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A Daily Diary Examination of Caffeine mixed with Alcohol among College Students

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Abstract

Objective—Caffeinated alcoholic beverage (CAB) use is associated with a range of substance-related problems. The majority of prior research on CABs is based on cross-sectional and retrospective reports, which do not account for intraindividual differences in use and may be subject to recall biases. The current research used a daily diary, within-subjects design to compare days where individuals simultaneously mixed alcohol with caffeine ("CAB days") and days where individuals drank other types of alcohol ("non-CAB days") on alcohol use outcomes. These relationships were tested further by examining the impact of the type of mixer (i.e., energy drink or cola-caffeinated).

Methods—Participants were 122 (73.8% women) heavy drinking, college student CAB users. Mean age was 20.39 (*SD* = 2.08) years. Students completed a baseline questionnaire and up to 14 consecutive, daily surveys about the previous night's drinking behavior.

Results—Multilevel modeling results indicated that CAB days were associated with heavier alcohol use, regardless of mixer type. In addition, beyond amount of alcohol consumed the previous night and trait impulsivity, CAB days were linked with more alcohol-related problems, but only when the mixer was an energy drink. CAB days did not differ from non-CAB days on driving or sex after drinking.

Conclusions—This study was the first to demonstrate the unique risks posed by simultaneously consuming caffeine and alcohol in a within-subjects, daily diary design. Future research investigating use patterns may benefit from the use of fine-grained approaches in order to provide information relevant for CAB prevention and intervention efforts.

Keywords

Alcohol and energy drinks; caffeinated alcohol; college students; alcohol-related problems

Prior experimental and cross-sectional evidence indicate that the use of caffeinated alcoholic beverages (CABs), or alcoholic beverages mixed with caffeine such as Red Bull and vodka

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or rum and Coke, is uniquely linked with negative outcomes such as heavy drinking, sex after drinking, driving under the influence, and stimulant drug use (see Linden & Lau-Barraco, 2014 for a review). The extent of our knowledge on CABs has been based primarily on between-subject and aggregate reports, which can limit information on intraindividual CAB drinking patterns and may be subject to recall bias. CABs are commonly consumed on college campuses with 75% of college students reporting lifetime use (Berger, Fendrich, & Fuhrmann, 2013) and 24% reporting past-month use (O'Brien, McCoy, Rhodes, Wagoner, & Wolfson, 2008). Given the popularity of CABs and associated harms, additional research is needed to better understand CAB use behaviors. In addition, limited research has examined the extent to which the type of caffeine mixer impacts alcohol use outcomes. Although the majority of researchers studying CABs have examined energy drinks mixed with alcohol, emerging research indicates that cola-caffeinated mixers (e.g., rum and soda) may produce similar levels of intoxication as alcohol and energy drinks (e.g., Red Bull and vodka) (e.g., Thombs, Rossheim, Barnett, Weiler, Moorhouse, & Coleman, 2011). Because cola-caffeinated mixers tend to be more popular than other types of caffeinated mixers, additional research exploring the role of caffeine in CAB use in this area is warranted. Toward this end, the current research employed a daily diary design to compare days where individuals consumed CABs with days in which individuals consumed other types of alcohol on alcohol use outcomes.

CAB consumption has been related consistently to more severe drinking and problems. One study found that CAB users had twice as many heavy drinking days and episodes of drunkenness as compared to non-users (O'Brien et al., 2008). Another study found a large effect (d = .99) in comparing heavy drinking occasions, such that CAB users reported consuming twice as much during their heaviest drinking occasion as compared to non-users (i.e., 18 versus 9 drinks; Woolsey, Waigandt & Beck, 2010). Further evidence supports that CAB use is related to various negative consequences even after controlling for a drinker's typical alcohol use. Overall, one study found that CAB users were at twice the odds of experiencing at least one negative consequence as compared to non-users (Brache & Stockwell, 2011). Some of these consequences include driving after drinking and being a passenger in a car with an intoxicated driver (Brache & Stockwell, 2011), engaging in sexual risk behaviors such as having unprotected sex or having sex after drinking too much (Snipes & Bentosch, 2013), using stimulant drugs (Brache & Stockwell, 2011; Snipes & Bentosch, 2013), and experiencing symptoms of alcohol use disorder (Snipes, Jeffers, Green, & Benotsch, 2015).

Results from experimental studies suggest one reason for the link between CAB use and alcohol outcomes may be that caffeine can reduce one's *feelings* of intoxication without reducing actual drunkenness. Marczinski and Fillmore (2006) found after consuming CABs as opposed to regular alcohol, participants felt less intoxicated but exhibited similar levels of physical alcohol-related impairment. Thus, the counteracting effects of caffeine on actual impairment may make someone more likely to engage in behaviors they normally would not otherwise, such as judging themselves to be able to drive or deciding to engage in sexual behavior than when feeling the sedative effects. Additionally, after drinking CABs, participants have been found to demonstrate less behavioral or impulse control (Marczinski, Fillmore, Bardgett, & Howard, 2011) as well as increased desire for more alcohol than when

alcohol was consumed alone (Marczinski, Fillmore, Henges, Ramsey, & Young, 2013). Therefore, one explanation for the strong link between CAB use and both heavy alcohol use and negative outcomes may be based on the physiological and subjective effects of the substance.

Despite consistent evidence supporting the link between CAB use and alcohol outcomes, the majority of our knowledge is based on between-subject cross-sectional designs, which do not take into account individual differences. Within-subject designs, on the other hand, allow for observations of individual variations in experiences on, for instance, days where individuals consumed CABs as opposed to days individuals consumed non-caffeinated alcohol. Such designs may be particularly beneficial in studying CAB use given recent evidence demonstrating substantial intraindividual variability in CAB use and associated consequences among users (Lau-Barraco, Milletich, & Linden, 2014; Mallett, Marzell, Scaglione, Hultgren, & Turrisi, 2014). In addition, because of the limitations of between-subject designs, such methodology has been called into question when studying the effects of CABs (de Haan, de Haan, der, Palen, Olivier, & Verster, 2012). That is, some researchers suggest that the link between CAB use and negative outcomes is better explained by one's impulsivity or propensity toward engaging in risky behaviors in general. Given that CAB users relative to non-CAB users exhibit higher levels of risk-taking propensity (e.g., Brache & Stockwell, 2011), a within-subjects design is needed to compare days where a participant consumed CABs as opposed to days in which other types of alcohol were consumed, after accounting for impulsivity.

Although a handful of researchers have previously used within-subject designs in studying CAB use (e.g., de Haan et al., 2012; Price, Hilchey, Darredeau, Fulton, & Barrett, 2010; Woolsey et al., 2010), most findings are based on cross-sectional reports in which participants are asked to report on their CAB versus alcohol use outcomes *in general* or in the past month(s). Retrospective methods of collecting data can have serious limitations. That is, participants may experience a recall bias when attempting to remember how many drinks they consumed over the past month(s) (Gmel & Daeppen, 2007). As a consequence to these risks, retrospective methodologies have been called into question (Ekholm, 2004). Alternatively, a daily diary design in which participants report on their behaviors close to the time they occur could address some of the potential inaccurate or biased report concerns typically associated with retrospective methods. To date, only one study has examined alcohol and caffeine consumption using such methodologies (Patrick & Maggs, 2014). Researchers compared drinking days where individuals did versus did not consume energy drinks. Findings indicated that on drinking days where participants consumed energy drinks, they consumed more alcohol, reached a higher BAC, and experienced more negative consequences (e.g., a hangover). This study design did not, however, directly assess the simultaneous consumption of alcohol and energy drinks/caffeine but rather the extent to which drinking an energy drink at one point during a drinking day increased the odds of experiencing certain alcohol-related outcomes. Thus, the extent to which simultaneous alcohol and caffeine consumption relates to these outcomes using within-subjects, daily diary methodology has not yet been tested.

One relatively unexplored area of research involving CABs is the impact of the caffeine mixer. Field research of patrons leaving a bar suggest that those who consumed cola-caffeinated mixers (e.g., rum mixed with Coke) exhibited similar levels of intoxication as those who consumed alcohol mixed with energy drinks (e.g., Red Bull mixed with vodka) (Thombs et al., 2011) and that those who consumed a cola-caffeinated mixer had higher levels of intoxication than those who consumed only non-caffeinated alcohol (Rossheim & Thombs, 2011). It is possible that because both beverages contain caffeine, which is thought to be an underlying factor for reducing sedative effects (e.g., Marczinski & Fillmore, 2006), *any* type of caffeine mixed with alcohol may pose risks above consuming regular alcohol. Far more research has, however, been conducted examining alcohol mixed with energy drinks relative to cola-caffeinated alcoholic drinks. Although energy drinks contain higher levels of caffeine than soda (80 mg vs. 34.5 mg; Reissig, Strain, & Griffiths, 2009), the popularity and potential for risk in cola-caffeinated mixers (Rossheim & Thombs, 2011; Thombs et al., 2011) warrants research teasing out the effects of the type of caffeine mixer in CABs.

The purpose of the present research was to examine the link between CAB use and alcohol outcomes through the use of daily assessments inquiring about the previous night's alcohol use over two weeks. The first aim was to compare days where individuals reported mixing any type of caffeine with alcohol (CAB days) as compared to days where individuals consumed only alcohol (non-CAB days) in terms of the most commonly reported outcomes in prior cross-sectional literature: alcohol consumption, general alcohol-related problems, and more specific types of alcohol-related consequences: engagement in sex after drinking and specific sexual outcomes (i.e., casual sex, unprotected sex), and driving after drinking. Given the potential confounding influence of impulsivity found in prior CAB work, trait impulsiveness was included as a covariate in analyses. It was hypothesized that, beyond one's trait level of impulsivity and the amount of alcohol consumed the previous night, participants would report experiencing more alcohol-related problems, greater odds of engaging in sex after drinking in general and casual sex and unprotected sex in specific, and driving home after drinking on CAB days relative to non-CAB days. In addition, after controlling for trait impulsivity, heavier alcohol use would occur on CAB days relative to non-CAB days. The second aim was to test the impact of the caffeine mixer by comparing days where participants did versus did not consume alcohol and energy drinks on outcomes, as well as comparing days where participants did versus did not consume cola-caffeinated alcoholic drinks on outcomes. It was hypothesized that poorer alcohol outcomes would be reported on days where alcohol mixed with energy drinks or cola-caffeinated mixers were consumed, relative to alcohol-only days.

Method

Participants and Procedure

Participants for the current study were college students from a public university. Participants were recruited through the university's psychology research pool. To be eligible, participants must have (1) been between the ages of 18 and 25 years old, (2) consumed CABs at least once in the past week, (3) been moderate to heavy drinkers (i.e., have engaged in heavy

episodic drinking or 4+/5+ drinks in one occasion for women/men at least twice in the past month), and (4) reported daily access to the Internet for two weeks. Following informed consent, participants completed an online assessment remotely in order for the researcher to determine eligibility and to provide baseline information. The initial assessment took approximately 30–45 minutes to complete. After completing the initial assessment, the researcher determined their eligibility. If eligible, participants were provided with instructions for how to complete the daily online surveys thereafter.

Follow-up assessments for the daily diary portion of the study were collected online to be completed on any device. Daily surveys were collected for 14 days (i.e., two weeks). All follow-up assessments were scheduled to start on a Tuesday and end on a Monday in order to ensure that data were collected across two weekends for all participants. Each morning, participants were sent an email reminder along with the survey link. Participants were instructed to complete the survey each day between 2:30 and 7 pm to control for any potential time of day effects. Participants who provided a cell phone number received a text message reminder at 2:30 pm to complete the survey.

Participants were compensated with research credit in their courses for their participation in the initial assessment. For the daily portion, participants were provided with their choice of either additional research credit or $10. Students who completed all daily assessments were entered into a raffle to win a $50 gift card. The current study was approved by Old Dominion University's Institutional Review Board and all APA ethical guidelines were followed (APA, 2010).

Six hundred participants were screened for inclusion in the current study. Of those screened, 363 did not meet study inclusion criteria and were therefore not provided with follow-up assessments. Two hundred thirty-seven students were eligible to participate in the follow-up assessments. Based on suggestions provided by Black, Harel, and Matthews (2011) and the nature of the research questions, only participants who provided at least two daily surveys and at least one drinking day were included. Among the 237 who met inclusion criteria, 115 completed no follow-up assessments or too few assessments to be included in analyses. Specifically, 85 did not complete any follow-up surveys, 11 completed only one follow-up survey, and 19 did not report drinking during the two-week period.

The final sample for analysis consisted of 122 (90 women) participants. The mean age was 20.39 (SD = 2.08) years with 52.5% under the age of 21. Class standing was 27.9% freshman, 23.8% sophomore, 13.9% junior, 32.8% senior, and 1.6% did not respond. Ethnicity was 54.9% Caucasian/White, 27.9% African American/Black, 6.6% self-reported "other" or biracial, 5.7% Hispanic, 3.3% Asian, and 1.6% Native American. The sample for analysis completed an average of 12.42 (SD = 2.16) daily reports out of 14. Of those included, most participants had high compliance (12 to 14 days; 76.2%); others had medium (7 to 12 days; 20.5%) or low (fewer than 7 days; 3.3%) compliance. Eligible but excluded participants did not differ on sex or race/ethnicity but excluded participants were younger, $t(226.10) = -2.34$, $p = .020$, more impulsive, $t(210) = 2.11$, $p = .036$, and experienced more alcohol-related harms in the past year, $t(216) = 2.52$, $p = .013$ than those in the final analytic sample. In line with study aims, only drinking days were included in subsequent analyses.

Participants provided a total of 389 daily diaries in which they consumed any type of alcohol. Approximately half (50.8%) of participants reported use of both CABs and non-CABs during the study time frame.

Measures

Initial assessment

Impulsivity: The Barratt Impulsiveness Scale (BIS-11; Patton, Stanford, & Barratt, 1995) measured the personality trait of impulsivity. The scale consists of 30 items in which participants indicate the degree to which they typically exhibit impulsive behavior (e.g., "I say things without thinking", "I get easily bored when solving thought problems", "I act on the spur of the moment"). Responses range from 1 (*rarely/never*) to 4 (*almost always/always*). Impulsivity was measured continuously; higher scores on the BIS-11 indicate greater levels of typical impulsivity. In the current study, $\alpha = .85$.

Daily assessments—The daily assessment consisted of reporting on the previous night's drinking.

Alcohol use: To measure the previous night's alcohol consumption, participants were asked to report the number of alcoholic drinks they consumed for each beverage. That is, they were asked the number of beers, glasses of wine, shots, mixed drinks, and CABs they consumed the night before. Picture examples were provided to demonstrate what classified as a standard alcoholic beverage for each type of drink. Total number of drinks consumed the previous night was calculated by summing the number of drinks consumed for each beverage.

CAB use the previous night was determined based on whether they reported consuming alcohol mixed with any type of caffeine (i.e., an energy drink or soda) the previous night. Responses were coded as either 0 (*did not drink CABs the previous night*) or 1 (*consumed at least one CAB the previous night*). Alcohol and energy drink use was determined based on whether they consumed alcohol mixed with an energy drink the previous night (e.g., Red Bull and vodka), coded as 0 (*did not drink alcohol mixed with energy drinks the previous night*) or 1 (*consumed at least one alcohol mixed with energy drinks the previous night*). Cola-caffeinated alcoholic beverage use was determined based on whether they consumed this beverage the previous night (e.g., rum and Coke), coded as 0 (*did not drink soda mixed with alcohol the previous night*) or 1 (*consumed at least one soda mixed with alcohol the previous night*). Diet and regular soda were considered "cola-caffeinated mixers."

Drinking-related outcomes: Participants were provided with several questions regarding drinking-related outcomes that occurred the previous night. First, participants were asked if they drove after drinking the previous night with yes (1) or no (0) response options. Second, they were asked if they engaged in sexual intercourse after drinking the previous night with yes (1) or no (0) response options. If the participant reported sex after drinking, they were provided with follow-up questions regarding type of sexual partner (i.e., whether they were a casual sexual partner) and engagement in unprotected sex. Third, participants were provided with the Brief Young Adult Alcohol Consequences Questionnaire (BYAACQ; Kahler,

Strong, & Read, 2005) asking about alcohol-related problems that occurred during the previous night, such as blacking out from drinking and social-interpersonal issues. The BYAACQ is a 24-item checklist with response options of yes (1) and no (0) for each item. Responses were summed to reflect the number of alcohol-related harms experienced the previous night with higher scores reflecting more problems experienced. In the present study, $\alpha = .90$.

Data Analytic Plan

Prior to conducting analyses, data were cleaned and statistical assumptions were addressed. Extreme outliers outside of the 3 *SD* range were winsorized (Barnett & Lewis, 1994) to match the next highest value. Minimal data that were missing (ranging from 0 to 3% across baseline measures and 0 to 5% on daily measures) were imputed using expectation maximization. Given the nature of the nested data, level-1 (daily) predictors were group-mean centered and level-2 (baseline) predictors were grand-mean centered (Raudenbush & Bryk, 2002). The purpose of centering is to separate between- and within-person clustering effects and to aid interpretation. When group-mean centering, individual scores can be interpreted relative to that individual's personal mean. Thus, group-mean centering allows researchers to interpret any effects as within-person fluctuations, such as whether the amount of alcohol one consumed on a particular day was high or low relative to that person's individual average. Grand-mean centering involves subtracting the grand mean from all individual scores across the sample. Therefore, grand-mean centered variables can be interpreted as how an individual's baseline value, such as their level of trait impulsivity, compares to the average impulsivity value of the sample. A Bernoulli distribution was specified for all dichotomous outcomes (e.g., whether someone drove home after drinking the previous night) and a Poisson distribution was specified for continuous outcomes (e.g., number of drinks consumed). All multilevel modeling analyses were conducted using HLM 7.01 software (Raudenbush, Bryk, & Congdon, 2013). Results from the unit-specific models (i.e., subject-specific models) using robust standard errors provided by HLM software are reported. In addition, we tested whether the level 1 slopes varied across level 2 units by entering slopes as random effects. Level 1 units such as the CAB effect, did not significantly vary in the majority of models, thus this slope was treated as a fixed effect in each model.

Multilevel modeling was used to test each outcome on daily CAB use. These outcomes included amount of alcohol consumed the previous night, number of alcohol-related problems experienced the previous night, engagement in sex after drinking the previous night, driving after drinking the previous night. The two follow-up questions regarding sex after drinking (i.e., casual sex, unprotected sex) were excluded from analysis due to the lack of variable responses across days. The remaining associations were tested after controlling for number of drinks consumed the previous night (level 1) and trait impulsivity (level 2), as these factors could confound the relationship between CAB use and outcomes. An example equation is provided below. Here, the likelihood of driving after drinking (0 = did not drive home after drinking, 1 = drove home after drinking the previous night) was predicted by whether they consumed CABs (CABuse), where time (t) is nested within individuals (i) after controlling for alcohol use the previous night (NumDrinks) and trait impulsivity (Impulsivity).

$$\log[\text{Driving}_{ti}] = \pi_{0i} + \pi_{1i} * (\text{CABuse}_{ti}) + \pi_{2i} * (\text{NumDrinks}_{ti} - \overline{\text{NumDrinks}}_{.i}) \quad \text{Level-1 model}$$

$$\pi_{0i} = \beta_{00} + \beta_{01} * (\text{Impulsivity}_{i} - \overline{\text{Impulsivity}}_{.}) + u_{0j} \; \pi_{1i} = \beta_{10} \; \pi_{2i} = \beta_{20} \quad \text{Level-2 model}$$

The above set of equations were tested for each individual outcome.

Results

Participants provided a total of 389 daily diaries in which they consumed any type of alcohol. Of drinking days, 101 (26%) days involved any CAB use. Of CAB days, cola-caffeinated alcoholic beverages were consumed on 57.43% of CAB days and alcohol mixed with energy drinks were consumed on 39.6% of CAB days. As can be seen in Table 1, descriptive statistics are provided for the mean number of drinks consumed, mean number of alcohol-related problems experienced, and percentage of days where sex after drinking and driving after drinking occurred for days in which participants consumed non-caffeinated alcohol (non-CAB days) and days in which participants consumed any type of caffeine mixed with alcohol (CAB days). Descriptive statistics for CAB use in general (“overall” column), and within CAB days, on days where cola-caffeinated mixers were used (“soda and alcohol” column) and days where energy drink mixers were used (“energy drink and alcohol” column) are also presented in Table 1.

CAB Days and Non-CAB Days

To test the first aim, multilevel models were used to compare CAB days and non-CAB days on the following outcomes: amount of alcohol used, number of alcohol-related problems experienced overall, odds of driving under the influence, and odds of engaging in sex after drinking. Daily level predictors included whether CABs were consumed and amount of alcohol consumed; person-level predictors included trait impulsivity. These predictors were entered in multilevel equations (presented above) predicting each individual outcome. As can be seen in Table 2, results indicated that using CAB as opposed to other types of alcohol on the previous night was associated with heavier alcohol use and more alcohol-related problems experienced. This association remained significant after controlling for the amount of alcohol consumed the previous night and one’s trait impulsivity. In other words, regardless of the total number of drinks consumed and how impulsive someone typically is, drinking a CAB on a particular occasion was linked with more alcohol-related harms experienced on that occasion relative to drinking episodes involving other types of alcohol. The odds of driving after drinking or engaging in sex after drinking were unassociated with use of CABs. That is, participants were equally likely to drive after drinking or engage in sex after drinking on days where they drank CABs as days where they drank other types of alcohol.

Descriptively, we compared the types of problems most commonly reported on CAB and non-CAB days. On non-CAB days, the three most frequently reported consequences were:

"I have had less energy or felt tired because of my drinking" (17.7% of non-CAB drinking days), "I have had a hangover (headache, sick stomach) the morning after I had been drinking" (16.7%), and "While drinking, I have said or done embarrassing things" (14.9%). These items correspond to the original YAACQ subscales of self-care, blacking out from drinking, and social/interpersonal problems. On CAB days, participants reported similar consequences. The three most commonly endorsed consequences were: "I have had a hangover (headache, sick stomach) the morning after I had been drinking" (35.6% of CAB days), "I have had less energy or felt tired because of my drinking" (25.7%), and "I have felt very sick to my stomach or thrown up after drinking" (24.8%). These correspond to the self-care and blacking out from drinking subscales from the full YAACQ.

Type of Caffeine Mixer

In addition to testing the association between CAB use overall and alcohol outcomes, the specific links between alcohol and energy drink use and outcomes as well as cola-caffeinated alcoholic beverage use and outcomes were tested. First, with regard to energy drink mixers, results indicated that relative to days in which participants did *not* use alcohol mixed with energy drinks, alcohol and energy drink days were associated with heavier alcohol use after controlling for typical level of impulsivity. In addition, after controlling for number of drinks consumed the previous night and trait impulsivity, alcohol and energy drink use was related to more alcohol-related harms experienced (see Table 3). Days in which participants consumed versus did not consume alcohol mixed with energy drinks did not differ on likelihood of driving or engaging in sex after drinking.

Separate models were tested for days in which cola-caffeinated mixers were used versus days in which other types of alcohol were consumed. As shown in Table 4, findings revealed that participants consumed more alcohol on days where participants consumed soda mixed with alcohol as compared to days where they drank other types of alcohol. After controlling for number of drinks consumed and trait impulsivity, soda and alcohol days versus alcohol-only days did not differ on number of alcohol-related problems experienced or odds of driving or engaging in sex after drinking.

Overall, these findings comparing specific types of mixers indicate that regardless of the type of mixer, participants drank more heavily on days where they mixed at least some of their alcohol with caffeine. Participants also experienced more alcohol-related harms on days where they mixed alcohol and energy drinks relative to drinking days where they did not mix alcohol with energy drinks. Cola-caffeinated alcoholic beverage use did not differ from drinking other beverages in predicting problems. Both mixers were not predictive of engagement in sex or driving after drinking.

Discussion

Caffeinated alcoholic beverages (CABs) have been consistently associated with a host of negative consequences. To date, the majority of research examining this link has been limited to comparing CAB users to non-users as opposed to assessing intraindividual differences in CAB use. To gain a more enhanced view of the way in which CABs relate to alcohol use outcomes, the current study compared days in which individuals consumed

CABs as opposed to days in which they consumed other types of alcohol. As a secondary aim, the relationship between CABs and outcomes was examined further by determining the extent to which the type of caffeine mixer impacts study associations.

Findings indicated that participants experienced more alcohol-related problems on days in which participants reported drinking CABs as opposed to days where participants consumed other types of alcohol. The two most commonly reported problems experienced across both CAB and non-CAB days related to blacking out from drinking and a lack of self-care. Blacking out from drinking is particularly important given that this type of alcohol-related problem has been found to be among the most predictive of problematic drinking in young adults (Read, Beattie, Chamberlain, & Merrill, 2008). We also found that CAB days relative to non-CAB days were linked with more alcohol-related problems above the total number of drinks consumed the previous night and one's trait impulsivity. This finding is important given prior research speculations that heavy drinking and impulsivity may account for the relationship between CAB use and negative consequences (e.g., Verster, Aufricht, & Alford, 2012). Although it is possible that CAB use may predict alcohol-related problems through heavier consumption, because of the nature of the study design, we were able to determine that the likelihood of experiencing negative consequences on CAB days as compared to non-CAB days occurred above the influence of these potential confounds.

The link between CAB use and alcohol-related problems is in line with past between-subjects, cross-sectional research (e.g., Brache & Stockwell, 2011; Snipes & Benotsch, 2013), but supplements these findings by demonstrating that problems do not necessarily differ solely between CAB users and non-users but rather between days that these same individuals report drinking CABs versus other types of alcohol. These findings may be due in part to the subjective feelings of intoxication between the two types of beverages (Marczinski & Fillmore, 2006) such that without feeling the sedative effects of alcohol as much in CABs, users may engage in behaviors that they normally would not if feeling highly intoxicated. Overall, CAB use may pose a unique risk for experiencing various negative consequences from drinking.

CAB days and non-CAB drinking days also were compared in the likelihood of driving after drinking and engaging in sex after drinking. No differences were found between drinking days. Past research comparing CAB users and non-users found that users were more likely to drive home after drinking, be a passenger in a car with an intoxicated driver (Brache & Stockwell, 2011; Woolsey, Williams, Housman, Barry, Jacobson, & Evans, 2015), and engage in sexual risk-taking behaviors (Berger et al., 2013; O'Brien et al., 2008). A discrepancy may have occurred because the link between CAB use and these behaviors is a between-subject effect, rather than a within-subject effect. That is, perhaps individuals who select CABs are generally more likely to drive home after drinking overall. Prior work has demonstrated that these between-subjects associations generally exist above one's heavy episodic drinking behavior and trait risk-taking tendency (e.g., Brache & Stockwell, 2011), but there may be other variables that underlie this relationship, such as perceived risk or beliefs about the effects of CABs. An alternative explanation may be that the current study was statistically lacking power to examine these relationships more in depth. That is, driving after drinking was a rare occurrence across non-CAB days and CAB days overall and thus

occasions were too limited to be able to fully examine differences, such as parsing out this relationship further to examine the intoxication level of the driver. Similarly, engagement in sex after drinking did not occur often and, even more uncommon were other sexual behaviors, such as engagement in casual sex and unprotected sex. A larger study involving more participants and more days of reporting driving and sex after drinking could help elucidate this relationship.

In addition to examining the link between CAB use overall as related to alcohol use outcomes, the impact of the caffeine mixer was examined. Drinking was heavier on days where participants mixed with either energy drinks or soda relative to drinking only alcohol, but only energy drink mixers were associated with experience of alcohol-related harms. Both types of mixers could be linked with heavier drinking because of the increase in motivation to continue drinking that has been observed in prior experimental work examining solely alcohol mixed with energy drinks (Marczinski et al., 2013). One explanation for the discrepancy in problems may be related to the amount of caffeine in these beverages. Given the level of caffeine content relative to soda (80 mg of caffeine in Red Bull relative to 34.5 mg of caffeine in Coca-Cola; Reissig et al., 2009), energy drink mixers may offset or “mask” the sedative effects of alcohol more so than soda mixers. Alternatively, users may have different expectancies or motivations for these beverages, such as perceptions that drinking alcohol and energy drinks can help avoid unintended sex and can help them drive more safely or feel more in control (MacKillop, Howland, Rohsenow, Few, Amlung, Metrik, & Calise, 2012), which may serve to underlie or strengthen the relationship between alcohol and energy drink use and harms (Linden-Carmichael, Lau-Barraco, & Stamates, 2015).

Although the current study offers a preliminary snapshot of CAB drinking days as compared to non-CAB drinking days, a more fine-grained daily assessment method is needed to better examine CAB use over the course of the evening. Ecological momentary assessment (EMA) designs permit the collection of real-time data (e.g., smartphone data collection) that could allow for a more detailed picture of CAB consumption (e.g., tracking CAB use over the course of an evening), including antecedents and consequences of CAB use. In light of findings that CABs are often used to pre-game (i.e., drinking before the main event; e.g., Jones, Barrie, & Berry, 2012) and at bars and clubs (Peacock, Bruno, & Martin, 2013), it is possible that individuals select CABs for particular reasons and in particular environments. It is possible that drinking in such contexts and for specific intentions may partially contribute to why CAB users experience more alcohol-related harms. EMA could test these direct or indirect associations by tracking participants throughout the night as well as inquiring about their intentions for drinking on CAB versus non-CAB drinking occasions. Also, the current study found significant associations between CAB use and outcomes above one’s trait level of impulsivity, suggesting that impulsivity does not fully account for the link between CAB use and negative consequences. It is possible, however, that one’s level of impulsivity fluctuates day to day (Tomko et al., 2014) and covaries with one’s decision to drink CABs on a daily basis. Given recent findings that hedonistic motives (i.e., motivated to drink for sensation seeking or pleasure-seeking ideals) are positively associated with alcohol and energy drink consumption (Droste, Tonner, Zinkiewicz, Pennay, Lubman, & Miller, 2014), it may be that because of the caffeine properties of the substance, users may be more likely to select these beverages on occasions where they feel particularly impulsive or seek

immediate pleasure. Therefore, it is possible that daily levels of impulsivity play a role in one's decision to drink CABs, as well.

There are several limitations that should be noted. First, although the current study found several links comparing CAB days and non-CAB days, the nature of the design precludes any causal inferences between CAB use and negative consequences. Second, the current study was limited in its ability to examine several consequences (driving after drinking, sex after drinking) more in-depth given the rarity of certain events and limited number of CAB days. The infrequency of these behaviors relative to other types of alcohol-related problems may suggest that these are less salient issues for CAB users, however the potential severity of consequences arising from engagement in behaviors such as driving under the influence or failing to use contraceptives warrants additional research in these areas. Relatedly, this study was limited in its comprehensiveness of measuring sexual behavior. That is, the current study only inquired about particular sexual risk behaviors (i.e., unprotected sex, type of sexual partner), but there are many other risk behaviors that have demonstrated linkages with CAB use such as sexual victimization (e.g., unwanted touching, sexual assault; Snipes, Green, Javier, Perrin, & Benotsch, 2014) and behaviors that have been relatively less explored, such as sexual behavior that does not involve intercourse. Gaining information on other types of sexual behavior using a longer study time frame (e.g., 30 days) may provide a more comprehensive overview of CAB use patterns. Third, response rates for participants were generally low (96 out of 237 eligible participants provided zero or only one daily diary). As mentioned elsewhere, eligible but excluded participants were younger, more impulsive, and reported more alcohol-related problems in the past year. While age was unrelated to major study variables and both impulsivity and alcohol-related harms were taken into account in the models, caution should be made when generalizing findings. Specifically, these findings may suggest that our final analytic sample is a relatively less risky group and thus, there may be an untapped sub-group of CAB users who exhibit higher trait levels of impulsivity and alcohol use severity and are thus perhaps at even greater risk for harms from use. Future studies using a similar design may benefit from using greater incentives for retaining participants for the daily diary portion of the study and perhaps making attempts to oversample more impulsive, more severe drinkers. Fourth, this study used the BYAACQ to measure daily negative consequences from drinking. Although the BYAACQ is an established measure and has been used to detect short-term alcohol-related problems in prior research (e.g., Lewis, Sheng, Geisner, Rhew, Patrick, & Lee, 2015; Pearson, D'Lima, & Kelley, 2013), this measure has not been standardized for use in a daily diary study. Although certain types of problems were detected on a daily level (50.9% of days involved at least one alcohol-related problem), a gold-standard measure is needed as many researchers move toward studying health behavior using daily or momentary assessments. Finally, the current study was a preliminary examination of CAB use over a two-week period. A larger sample with a longer assessment window (e.g., 30 days) could provide an enhanced view of study findings, particularly by examining CAB use continuously (i.e., the number of CABs consumed) rather than dichotomously (i.e., whether CABs were consumed).

This study represented the first to examine CAB use drinking patterns in a longitudinal, daily diary design. It was found that when comparing CAB days and non-CAB drinking

days, CAB days were linked with heavier drinking and more alcohol-related harms experienced, even after controlling for the previous night's drinking and trait impulsivity. In addition to examining CAB use overall, it was found that both soda and energy drink mixers were associated with heavier drinking but that only alcohol mixed with energy drinks were related to harms. These findings demonstrate the uniqueness of CAB use as compared to the use of other types of alcoholic beverages. Future research is needed to examine underlying reasons for and the temporal nature of CAB drinking patterns using more fine-grained approaches to better inform prevention and intervention efforts when working with frequent CAB consumers.

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Table 1

Descriptive Statistics across Study Variables

	Non-CAB days	CAB days		
	(*n* = 288)	Overall (*n* = 101)	Energy drink and alcohol (*n* = 40)	Soda and alcohol (*n* = 71)
M (*SD*) drinks consumed last night	4.21 (3.51)	5.93 (3.87)	6.95 (3.66)	5.48 (3.84)
M (*SD*) alcohol-related problems last night	1.73 (2.90)	2.72 (3.44)	2.60 (2.74)	2.55 (3.64)
% days drove after drinking	10.76	9.90	5.00	11.27
% days engaged in sex after drinking	12.59	15.84	22.50	16.90

Note. CAB = caffeinated alcoholic beverage.

Table 2

Multilevel Models of CAB Use Predicting Daily Alcohol Outcomes

	Number drinks last night ERR (CI)	Number problems last night ERR (CI)	Sex after drinking OR (CI)	Drove after drinking OR (CI)
Intercept	3.84 (3.42–4.30) ***	1.17 (0.91–1.50)	0.13 (0.08–0.20) ***	0.09 (0.06–0.14) ***
Level 1: Daily level				
CAB use last night	1.37 (1.20–1.57) ***	1.43 (1.13–1.82) **	0.79 (0.36–1.75)	0.99 (0.47–2.07)
Number drinks last night	--	1.13 (1.05–1.22) **	1.22 (1.07–1.40) **	1.05 (0.92–1.20)
Level 2: Person level				
Impulsivity	1.00 (1.00–1.01)	1.02 (1.00–1.04) *	1.01 (0.97–1.04)	1.02 (0.97–1.06)

Note. Separate models were conducted for each outcome. CAB = caffeinated alcoholic beverage as measured by 0 = did not drink CABs during the previous night's drinking episode and 1 = used at least one CAB the previous night. OR = odds ratio from Bernoulli multilevel modeling distribution. ERR = event rate ratio from Poisson distribution. CI = confidence interval.

*** $p < .001$.

** $p < .01$.

* $p < .05$.

Table 3

Multilevel Models of Alcohol and Energy Drink Use Predicting Daily Alcohol Outcomes

	Number drinks last night ERR (CI)	Number problems last night ERR (CI)	Sex after drinking OR (CI)	Drove after drinking OR (CI)
Intercept	4.01 (3.59–4.48) ***	1.24 (0.97–1.59)	0.12 (0.08–0.18) ***	0.09 (0.06–0.15) ***
Level 1: Daily level				
Alcohol and energy drink use last night	1.51 (1.30–1.77) ***	1.48 (1.02–2.14) *	1.26 (0.50–3.21)	0.53 (0.14–2.06)
Number drinks last night	--	1.13 (1.05–1.23) **	1.21 (1.05–1.39) **	1.06 (0.93–1.21)
Level 2: Person level				
Impulsivity	1.00 (1.00–1.01)	1.02 (1.00–1.04) *	1.01 (0.97–1.04)	1.02 (0.97–1.07)

Note. Separate models were conducted for each outcome. Alcohol and energy drink use is measured by 0 = did not drink alcohol mixed with energy drinks during the previous night's drinking episode and 1 = used at least one alcoholic beverage mixed with energy drinks the previous night. OR = odds ratio from Bernoulli multilevel modeling distribution. ERR = event rate ratio from Poisson distribution. CI = confidence interval.

*** $p < .001$.

** $p < .01$.

* $p < .05$.

Table 4

Multilevel Models of Cola-caffeinated Alcohol Use Predicting Daily Alcohol Outcomes

	Number drinks last night ERR (CI)	Number problems last night ERR (CI)	Sex after drinking OR (CI)	Drove after drinking OR (CI)
Intercept	3.99 (3.57–4.47) ***	1.25 (0.98–1.59)	0.12 (0.08–0.19) ***	0.09 (0.05–0.14) ***
Level 1: Daily level				
Soda and alcohol last night	1.28 (1.10–1.49) **	1.23 (0.89–1.70)	0.85 (0.32–2.27)	1.13 (0.49–2.59)
Number drinks last night	--	1.14 (1.05–1.23) **	1.22 (1.07–1.39) **	1.05 (0.92–1.20)
Level 2: Person level				
Impulsivity	1.00 (1.00–1.01)	1.02 (1.00–1.04) *	1.01 (0.97–1.04)	1.02 (0.97–1.06)

Note. Separate models were conducted for each outcome. Cola-caffeinated use as measured by 0 = did not drink soda mixed with alcohol during the previous night's drinking episode and 1 = used at least one soda mixed with alcohol the previous night. OR = odds ratio from Bernoulli multilevel modeling distribution. ERR = event rate ratio from Poisson distribution. CI = confidence interval.

*** $p < .001$.

** $p < .01$.

* $p < .05$.