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Faster Self-paced Rate of Drinking for Alcohol Mixed with Energy Drinks versus Alcohol Alone

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Abstract

The consumption of alcohol mixed with energy drinks (AmED) has been associated with higher rates of binge drinking and impaired driving when compared to alcohol alone. However, it remains unclear why the risks of use of AmED are heightened compared to alcohol alone even when the doses of alcohol consumed are similar. Therefore, the purpose of this laboratory study was to investigate if the rate of self-paced beverage consumption was faster for a dose of AmED versus alcohol alone using a double-blind, within-subjects, placebo-controlled study design. Participants (n = 16) of equal gender who were social drinkers attended 4 separate test sessions that involved consumption of alcohol (1.97 ml/kg vodka) and energy drinks, alone and in combination. On each test day, the dose assigned was divided into 10 cups. Participants were informed that they would have a two hour period to consume the 10 drinks. After the self-paced drinking period, participants completed a cued go/no-go reaction time task and subjective ratings of stimulation and sedation. The results indicated that participants consumed the AmED dose significantly faster (by approximately 16 minutes) than the alcohol dose. For the performance task, participants' mean reaction times were slower in the alcohol conditions and faster in the energy drink conditions. In conclusion, alcohol consumers should be made aware that rapid drinking might occur for AmED beverages thus heightening alcohol-related safety risks. The fast rate of drinking may be related to the generalized speeding of responses following energy drink consumption.

Keywords

Alcohol; Energy drinks; Drinking Rate; Stimulation; Reaction Time

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One common recommendation to alcohol consumers for reducing the likelihood of alcohol-related problems is to pace drinking so that consumption is slow (NIAAA, 2016). Alcohol consumed at a faster rate induces greater intoxication and makes it more difficult for consumers, including young social drinkers, to stay within moderate drinking guidelines given that alcohol is a rewarding and reinforcing drug (Leeman et al., 2013; Stafford &

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Dodd, 2013). Fast paced drinking also results in a faster rate of rise in blood alcohol concentration (BAC) and swifter rates of rise in BAC are associated with greater behavioral impairments, independent of the actual BAC (Fillmore & Vogel-Sprott, 1998; Jones & Vega, 1973; Moskowitz & Burns, 1976). Since fast drinking is associated with greater alcohol consumption and greater alcohol-related harms, a variety of public health intervention programs emphasize spacing drinks as one way to slow the rate of drinking. For example, protective behavioral strategies interventions with young social drinkers emphasize that fast drinking contributes to drinking harms. Individuals who already space drinks or individuals who learn to incorporate the direct strategy of slowing the pace of drinking tend to have reduced alcohol problems (DeMartini et al., 2013). Even vulnerable populations, such as the chronically homeless, benefit from safer drinking interventions that teach spacing alcoholic drinks and drinking slowly so that overall alcohol consumption is less (Grazioli et al., 2015).

A further concern with faster rates of alcohol consumption relates to overall poor decision making including driving-related risk-taking. In one laboratory study with social drinkers, faster self-paced drinking of alcohol was related to increased driving confidence even though actual driving was impaired, as measured via a driving simulator (Bernosky-Smith et al., 2012). In that study, the authors suggested that faster drinking was problematic as it leads individuals to erroneously conclude that they are sober enough to drive given the time delay from the last alcoholic drink consumed before driving. The observations that fast rate of drinking is associated with both binge drinking and risky decision-making in the context of driving parallels what has also been reported in the literature regarding the consumption of energy drink mixers with alcohol. The consumption of alcohol mixed with energy drinks (AmED) has been associated with binge drinking and greater intentions to drive while impaired when compared to alcohol alone (for reviews, see Marczinski, 2015; Marczinski & Fillmore, 2014). Therefore, the purpose of this study was to examine if alcohol mixed with energy drink (AmED) is consumed faster than alcohol alone.

Energy drinks are beverages with levels of caffeine double or triple the levels of caffeine found in soft drinks and are advertised to increase energy levels and mitigate fatigue (Howard & Marczinski, 2010; McCusker et al., 2006). Energy drinks have become increasingly popular mixers for alcohol (Marczinski, 2011). Based on findings from prior research, there may be two reasons why one might observe faster consumption for AmED beverages when compared to alcohol alone. First, energy drinks can antagonize alcohol-induced impairments on motor speed. The acute administration of alcohol results in a dose-dependent slowing of reaction times that can be observed using a variety of cognitive tasks (Marczinski & Fillmore, 2003a,b; Marczinski & Stamates, 2013; Marczinski et al., 2011, 2012). Energy drinks (or caffeine alone) can antagonize this alcohol-induced motor slowing (Marczinski & Fillmore, 2003a; Marczinski et al., 2011). The heightened arousal that occurs with consumption of energy drink mixers could increase the rate of drinking based on an antagonism of alcohol-induced motor slowing.

The second reason why AmED beverages may be consumed faster than alcohol alone pertains to the finding from several studies that energy drinks (or caffeine) appear to enhance the rewarding/reinforcing properties of alcohol. In three different laboratory studies, a moderate (i.e., ‘priming’) dose of alcohol was given to participants to induce the desire for more alcohol. When the priming dose of alcohol contained caffeine, either as part of an energy drink (Marczinski et al., 2013, in press) or as an additive (Heinz et al., 2013), participants reported a greater desire for more alcohol. These laboratory-based findings coincide with findings from field studies where bar patrons who consume AmED beverages are more likely to leave bars intoxicated (Hughes et al., 2012; Thombs et al., 2010). There appears to be a dose dependent relationship between level of caffeine use (via energy drinks or cola beverages) and the magnitude of alcohol intoxication in bar patrons (Thombs et al., 2011).

However, it is important to acknowledge that the literature covering whether AmED beverages are riskier than alcohol alone is controversial. It has been argued that AmED consumers just tend to be heavier drinkers in general when compared to alcohol consumers who do not select energy drink mixers (Rossheim et al., 2016; for a review, see Verster et al., 2016). Therefore, the purpose of this study was to determine if the rate of drinking is greater when individuals consume alcohol mixed with energy drinks compared with when the same individuals consume the same dose of alcohol mixed with a non-energy drink mixer. Social drinkers consumed 10 small drinks so that speed of beverage intake for alcohol and energy drinks, alone and in combination, could be recorded. After drinking, participants completed a cued go/no-go reaction time task and completed subjective ratings of stimulation and sedation. It was predicted that alcohol would be consumed faster when the mixer included the energy drink as compared to the same amount of alcohol consumed with a decaffeinated soft drink mixer. In addition, it was hypothesized that AmED consumption would result in faster reaction times and greater subjective stimulation when compared to alcohol alone.

Methods

Participants

Sixteen social drinkers (8 women) between the ages of 21 and 30 participated in this study. The mean (*SD*) age of the sample was 22.94 (2.57). The self-reported racial make-up of the sample included 2 African-American and 14 Caucasian participants. For ethnicity, 1 participant reported being Hispanic with the remaining identifying not Hispanic. Potential volunteers completed questionnaires providing demographic information and physical and mental health status. Exclusion criteria included self-identified substance abuse disorders, psychiatric disorder, diabetes, phenylketonuria, head trauma, or other central nervous system injury. Individuals who drank less than two standard drinks of alcohol per month were excluded. Individuals with a potential risk of alcohol dependence were also excluded, as assessed by a SMAST score (Selzer et al., 1975) of 5 or higher or an AUDIT score (Barbor et al., 1989) of 8 or higher (Barry & Fleming, 1993). Inclusion criteria included self-reported consumption of at least one energy drink in the past year and consumption of at least one caffeinated beverage in the past two weeks (e.g., coffee, tea, soft drink, chocolate, and/or energy drink).

Participants were informed that they would be asked to provide a urine sample at the start of each test session to test for recent use of amphetamines, barbiturates, benzodiazepines, cocaine, ecstasy, methamphetamine, opiates, and tetrahydrocannibol. Any participant who tested positive for the presence of any of these drugs was excluded from the study. Females who were pregnant or breast-feeding were also excluded, as determined by both self-report and the results of a urine gonadotrophin (HCG) test.

Participants were recruited via notices posted on university community bulletin boards and through university student e-mail distribution lists. All volunteers provided informed consent before participating. The Northern Kentucky University Institutional Review Board approved this study. Participants received $150 as compensation for completing the entire 5 session study. All participants completed all sessions in this study.

Materials

Personal Drinking Habits Questionnaire (PDHQ: Vogel-Sprott, 1992)—The PDHQ measures an individual's recent typical drinking habits including number of standard drinks (i.e., bottles of beer, glasses of wine, and shots of liquor) typically consumed during a single drinking occasion, dose (grams of absolute alcohol per kilogram of body weight typically consumed during a single drinking occasion), weekly frequency of drinking, and hourly duration of a typical drinking occasion. The PDHQ also measures history of alcohol use in the number of months that an individual has been drinking on a regular basis or customarily on social occasions.

Timeline Follow-back (TLFB; Sobell & Sobell, 1992)—The TLFB assesses self-reported daily patterns of alcohol consumption during the past 30 days including maximum number of continuous days of drinking, maximum number of continuous days of abstinence, total number of drinking days, total number of drinks consumed in the past month, highest number of drinks consumed in one day, total number of heavy drinking (5+ drinks) days, and total number of "drunk" days (i.e., days on which the participants felt intoxicated).

Caffeine Use Questionnaire (CUQ)—The CUQ assesses self-reported typical average daily caffeine consumption in milligrams per kilogram of body weight. Estimates of the caffeine content in foods and beverages were taken from Barone and Roberts (1996) and McCusker et al. (2006). Manufacturer websites were consulted for caffeine content information for newer products.

Impulsivity Measures—Two measures assessed self-reported impulsivity, with higher scores indicating greater impulsivity. The Eysenck Impulsiveness Questionnaire (Eysenck et al., 1985) assesses impulsivity by posing 19 yes/no questions. The Barratt Impulsiveness Scale-11 (BIS-11; Patton et al., 1995) assesses impulsivity by asking participants to rate how typical 30 different statements are for them on a 4-point Likert scale. Typical social drinking college students will report mean BIS-11 scores of approximately 52–56 (Henges & Marczinski, 2012).

Self-paced Speed of Drinking Task—The pace of drinking was measured using a self-paced speed of drinking task (Bernosky-Smith et al., 2012). Participants were informed that they would be given 10 small drinks to consume at a comfortable pace over a 2 hour period. Participants were asked to alert the research assistant when they desired a new drink. The time to complete each drink was unobtrusively recorded. During the task, participants were not prohibited from viewing the time and participants were offered magazines to read during the task.

Cued go/no-go reaction time task—The cued go/no-go reaction time task was used to assess the ability to activate and inhibit responses (Marczinski & Fillmore, 2003a,b). This task is sensitive to the effects of moderate doses of alcohol and energy drinks (Marczinski et al., 2011). The task was operated using E-Prime 2.0 software (Schneider et al., 2002) on a Dell Latitude laptop computer (Dell Inc., Round Rock, TX). A test consisted of 250 trials involving four possible cue-target combinations and took approximately 15 minutes to complete. A trial involved the following sequence of events: (i) a fixation point (+) for 800 ms, (ii) a blank screen for 500 ms, (iii) a cue (a horizontal or vertical white rectangle), displayed for one of five stimulus onset asynchronies (SOAs = 100, 200, 300, 400, and 500 ms), (iv) a go or no-go target (green or blue rectangle), visible until a response occurred or 1000 ms elapsed, and (v) an intertrial interval of 700 ms.

The cue orientation (horizontal or vertical) correctly indicated the target 80% of the time. Participants were instructed to press the forward slash (/) key on the keyboard as soon as a go (green) target appeared and to suppress (inhibit) any response if a no-go (blue) target appeared. Activational and inhibitory tendencies show rapid development of cue dependence as cues help an individual prepare for the appropriate execution or inhibition of behavior (Miller et al., 1991). For response activation, the acute effects of alcohol typically slow mean reaction times (RT) to go targets, particularly in the no-go cue condition (Marczinski & Fillmore, 2003a,b). For response inhibition, the go cue generates the proclivity to prepare to act, yet subjects must overcome this response prepotency to successfully inhibit the response when a no-go target is displayed. For response inhibition, the acute effects of alcohol typically result in impairments in response inhibition, particularly in the go cue condition (Marczinski & Fillmore, 2003a,b). When alcohol is administered in moderate doses, the co-administration of caffeine/energy drinks antagonizes the impairment by alcohol for response execution (as measured by RTs to go targets) but does not alter the alcohol impairment on response inhibition (as measured by the proportion of failures to inhibit responses to no-go targets) (Marczinski & Fillmore, 2003a; Marczinski et al., 2011).

Biphasic Alcohol Effects Scale—Subjective ratings of stimulation and sedation were evaluated using this 14-adjective rating scale. Participants rate 7 adjectives describing stimulation effects (e.g., stimulated, elated) and 7 adjectives describing sedation effects (e.g., sedated, sluggish) (Martin et al., 1993). Each item is rated on an 11-point Likert scale ranging from not at all (0) to extremely (10). Sedation and stimulation scores were summed separately (subscale score range = 0 to 70).

Procedure

Pre-laboratory Screening—Potential volunteers were informed during a phone screening that the purpose of this five session study was to study the effects of alcohol and energy drinks on behavior. Individuals were notified that the study procedures included consumption of alcoholic, soft drink, and/or energy drink beverages and completion of questionnaires and a computer task. The contents of beverages were never disclosed to participants. However, they were informed that the amount of alcohol consumed on a session might be the equivalent to about 3 standard beers and the energy drink might contain the maximum dose of caffeine found in a cup of coffee. Before any test session, participants were required to fast for 2 hours, abstain from any form of caffeine for 8 hours, and abstain from alcohol for 24 hours.

Session Testing—Each participant was tested individually by a research assistant. Testing began between 10 a.m. and 4 p.m. Testing times within one subject were kept as similar as possible and did not vary more than 4 hours. Upon arrival in the laboratory for the first session, the participant provided informed consent in a private testing room that contained a desk and laptop computer. The participants also completed a general health questionnaire, PDHQ, TLFB, CUQ, Eysenck, and BIS-11 questionnaires. The participant completed the cued go/no-go task so that they would be familiar with the task.

At the start of every session, the participant was weighed and completed a medical screening questionnaire to ensure that the participant was healthy and had not recently taken any prescription or over-the-counter medications. A zero breath alcohol concentration (BrAC) was confirmed using an Intoxilyzer Model 400 (CMI Inc., Owensboro, KY). The participant also provided a urine sample in a private bathroom in the laboratory. The sample was tested for the presence of drug metabolites for all participants and HCG for women only (Bioscreens Inc., Norfolk, VA).

Dose Administration—On each test day, participants received 1 of 4 possible doses for the self-paced speed of drinking task: 1) 1.97 ml/kg vodka + 5.91 ml/kg decaffeinated soft drink, 2) 1.97 ml/kg vodka + 5.91 ml/kg energy drink, 3) 5.91 ml/kg decaffeinated soft drink, and 4) 5.91 ml/kg energy drink. Dose administration was double-blind and dose order was counterbalanced between participants. Doses were calculated based on body weight. For the alcohol doses, the 1.97 ml/kg vodka (40% alcohol/volume Smirnoff Red Label vodka, No. 21, Smirnoff Co., Norwalk, CT) was reduced to 87% for female participants. The alcohol dose was mixed with 5.91 ml/kg of Squirt, a decaffeinated soft drink (Dr. Pepper Snapple Group, Plano, TX) resulting in a 3:1 (soft drink:vodka) ratio. Squirt was selected as the decaffeinated soda given its similarity to the energy drink with respect to calories, taste, carbonation, and appearance. For the AmED condition, the 1.97 ml/kg dose of vodka was mixed with 5.91 ml/kg of Red Bull energy drink (Red Bull, Switzerland).

Once the assigned dose was prepared, it was divided equally into 10 small unmarked glasses. For the control conditions where energy drink or decaffeinated soft drink were consumed without alcohol, 1 ml of vodka was floated on the top of each glass so that a total of 10 ml was administered to give the drink an alcohol scent. Previous research has demonstrated that this approach results in an effective placebo as individuals report that this beverage contains alcohol (Marczinski et al., 2011). In the current study, we confirmed that all participants thought that they had consumed at least 0.5 alcoholic drinks in each condition using a standard beverage rating scale that asked a participant how many standard drinks of alcohol they thought we gave them in the test session. The mean (*SD*) ratings for the placebo and energy drink conditions were 0.81 (0.89) and 0.88 (1.71), respectively.

As described above in the dose administration procedures, the average male in the study (75.95 kg body weight) consumed a total of 149.62 ml of vodka (i.e., 5.06 oz.) for the alcohol dose administration sessions mixed with 448.86 ml of Squirt or Red Bull. On the alcohol sessions, the total was divided into the 10 glasses so that each glass contained approximately 60 ml of the drink mixture. For the decaffeinated soft drink and energy drink conditions, the vodka was reduced to 10 ml total so that each individual glass contained approximately 46 ml of the drink mixture. The average female in the study (67.61 kg body weight) consumed a total of 133.19 ml of vodka (i.e., 4.50 oz.) for the alcohol sessions mixed with 399.58 ml of Squirt or Red Bull. Thus, each of the 10 glasses contained approximately 53 ml of the drink mixture. For the decaffeinated soft drink and energy drink conditions for the average female, the vodka was again reduced to 10 ml total so that each individual glass contained approximately 41 ml of the drink mixture.

Using the assigned dose for a session, the pace of drinking was measured using a self-paced speed of drinking task (Bernosky-Smith et al., 2012). Participants were informed at the beginning of each session that there are 10 small drinks to be consumed at their desired space and this portion of the study always lasts the full 2 hours. Participants were reminded that they would complete a computer task and questionnaire after the drinking period. Each participant had a private testing room to consume the drinks but was within earshot of the research assistant who delivered each drink in succession as requested. Time of completion of each drink was unobtrusively recorded.

After the 2 hour drinking period, breath alcohol concentrations (BrACs) were taken at 120, 130, and 170 min. after drinking began. Breath samples were also provided by participants given the energy drink and decaffeinated soft drink beverages at those some intervals, ostensibly to measure their BrACs. After the 120 min. BrAC reading, participants completed the BAES. After the 130 min. BrAC reading, participants completed the cued go/no-go reaction time task. Upon completion of testing after the 170 min. BrAC reading, participants were given a meal. Participants were then debriefed and released once BrAC was below .02 g%.

Data Analysis

Gender was included as an initial between subjects factor in all analyses. However, no main effects or interactions with gender were obtained. Therefore, gender is only reported in the analyses for the demographic characteristics and baseline measures related to drinking habits.

For the dependent measures obtained, the data was submitted to separate 2 (Alcohol Dose: 1.97 ml/kg vodka v. 0.00 ml/kg) × 2 (Energy Drink (5.91 ml/kg energy drink v. 5.91 ml/kg decaffeinated soft drink) within-subjects ANOVAs. The alpha level was set to .05 for all statistical tests and SPSS 17.0 was used to conduct the analyses.

Results

Demographic Characteristics and Baseline Measures

Table 1 lists all demographic and baseline questionnaire measures for the male and female participants in the study. Possible gender differences for the baseline measures reported in Table 1 were compared using independent samples *t* tests. From the PDHQ, it was observed that males reported a longer duration typical drinking episode when compared to females, $t(14) = 2.84$, $p = .013$. For the remaining tests, no significant differences were observed for any of the measures including the impulsivity measures, *p*s >.104.

BrACs

No detectable BrACs were observed under the energy drink or placebo conditions. For only the alcohol conditions, the results of a 2 (Energy Drink) × 3 (Time) within-subjects ANOVA revealed only a significant main effect of Time, $F(2,30) = 90.76$, $p < .001$, $\eta^2 = .858$. There was no other main effect or interaction for this analysis, *p*s > .249. The mean (*SD*) BrACs at 120, 130, and 170 min. were .066 (.003), .060 (.003), and .048 (.002) g% respectively. Post-hoc LSD tests revealed that all time points were significantly different from one another, *p*s < .001.

Self-paced Rate of Drinking

The results of a 2 (Alcohol) × 2 (Energy Drink) within-subjects ANOVA for the self-paced time to consume all 10 drinks revealed a significant main effect of Alcohol, $F(1,15) = 19.40$, $p = .001$, $\eta^2 = .564$, and a significant Alcohol × Energy Drink interaction, $F(1,15) = 6.04$, $p = .027$, $\eta^2 = .287$. The main effect of Alcohol occurred as alcohol was consumed more slowly than no alcohol. Figure 1 illustrates the Alcohol × Energy Drink interaction which reveals that the energy drink mixer increased the speed of consumption only in the presence of alcohol. A paired samples *t* tests revealed that the AmED dose was consumed significantly faster (by approximately 16 minutes) than the alcohol alone dose, $t(15) = 2.36$, $p = .032$.

Biphasic Alcohol Effects Scale

Table 2 shows the mean subjective ratings of stimulation and sedation from the Biphasic Alcohol Effects Scale. Results of a 2 (Alcohol) × 2 (Energy Drink) within-subjects ANOVA for Stimulation ratings revealed a significant main effect of Alcohol, $F(1,15) = 10.38$, $p = .006$, $\eta^2 = .409$, and a significant main effect of Energy Drink, $F(1,15) = 11.43$, $p = .004$, $\eta^2 = .433$. No interaction was observed, $p = .355$. The main effect of Alcohol reflected higher mean stimulation ratings under the alcohol conditions (25.07) versus conditions without alcohol (13.38). The main effect of Energy Drink reflected higher mean stimulation ratings under the energy drink conditions (21.88) versus conditions without energy drink (16.57).

Results of the 2 (Alcohol) × 2 (Energy Drink) within-subjects ANOVA for Sedation ratings revealed a significant main effect of Alcohol, $F(1,15) = 4.54$, $p = .050$, $\eta^2 = .232$. There was no main effect of Energy Drink and no interaction, *p*s > .123. The main effect of Alcohol reflected higher mean sedation ratings under the alcohol conditions (9.85) versus conditions without alcohol (5.85).

Cued go/no-go task performance

The results of a 2 (Alcohol) × 2 (Energy Drink) × 2 (Cue) within-subjects ANOVA for mean RTs from the cued go/no-go task revealed a significant main effect of Alcohol, $F(1,15) = 23.65$, $p < .001$, $\eta^2 = .612$, a significant main effect of Energy Drink, $F(1,15) = 5.47$, $p = .034$, $\eta^2 = .267$, and a significant main effect of Cue, $F(1,15) = 38.99$, $p < .001$, $\eta^2 = .722$. There were no other significant interactions for this analysis, *p*s > .180. The main effect of Alcohol reflected that mean RTs were significantly slower when alcohol was administered versus not (309.53 v. 294.18). The main effect of Energy Drink reflected that mean RTs were significantly faster when energy drinks were administered versus not (294.81 v. 308.90). Finally, the main effect of Cue reflected that mean RTs were significantly faster following the go cue versus the no-go cue (288.19 v. 315.52). Table 2 presents the means and SD for all dose and cue conditions for the cued go/no-go task performance. Finally, the results of the 2 × 2 × 2 ANOVA for p-inhibition failures from the cued go/no-go task revealed a significant main effect of Cue, $F(1,15) = 7.96$, $p = .013$, $\eta^2 = .347$. The main effect of Cue reflected the fact that p-inhibitory failures were greater following the go cue versus the no-go cue (0.15 v. 0.06). There were no other main effects or interactions for this analysis, *p*s > .375.

Discussion

This study examined self-paced rate of drinking alcohol and energy drinks, alone and in combination, in social drinkers using a within-subjects, double-blind, placebo-controlled design. The question was whether alcohol mixed with energy drinks (AmED) would be consumed faster than the similar dose of alcohol mixed with a decaffeinated mixer. The observed results revealed that energy drink mixers increased the speed of drinking alcohol in the same participants. During the 2 hour drinking period, participants consumed the alcohol dose with energy drink mixer approximately 16 minutes faster than the same dose of alcohol mixed with a decaffeinated soft drink mixer. After the drinking period, subjective ratings of stimulation and sedation were assessed followed by objective performance measured on a cued go/no-go task. For the subjective ratings, alcohol administration resulted in higher ratings of both stimulation and sedation whereas energy drink administration resulted in higher ratings of stimulation. For the performance task, the results indicated that while alcohol slowed mean reaction times, energy drink mixers resulted in faster reaction times. Since the subjective ratings were taken before the participants completed the computer task, it appeared that the participants were readily able to recognize the sedating effects of alcohol and the stimulating effects of both alcohol and energy drinks without any feedback from the objective task. In sum, alcohol slowed behavior whereas energy drinks sped up behavior. This was observed in reaction times on a computer task and in how fast participants drank their assigned beverages.

The findings of this study are similar to other studies that have found that self-paced consumption rates for alcoholic beverages can be modified by the type of beverage. For example, Higgs et al. (2008) reported that participants given a 7% abv. lager-based beverage took significantly longer to consume the drink when compared to a similar 3% abv. beverage. The researcher argued that the perceived pharmacological effect of the alcohol served as a signal to alter drinking speed. In the current study, the alcohol content was held constant but the mixer type altered the consumption rate and the participants rated the AmED versus alcohol beverages differently in terms of stimulation and sedation outcomes. The current results suggest that alcohol intake speed, general motor speed, and subjective responses may be connected and should be further studied in a more systematic manner. Also, it should be noted that the paradigm used in the current study has not been widely adopted in the literature. Thus, future work is needed to determine if the consumption rates identified using this model correspond with actual speed of ordering drinks in bar settings or if consumption rates observed in the laboratory diverge from actual drinking behavior.

The current findings add to a growing literature which is consistent with the view of the U.S. Food and Drug Administration (FDA) position that caffeine is a generally recognized as safe (GRAS) compound when used alone but high levels of caffeine found in energy drinks is not GRAS in the presence of alcohol (US FDA, 2010). In this laboratory study, participants consumed the AmED dose approximately 16 minutes faster than the alcohol alone dose. Given that AmED beverages result in greater duration of alcohol priming (i.e., enhanced desire to drink alcohol) than alcohol alone (Marczinski et al., 2013, in press), the faster consumption rate combined with the greater motivation to drink explains the higher rates of binge drinking in AmED consumers. Given that one of the indicators of problem drinking is drinking too much alcohol too fast (Leeman et al., 2010), use of AmED beverages may make it difficult for consumers to stay in a moderate drinking range. Consumers should be made aware of these findings so that they can modify their drinking behavior accordingly.

Finally, every study has limitations that need to be acknowledged. In the current study, participants were administered alcohol doses alone in a laboratory that resulted in BrACs that were only measured at a mean peak of approximately .066 g%. Given that AmED use is associated with social contexts, binge drinking and alcohol-impaired driving, it would be important to determine if the findings observed in the current study would replicate in bar laboratory settings and/or with higher alcohol and energy drink doses. In addition, the consumption of AmED beverages versus alcohol alone in the real world is likely not a dichotomy and motives and expectancies regarding AmED (e.g., MacKillop et al., 2012) may potentially influence the use of these beverages and also the pace of drinking. Also, consumers probably consume some AmED beverages and some alcohol alone beverages within the same drinking episode. Furthermore, soft drinks that contain caffeine may be consumed with alcohol or alone also during a drinking episode. In future work, it would be important to determine if there is a dose dependent relationship between caffeine intake and alcohol consumption rate. Another consideration is that taste or other general gustatory factors may be playing a role in the rate of consumption. As such, the perceived taste properties of AmED beverages versus alcohol alone may warrant greater attention. Finally, the small sample of social drinkers in the current study prevented us from systematically examining individual difference variables, including alcohol and caffeine use habits, and how those variables relate to self-paced rate of consumption. It is possible that faster consumption of AmED versus alcohol alone is a concern for only some types of social drinkers but this needs further study.

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References

Barbor, TF., de la Fuente, JR., Saunders, J., Grant, M. AUDIT: The Alcohol Use Disorders Identification Test: Guidelines for Use in Primary Health Care. World Health Organization; Geneva, Switzerland: 1989. WHO/MNH/DAT 89.4

Barone JJ, Roberts HR. Caffeine consumption. Food & Chemical Toxicology. 1996; 34:119–129. [PubMed: 8603790]

Barry KL, Fleming MF. The alcohol use disorders identification test (AUDIT) and the SMAST-13: Predictive validity in a rural primary care sample. Alcohol and Alcoholism. 1993; 23:33–42.

Bernosky-Smith KA, Aston ER, Liguori A. Rapid drinking is associated with increases in driving-related risk-taking. Human Psychopharmacology. 2012; 27:622–625. [PubMed: 23027650]

DeMartini KS, Palmer RS, Leeman RF, Corbin WR, Toll BA, Fucito LM, O'Malley SS. Drinking less and drinking smarter: direct and indirect protective strategies in young adults. Psychology of Addictive Behaviors. 2013; 27:615–626. [PubMed: 23088406]

Eysenck SBG, Pearson PR, Easting G, Allsop JF. Age norms for impulsiveness, venturesomeness and empathy in adults. Personality and Individual Differences. 1985; 6:613–619.

Fillmore MT, Vogel-Sprott M. Behavioral impairment under alcohol: Cognitive and pharmacokinetic factors. Alcoholism: Clinical and Experimental Research. 1998; 22:1476–1482.

Grazioli VS, Hicks J, Kaese G, Lenert J, Collins SE. Safer-drinking strategies used by chronically homeless individuals with alcohol dependence. Journal of Substance Abuse Treatment. 2015; 54:63–68. [PubMed: 25690515]

Heinz AJ, de Wit H, Lilje TC, Kassel JD. The combined effects of alcohol, caffeine, and expectancies on subjective experience, impulsivity, and risk-taking. Experimental and Clinical Psychopharmacology. 2013; 21:222–234. [PubMed: 23750693]

Henges AL, Marczinski CA. Impulsivity and alcohol consumption in young social drinkers. Addictive Behaviors. 2012; 37:217–220. [PubMed: 21981824]

Higgs S, Stafford LD, Attwood AS, Walker SC, Terry P. Cues that signal the alcohol content of a beverage and their effectiveness at altering drinking rates in young social drinkers. Alcohol and Alcoholism. 2008; 43:630–635. [PubMed: 18583545]

Howard MA, Marczinski CA. Acute effects of a glucose energy drink on behavioral control. Experimental and Clinical Psychopharmacology. 2010; 18:553–561. [PubMed: 21186930]

Hughes K, Quigg Z, Bellis MA, Calafat A, van Hasselt N, Kosir M, Voorham L, Goossens FX, Duch M, Juan M. Drunk and disorganized: Relationships between bar characteristics and customer intoxication in European drinking establishments. International Journal of Environmental Research and Public Health. 2012; 9:4068–4082. [PubMed: 23202832]

Jones BM, Vega A. Fast and slow drinkers: Blood alcohol variables and cognitive performance. Quarterly Journal on Studies of Alcohol. 1973; 34:797–806.

Leeman RF, Corbin WR, Nogueira C, Krishnan-Sarin S, Potenza MN, O'Malley SS. A human alcohol self-administration paradigm to model individual differences in impaired control over alcohol use. Experimental and Clinical Psychopharmacology. 2013; 21:303–314. [PubMed: 23937598]

Leeman RF, Heilig M, Cunningham CL, Stephens DN, Duka T, O'Malley SS. Ethanol consumption: How should we measure it? Achieving consilience between human and animal phenotypes. Addictive Biology. 2010; 15:109–124.

MacKillop J, Howland J, Rohsenow DJ, Few LR, Amlung MT, Metrik J, Calise TV. Initial development of a measure of expectancies for combinations of alcohol and caffeine: the Caffeine + Alcohol Combined Effects Questionnaire (CACEQ). Experimental and Clinical Psychopharmacology. 2012; 20:466–472. [PubMed: 23230858]

Marczinski CA. Alcohol mixed with energy drinks: Consumption patterns and motivations for use in U.S. college students. International Journal of Environmental Research and Public Health. 2011; 8:3232–3245. [PubMed: 21909303]

Marczinski CA. Can energy drinks increase the desire for more alcohol? Advances in Nutrition. 2015; 6:96–101. [PubMed: 25593148]

Marczinski CA, Fillmore MT. Dissociative antagonistic effects of caffeine on alcohol-induced impairment of behavioral control. Experimental and Clinical Psychopharmacology. 2003a; 11:228–236. [PubMed: 12940502]

Marczinski CA, Fillmore MT. Preresponse cues reduce the impairing effects of alcohol on the execution and suppression of responses. Experimental and Clinical Psychopharmacology. 2003b; 11:110–117. [PubMed: 12622349]

Marczinski CA, Fillmore MT. Energy drinks mixed with alcohol: What are the risks? Nutrition Reviews. 2014; 72(S1):98–107. [PubMed: 25293549]

Marczinski CA, Fillmore MT, Bardgett ME, Howard MA. Effects of energy drinks mixed with alcohol on behavioral control: Risks for college students consuming trendy cocktails. Alcoholism: Clinical and Experimental Research. 2011; 35:1282–1292.

Marczinski CA, Fillmore MT, Henges AL, Ramsey MA, Young CR. Effects of energy drinks mixed with alcohol on information processing, motor coordination and subjective reports of intoxication. Experimental and Clinical Psychopharmacology. 2012; 20:129–138. [PubMed: 22023670]

Marczinski CA, Fillmore MT, Henges AL, Ramsey MA, Young CR. Mixing an energy drink with an alcoholic beverage increase motivation for more alcohol in college students. Alcoholism: Clinical and Experimental Research. 2013; 37:276–283.

Marczinski CA, Fillmore MT, Stamates AL, Maloney SF. The desire to drink alcohol is enhanced with high caffeine energy drink mixers. Alcoholism: Clinical and Experimental Research. in press.

Marczinski CA, Stamates AL. Artificial sweeteners versus regular mixers increase breath alcohol concentrations in male and female social drinkers. Alcoholism: Clinical and Experimental Research. 2013; 37:696–702.

Martin CS, Earleywine M, Musty RE, Perrine MW, Swift RM. Development and validation of the Biphasic Alcohol Effects Scale. Alcoholism: Clinical and Experimental Research. 1993; 17:140–146.

McCusker RR, Goldberger BA, Cone EJ. Caffeine content of energy drinks, carbonated sodas, and other beverages. Journal of Analytical Toxicology. 2006; 30:112–114. [PubMed: 16620542]

Miller K, Schaffer R, Hackley SA. Effects of preliminary information in a go versus no-go task. Acta Psychologica. 1991; 76:241–292. [PubMed: 1927576]

Moskowitz H, Burns M. Effects of rate of drinking on human performance. Journal of Studies on Alcohol. 1976; 37:598–605. [PubMed: 966769]

National Institute on Alcohol Abuse and Alcoholism (NIAAA), National Institutes of Health, U.S. Department of Health and Human Services. Rethinking Drinking: Alcohol & Your Health – Tips to Try. 2016. Retrieved (June 13, 2016) from http://rethinkingdrinking.niaaa.nih.gov/Thinking-about-a-change/Strategies-for-cuttingdown/Tips-To-Try.aspx

Patton JH, Stanford MS, Barratt ES. Factor structure of the Barratt impulsiveness scale. Journal of Clinical Psychology. 1995; 51:768–774. [PubMed: 8778124]

Rossheim ME, Thombs DL, Weiler RM, Barry AE, Suzuki S, Walters ST, Barnett TE, Paxton RK, Pealer LN, Cannell B. Alcohol mixed with energy drink: Use may be a consequence of heavy drinking. Addictive Behaviors. 2016; 57:55–61. [PubMed: 26890245]

Schneider, W., Eschman, A., Zuccolotto, A. E-Prime User's Guide. Psychology Software Tools; Pittsburgh, PA: 2002.

Selzer ML, Vinokur A, Van Rooijen L. A self-administered Short Michigan Alcoholism Screening Test (SMAST). Journal of Studies on Alcohol. 1975; 36:117–126. [PubMed: 238068]

Sobell, L., Sobell, M. Timeline follow-back: A technique for assessing self-reported alcohol consumption. In: Litten, R., Allen, J., editors. Measuring Alcohol Consumption: Psychosocial and Biomedical Methods. Humana Press; Totowa, NJ: 1992. p. 41-72.

Stafford LD, Dodd H. Music increases alcohol consumption rate in young females. Experimental and Clinical Psychopharmacology. 2013; 21:408–415. [PubMed: 24099360]

Thombs DL, O'Mara RJ, Tsukamoto M, Rossheim ME, Weiler RM, Merves ML, Goldberger BA. Event-level analyses of energy drink consumption and alcohol intoxication in bar patrons. Addictive Behaviors. 2010; 35:325–330. [PubMed: 19954894]

Thombs D, Rossheim M, Barnett TE, Weiler RM, Moorhouse MD, Coleman BN. Is there a misplaced focus on AmED? Associations between caffeine mixers and bar patron intoxication. Drug and Alcohol Dependence. 2011; 116:31–36. [PubMed: 21177047]

U.S. Food and Drug Administration. Serious concerns over alcoholic beverages with added caffeine. 2010 Nov 17. Available at http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm233987.htm

Verster JC, Benson S, Johnson SJ, Scholey A, Alford C. Mixing alcohol with energy drink (AMED) and total alcohol consumption: A systematic review and meta-analysis. Human Psychopharmacology. 2016; 31:2–10. [PubMed: 26781580]

Vogel-Sprott, M. Alcohol Tolerance and Social Drinking: Learning the Consequences. Guilford; New York, NY: 1992.

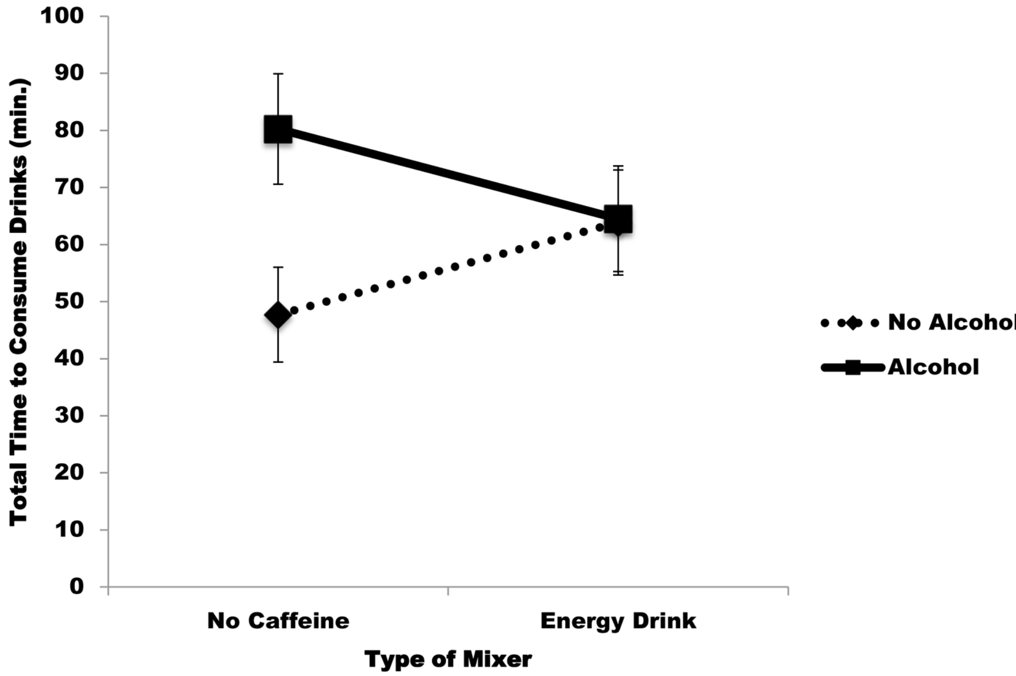

Figure 1.

Mean total time to consume all 10 drinks in the four dose conditions (alcohol, alcohol mixed with energy drink, energy drink, or placebo). Vertical bars show standard errors of the mean.

Table 1

Demographic characteristics and self-reported alcohol/caffeine use for the male ($n = 8$) and female ($n = 8$) participants.

	Males		Females	
	M	**SD**	**M**	**SD**
Age	23.13	1.89	22.75	3.24
Weight (kg)	75.95	11.30	67.61	7.74
Body Mass Index	23.70	4.39	24.98	2.63
Daily caffeine use (mg/kg)	3.53	3.71	3.29	2.09
SMAST	0.00	0.00	0.00	0.00
AUDIT	4.50	1.51	3.63	1.41
Personal Drinking Habits Questionnaire (PDHQ):				
History (months)	58.63	27.42	52.50	40.42
Frequency (occasions/wk)	1.41	0.46	1.34	0.77
Drinks per occasion	3.13	1.13	3.88	2.63
Alcohol dose (g/kg)	0.72	0.26	0.96	0.62
Duration (hr)	4.06	1.29	2.13	1.43
Timeline Follow-back (TLFB):				
Continuous drinking days	2.00	1.07	2.13	1.25
Continuous abstinence days	8.13	3.44	11.88	5.06
Total no. drinking days	6.63	2.97	5.63	2.77
Total no. drinks	26.38	27.57	14.50	9.30
Highest no. drinks in 1 day	6.81	5.84	4.13	1.46
Heavy drinking days	2.00	2.88	0.63	1.06
Drunk days	2.38	2.33	1.25	1.28
Eysenck	2.25	2.38	3.88	3.36
BIS-11	44.13	8.92	50.38	8.96

Table 2

Mean (SD) responses for the self-reported subjective ratings on the Biphasic Alcohol Effects Scale (BAES) and the cued go/no-go reaction time task performance under all four dose conditions for the male ($n = 8$) and female ($n = 8$) participants.

	Dose Conditions							
	0.00 ml/kg Alcohol				1.97 ml/kg Alcohol (40% abv. vodka)			
	5.91 ml/kg Placebo		5.91 ml/kg Energy Drink		5.91 ml/kg Placebo		5.91 ml/kg Energy Drink	
Variable	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**
Biphasic Alcohol Effects								
Scale (BAES):								
Stimulation	11.50	14.99	15.25	14.90	21.63	18.04	28.50	20.34
Sedation	7.44	7.28	4.25	7.61	11.81	11.85	7.88	10.05
Cued go/no-go task:								
RT (go cue)	290.33	45.64	272.84	29.51	302.46	45.04	287.14	29.72
RT (no-go cue)	315.36	47.65	298.21	28.56	327.46	39.50	321.05	32.46
p-inhibitory failures (go cue)	0.14	0.18	0.15	0.17	0.16	0.18	0.16	0.15
p-inhibitory failures (no-go cue)	0.06	0.12	0.05	0.09	0.07	0.09	0.06	0.07