.3%) in the BAI group had an arrest for DUI compared to 14 of 64 patients (21.9%) in the standard scare condition. D'Onofrio and colleagues (2012) randomly assigned 889 adult ED (emergency department) patients with harmful or hazardous drinking to receiving a brief intervention delivered by an emergency practitioner, a brief intervention with a one-month booster session, or standard care. ED patients assigned to the BAI and BAI with booster session showed significantly greater reductions in rates of driving after three or more drinks at 12-month follow-

up than those in the standard care condition. Additionally, BAIs have been shown to reduce risky drinking outcomes among alcohol-positive adolescents in the emergency room (Spirito et al., 2004). Spirito and colleagues (2004) randomized adolescents (ages 13-17) admitted to the ER with positive blood alcohol concentrations to receive either standard care or a motivational interview. The MI protocol was completed in one 35-45 minute session and included exploration of drinking motivation, a discussion of potential negative consequences, personalized feedback about their drinking pattern, a discussion about their future if they continue high risk drinking, and goal setting. In contrast, those in the standard care condition were advised by a physician to quit drinking and given handout on avoiding drinking and driving. Results indicated that rates of drinking and driving decreased from 24% at baseline to 10% for those in the MI condition compared to a decrease from 33% to 29% in the standard care condition at three month follow-up. However, differences in drinking and driving at follow-up were not statistically significant after controlling for baseline drinking and driving. Notably, the three interventions described above used only standard BAI content and did not include AI-driving specific content. In addition, brief interventions have been conducted with subcritically injured emergency department patients (Mello, Longabaugh, Baird, Nirenberg, & Woolard, 2008) and adults in the emergency department screening positive for both risky drinking and driving behaviors (Sommers et al., 2013). However, no differences between a BAI and scripted discharge instructions on alcohol outcomes were found in hazardous and harmful drinkers in the ER (D'Onofrio, 2008).

Brief Interventions for DUI Offenders

Additionally, a limited amount of research has examined the effects of BAIs on subsequent risky driving or risky drinking behaviors among individuals who have been arrested

for DUI. Wells-Parker and colleagues (1995) conducted a meta-analysis of existing intervention studies for DUI offenders and found that the combined use of psychotherapy, education, and follow-ups were associated with larger intervention effect sizes. Results also revealed that incorporating elements of BAIs with traditional DUI program components, such as education, was the most effective strategy for shorter duration DUI programs. Wells-Parker and Williams (2002) randomized first-time DUI offenders (N = 4,074) to receive a standard first-offender education program or an enhanced program that included two 20-minute individual brief intervention sessions incorporating personalized assessment feedback and a follow-up session. Interestingly, differential effectiveness of the interventions was only shown for DUI offenders who indicated depressed mood. Depressed DUI offenders receiving an enhanced intervention were 35% less likely to recidivate than depressed offenders receiving the standard intervention. However, when controlling for depression level, no significant differences were found between groups, suggesting that brief individual interventions involving feedback may not be necessary for all DUI offenders. Rather, enhanced interventions utilizing brief individual intervention components combined with standard DUI education may be most effective for reducing impaired-driving risk among depressed DUI offenders, an especially high-risk group that has been shown to be more likely to recidivate.

More recently, Brown and colleagues (2010) conducted a randomized controlled trial (RCT) with DUI recidivists with alcohol use problems to investigate whether a BAI resulted in significantly greater reductions in risky drinking than an information/advice control condition. The BAI intervention was delivered in MI style and included personalized feedback, while the control intervention consisted of in-person delivery of information on risks associated with heavy drinking and DUI. With the exception of specific content, the control intervention mimicked the

BAI intervention. Findings indicated that both interventions significantly reduced risky drinking at 6- and 12-month follow-ups. However, only recidivists in the BAI condition showed significant reductions in percent of risky drinking days from baseline to follow-up; receiving the BAI intervention decreased their number of risky drinking days by 25% at 12-month follow-up.

Ouimet and colleagues (2013) extended Brown and colleagues' (2010) trial described above by examining risky driving convictions and crashes 5 years post-intervention. Notably, no group differences were found between BAI and control until age was taken into account. BAI was significantly more effective at delaying subsequent DUI conviction, speeding, and other traffic violations five year post-intervention compared to control in younger recidivists (26 to 43 years of age). No significant group differences were found for recidivists ages 41-65 at 5 year follow-up, suggesting that BAI may be more efficacious at delaying convictions long-term in younger drivers, an important high-risk group.

Brief Interventions for College Students Selected on the Basis of Heavy Drinking- AI-Driving Outcomes

Existing intervention studies examining AI-driving are limited by including general samples of heavy drinkers or individuals who have been arrested for DUI or involved in an accident. Effective prevention should focus on individuals who report any recent AI-driving. To date, only three published studies have examined whether BAIs effectively reduce AI-driving among college-aged drinkers, and none of these selected participants on the basis of recent drinking and driving or used a mobile/remote intervention platform. Monti and colleagues (1999) examined whether the use of a BAI compared to standard care reduced specific alcohol-related consequences, including driving after drinking, among 94 adolescents (ages 18-19) treated in an

emergency room. At 6-month follow-up, participants in the standard care condition were almost 4 times as likely to report driving after drinking than those in the BAI condition.

Schaus and colleagues (2009) conducted an RCT to determine whether a BAI given to drinkers in a college health center significantly decreased drinking level and alcohol problems. Students who reported at least one heavy episodic drinking (HED) episode in the past two weeks were randomized into either a control group (*n*=182) or a brief intervention group (*n* =181). Participants in the brief intervention group received two 20-minute BAI sessions delivered in MI style, while participants in the control condition received a brochure on "alcohol prevention." A participant feedback document summarizing overall healthy lifestyle behaviors, personalized drinking information, social norms clarification, alcohol-related consequences (including driving after drinking), alcohol expectancies, and use of protective behavioral strategies was compiled and used as the source of normative feedback information during the interventions. Participants provided data at baseline and completed follow-ups 3, 6, 9, and 12 months after the intervention. There was a statistically significant reduction in the intervention group in the number of times participants drove after three of more drinks at 3-month follow-up. However, the intervention group and the control group did not significantly differ in number of times driving after drinking at any subsequent follow-up.

Teeters and colleagues (2015) analyzed data from three separate RCTs of BAIs to evaluate whether BAIs are associated with reductions in AI-driving among college student drinkers. Participants in all three studies were selected on the basis of recent heavy drinking (study 1 and 3) or an alcohol policy violation (study 2) and randomized to BAI or control conditions. In *Study 1* (Murphy, Dennhardt, Skidmore, Martens, & McDevitt- Murphy, 2010), participants were randomized into one of two groups: BAI (*n* = 38) and Alcohol 101 Plus (*n* =

35). *Study 2* (Borsari et al., 2012) evaluated a stepped care approach with mandated students. Students who reported four or more HED episodes and/or scored 5 or more on the Young Adult Alcohol Consequences Questionnaire (YAACQ) at the 6-week follow-up were identified as high risk drinkers (n = 462) and were randomly assigned to either a BAI (n = 211) or assessment only (n = 194). In *Study 3* (Martens et al., 2013), students were randomized into one of three groups: a single-component BAI focused on correcting misperceptions of descriptive norms (n =121), a single-component BAI focused on use of PBS (n = 111), or Alcohol Education (AE; n = 133). For studies 1 and 2, BAIs included feedback on AI-driving for participants who endorsed that behavior at baseline and protective behavioral strategies including strategies to avoid AI-driving.

Analyses revealed that receiving a BAI was significantly associated with reductions in AI-driving at final (6-month and 9-month, respectively) follow-up compared to the control conditions in all three studies. Results also revealed that a single-component BAI focused on correction of misperceptions of descriptive norms was significantly associated with reductions in AI-driving compared to the control group at final (6-month) follow-up, while a single-component BAI focused on use of protective behavioral strategies was not. The authors concluded that counselor-administered BAIs that include descriptive normative feedback are associated with significant reductions in AI-driving compared to control. Notably, intervention effects were not explained by reductions in typical weekly drinking.

Unfortunately, despite the demonstrated efficacy of BAIs, it is often not economically feasible for universities to hire and train staff to deliver in-person BAIs to a large number of risky drinking college students. Additionally, very few heavy drinking college students seek out alcohol prevention or treatment services available on campus or in the surrounding community (Buscemi et al., 2010), and even when incentivized with research credit it is often difficult to get

student to attend in-person sessions. This has led researchers to attempt to develop innovative ways of delivering BAIs to reach a larger audience based on effective components of in-person BAIs (Cronce, Bittinger, Liu, & Kilmer, 2015). Identifying students for BAI services based on drinking and driving behavior specifically, rather than enrolling all heavy drinkers (only about one-third of whom will report AI-driving), is an efficient way to ensure that limited intervention resources are allocated toward the most pernicious alcohol-related risk behavior and might enhance the overall public health impact of BAIs while limiting costs.

Previous research suggests that personalized feedback delivered without a one-on-one intervention may effectively reduce alcohol use and problems (White, 2006). In a recent meta-analysis, Cadigan and colleagues (2016) found no significant differences on any alcohol outcome between personalized feedback delivered in-person and computer delivered personalized feedback at short-term follow-ups (less than 4 months post-baseline intervention). Although in-person brief interventions were more effective in reducing drinking quantity and drinks per week at long-term follow-up (over 4 months from baseline) relative to computer-delivered feedback interventions (Murphy et al., 2010; Walters, Vader, Harris, Field, & Jouriles, 2009), no between-condition effects were found for alcohol-related problems at long-term follow-up. Thus, computerized personalized feedback interventions represent a brief, empirically supported, cost-effective method for delivering alcohol interventions to large audiences. Furthermore, web based BAIs require little time/effort on the part of participants and may be a preferred modality among young adults (Buscemi et al., 2010).

Technology-based interventions

BAIs have traditionally been delivered in person, by computer, or via mail (White, 2006). An important alternative delivery method for delivering BAI that has received little attention is

short message service (SMS) or text messaging. Text messaging is now a ubiquitous form of communication. Approximately 98% of Americans ages 18-29 own a cell phone and 97% of cell phone owners in this age group report using their cell phones to send and receive text messages (Pew Research Center, 2014). Delivering health behavior interventions through text message has a number of potential advantages including the ability to reach a large number of people at a low cost per person, portability, and the ability to tailor, personalize, and interact (Hall, Cole-Lewis, & Bernhardrt, 2015). Evidence from clinical trials indicates that personalized text messages are efficacious in promoting physical activity (Hurling, 2007), weight-loss management (Gerber, Stolley, Thompson, Sharp, & Fitzgibbon, 2009), smoking cessation (Free, 2009), diabetes self-management (Kim, 2007), and medication adherence (Cocosila, 2009).

Mobile phone technology is considered an "emerging technology" in alcohol research and is quickly becoming a popular method for both collecting data on alcohol use and delivering interventions (Cunningham, Kypri, & McCambridge, 2011). Though research indicates that participants prefer text messages to telephone calls and emails and rate this medium positively (Moore et al., 2013), only a few published studies in the alcohol literature have implemented a stand-alone text-messaging intervention. Suffoletto and colleagues (2014) conducted a text-messaging based intervention with 765 risky drinking young adult emergency department patients. Each week for 12 weeks, participants received text messages that included prompts for setting a low-risk drinking goal, feedback to promote reflection on drinking behavior or support a low-drinking goal, and strategies for reducing alcohol consumption and goal setting. Those in the text message intervention condition decreased their alcohol consumption (heavy episodic drinking episodes and drinks consumed per drinking episode) at three-month follow-up. In addition, Mason and colleagues (2014) tested the efficacy of a brief text-messaging alcohol

intervention based on MI principles for increasing readiness to change. After completing a baseline assessment, participants were sent between 4 and 6 personalized text messages daily for 4 days. Text messages included drinking feedback and information on peer risks and protective strategies. At one-month follow-up, participants in the intervention group reported significant increases in readiness to change alcohol use.

More recently, Suffoletto and colleagues (2016) examined a text-messaging program as a booster to in-person alcohol education classes with college students mandated to complete an alcohol education due to violating campus alcohol policies. After completing two alcohol education classes, students were enrolled in an alcohol text-messaging program in which they received brief text messages on Thursdays and Sundays for six weeks. The text messages asked students if they planned on drinking during the coming weekend, and if yes, if they would commit to setting a drinking limit. Students were then provided with personalized feedback on their drinking goal. Results indicated that binge drinking decreased over the 6-week text-messaging period and that commitment to a low-risk drinking goal was associated with reductions in binge drinking intentions. Notably, 90% of students in this study responded to all text messaging prompts even though the messages were not mandatory (students were given the option to opt out at any time) and they were not compensated for participation. However, this was not a randomized controlled trial and the booster intervention was not compared against treatment as usual or an alternative booster intervention (e.g., phone calls or emails) making it difficult to draw definitive conclusions about the efficacy of text-messaging boosters.

In order examine the efficacy and feasibility of an event-specific, text-message PFI (personalized feedback intervention) in reducing alcohol use and problems when tailgating, Cadigan and colleagues (under review) recruited 130 students who reported, a) tailgating during

the past 30 days and b) engaging in a binge drinking episode while tailgating in the past year. Participants were randomly assigned to one of two text-messaging conditions: 1) an event-specific personalized feedback intervention or 2) an alcohol education control. Participants were sent text messages the morning of a home football game asking whether or not they would be tailgating today. If the participant responded positively, they received either the PFI on typical tailgating alcohol use (consisting of personalized feedback on number of drinks and social norms comparison, estimated BAC, and alcohol-related problems) or information about the effects of alcohol on the body. Participants completed a follow-up the next day and a second follow-up 30 days post intervention. Participants in the PFI condition consumed significantly fewer drinks and had a lower peak eBAC than those in the education condition at both 1 day and 1-month follow-up. These findings provide preliminary evidence for an event-specific text-messaging intervention in reducing risky alcohol use for college students while tailgating.

Text messages may be a particularly advantageous way to provide BAIs as they can be highly personalized to the individual, accessed at any time that suits the individual's needs, and allow for engagement and interaction between the interventionist and participant (Fjeldsoe, Marshall, & Miller, 2009). Text messages may mitigate potential limitations of web-based feedback – the lack of interaction with a clinician, and the minimal/uncertain comprehension and processing of intervention material that might occur with remote web-based interventions. Text messaging interventions may represent a valuable method for reaching high-risk drinkers as well as online students who may not be willing to come into the laboratory to complete an intervention session (Irvine et al., 2012).

Current Study

Though previous studies have examined the impact of BAIs on AI-driving among DUI offenders and emergency department patients, no studies have examined the effects of an AI specific BAI among college student drinkers who report recent AI. This is concerning considering that AI-driving remains the leading cause of alcohol-related death among college students, a high-risk subgroup that are more likely to drive after drinking than any other subgroup (Hingson et al., 2009). The development of efficacious interventions for college students is an important area of research. The overall goal of the current study is to develop and evaluate a brief, AI-driving focused intervention to decrease drinking and driving among college students. To do this, we created and delivered an intervention that includes efficacious elements of brief alcohol interventions along with personalized feedback elements specifically targeting AI-driving. We evaluated the efficacy of the mobile-based AI-driving specific intervention compared to a generic alcohol information intervention in the context of a randomized pilot trial.

We conducted a randomized 2-group (alcohol information vs. AI-driving specific personalized feedback) pilot trial with 82 college students. Hypotheses are as follows:

Hypothesis 1) Students receiving the AI-driving intervention will report greater reductions in driving after drinking ("anything at all" and 3 or more drinks) at 3-month follow-up compared to students receiving the alcohol information intervention.

Hypothesis 2) Students receiving the AI-driving intervention will report greater reductions in driving after combined use of alcohol and another substance at 3-month follow-up compared to students receiving the alcohol information intervention.

Hypothesis 3) Students receiving the AI driving intervention will report significantly greater reductions in estimated BAC prior to driving and total number of drinks

consumed before driving at 3-month follow-up compared to students receiving the alcohol information intervention.

Hypothesis 4) Students receiving the AI driving intervention will report greater reductions in alcohol use at 3-month follow-up compared to students receiving the alcohol information intervention.

Method

Participants

A power analysis for a design with two conditions being measured on two occasions was run using the G-Power software (Erdfelder, Faul & Buchner, 1996). Based on the Murphy et al. (2010) study examining AI-driving outcomes among students receiving a BAI or education control intervention (previously discussed) and the review of behavior change interventions delivered by mobile telephone short-message service (Fjeldsoe, 2009), we chose to utilize an anticipated between-groups effect of .58, which was the mean of the effect size found with alcohol-impaired driving outcomes (d=.42) and mobile delivered behavior change interventions (d=.73). This would require 38 participants per condition total to have a power of .80, assuming $\alpha = .05$. In order to achieve this sample size at follow-up, we planned to enroll 41 participants per condition, allowing for some attrition.

Participants were approximately 500 undergraduate students recruited from the University of Memphis psychology subject pool, other undergraduate courses, and flyers posted around Memphis area college campuses. In total, 82 students participated in the pilot trial (67.1% women, 32.9% men; average age = 23.1, *SD* = 6.31; 18.3% freshman, 19.5% sophomores, 34.1% juniors, and 28% seniors or above) from a large public university in the southern United States Students were eligible to participate if they were at least 18 years old, had access to a motor

vehicle, and reported driving after drinking 2 or more drinks at least twice in the past three months. The sample was ethnically diverse: (52.4% Caucasian, 42.7% African American, 4.9% Hispanic or Latino, 1.2% American Indian, 1.2% Native Hawaiian/Pacific Islander, and the remainder not specifying their ethnicity). 23.2% (n = 19) were members of a fraternity or sorority.

Screening

Approximately 500 students (recruited from a university-wide email system, the psychology subject pool, undergraduate classrooms, and by posted flyers) complete a brief (3-5 minute) screening survey to identify those students eligible to participate in this study. Students 18 years or older with current access to a motor vehicle who report driving after drinking two or more drinks at least two times in the past three months were eligible to participate in this trial. If the participant met eligibility criteria, the researcher contacted the participant, explained the project procedures and confidentiality, invited the participant to participate in further phases of the study. See Figure 1 for a flowchart illustrating recruitment, intervention assignment, and follow-up assessment.

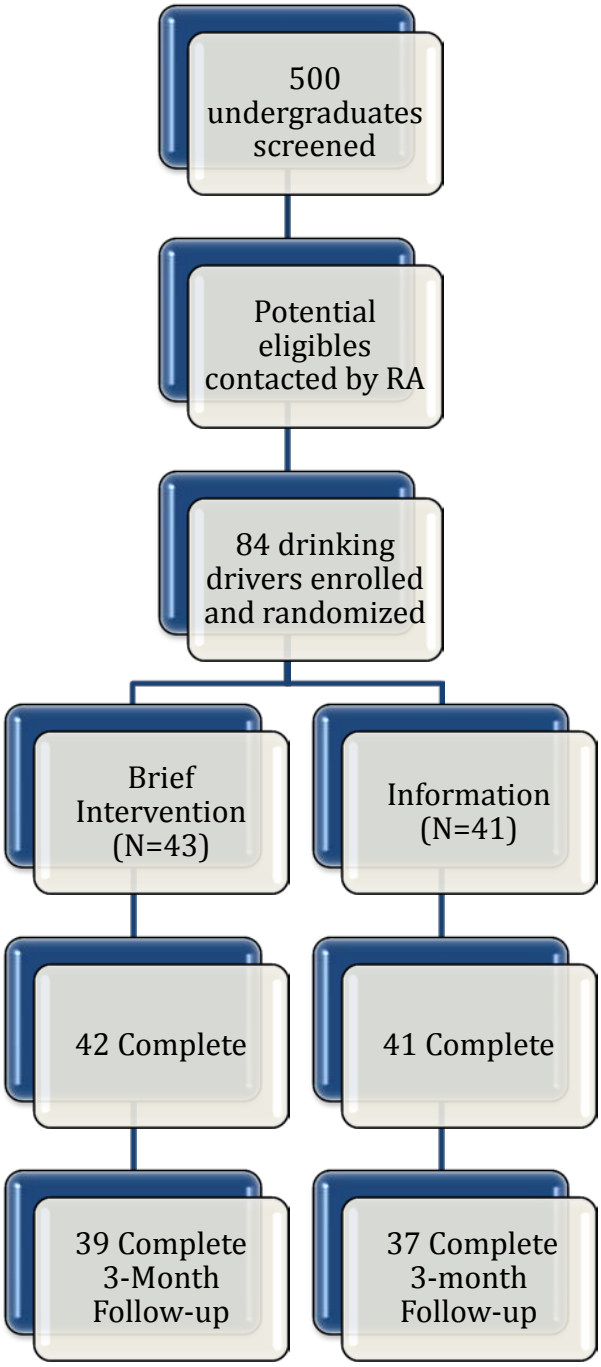

Figure1. Flowchart illustrating recruitment, intervention and follow-up assessment. All participation occurred remotely via text messages and email/web links.

Measures

Demographics. Participants completed a brief questionnaire regarding age, race/ethnicity, sorority/fraternity affiliation, gender, height, weight, and SES.

Alcohol use. Typical drinks per week were assessed by the Daily Drinking Questionnaire (DDQ; Collins, Parks, & Marlatt, 1985). Students were asked to estimate the total number of standard drinks they consumed on each day during a typical week in the past month. The DDQ is frequently used to assess alcohol consumption patterns among college students and is correlated with self-monitoring and retrospective drinking measures (Kivlahan, Marlatt, Fromme, Coppel, & Williams, 1990). A separate item was included to assess binge drinking. Students were asked to report how many times they had drunk 4 or more (if female) or 5 or more (if male) standard drinks in one occasion during the past month (Wechsler et al., 1995). This measure was used as a secondary intervention outcome variable.

Impaired Driving Questions. The questions below were used as the primary and secondary intervention outcome variables.

Alcohol-Impaired Driving Behavior. Driving after drinking was assessed with open-ended questions adapted from prior studies measuring driving after drinking (LaBrie et al., 2011, 2012; Teeters & Murphy, 2015). Participants reported how many times in the past three months they have driven after drinking "anything at all" and how many times they have driven after drinking three or more drinks. We chose to use three or more drinks as outcome variables based on previous studies that have classified impaired drivers as a person that drives after consuming three or more drinks (LaBrie et al., 2011, 2012; McCarthy, 2007; Schaus et al., 2009). Notably, depending on the student's weight, gender, rate of consumption, food consumed, total time drinking, etc.,

he or she may or may not be above the legal intoxication limit after consuming three drinks prior to driving. However, research suggests that driving is impaired below the legal limit (.05; Bailey, 1993). Additionally, for participants under 21 years of age, drinking any amount of alcohol prior to driving is illegal. Given zero tolerance laws and evidence that there may be impairments in driving abilities at or below the legal limit, we chose to include an additional outcome variable of driving after consuming "anything at all." Students were asked to report on both categories separately.

DUI. Participants were asked if they had been charged with DUI in the past three months.

Estimated BAC prior to driving. Participants were also asked specific questions about their most recent alcohol-impaired driving episodes, such as a) what time did you take the first sip of your first drink, b) how many total standard drinks did you consume prior to driving, c) what time did you take the last sip of your last drink and, d) how much time passed from the last sip of your last drink until beginning to drive. This data was used along with gender, weight, and type of beverage consumed to calculate an estimated BAC prior to driving. This information was given to the participants in the BAI group in the form of personalized feedback on driving impairment during previous driving episodes. Though no previous studies have employed this specific methodology, many studies have called for a more precise estimate of impairment prior to driving (McCarthy et al., 2007; LaBrie et al., 2011, 2012; Teeters et al., 2014, 2015).

Attitudes toward AI-driving. Participants were asked to report how dangerous they believe it is to drive within 2 hrs of consuming one drink, three drinks, and five or more drinks (adapted from Amlung et al., 2014; Morris et al., 2014).

Norms. Participants were asked to estimate the percentage of drinkers that report past 3-month alcohol-impaired driving. This data was used to compare normative estimates to actual data on percentage of drinkers report AI-driving in the personalized feedback condition.

Driving after Combined Use. Driving after combined use of alcohol and other substances was assessed with open-ended questions adapted from prior studies measuring driving after drinking (LaBrie et al., 2011, 2012l; Teeters & Murphy, 2015). Participants reported how many times in the past three months they have driven after using a combination of alcohol and other substances. The following information was included in the feedback document based on participant's answer to this question: "You reported occasionally using marijuana in combination with alcohol prior to driving. Using substances simultaneously heightens the effect of both drugs placing you at risk for severe consequences: Coma, Overdose, Death/suicide, Increased impairment, Increased risk for substance related consequences, Increased risky sexual behaviors, Violence related consequences (arguments, hurt/injured)."

Procedures

The current study is a randomized clinical trial in which we tested the feasibility and efficacy of a mobile-based, AI-driving specific intervention with college students. Participants who met eligibility criteria were recruited to participate in the clinical trial and completed a baseline assessment session via computer or mobile phone. The computer or mobile-based assessment began with the informed consent procedure in which the nature of the sessions and the follow-up assessment was explained. Additionally, the informed consent document explained confidentiality and its limits. Following consent, participants completed the battery of assessment measures. After

completing the baseline measures, participants were randomized to an alcohol information condition (which provided non-personalized information on alcohol use and alcohol-impaired driving) or an AI-driving BAI condition. A random number generator was used to randomly assign participants to conditions.

Based on condition assignment, participants were sent a link via text message to a secure website containing either their personalized feedback document or a generic alcohol information document. Participants were instructed to view either the informational or personalized feedback document and respond to a number of questions embedded in the documents as a fidelity check. After viewing the feedback or informational document and responding to the questions, participants sent a text message indicating completion to the study administrator. All study participants were then emailed 2 documents: the first document contained strategies for avoiding AI-driving and the second document contained information on low-cost mental health resources available on campus and in the local community. After responding to the text messages, the participant was thanked for completing the study and was informed that he or she would a) receive extra credit for participating or b) be sent a $20 Amazon gift card.

A follow-up assessment to examine changes in the outcome variables occurred 3-months after the intervention. All follow-up assessments took place via a secure web-survey that was completed via mobile-phone or web. A text message containing the follow-up survey was sent to each participant. Web surveys were collected via a secure site. Participants completed a number of self-report questionnaires related to alcohol use and alcohol-impaired driving behaviors, attitudes regarding alcohol use and AI-driving, and standard demographic questions. All data were used strictly for research purposes with the informed consent of the participants and was treated as confidential. Participants received a $20 Amazon giftcard or extra credit for completing the follow-

up assessment.

AI-driving Intervention. Following the baseline assessment, participants were sent a link via text message to a secure website containing alcohol-impaired driving specific personalized feedback. Feedback included the following elements: a personalized drinking profile and AI-driving profile, information on social norms related to drinking and AI-driving, personalized information on BAC prior to driving, costs associated with a DUI citation, and information on combined drug and alcohol impaired driving risk (if endorsed).

The goals of this session were to raise concern about potential consequences relating to drinking and driving, correct faulty normative perceptions of drinking and AI-driving behavior, provide information about BAC level in relation to driving, and assist students in strategizing means for avoiding future episodes of AI-driving. Participants were instructed to view the personalized feedback document and to respond to a number of questions embedded in the feedback document as a comprehension and fidelity check. Participants were asked to send a text message back to the study administrator after viewing the feedback document and responding to the questions. After confirming receipt and processing of the document, the study administrator sent the participant 4 text messages containing the following open-ended questions: 1) Of the information you just viewed, what was most interesting?, 2) How would receiving a DUI impact your future career goals, and 3) Would you be willing to set a goal to reduce future driving after drinking? or What is your plan for driving after drinking in the future? A 4th text message will be sent to acknowledge their goal or lack thereof and provide appropriate reflection/encouragement in MI style. The interactive texts were expected to enhance intervention retention/processing and also provide an interpersonal/interactive element that may enhance efficacy (Walters et al., 2009).

Information Condition. Students randomized to the information condition received standard information about alcohol and AI-driving via a link to a website delivered through text message. Specifically, the informational document provided detailed information about how alcohol and combining alcohol and other drugs affects the brain and nervous system, memory, and driving performance. The control intervention format mimicked the intervention format; however, the information was not personalized and did not include goal setting. Once again, participants were instructed to respond to a number of questions embedded in the informational document as a comprehension and fidelity check. Students were provided the opportunity to ask any questions related to the information provided via interactive text message, and any questions the students had were answered factually without initiating an exchange about the participant's personal AI-driving habits. The information provided during this session was similar to traditional alcohol education programs commonly found on college campuses, which provide information about the risks of alcohol and AI-driving via lectures, written materials, and public service announcements on local media.

Data Analysis Plan

Analyses were conducted using SPSS version 21.0 and R version 2.12.0. To minimize the impact of outliers, values greater than 3.29 SDs above the mean on a given variable were Winsorized to one unit greater than the greatest nonoutlier value (Tabachnick & Fidell, 2013). Additionally, variables that are skewed or kurtotic were transformed using square root and/or log transformation.

Baseline descriptive characteristics of the overall sample were conducted, including demographic information (gender, age, ethnicity) as well as the means and standard deviations for the primary outcome variables (alcohol-impaired driving, combined alcohol/drug impaired driving, estimated BAC). Additionally, *t*-tests and chi square analyses were performed to determine whether or not the intervention group and the control group were significantly different at baseline on any

demographic or alcohol-related variables (Table 1).

The primary study analyses examined whether or not there is a statistically significant difference between treatment groups on changes in self-reported AI-driving. A series of repeated measures mixed modeling analyses were conducted to examine hypothesis 1 (students receiving the AI driving intervention will report greater reductions in driving after drinking at 3-month follow-up compared to control participants, hypothesis 2 (students receiving the AI driving intervention will report greater reductions in driving after combined substance use at 3-month follow-up compared to control participants, hypothesis 3 (students receiving the AI driving intervention will report significantly greater reductions in estimated BAC and drinks consumed prior to driving at 3-month follow-up compared to control participants and hypothesis 4 (students receiving the Al driving intervention will report greater reductions in alcohol use at 3-month follow-up compared to control participants). Mixed modeling examines data similarly to repeated measures ANOVA; however, mixed modeling provides increased flexibility in handling missing data by utilizing all available data for each participant and provides ease of adaptation for multiple research designs (Hox, 2010).

Generalized linear mixed models (GLMM) represent an extension of linear mixed models to non-normal data. GLMM with a negative binomial distribution, which allows for over-dispersion in count outcomes, were utilized for outcomes of non-normally distributed count data (i.e., total number of times driving after drinking, driving after combined substance use, and total weekly drinks consumed). AI-driving after “anything to drink” and three or more drinks, driving after combined substance use, and total weekly drinks consumed were found to be overdispersed (i.e., variance exceeds mean). Additionally, each of these variables contained greater than 15% zeros. A negative binomial hurdle (NBH) model in which all participants can be considered “at-risk” for an outcome was chosen for these analyses because all individuals included in the present study reported driving after drinking in the past

three months. The NBH regression involves first identifying sampling zeroes (the "hurdle" part of the model) followed by examining those who cross the hurdle (values > 0; "binomial" part of the model). Thus, our analyses separately predicted sampling zeroes (i.e., not endorsing the outcome variable) and counts > 0 (i.e., outcome variable> 0). For each model tested, one of the primary outcome variables served as the dependent variable with gender, ethnicity, and age included as covariates. Repeated measures mixed models analyses were conducted for number of drinks consumed prior to driving (normally distributed) and the non-count outcome variable, eBAC. Cohen's D effect sizes were computed and interpreted using the conventional metrics of d = 0.2, 0.5 and 0.8 indicating small, medium and large effects (Cohen, 1992).

Results

Baseline Characteristics

Overall, participants reported driving an average of 4.06 times (*SD* = 4.47) after consuming "anything at all", 3.96 times (*SD* = 6.07) after consuming 3 or more drinks, and 1.34 times (*SD* = 3.19) after consuming both alcohol and another substance in the past 3 months. All participants (100%) reported driving after drinking "anything at all", 72.4% reported driving after consuming 3 or more drinks, and 35.5% reported driving after combined substance use. The average eBAC prior to the most recent driving episode in the past 3 months was .06 (*SD* = .06). Participants reported drinking an average of 12.0 standard drinks (*SD* = 16.96) in a typical week and engaging in an average of 3.66 binge episodes (*SD* = 3.73) in the past month. The intervention group reported driving after drinking "anything at all" and 3 or more drinks significantly more times than the control group (see Table 1). There were no other significant baseline differences. Seven participants did not complete the 3-month follow-up (91.7% overall follow-up rate; three from the feedback condition and four from the information condition).

Table 1

Descriptive Statistics for Outcome Variables and Covariates: Baseline and 3-Month Follow-Up

	Total Sample (N = 76)	BI (*n* = 37)	Information (*n* = 39)	Statistical Test	
				χ^2	Φ
Gender				.01	-.01
Male	*n* = 27 (35.5%)	*n* = 13 (35.1%)	*n* = 14 (35.9%)		
Female	*n* = 49 (64.5%)	*n* = 24 (64.9%)	*n* = 25 (64.1%)		
Ethnicity				9.15*	.35*
White	*n* = 42 (55.3%)	*n* = 27 (73%)	*n* = 15 (38.5%)		
Non- White	*n* = 34 (44.7%)	*n* = 10 (27%)	*n* = 24 (61.5%)		
				Statistical Test	
				t	*df*
Age	22.55 (4.99)	22.14 (3.83)	22.95 (5.92)	-.71	74
Drinks Per Week	11.89 (16.59)	11.35 (8.67)	12.41 (21.70)	-.27	74
Drinks Per Week-3M	7.97 (7.46)	8.89 (7.98)	7.13 (6.92)	-.28	74
Past 3 month AI-Driving					
Any Drink	4.06 (4.28)	5.14 (4.46)	3.05 (3.89)	2.00*	74
Any Drink-3M	2.07 (3.25)	2.44 (3.62)	1.74 (2.90)	.91	71
3 or More Drinks	3.96 (6.07)	5.38 (6.74)	2.62 (5.07)	2.83*	74
3 or More Drinks-3M	1.83 (3.97)	1.62 (3.26)	2.03 (4.55)	-.43	70
Combined Use	1.34 (3.08)	1.87 (4.11)	0.84 (1.45)	7.54	74
Combined Use-3M	1.34 (3.08)	1.15 (5.13)	2.03 (7.31)	1.52	70

Table 1 (Continued)

	Total Sample (N = 76)	BI (*n* = 37)	Information (*n* = 39)	Statistical Test	
				χ^2	Φ
eBAC	.06 (.06)	0.06 (.056)	0.05 (.06)	.18	69
eBAC	.04 (.05)	0.03 (.04)	0.04 (.06)	-.48	62
Total Drinks before Driving	2.97 (1.95)	3.24 (1.53)	2.72 (2.28)	1.46	74
Total Drinks before Driving-3M	2.78 (2.59)	2.44 (1.94)	3.08 (3.04)	-1.05	71

* = <.05

Analysis of Study Outcomes

Results for the mixed models analyses are presented in Tables 2-6.

Alcohol-Impaired Driving. Generalized linear mixed models (GLMM) with a negative binomial distribution were utilized to determine if driving after consuming "3 or more drinks" and "anything at all" differed over time for participants who received the AI-driving intervention vs. those who received the information intervention. Results of these analyses are presented in tables 2 and 3, respectively. After controlling for age, gender, and ethnicity, there were significant reductions in AI-driving over time and a significant interaction between condition and time for driving after drinking 3 or more drinks (see Table 2 and Figure 2). The treatment condition X time interaction indicated that the AI-driving intervention was associated with larger reductions in number of times driving after drinking three or more drinks than the information intervention at the 3-month follow-up (*ds* = .70 and .12, respectively). There was a significant reduction over time in driving after having "anything to drink" (controlling for the same covariates), but no significant effects for condition or condition by time interaction (see Table 3

and Figure 3). However, the AI-driving intervention was associated with larger effect size reductions in number of times driving after having anything to drink than the education intervention (*d*= .66 and .38, respectively).

Table 2

Negative Binomial Hurdle Mixed Model Results for Driving after 3 or More Drinks

Count Sub-model				
			CI for RR	
	RR[a]	B	*Lower*	*Upper*
Intercept	3.22	1.17	1.93	5.42
Condition	0.64	−0.44	0.28	1.31
Time	0.68	−0.38	0.29	1.31
Condition × Time	1.22	0.20	.44	3.78
Logit Sub-model				
			CI for OR	
	OR[a]	B	*Lower*	*Upper*
Intercept	4.22	1.44	3.74	6.47
Condition	.30	−1.22	0.07	1.18
Time	0.11	−2.22**	0.02	0.44
Condition × Time	6.11	1.81*	1.02	38.86

Note. B = Coefficient on linear-predictor scale (i.e., log of outcome); RR = Rate ratio; OR = Odds ratio; 95% CI = 95% confidence interval.

[a]RRs, ORs, and 95% CI are unit-specific (or conditional) estimates, as opposed to population average (or marginal) estimates.
* = <.05
** = <.01

Driving after Combined Substance Use. There was no significant overall change in combined use over time or the interaction between condition and time for driving after combined substance use (see Table 4 and Figure 4).

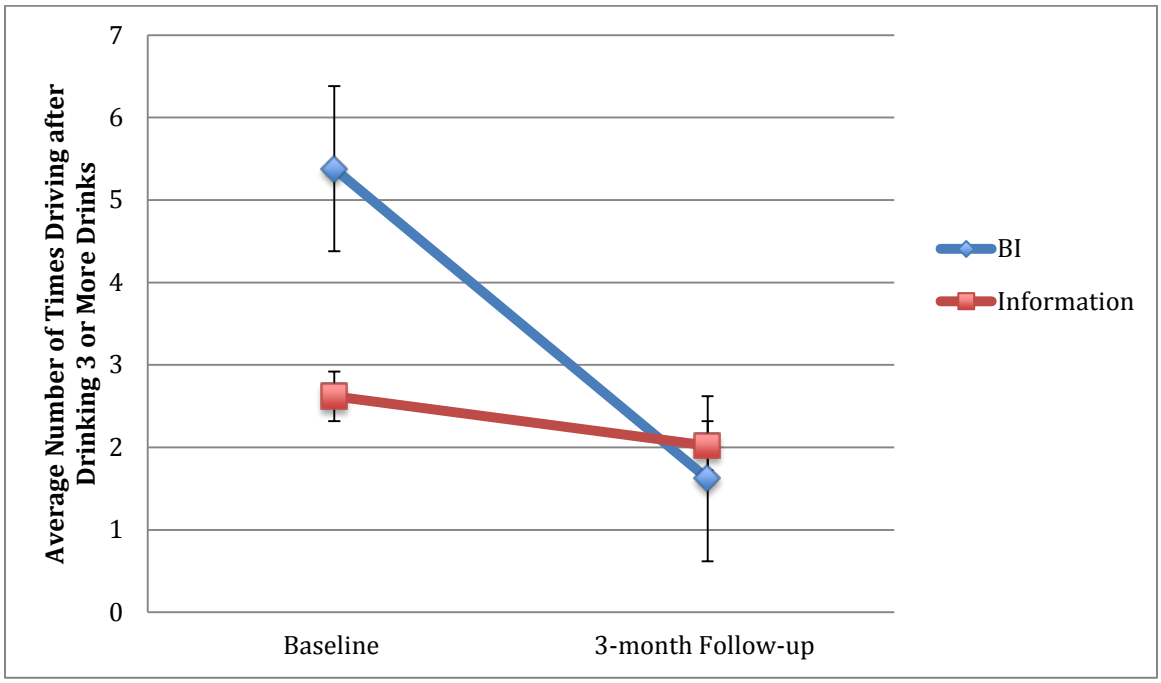

Figure 2. Number of times driving after drinking 3 or more drinks by condition at baseline and 3-month follow-up.

Table 3

Negative Binomial Hurdle Mixed Model Results for Driving after Any Drinks

Count Sub-model				
			CI for RR	
	RR[a]	B	*Lower*	*Upper*
Intercept	3.53	1.16	1.93	5.05
Condition	.64	-.44	.30	1.34
Time	.60	-.51	0.21	1.22
Condition× Time	1.20	.18	.30	3.97
Logit Sub-model				
			CI for OR	
	OR[a]	B	*Lower*	*Upper*
Intercept	3.53	1.16	1.93	5.05
Condition	.64	-.44	.30	1.34
Time	.60	-.51	0.21	1.22
Condition× Time	1.20	.18	.30	3.97

Note. B = Coefficient on linear-predictor scale (i.e., log of outcome); RR = Rate ratio; OR = Odds ratio; 95% CI = 95% confidence interval.

[a]RRs, ORs, and 95% CI are unit-specific (or conditional) estimates, as opposed to population average (or marginal) estimates.
* = <.05
** = <.01

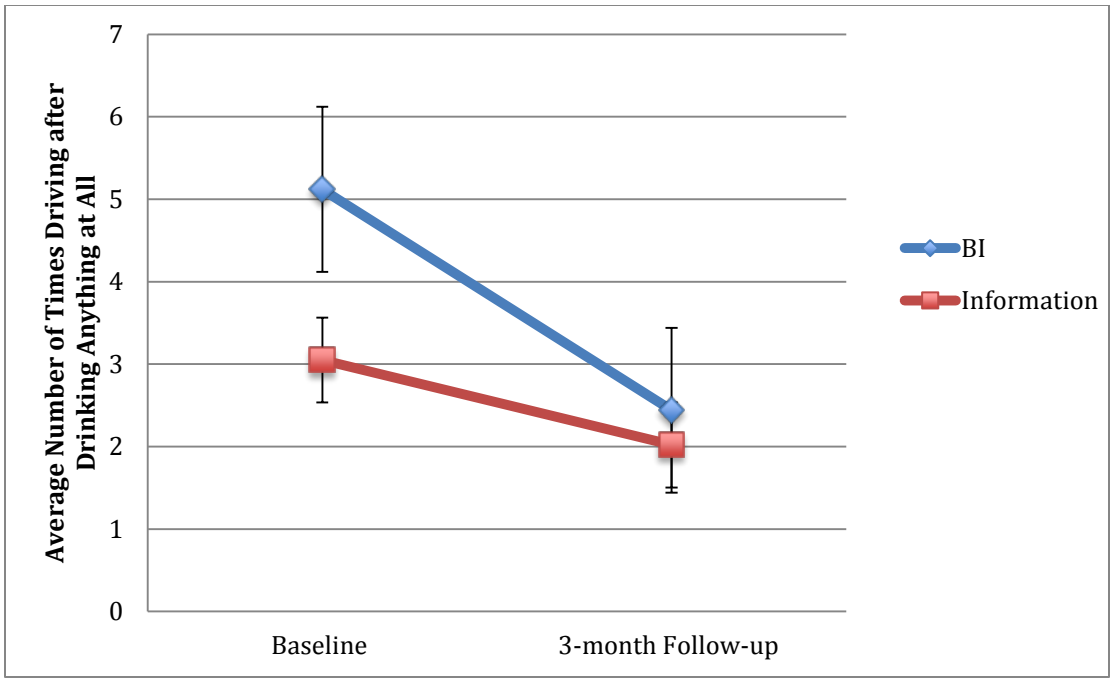

Figure 3. Number of times driving after drinking "anything at all" by condition at baseline and 3-month follow-up.

Driving after Combined Substance Use. There was no significant overall change in combined use over time or the interaction between condition and time for driving after combined substance use (see Table 4 and Figure 4).

Table 4

Negative Binomial Hurdle Mixed Model Results for Driving after Combined Use

Count Sub-model				
			CI for RR	
	RR[a]	B	*Lower*	*Upper*
Intercept	1.25	0.22	.94	2.68
Condition	2.46	0.90	.98	6.88
Time	1.82	0.60	.38	7.32
Condition× Time	.16	-1.85	.017	1.64
Logit Sub-model				
			CI for OR	
	OR[a]	B	*Lower*	*Upper*
Intercept	.14	-1.99	.02	.70
Condition	0.40	-0.91	0.04	4.57
Time	0.24	-1.43	0.03	1.63
Condition x Time	2.50	0.92	.10	49.40

Note. B = Coefficient on linear-predictor scale (i.e., log of outcome); RR = Rate ratio; OR = Odds ratio; 95% CI = 95% confidence interval.

* = <.05
** = <.01

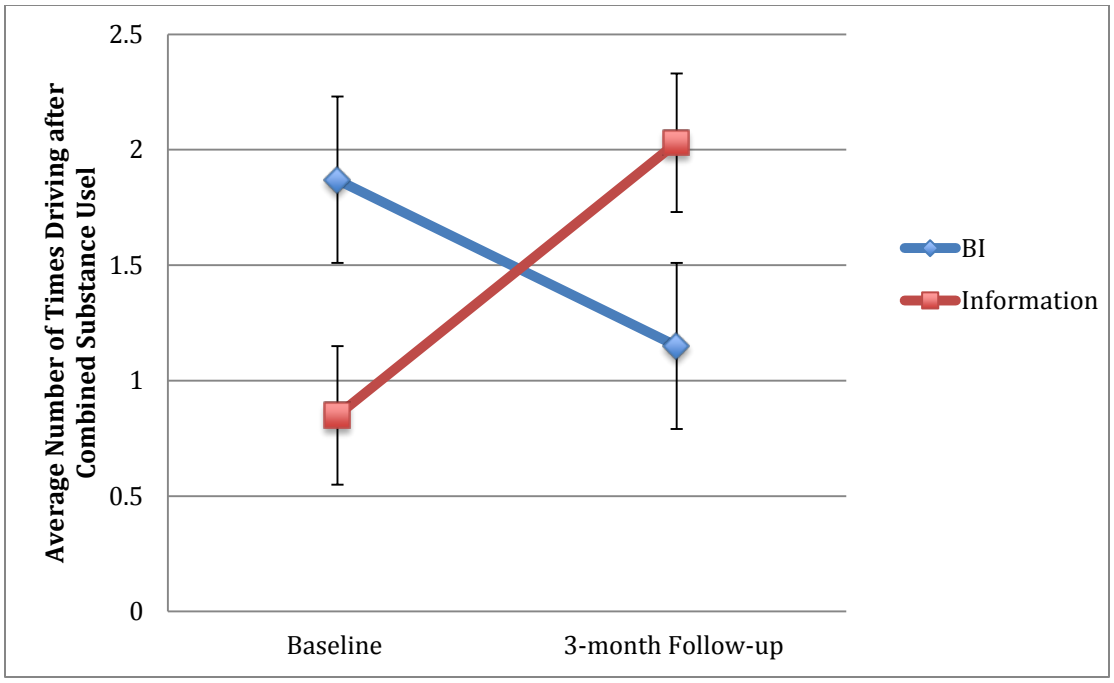

Figure 4. Number of times driving after combined substance use by condition at baseline and 3-month follow-up.

Estimated BAC Prior to Driving. There was no significant change in eBAC over time, condition, or the interaction between condition and time (see Table 6 and Figure 5).

Table 6

Repeated Measures Mixed Model Results for eBAC and Drinks Prior to Driving

Outcome	Effects	*Numerator df*	*Denominator df*	*F*	*p*
Number of Drinks Prior to Driving	Time	1	71.88	.80	.38
	Condition	1	74.38	4.46	.04
	Condition x Time	1	71.88	4.63	.04
Estimated BAC	Time	1	62.94	1.13	.20
	Condition	1	66.28	1.18	.28
	Condition x Time	1	62.94	1.23	.27

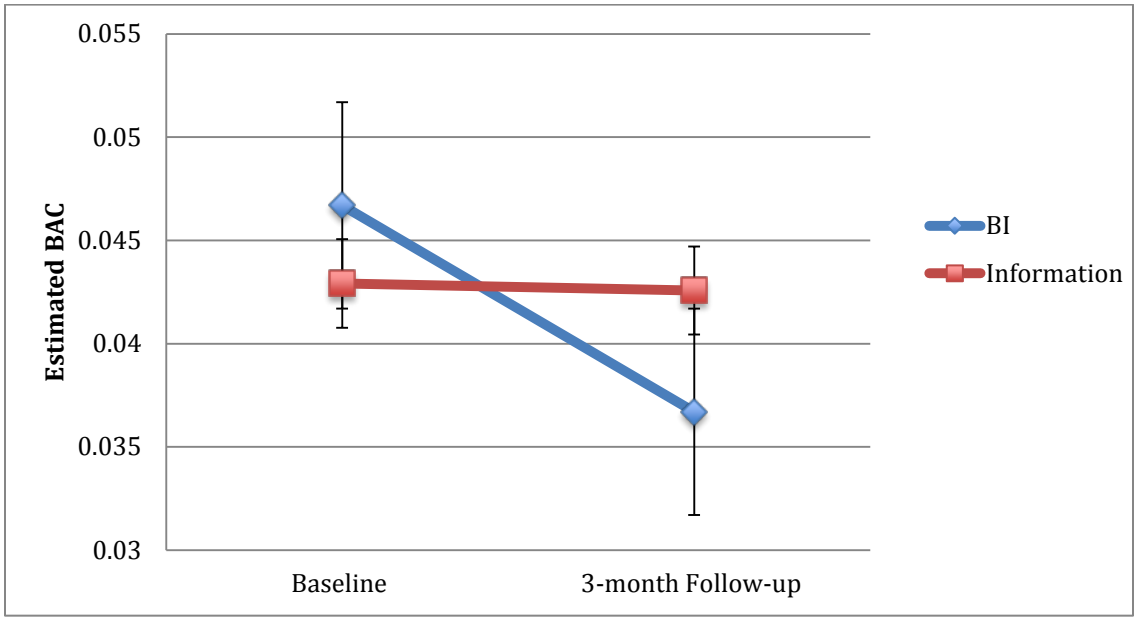

Figure 5. Estimated BAC by condition at baseline and 3-month follow-up.

Total Drinks Consumed Before Driving. There was no significant overall reduction in total drinks consumed before driving over time [F(1, 71.88) = .796, *p* =.38]. However, there was a significant effect for condition [*F*(1, 74.38) = 4.46, *p* = .04] and a significant interaction between condition and time [*F*(1, 71.88) = 4.63, *p* = .04] (see Table 6 and Figure 6). Consistent with this treatment condition X time interaction, the AI driving intervention was associated with larger effect size reduction in number of drinks consumed before driving than the education intervention at the 3-month follow-up (*d*= .46 and .13, respectively).

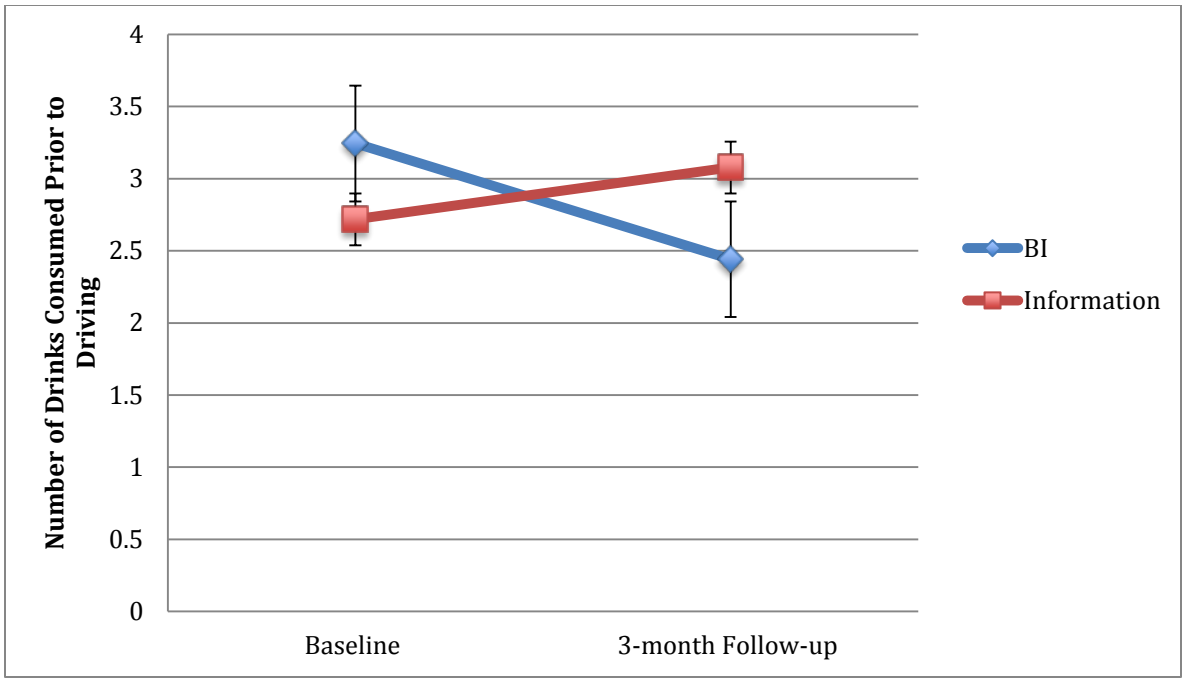

Figure 6. Number of drinks consumed prior to driving by condition at baseline and 3-month follow-up.

Number of Drinks per Week. Analyses revealed a significant overall reduction over time for total number of drinks per week. However, no significant changes were found by condition or for the interaction between condition and time (see Table 5 and Figure 7).

Table 5

Negative Binomial Hurdle Mixed Model Results for Drinks per Week

Count Sub-model				
			95% CI for RR	
	RR[a]	B	*Lower*	*Upper*
Intercept	1.25	0.22	.94	2.68
Condition	2.46	0.90	.98	6.88
Time	1.82	0.60	.38	7.32
Condition× Time	.16	-1.85	.017	1.64
Logit Sub-model				
			95% CI for OR	
	OR[a]	B	*Lower*	*Upper*
Intercept	.14	-1.99	.02	.70
Condition	0.40	-0.91	0.04	4.57
Time	0.24	-1.43*	0.03	1.63
Condition × Time	2.51	0.92	0.09	53.5

Note. B = Coefficient on linear-predictor scale (i.e., log of outcome); RR = Rate ratio; OR = Odds ratio; 95% CI = 95% confidence interva

[a]RRs, ORs, and 95% CI are unit-specific (or conditional) estimates, as opposed to population average (or marginal) estimates.

* = <.05
** = <.01

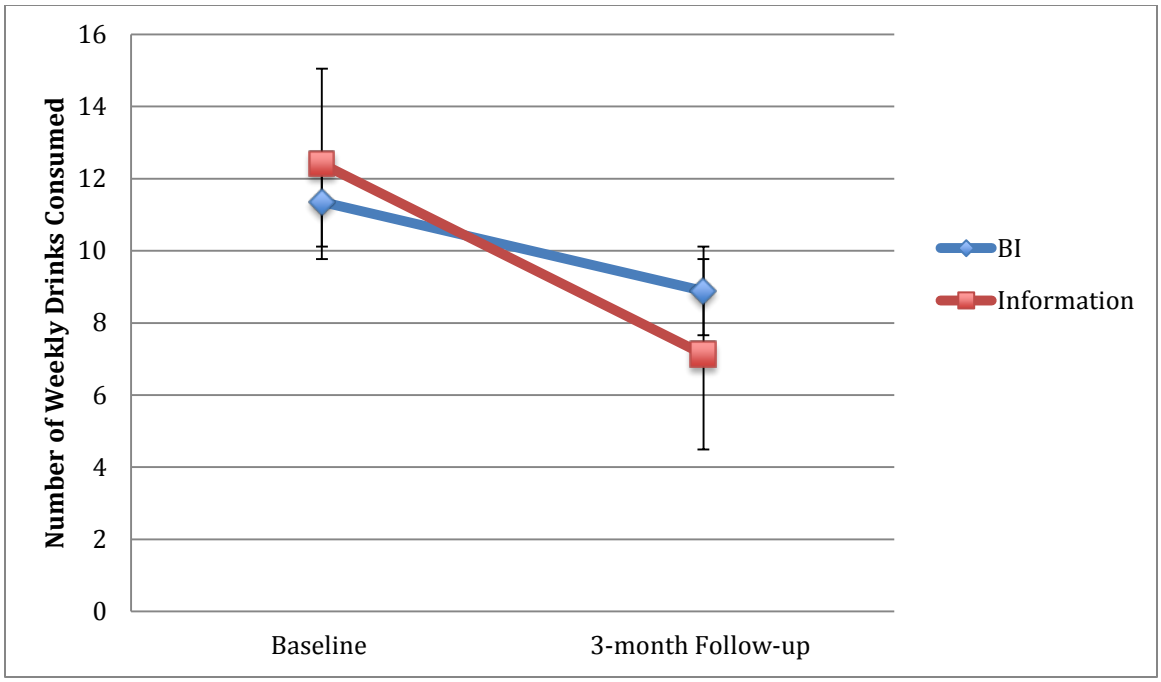

Figure 7. Number of average drinks consumed per week by condition at baseline and 3-month follow-up.

Discussion

Alcohol-impaired driving is a significant public health concern and college students are more likely than any other age group to report driving under the influence of alcohol (Hingson et al., 2009). There remains a need to develop efficacious interventions for reducing this risky behavior in this high-risk population. The purpose of the present study was to develop and evaluate a brief, mobile-based intervention to decrease AI-driving among college students. The overall pattern of results provide initial support for the efficacy of this intervention. Specific findings are discussed below in conjunction with study limitations.

Number of Times Driving after Drinking

Consistent with previous research examining the impact of in-person BAIs on driving after drinking in emergency room settings (Schermer, Moyers, Miller, & Bloomfield, 2006), with DUI offenders (D'Onofrio et al., 2008) and among adolescent and college-aged drinkers (Monti et al., 1999; Schaus, 2009; Teeters et al., 2015), the AI-driving intervention delivered in the present study successfully reduced driving after drinking behaviors over time compared to a generic alcohol information intervention. Students who received an AI-driving BAI significantly reduced the number of times driving after drinking three or more drinks over time compared to students receiving a generic alcohol information intervention. Specifically, students in the AI-driving condition decreased their number of times driving after drinking three or more drinks in the past 3-months from 5.38 times at baseline to 1.62 times at 3-month follow-up, whereas students in the information condition decreased their number of times driving after drinking in the past 3-months from 2.62 at baseline to 2.02 at 3-month follow-up. Interestingly, although all students decreased AI-driving after consuming "anything at all" (from 5.15 times at baseline to 3.62 times at 3-month follow-up and from 3.05 times at baseline to 1.74 times in the intervention and information condition, respectively), a main effect for condition and an interaction effect for condition by time were not found. This suggests that this intervention was most efficacious for reducing the number of times driving after drinking higher amounts of alcohol (three or more drinks), which arguably places students at the highest risk of experiencing harmful consequences. Stated another way, it appears that both a generic alcohol information intervention and an AI-driving BAI can be successfully employed among college students to reduce the number of times driving after consuming "anything at all." However, findings indicate that for

those driving after drinking three or more drinks, an AI-driving brief intervention reduces the number of times driving after drinking significantly more than an information intervention.

This may reflect that fact that all feedback elements were specifically designed to target driving after drinking three or more drinks, as this has been considered the threshold for possible intoxication prior to driving in previously published studies (LaBrie et al., 2011, 2012, McCarthy et al., 2007; Schaus et al., 2009). Normative feedback and percentile rankings generated in the feedback document were explicitly based on having at least three or more drinks prior to driving. Students were asked to estimate the total number of college students who reported driving after consuming "three or more drinks" in the past month and a percentile was generated based on the total number of times driving after consuming "three or more" drinks as compared to other college students. Additionally, depending on the student's weight, gender, rate of consumption, food consumed, total time drinking, etc., he or she may or may not have been above the legal intoxication limit after consuming 1-2 drinks. Thus, a student who drove after drinking 1-2 drinks may have received feedback indicating that he or she was below the legal limit (for students 21 and over) on previous AI-driving occasions causing the information on costs associated with receiving a DUI and other subsequent information to become less relevant. Therefore, that student may not have been as motivated to change his or her AI-driving behavior. In contrast, a student who consumed three or more drinks would most likely have seen a BAC feedback result over the U.S. legal limit for adults 21 and over and may have been more attuned to subsequent information, such as costs associated with receiving a DUI. Notably, for participants under 21 years of age, drinking any amount of alcohol prior to driving is illegal and research suggests that driving is impaired below the legal limit (.05; Bailey, 1993).

Driving after Combined Substance Use

Interestingly, neither the AI-driving BAI nor the information intervention significantly reduced the number of times driving after using alcohol and another substance (combined substance use). However, students in the AI-driving BAI slightly decreased their number of times driving after combined use whereas students in the information condition *increased* their number of times driving after combined use. However, the limited power makes it difficult to interpret this non-significant outcome.

Feedback on the risks associated with driving after combined use of substances was provided. However, this information was not personalized to the particular substance combination used (e.g., alcohol and marijuana use vs. alcohol and cocaine use vs. alcohol and sedatives) and we did not include the exact number of times the participant reported this behavior. No other information on driving after combined use of substances was provided. These results suggest that neither the information provided in the BAI nor the information presented in the information intervention was sufficient for reducing this dangerous risk behavior. Notably, the feedback group did demonstrate slight reductions in driving after combined use while the control group demonstrated slight increases. However, because the study is likely underpowered for identifying small effects, it may have been difficult to detect slight changes in combined use.

Previous research indicates that additional BAI components improve outcomes only when the component is highly personalized to the participant, (Ray et al., 2014). As such, it is possible that the information provided on driving after combined substance use was too generic and thus may not have been a meaningful addition to this intervention. Future studies should attempt to personalize information on driving after using multiple substances in order to make the information more relevant and salient to participants. For example, a relatively simple

addition would be to include the number of times the participant reported driving after combined substance use into the feedback component along with the increased odds of a traffic fatality. Providing and generating a percentile ranking comparing the participant's behavior with that of peers or the population might also be effective.

Estimated Blood Alcohol Concentration

Surprisingly, students receiving the AI-driving intervention did not demonstrate significant reductions in estimated BAC prior to driving in comparison to those receiving the information intervention.

In order to calculate estimated BAC, participants were asked specific questions about their most recent driving episode. We asked participants "what time did you take the first sip of your first drink, b) how many total standard drinks did you consume prior to driving, c) what time did you take the last sip of your last drink and, d) how much time passed from the last sip of your last drink until beginning to drive." These data were used along with the participant's gender, weight, and reported type of beverage consumed to calculate an estimated BAC prior to driving. An online calculator using a modified Widmark Formula (accounting for estimated numbers of standard drinks, alcohol content in each drink, gender, weight, time spent drinking, time before driving, and gender) for BAC was used to calculate each person's estimated BAC on his or her most recent AI-impaired driving occurrence: (http://www.drinkdriving.org/drink_driving_information_bloodalcoholcontentcalculator.php). However, BAC estimates based on retrospective self-reports should be interpreted with caution due to previous research indicating that college students are often inaccurate when estimating how many standard drinks they have consumed. For example, using a free-pour paradigm in which college students were asked to free-pour fluid into cups of varying sizes, White and

colleagues (2003) demonstrated that college students consistently overestimated how much fluid they should pour to create a standard drink. Thus, some students in the present study may have underestimated the total number of standard drinks consumed leading to a lower estimated BAC levels. In addition, retrospective self-report drinking measures can be influenced by poor event recall and intoxication level (Carey & Hustad, 2005), making it difficult to draw conclusions about the accuracy of a) standard drink estimates, b) number of hrs spent drinking, and c) amount of time elapsed prior to driving.

We chose to include a measure of eBAC in the present study due to the assertion in many previous studies that more precise estimates of impairment prior to driving are needed (LaBrie et al., 2011, 2012; McCarthy et al., 2007, 2010; Teeters et al., 2014, 2015). This study represents a first attempt to more precisely quantify blood alcohol concentration prior to driving in the context of an intervention study. Though this methodology is a step in the right direction, future studies would benefit from using even more precise and specified measures of estimated BAC prior to driving. For example, ecological momentary assessment may represent one in-the-moment method of assessing number of drinks consumed, time spent drinking, and time prior to driving. Alternatively, objective measures, such as remote breathalyzer tests and transdermal sensors, could be administered to participants prior to driving (Bihar et al., 2016; Leffingwell et al., 2013).

Total Drinks Consumed Before Driving

Participants who received the AI-driving intervention significantly reduced the total number of drinks they consumed prior to driving compared to those receiving the information intervention at three-month follow-up. Students receiving the AI-driving BAI decreased their consumption prior to driving on their last AI-driving occasion by approximately one standard

drink while students in the information condition increased their reported number of drinks prior to driving. Though there are a number of factors that influence intoxication level prior to driving, the reductions shown by the intervention group from three standard drinks to two standard drinks, as well as the increases shown by the control group from two to three standard drinks, may have reasonably been the difference between a student driving while impaired and above or below the legal limit.

Average Weekly Drinks Consumed

Contrary to our hypothesis, participants receiving the AI-driving BAI did not reduce their average weekly drinking significantly more over time than those receiving the alcohol information intervention. Instead, participants in both conditions significantly reduced their average number of drinks per week over time. Participants receiving the AI-driving intervention reduced their number of weekly drinks by approximately three standard drinks per week and participants receiving the alcohol information intervention reduced their drinks by approximately five standard drinks per week.

These findings are somewhat surprising given that many previous meta-analyses and reviews have indicated that BAIs succeed in reducing alcohol use significantly more than control conditions (frequency, quantity, and level of intoxication; see Cronce et al., 2012 and Mun et al., 2014, for review). However, a recent review by Foxcroft and colleagues (2016) concluded that BAIs do not show substantial or meaningful benefits in reducing drinking levels at long-term follow-ups compared to control conditions. Importantly, previous reviews and meta-analyses have concluded that in-person BAIs and remotely delivered BAIs produce similar effects at short-term follow-ups (immediately post-session through four months) but in-person BAIs show an advantage in reducing alcohol use at longer term follow-ups (Cadigan et al., 2016; Foxcroft et

al., 2016). Future research is needed to determine whether the intervention utilized in the present study would have been more effective in reducing weekly drinking over time if delivered in person vs. via mobile phone.

It is often difficult to determine which specific elements are most potent in producing changes in drinking. Research indicates that providing normative information may be an especially effective feedback element (Miller et al., 2013). In fact, a number of studies have found significant drinking reductions utilizing solely a descriptive normative component (Lewis et al., 2007; Martens et al., 2013; Neighbors et al., 2010). This suggests that BAIs focusing specifically on social norms information may be enough to produce reliable changes in drinking. Given these findings, we opted to include a descriptive normative feedback component in our intervention in hopes of reducing overall drinking and expected that including this information would be enough to produce significantly greater changes in drinking than generic alcohol information. Though our intervention did successfully reduce the number of weekly drinks consumed over time, it was no more successful at reducing average weekly drinking than the generic alcohol information intervention. Though empirical research is necessary to determine the reason for these non-significant group differences, one possible explanation may be that the bulk of the feedback elements included in this study, as well as the interactive text-messaging discussion post-feedback, were specific to AI-driving rather than drinking. Previous studies that have shown reductions in drinking utilizing solely normative components have not included other additional components on driving or other risk behaviors (Lewis et al, 2007; Martens et al., 2013; Neighbors et al., 2010). It would be interesting for future AI-driving interventions to vary the length and amount of personalized drinking information in order to determine if more highly personalized, drinking-specific feedback components (such as peak BAC while drinking, calories

from drinking, money spent on alcohol) in addition to AI-driving specific components could simultaneously reduce both drinking levels and driving after substance use significantly more than control or assessment only interventions.

Implications

Overall, the results of the present study indicate that a brief, mobile-delivered, alcohol-impaired driving intervention shows some evidence of reducing driving after drinking after three or more drinks and the number of drinks consumed prior to driving among a sample of college students with a previous pattern of driving after drinking. This study extends previous research on interventions for AI-driving, which have traditionally included general samples of heavy drinkers, accident victims, and individuals arrested for DUI. In contrast, the present study screened and recruited participants based on DUI risk (reporting any recent AI-driving). This allowed us to directly target AI-driving among those arguably most at risk for experiencing consequences related to AI-driving.

Only three published studies have examined whether BAIs effectively reduce AI-driving among college-aged drinkers. All of these studies examined the effect of in-person BAIs on AI-driving whereas the present study used a mobile intervention platform. Monti and colleagues (1999) utilized a logistic regression approach to compare a BAI group to a standard care group on whether or not they had driven after drinking at follow-up. Those in the standard care condition were nearly four times as likely to report any AI-driving than those in the BAI condition at 6-month follow-up. According the GLMM analyses utilized in the present study, for participants who indicated driving after drinking three or more drinks at baseline, those in the alcohol information condition were over six times more likely to engage in AI driving (after three or more drinks) than those in the BAI condition. In contrast to the present study, Monti and

colleagues selected participants who were alcohol-positive in the ER and utilized a traditional BAI rather than feedback elements specifically targeting alcohol-impaired driving.

Schaus and colleagues (2009) conducted an RCT to determine whether a BAI given to drinkers in a college health center significantly decreased drinking level and the number of times driving after drinking three or more drinks. Though a statistically significant reduction in the number of times participants drove after three of more drinks in the intervention group compared to the control group at 3-month follow-up, these effects did not last at the 6, 9, and 12-month follow-ups. We chose to use the same outcome variable as our main outcome variable in the present study and consistent with Schaus and colleagues' findings, the results from the present study indicate that the AI driving BAI effectively reduced the number of times driving after drinking compared to the control group. However, the present study differed from Schaus and colleagues in that it was delivered via a mobile phone and included feedback specifically related to driving after drinking. Notably, because Schaus and colleagues found significant effects up to 3-months post intervention, an important next step would be to examine whether the significant effects found in the present pilot trial persist beyond the three-month follow-up.

In addition, Teeters and colleagues (2015) analyzed data from three separate RCTs of BAI and found that receiving a BAI was significantly associated with reductions in any AI-driving at final (6-month and 9-month, respectively) follow-up compared to the control conditions in all three studies. Mediation analyses indicated that intervention effects were not explained by reductions in typical weekly drinking. The three studies included selected participants based on recent heavy episodic drinking episodes, were delivered in-person, and did not include specific feedback elements designed to target driving after drinking. These results are promising regarding the efficacy of existing BAI approaches on reducing alcohol-impaired

driving. Unfortunately, it is often not economically feasible or practical for universities to hire and train staff to deliver in-person BAIs to a large number of risky drinking college students. Additionally, very few heavy drinking college students seek out alcohol prevention or treatment services available on campus or in the surrounding community. These limitations combined with the desire to reach more at-risk students at a lower cost led to the development and implementation of the present intervention as an innovative way of delivering an AI-driving specific BAI to reach a larger audience at a very low cost per person.

The present study also adds to the literature on mobile-based interventions. Only a few published studies in the alcohol literature have implemented text messaging as a stand-alone intervention. In a young adult emergency room sample, Suffoletto and colleagues (2014, 2015) found reductions in heavy episodic drinking episodes and drinks consumed per drinking episode in response to a text-messaging intervention at three-month, six-month, and nine-month follow-ups. Additionally, Suffoletto and colleagues (2016) demonstrated reductions in binge drinking during a 6-week text-messaging intervention. The results of the present study complement and extend these findings by demonstrating some evidence that a stand-alone text-messaging based intervention can reduce driving after drinking three or more drinks and the number of drinks consumed prior to driving in a sample of college students with a pattern of driving after drinking.

In addition, web-based feedback interventions have been criticized due to potential concerns about variance in the actual amount of processing and comprehension of the information presented in the feedback document. Notably, web-based interventions have demonstrated smaller effect sizes than in-person interventions at follow-ups longer than four months (Cadigan et al., 2016; Foxcroft et al., 2016; Murphy et al., 2010; Walters et al., 2009). In order to negate concerns about the lack of interaction with a clinician and the minimal/uncertain

comprehension and processing of intervention material that might occur with remote web-based interventions, interactive text messages were utilized in the present study. After viewing the feedback document, participants in the present study were sent 4 text messages containing the open-ended questions described in the method section above. Because this intervention did not compare an AI-driving feedback only condition to the AI-driving + brief text conversation condition, it is not possible to determine the extent to which the interactive text messages employed in this study were responsible for reductions in AI-driving behaviors. However, the effect sizes generated in this study are higher than effect sizes cited in other studies of electronically delivered BAIs, potentially suggesting that the interactive component utilized in this study may have resulted in larger effect sizes than non-interactive text-based studies (see Mason, Benotsch, Way, Kim, & Snipes, 2015 for meta-analysis). However, because no research currently exists directly comparing interactive text-based interventions to non-interactive text-based interventions, the previous assertion is speculative and needs to be empirically tested in future studies. Future studies are also necessary to directly compare different modalities for AI driving interventions, (e.g., in-person vs. web-based vs. text-based vs. text-based with an interactive component). Only one previous study (Cadigan and colleagues, under review) has examined an in-the-moment, event specific text-messaging intervention resulting in significant reductions in the number of drinks consumed at a tailgating event. This same methodology could be applied to AI-driving interventions in the future by delivering the intervention to participants with a pattern of past AI-driving while they are out drinking and thus at high risk for possible DUI. Implementation of this intervention at the event-level represents a key next study to extend the present study.

The present study represents an important contribution to the literature on technology-based substance use interventions. The findings demonstrate that a brief, low-cost, mobile-based intervention can be efficiently employed to successfully reduce driving after drinking among college students. Though a variety of policy-based public health interventions (i.e., raising the legal drinking age, lowering the legal BAC driving limit, sobriety checkpoints, zero tolerance laws, server training, etc.), media campaigns, school-based instructional programs, and peer organizations have been implemented to decrease AI-driving among college students, there is insufficient evidence that these approaches reduce AI-driving. In contrast, the present study provides preliminary evidence that a mobile-based intervention can reduce rates of AI-driving among this important high-risk population. Though several previously mentioned studies (Mason et al., 2014; Suffoletto et al., 2014, 2015) have examined the impact of text-based interventions on drinking levels and motivation to change drinking behaviors, this is the first study to recruit participants with a history of driving after drinking and to specifically target AI-impaired driving. Screenshots taken from actual text exchanges in the study are presented in Figures 8 and 9.

Results of the present study also have implications for clinical practice. Because thirty percent of college students report driving after drinking use in the past year (Hingson et al., 2009), clinicians in college counseling centers and other providers who conduct therapy with young adults are likely to treat clients who have driven after using alcohol and/or other substances in the past. Due the severe consequences associated with AI-driving and because drinking and/or impaired driving may or may not be among the client's presenting concerns, it is important to have tools available to address this extremely risky substance-related behavior. The intervention utilized in the present study is very brief and cost-effective and could serve as one

potential tool for reducing AI-driving among college students. Future research should investigate the feasibility and acceptability of this intervention as an adjunct to existing evidence-based psychotherapies.

Limitations

Several limitations should be considered when interpreting these findings. The study design was limited to an intervention condition and an active control group (information only). Thus, all participants in this study received some type of intervention. It would be worthwhile to see how these conditions would perform in comparison to an assessment only condition. Next, the small sample size may have limited the ability to find significant differences between groups at follow-up. Although the power analysis revealed that 38 participants per group would produce adequate power for medium to large effect sizes, the sample size was likely not large enough to detect small effect sizes. Another limitation is that participants were enrolled on a rolling basis and therefore completed baseline and follow-up measures at discrepant points in the semester. Research indicates that college students have season or event specific drinking patterns. For example, college students tend to drink heavier during spring break, summer break, 21st birthdays, and while tailgating and tend to cut back on drinking amount during midterm and final exams (Del Boca, Darkes, Greenbaum & Goldman, 2004; Greenbaum, Del Boca, Darkes, Wang, & Goldman). Because impaired driving patterns are highly related to heavy drinking patterns, students who completed the intervention at certain time periods may have been more likely to drink and drive than students who received the intervention at times associated with lower drinking. Thus, differences in assessment period may have led to fluctuations in alcohol use and AI-driving unrelated to the intervention. However, this would not explain the group differences found as participants were randomly assigned to condition. Furthermore, the present study was

conducted in a primary commuter student sample and therefore their drinking and driving patterns may be relatively less influenced by the academic calendar. Additionally, this study included only one follow-up three months post-intervention. Future research should consider including additional follow-up assessments to determine if the intervention effects remain stable over longer periods of time.

Due to the design of this pilot trial, it is not possible to parse out which parts of the intervention were most potent. Dismantling studies are necessary to elucidate which elements of the personalized feedback are most salient. Furthermore, it is unclear how much the interactive text messaging contributed to intervention effects. Future research should compare the AI-driving feedback alone vs. AI driving feedback + interactive text messaging. All alcohol use data were collected via retrospective self-reports and may have been subject to biases. Previous research is mixed regarding the accuracy of retrospective self-reports of alcohol use and alcohol-related problems with some researchers indicating that self-report assessments of alcohol use and alcohol-related problems have been shown to be valid and reliable (Martens, Arterberry, Cadigan, & Smith, 2012) while others indicate that college students are often inaccurate when estimating how many standard drinks they have consumed (Carey & Hustad, 2005; White et al., 2003). Finally, significant baseline differences between the intervention and the control group were found for the following outcome variables: number of times driving after drinking "anything at all" and "3 more drinks" and one of the covariates (ethnicity). No baseline differences were found for any other outcome variables (eBAC, number of drinks consumed prior to driving, driving after combined use, and drinks per week). Unfortunately, the baseline differences on the number of times driving after drinking outcomes makes it difficult to rule out the possibility that regression to the mean influenced these specific study results.

Despite these limitations, this study has potential public health implications and makes a contribution to the alcohol-impaired driving and technology based intervention literatures. The findings of this study provide preliminary support for the short-term efficacy of a mobile-based brief intervention for reducing driving after three or more drinks and the number of drinks consumed prior to driving among college students. Furthermore, this study's findings suggest that the current strategy employed by the majority of college campuses, providing information about the risks associated with alcohol-impaired driving, is not enough to reduce AI-driving among college students. The results of the present study provide a measurable public health metric and offer support for implementation of brief, inexpensive technology-based interventions. In the past, brief interventions have traditionally been counselor delivered, accruing costs associated with hiring a staff. The results of the present study provide some evidence that a single component intervention delivered entirely through mobile phone reduces driving after consuming three or more drinks and the number of drinks consumed prior to driving among college students.

Future Directions

Although this study provides an important contribution, a number of substantial gaps in the literature should be addressed in future studies. Because text messaging has only been utilized in few published intervention studies, it is not yet possible to determine the ideal timing, length, or dose of intervention. Suffoletto and colleagues (2014, 2015) demonstrated that a 12-week intervention was sufficient in reducing drinking outcomes at long-term follow-ups (6 and 9 months), whereas Cadigan and colleagues (in press) utilized a single-component text messaging intervention consisting of a single text message providing a link to a personalized feedback document with no post-feedback interaction and found significant between group

differences in outcomes at follow-ups. Additionally, it is important for future studies to elucidate the length and content of interventions needed to elicit meaningful change in drinking behaviors among specific groups (e.g., college students vs. treatment seeking populations vs. community populations). Also, given the results of laboratory studies suggest that the risk of driving after drinking may be especially heightened on the descending limb of the blood alcohol curve due to lower perceptions of intoxication and dangerousness of driving after drinking, timing of the intervention may also influence intervention effects. Future research should determine if an intervention is more or less effective when delivered days prior to a drinking episode, on the day of a drinking episode, or on the descending limb of the blood alcohol curve. In addition, future research is needed to clarify the mechanisms underlying behavior change in the present study as well as previous studies of mobile-based interventions. Only one published article has attempted to systemically review the mechanisms associated with change in technology-based interventions finding that similar mechanisms shown to be associated with change in in-person treatment have also been found as mechanisms driving behavior change in technology-based interventions (Dallery, Jarvis, Marsch, & Xie, 2015). For example, perceived peer drinking was the only mechanism identified for alcohol use in multiple technology-based studies. No published studies have attempted to systematically review moderators of treatment outcomes in mobile-based interventions. This is extremely important going forward as alcohol use and behaviors may vary depending on motivation and severity. Thus, researchers should be mindful of these variables when creating interventions for various subpopulations. Additional research on mediators and moderators of treatment outcomes is greatly needed in order to: a) better understand factors underlying treatment effects and b) create targeted efficacious interventions for varying populations.

Technology based interventions are rapidly gaining attention and popularity and represent an exciting future direction for substance use treatment. However, the recent increase in media attention and popularity for these intervention approaches makes it extremely important that well-designed RCTs are implemented in order to evaluate the efficacy of these approaches (Fowler et al., 2015). The present study demonstrated that a brief, mobile-based intervention reduces AI-driving behaviors more than an information intervention. Future studies should attempt to replicate these findings at other college campuses. Additionally, future research is needed to determine whether this intervention produces similar effects in high schools, treatment seeking samples, and community settings.

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