



# Drinking patterns and risk behaviors associated with combined alcohol and energy drink consumption in college drinkers

Kristina Brache\*, Timothy Stockwell

University of Victoria, Centre for Addictions Research of BC, Department of Psychology, P.O. Box 1700 STN CSC, Victoria BC, Canada V8W 2Y2

## ARTICLE INFO

### Keywords:

Energy drinks  
Alcohol  
Risk taking  
Stimulant use  
Heavy drinking  
Harms

## ABSTRACT

**Objective:** In recent years the consumption of alcohol mixed with energy drinks (AmED) has become popular in young adults in North America. There have been few studies into the drinking patterns and risk behaviors that accompany this new form of alcoholic beverage consumption and more information is required to support harm reduction and prevention efforts. This paper goes beyond previous research by investigating risk behaviors associated with AmED use while (1) controlling for risk-taking propensity, (2) examining a range of outcomes (e.g. stimulant drug use), and (3) replicating previous findings in a Canadian sample.

**Method:** In winter 2009/10, a web-based survey was completed by 465 students (56% female) attending a university in Western Canada. Regression analyses were used to investigate whether consumption of AmED is associated with heavy drinking, stimulant drug use, and alcohol-related consequences.

**Results:** A total of 105 students (23%) reported consuming AmED in the past 30 days. These students were more likely to be heavier drinkers, than non-AmED users after controlling for risk-taking propensity. More frequent AmED drinkers had twice the odds of experiencing one or more negative consequences from AmED use (e.g. drinking and driving, being hurt or injured), compared to less frequent drinkers after controlling for risk-taking propensity and drinking behavior.

**Conclusions:** Students who consume AmED are at increased risk for harms. Therefore, consuming AmED should be considered “high-risk drinking” for university students and efforts should be made to discourage combined consumption.

© 2011 Elsevier Ltd. All rights reserved.

## 1. Introduction

In recent years the consumption of energy drinks has become popular for young adults in North America. Energy drinks are caffeinated beverages that intend to provide a burst of energy and/or enhance alertness. The principle stimulant ingredient in energy drinks is caffeine, although they may or may not include high doses of sugar (or a sugar substitute), and they generally include B vitamins, an amino acid (e.g. taurine or L-carnitine), and plant/herbal extracts (e.g. ginseng, milk thistle, *Ginkgo biloba*). The increased popularity of energy drinks among adolescents and young adults is not surprising given the aggressive and questionable marketing strategies to this population (Jones & Barrie, 2009; Simon & Mosher, 2007). As a result of the popularity of energy drinks in this age group and the legal drinking age, the consumption of alcohol mixed with energy drinks (AmED) is a common drinking behavior on college campuses. Research on this type of beverage consumption is now crucial as the combined use of alcohol and caffeinated beverages is increasing sharply, despite warnings

against combined consumption (Health Canada, 2005; Jones & Barrie, 2009; Marczynski & Fillmore, 2006; Reissig, Strain, & Griffiths, 2009).

Research with U.S. college students indicates that about 24% of current drinkers had consumed AmED in the past 30 days (O'Brian, McCoy, Rhodes, Wagoner, & Wolfson, 2008). Miller (2008a) found that 26% of university students reported past 30 day AmED consumption. Other research in Italian university students has reported a somewhat higher prevalence of 48.4% who have reported using AmED in the past month (Oteri, Salvo, Caputi, & Calapi, 2007). Consuming AmED while drinking socially is a common reason reported among college student for consuming energy drinks, where research has identified that 54% of college students who consume energy drinks report using for this purpose (Malinauskas, Aeby, Overton, Carpenter-Aeby, & Barber-Heidal, 2007). The use of energy drinks in general, as well as in the form of AmED, has been identified as being more frequent in men, in athletes, and in younger adults (Levy & Tapsell, 2007; Miller, 2008a, 2008b; O'Brian et al., 2008).

To date limited research has investigated the differences in drinking patterns, alcohol related consequences, and risk behaviors that accompany this trendy pattern of alcoholic beverage consumption. In general, the research that has been conducted in this field indicates that energy drink consumption is positively associated with risk-taking behaviors and substance use (Miller, 2008a; Woolsey &

Abbreviations: AmED, alcohol mixed with energy drinks.

\* Corresponding author. Tel.: +1 250 853 3229; fax: +1 250 472 5321.

E-mail address: kbrache@uvic.ca (K. Brache).

Kensinger, 2009). Researchers have found that college students who use AmED tend to consume more alcohol and consume alcohol more often than those who do not combine alcohol with energy drinks (O'Brian et al., 2008; Thombs et al., 2010). There is also evidence for increased consumption of energy drinks, when energy drinks are used in combination with alcohol. For example Malinauskas et al. (2007) found that the majority of energy drink users in their sample reported consuming one energy drink in most situations, whereas it was common to drink more energy drinks when consuming with alcohol while drinking socially. In a social drinking situation 49% of energy drink users reported consuming three or more energy drinks with alcohol. In addition to the increased consumption of alcohol and energy drinks when consuming AmED, research suggests that energy drink consumption is associated with smoking, illicit prescription use, and stimulant drug use (e.g. amphetamine) (Arria et al., 2010; Miller, 2008a; Reissig et al., 2009; Woolsey & Kensinger, 2009).

Not only do college students who mix alcohol and energy drinks appear to be consuming more alcohol and energy drinks, research indicates that they also have a significantly higher prevalence of alcohol-related consequences. These include higher prevalence of being taken advantage of, or taking advantage of another student, sexually, riding in an automobile with a driver under the influence of alcohol, being hurt or injured, and requiring medical treatment, after adjusting for the amount of alcohol consumed (O'Brian et al., 2008). Thombs et al. (2010) conducted an alcohol field study where patrons in a U.S. college bar district were interviewed, surveyed, and administered a breath alcohol concentration test when leaving the bar. This is the only study to date that has examined event-level connections between AmED use and risky driving behavior, as opposed to other associational analyses (e.g. O'Brian et al., 2008). Their results revealed that compared to other drinking patrons, patrons who had consumed alcohol mixed with energy drinks were at a 3 fold increased risk of leaving a bar highly intoxicated, as well as a 4 fold increased risk of intending to drive.

Of all the harms researched, drinking and driving related harms due to the use of AmED are an area of particular concern that has received much of the research attention in this field. It has been suggested that the stimulant effects of the energy drinks attenuate the negative effects of alcohol (Ferreira, Quadros, et al., 2004; Marczynski & Fillmore, 2006), therefore, perhaps leaving drinkers of AmED believing they are less intoxicated and more able to drive. Some research has found attenuation in certain areas of functioning, but not in others. For example, Marczynski and Fillmore's (2003) findings suggest that caffeine antagonizes alcohol's effect on response execution but has no effect on inhibitory control. Their findings also suggest that, overall, caffeine co-administration with alcohol does counteract some aspects of performance that are impaired by alcohol (i.e. response speed) but not others (i.e. response accuracy) (Marczynski & Fillmore, 2006).

Other research indicates that consumers of AmED have positive subjective effects from combining, such as a significant reduction in subjects' perception of intoxication including headache, weakness, dry mouth, and impairment of motor coordination compared to the ingestion of alcohol alone (Ferreira, de Mello, Pompeia, & de Souza-Formigoni, 2006). More importantly, especially in terms of driving, despite subjective feelings, Ferreira et al. (2006) found that the ingestion of energy drinks did not reduce the deficits caused by alcohol on objective measures of motor coordination and visual reaction time. In addition, it did not alter the participant's breath alcohol concentration. Research has also found deficits in cognitive performance with AmED consumption where combined use negatively influenced a global measure of cognitive functioning, specifically visuospatial/constructional and language performance scores, compared to participants who consumed caffeine only (Curry & Stasio, 2009). Unfortunately, this study did not have an alcohol only group to compare their results.

In general, although there are mixed results, the idea that energy drinks fully attenuate the negative effects of alcohol has not been supported in the research literature, despite subjective perceptions of positive effects (Ferreira, de Mello, Rossi, & Souza-Formigoni, 2004). Some negative effects may be attenuated with AmED consumption, but overall impairment still exists, signifying an inability to conduct complex tasks that involve significant motor and cognitive capabilities, such as driving.

We speculate that the association between AmED and risk-taking behavior, above and beyond the consumption of alcohol alone, may be due to the ability of energy drink consumption to alter subjective intoxication and antagonize alcohol's effect on response execution. Alcohol consumption, at heavier doses, is associated with decreased activity level, lowered inhibition, and slowed response speed (Ferreira et al., 2006; Marczynski & Fillmore, 2003, 2006). It is also associated with an increased disposition to take risks (Cherpitel, 1999). The use of energy drinks when drinking alcohol may increase energy and decrease subjective intoxication leading to an increased activity level. This increased energy and activity level combined with an increased disposition to take risks could result in increased risk-taking behavior. The increased risk taking behavior associated with AmED may also be due to the increased consumption of alcohol when consuming energy drinks or possible selection effects.

The small body of research on AmED use is calling for future research to help understand the associations between AmED use, drinking patterns, substance use, and risk behaviors. The relationships between these variables has been speculated to be the result of selection effects; specifically, sensation seeking individuals, or individuals with a high risk taking tendency, may be drawn to energy drinks, heavy alcohol consumption, and risky behaviors (Miller, 2008a; O'Brian et al., 2008). In order to address this potential selection effect and to increase understanding of the relationships between variables, the current study has incorporated a measure of risk taking tendency which was used as a covariate in the statistical analyses investigating the associations between AmED, heavy alcohol use, alcohol-related consequences, and stimulant substance use. The association between AmED use and stimulant drug use was investigated in order to clarify whether the association exists, particularly after controlling for alcohol consumption. Alcohol consumption could explain the association between stimulant drug use and AmED use as various stimulants (e.g. caffeine, cocaine) are often used in combination with alcohol, particularly by stimulant users (Brache, 2009). Further, we investigated AmED in a Canadian sample where unlike in the United States, only two premixed alcoholic energy drinks are available on the market. The overall aim of this study was to investigate the drinking patterns, substance use, and alcohol-related consequences associated with AmED consumption in a sample of 465 Western Canadian university students. We hypothesize that even after controlling for risk taking tendency the consumption of AmED will be significantly associated with heavier drinking, stimulant drug use, and alcohol related consequences.

## 2. Methods

### 2.1. Procedures

Students at a university in Western Canada were recruited from November, 2009 until February, 2010 by posters and recruitment emails to complete an online survey about alcohol and energy drinks. The posters were in all buildings on campus and the emails were sent to all faculty secretaries on campus in order to widely sample the university student population. Faculty secretaries were directed to forward the recruitment email, which contained a link to the survey, to all students in their faculty. All participants who responded to the posters on campus were emailed a link to the online survey. Informed consent was given for participation in the research. Students were

compensated \$10 for their participation in the study. This research was approved by the Western Canadian University's Research Ethics Board.

## 2.2. Measures

The survey was comprised of questions relating to student's alcohol consumption, energy drink consumption, and their AmED consumption. Frequency of use was reported as the number of days consumed in the past 30 days. The assessment of AmED consumption included the consumption of premixed alcoholic energy drinks (e.g. "Rockstar with vodka") and, the more common phenomenon, of manually mixing an energy drink with alcohol (e.g. where an individual or bartender would mix Red Bull with Jägermeister). Other variables investigated included their past year stimulant substance use and lifetime experience of negative outcomes when combining alcohol and energy drinks (e.g. drinking and driving, injury).

A slightly adapted measure of risk taking tendency (see Fig. 1), which has been previously developed and used in predicting substance use and injury, was included in the survey (McLeod et al., 2003; Thorson & Powell, 1987). The questions were originally derived from previous injury studies that identified common risk behaviors of injured people and were selected as items that were the best predictors of lethality as indicated by factor analysis (McLeod et al., 2003). The development and analysis of this scale by McLeod et al. (2003) was in part an attempt to address limitations in other scales, such as Zuckerman's sensation-seeking measure, in predicting actual risk taking behavior. Factor analysis using principal components with varimax rotation of the scale by McLeod et al. (2003) revealed two clear factors: health risk taking, and adventurous risk taking. The 14 item measure includes questions pertaining to risk taking that directly and obviously affects physical health and safety and risk taking related to a preference for thrill seeking and adventurous behavior. The items were both behavioral (e.g. In the past 12 months have you been involved in a physical fight?) and non-behavioral (e.g. Are you the sort of person who would enjoy exploring a cave?). The purpose of this risk taking tendency scale was to attempt to measure a general (intrinsic) tendency to take risks and a discrete personality trait or construct (McLeod et al., 2003). Chronbach's alpha, testing reliability of the scale, was 0.62 which is similar to previous reliability estimates (McLeod et al., 2003; Thorson & Powell, 1987). This reliability would not be improved by the elimination of any item.

## 2.3. Participants

All of the 19,244 students attending the university were eligible to complete the survey until a maximum number of 501 survey responses were collected. A total of 501 participants began the online

In the past 12 months have you...

- Been ticketed for speeding?
- Owned a motorbike in the last 12 months?
- Been involved in a physical fight?
- Passed out from drinking or drugs?
- Had unprotected sex with someone you didn't know very well?
- Attended an emergency unit with an injury?

We are also interested in the types of risks people might take.

- Are you the sort of person who would enjoy exploring a cave?
- Do you enjoy watching movies or TV shows that have a lot of violence?
- Do you ever take chances or do dangerous things for the thrill of it?
- When driving, do you generally pass most other cars on the freeway?
- Have you ever gone scuba diving?
- Have you ever driven a motorcycle?
- Would you like to pilot your own airplane?
- Do you smoke?

Fig. 1. Risk taking tendency measure.

survey, with 465 participants (93%) fully completing the survey with valid data. Of those who began the online survey 31 participants (6%) did not fully complete the survey, therefore, they were not included in the analyses for the present study. Completers did not differ significantly from non-completers on age, sex, and past 30 day consumption of AmED, however, non-completers were less likely than completers to have consumed alcohol (without energy drinks) in the past 30 days (75% vs. 88%). Four participants reported that they were not students at the university and, as a result, their data were removed. One participant's data were removed as they were inconsistent regarding whether they had consumed alcohol in the past 30 days.

## 2.4. Data analysis

The goals of the statistical analysis were to: (1) examine the associations of mixing alcohol with energy drinks and drinking behavior, after adjusting for age, sex, and risk taking tendency; (2) examine the associations of mixing alcohol with energy drinks and stimulant drug use, after adjusting for age, sex, drinking behavior, and risk taking tendency; and (3) examine the associations between frequency of mixing alcohol with energy drinks and experiencing alcohol and energy drink-related consequences, after controlling for age, sex, drinking behavior, and risk taking tendency. Overall, we sought to examine the additional risk of adding energy drinks to alcohol; therefore the analyses were restricted to past 30-day drinkers. A two-sided  $p$ -value  $< 0.05$  was considered statistically significant. Drinking behavior was analyzed between AmED and non-AmED groups using separate linear regressions for each drinking behavior, as well as across specific drinking episodes within the AmED group using a paired samples  $t$ -test. Stimulant drug use and alcohol and energy drink-related consequences were analyzed using separate logistic regressions for each variable. The probability of stimulant drug use was compared between AmED and non-AmED groups. Alcohol and energy drink-related consequences were assessed by determining the probability of reporting a given consequence with each day increase in frequency of AmED use in the past 30 days. Participants who reported having ever used AmED were included in this analysis.

## 3. Results

### 3.1. Demographics

A total of 465 participants fully completed the survey. The average student age was 24.03 (range = 17–51 years) (see Table 1). Our sample of university students had similar sex demographics compared to the overall institution ( $N = 19,244$ ) for the 2009/10 academic year (55.9% female for the study vs. 57.6% overall), but had a larger proportion of graduate student respondents compared to the institution (31.4% vs. 14.3%). Of the 465 students, 410 (88%) reported drinking alcohol at least once in the past 30 days. Among drinkers, 26% (105 students) reported consuming AmED on at least one occasion in the past 30 days. Thirty nine percent (41 students) of those who reported consuming AmED in the past 30 days reported consuming a pre-mixed alcoholic energy drink within the past 30 days. All subsequent analyses are restricted to past 30-day drinkers.

Subsequent logistic regression analyses revealed that students who were younger ( $p < 0.001$ , odds ratio (OR) = 1.13), in their undergraduate ( $p < 0.001$ , OR = 4.05), and lived on campus ( $p < 0.05$ , OR = 1.83) were more likely to consume AmED in the past 30 days.

### 3.2. Risk taking tendency

Students who reported consuming AmED in the past 30 days scored higher on the risk taking measure than those who did not

**Table 1**  
Characteristics of students who mix alcohol and energy drinks (AmED), only drink alcohol, and are nondrinkers ( $n = 465$ ).

Characteristics, $n$ (%) or $M \pm SD$	Overall $n = 465$	Nondrinkers $n = 55$ (12%) <sup>a</sup>	All drinkers $n = 410$ (88%) <sup>a</sup>	Drinkers by group	
				Non-AmED, $n = 305$ (65%) <sup>b</sup>	AmED, $n = 105$ (23%) <sup>c</sup>
Gender					
Male	203 (44)	25 (45)	178 (43)	133 (44)	45 (43)
Female	260 (56)	29 (53)	231 (56)	171 (56)	60 (57)
No response	2 (<1)	1 (3)	1 (<1)	1 (<1)	0 (0)
Age	24.03 $\pm$ 6.7	23.63 $\pm$ 6.8	24.09 $\pm$ 6.7	24.90 $\pm$ 7.2	21.72 $\pm$ 4.2***
Ethnicity					
Caucasian	379 (81)	30 (54)	349(85)***	260(85)***	89 (85)
Asian	47 (10)	13 (24)	34 (8)***	27 (9)***	7 (6)
Other	26 (6)	10 (18)	16 (4)***	12 (4)***	4 (4)
No response	13 (3)	2 (4)	11 (2)	6 (2)	5 (5)
Residence					
On campus	106 (23)	15 (27)	91 (22)	59 (19)	32 (30)*
off campus	294 (63)	32 (58)	262 (64)	201 (66)	61 (59)
With parents	59 (13)	6 (11)	52 (13)	42 (14)	11 (10)
Other	6 (1)	2 (4)	1 (1)	3 (1)	1 (1)
Academic year					
Undergraduate					
First year	112 (24)	17 (31)	95 (23)	60 (20)	35 (33)
Second year	36 (8)	3 (5)	33 (8)	24 (8)	9 (9)
Third year	57 (12)	4 (7)	53 (13)	36 (12)	17 (16)
Fourth year	93 (20)	8 (15)	85 (21)	59 (19)	26 (25)
Fifth or more	21 (4)	1 (2)	20 (5)	15 (5)	5 (5)
Total	319 (69)	33 (60)	286 (70)	194 (64)	92 (88)***
Graduate					
Master	101 (22)	9 (16)	92 (22)	82 (27)	10 (9)
PhD	45 (10)	13 (24)	32 (8)	29 (9)	3 (3)
Total	145 (31)	22 (40)	124 (30)	111 (36)	13 (12)***
Risk taking tendency <sup>d</sup>	3.44 $\pm$ 2.2	2.13 $\pm$ 1.6	3.62 $\pm$ 2.2***	3.33 $\pm$ 2.1***	4.42 $\pm$ 2.4***

<sup>a</sup> \* $p < 0.05$ , \*\* $p < 0.01$ , and \*\*\* $p < .001$  from logistic regression comparing All drinkers vs. Nondrinkers.

<sup>b</sup> \* $p < 0.05$ , \*\* $p < 0.01$ , and \*\*\* $p < .001$  from logistic regression comparing nondrinkers vs. non-AmED.

<sup>c</sup> \* $p < 0.05$ , \*\* $p < 0.01$ , and \*\*\* $p < .001$  from logistic regression comparing AmED vs. non-AmED.

<sup>d</sup> Risk taking tendency score ranging from 0 to 14 with a higher score indicating higher risk.

( $M = 4.42$ ,  $SD = 2.4$ , vs.  $M = 3.33$ ,  $SD = 2.1$ ,  $p < 0.001$ ,  $OR = 1.24$ ). This indicated that there is a significant association between general risk taking tendency and the likelihood of consuming AmED.

### 3.3. Drinking behavior

In multivariate linear regression analyses, the consumption of AmED was strongly associated with all measures of drinking behavior, where the AmED group engaged in more drinking and more high-risk drinking behaviors (see Table 2). Even after controlling for risk taking propensity, the consumption of AmED was significantly associated with four measures of drinking behavior: typical number of drinks on a typical drinking day, greatest number of drinks in a single day in the past 30 days, number of days with heavy episodic drinking in the past

30 days, and number of days intoxicated in a typical week. Compared to current drinkers who did not report consuming AmED, students who reported consuming AmED drank significantly more during a typical drinking session, reported a higher number of days intoxicated in a typical week, and reported more than twice as many heavy episodic drinking days in the past 30 days, as defined by the gender-specific measure of four or more alcoholic beverages in a row for females and five or more alcoholic beverages in a row for males. Among students who reported mixing alcohol and energy drinks, the greatest number of drinks in a single episode of drinking was 64% higher, compared to drinking students who did not report mixing alcohol with energy drinks.

In addition to higher levels of drinking being found across groups, a paired samples  $t$ -test revealed that students consuming AmED reported

**Table 2**  
Comparison of drinking behaviors between drinkers who mix alcohol and energy drinks and drinkers who do not ( $n = 410$ ).<sup>a</sup>

Drinking behavior, $M \pm SD$	Non-AmED, $n = 305$ (74%)	AmED, $n = 105$ (26%)	$b^b$ (95% CI) Model 1 <sup>c</sup>	$b^b$ (95% CI) Model 2 <sup>c</sup>
No. of days of alcohol consumption in the past 30 days	8.35 $\pm$ 6.45	9.49 $\pm$ 6.47	1.97 (0.55, 3.38)**	1.38 (-0.06, 2.82)*
Typical no. of drinks on a typical drinking day	3.04 $\pm$ 2.04	5.34 $\pm$ 3.52	1.95 (1.41, 2.49)***	1.66 (1.12, 2.20)***
Greatest no. of drinks in single day in the past 30 days	6.32 $\pm$ 3.93	10.42 $\pm$ 5.31	3.86 (2.92, 4.79)***	3.21 (2.28, 4.13)***
No. of days with 5/4 heavy episodic drinking in the past 30 days	2.37 $\pm$ 2.98	5.63 $\pm$ 4.89	3.19 (2.37, 4.00)***	2.64 (1.84, 3.43)***
No. days intoxicated in a typical week	0.38 $\pm$ 0.71	0.91 $\pm$ 0.85	0.46 (0.29, 0.63)***	0.39 (0.22, 0.56)***

<sup>a</sup> Students who reported drinking in the past 30 days only.

<sup>b</sup>  $p$ -value is from comparing AmED vs. non-AmED (reference group) for each drinking behavior (outcome variable).

<sup>c</sup>  $b$  is the regression coefficient of the indicator variable comparing AmED to non-AmED drinkers. Separate linear regression analyses adjusting for: Model 1: age and sex; Model 2: age, sex, and risk taking propensity.

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

\*\*\*  $p < .001$ .

**Table 3**  
Comparison of stimulant drug use between drinkers who mix alcohol and energy drinks and drinkers who do not ( $n = 410$ ).<sup>a</sup>

Stimulant substance, $n$ (%)	Non-AmED, $n = 305$ (74%)	AmED, $n = 105$ (26%)	Adj OR <sup>b</sup> (95% CI) Model 1 <sup>c</sup>	Adj OR <sup>b</sup> (95% CI) Model 2 <sup>c</sup>	Adj OR <sup>b</sup> (95% CI) Model 3 <sup>c</sup>
	Cocaine	8 (2.6)	8 (7.6)	4.71 (1.52, 14.60)**	2.17 (0.61, 7.68)*
Amphetamines (speed, diet pills, ecstasy)	22 (7.2)	21 (20.0)	3.30 (1.69, 6.45)***	1.91 (0.91, 4.03)	1.59 (0.74, 3.44)
Any stimulant drug <sup>d</sup>	24 (7.9)	23 (21.9)	2.86 (1.53, 5.35)**	1.60 (0.80, 3.21)	1.48 (0.71, 3.06)

<sup>a</sup> Students who reported drinking in the past 30 days only

<sup>b</sup> Adjusted Odds Ratio's (OR) from comparing AmED vs non-AmED (referent group) for each stimulant substance use (outcome variable).

<sup>c</sup> Separate logistic regression analyses adjusting for: Model 1: age and sex; Model 2: age, sex, and heavy episodic drinking; Model 3: age, sex, heavy episodic drinking, and risk taking propensity.

<sup>d</sup> Includes cocaine, crack-cocaine, amphetamines and crystal meth use.

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

\*\*\*  $p < .001$ .

consuming more alcoholic beverages on a typical drinking occasion where they were mixing alcohol with energy drinks than on a typical drinking occasion where they were not consuming energy drinks ( $M = 6.5$  drinks,  $SD = 3.56$ , vs.  $M = 5.29$  drinks,  $SD = 5.91$ ,  $t(104) = 3.08$ ,  $p < 0.01$ ). This within subject analysis controls for inherent personality variables, including risk taking propensity.

### 3.4. Stimulant drug use

Our investigation into use of other stimulant drugs identified significant associations between the consumption of AmED and any stimulant drug use (cocaine, crack-cocaine, amphetamines, and crystal meth) after controlling for age and sex (see Table 3). Those who reported consuming AmED engaged in more stimulant drug use in the past 12 months than those who did not report consuming AmED. Specifically, they engaged in more cocaine and amphetamine (speed, diet pills, ecstasy) use. These associations were no longer significant after controlling for heavy episodic drinking and risk taking tendency. There was no sufficient statistical power to investigate group differences in crack-cocaine and crystal meth use due to their low prevalence.

### 3.5. Alcohol mixed with energy drink—related consequences

In multivariate analyses students who reported ever consuming AmED were investigated in order to assess the association between frequency of past 30 day AmED use and negative consequences experienced due to this use. The odds of experiencing one or more negative consequences were 1.89 times for every increased day of AmED use in the past 30 days after controlling of age, sex, heavy

episodic drinking and risk taking propensity (see Table 4). Specifically, after controlling for sex, age, heavy episodic drinking, and risk taking propensity they were more likely to have ridden home with a driver who had been drinking, driven home after drinking, and been hurt or injured. They were not more likely to have been in a verbal fight after controlling for heavy episodic drinking. The rates of other negative consequences measured (i.e. been in a physical fight, required medical treatment, been taken advantage of sexually, and taken advantage of someone else sexually) had low prevalence. As a result, there was no sufficient statistical power to investigate group differences on these variables individually.

## 4. Discussion

Approximately one quarter of university students in the current study reported mixing alcohol with energy drinks in the past 30 days, similar to the prevalence found in previous research conducted at universities in the United States where a greater number and variety of alcoholic energy drinks are available (Miller, 2008a; O'Brian et al., 2008). Those who consumed AmED were more likely to be younger, to live on campus, and to score higher on a measure of risk taking tendency. The higher prevalence of AmED in the younger age groups may point to a cohort specific type of alcoholic beverage consumption. The age differences may also simply indicate the decrease of this type of consumption with age; however, due to the relative recency of this caffeinated alcoholic beverage phenomenon, and the specific marketing strategies of these beverages to youth, a cohort effect is a likely explanation for these differences. In reality, both factors may play a role.

**Table 4**  
Association between frequency of alcohol mixed with energy drink use and negative consequences experienced by alcohol mixed with energy drink users ( $n = 305$ ).<sup>a</sup>

Negative outcome, $M \pm SD$	No. of days using AmED in the past 30 days		Adj OR <sup>b</sup> (95% CI) Model 1 <sup>c</sup>	Adj OR <sup>b</sup> (95% CI) Model 2 <sup>c</sup>	Adj OR <sup>b</sup> (95% CI) Model 3 <sup>c</sup>
	No	Yes			
Rode home with a driver who had been drinking	0.51 $\pm$ 1.15	2.16 $\pm$ 2.57	1.64 (1.30, 2.07)***	1.39 (1.06, 1.83)*	1.36 (1.03, 1.80)*
Driven home after drinking	0.62 $\pm$ 1.40	1.87 $\pm$ 1.92	1.36 (1.10, 1.69)**	1.30 (0.96, 1.77)	1.45 (1.03, 2.05)*
Been in a verbal fight	0.58 $\pm$ 1.34	1.42 $\pm$ 2.05	1.28 (1.07, 1.55)**	1.27 (1.00, 1.62)	1.26 (0.98, 1.61)
Been hurt or injured	0.58 $\pm$ 1.28	2.28 $\pm$ 2.68	1.48 (1.20, 1.83)***	1.40 (1.03, 1.90)*	1.38 (1.02, 1.88)*
One or more negative consequences <sup>d</sup>	0.37 $\pm$ 0.81	1.87 $\pm$ 2.45	2.15 (1.63, 2.83)***	1.87 (1.40, 2.49)***	1.89 (1.42, 2.53)***

<sup>a</sup> Students who reported drinking in the past 30 days and consumed AmED in their lifetime.

<sup>b</sup> Adjusted Odds Ratio's (OR) from comparing frequency of past 30 days AmED use (0 days being the referent group) for each negative consequence (outcome variable).

<sup>c</sup> Separate logistic regression analyses adjusting for: Model 1: age and sex; Model 2: age, sex, and heavy episodic drinking; Model 3: age, sex, heavy episodic drinking, and risk taking propensity.

<sup>d</sup> One or more negative consequences (including the four in the table and being in a physical fight, requiring medical treatment, being taken advantage of sexually, and taking advantage of someone else sexually) vs. 0 consequences.

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

\*\*\*  $p < .001$ .

Unlike previous research we did not find an effect of gender (Miller, 2008a; O'Brian et al., 2008) since we found that females were as likely as males to consume AmED. Students who used AmED were more likely to drink larger amounts of alcohol, and engage in higher risk drinking practices (i.e. heavy episodic drinking), independent of their age, gender, and risk taking tendency, than those who do not consume AmED. Those who consumed AmED were more likely to consume more alcohol on a typical drinking occasion when combining than on a typical drinking occasion when only consuming alcohol, indicating that even when accounting for personality variables, higher risk drinking is occurring when alcohol is combined with energy drinks.

These results are consistent with evidence that caffeine may alter the pattern and intake of alcohol, such as findings indicating that moderate doses of caffeine may enhance ethanol ingestion in rats (Kunin, Gaskin, Rogan, Smith, & Amit, 2000). Suggested reasons for the increased ingestion of alcohol with caffeine may be (1) related to alcohol self-medication in order to attenuate enhanced hyperactivity from caffeine or (2) that caffeine may sensitize one to ethanol's reinforcing effects (Kunin et al., 2000). This association may also be due to the reduced subjective perception of intoxication (Ferreira et al., 2006) after consuming AmED that could result in increased alcohol use as the drinker may believe that they are not that intoxicated and could therefore consume more alcohol. Increased alcohol may also be due to the increased energy, resulting from energy drink consumption, leading to staying awake longer and consuming more alcohol.

Those who used AmED were more likely to consume stimulant drugs in the past year after controlling for age and gender, but not after controlling for heavy episodic drinking. As a result, the association between AmED use and stimulant use may be due to a third variable, such as heavy episodic drinking, where increased alcohol consumption may increase the likelihood of stimulant use and energy drink use. Stimulant users may simply have a preference for various types of stimulants, including energy drinks and illicit stimulant drugs. Using various stimulants may be associated with heavy episodic drinking for multiple reasons such as users' desires to stay awake, feel less intoxicated, and drive home after drinking (Brache, 2009).

More frequent use of AmED in the past 30 days was associated with negative consequences such as being hurt or injured. Participants had 1.36 times the odds of riding home with a driver who had been drinking, and 1.45 times the odds of driving home after drinking, for every increased day of AmED use in the past 30 days after controlling of age, sex, heavy episodic drinking, and risk taking propensity. These clearly risky and concerning behaviors add to the overall depiction of risk associated with AmED use particularly as these relationships continue to be significant after controlling for heavy episodic drinking and risk taking propensity. The increase in likelihood of being in a vehicle with a driver who was intoxicated with more frequent consumption of AmED greatly emphasizes the importance of this variable for future prevention and research efforts. These results are similar to previous research findings (O'Brian et al., 2008) but provide the added benefit of controlling for risk taking tendency. They are consistent with the conclusion that AmED consumption may compromise one's ability to judge intoxication (in other's and oneself) and may overall affect one's ability to gauge risk, resulting in injury and poor judgment.

These results suggest that there is something about the combination of AmED, independent of risk taking tendency, that is associated with heavy drinking and alcohol and energy drink related consequences. These associations may be a result of changes in the drinker's subjective perception of intoxication (Ferreira et al., 2006), where the perception of being less intoxicated may cause them to be more likely to consume more alcohol and engage in risky behaviors such as drinking and driving. Use of stimulant and depressant drugs in combination is common, and has been widely researched, due to the synergistic nature of the effects of combining a stimulant and depressant drug (Brache & Stockwell, 2008). Similar to research on alcohol and other stimulant use

(Brache, 2009), participants may choose to use AmED because it allows them to regulate their experienced high. For example, alcohol consumption may make someone tired, and using energy drinks will give them energy, perhaps to continue drinking socially, or, alcohol makes one drunk, where energy drinks enable a subjective experience of being less intoxicated and more able to function. It should also be noted that our findings support the view that individuals with high risk taking propensity are more likely to both drink alcohol at hazardous levels and to combine this with energy drinks. We are not aware, however, of previous research which has reported significant increases in risky behaviors associated with alcoholic energy drink consumption after controlling for both risk-taking propensity and level of alcohol consumption.

Overall, previous research and the current findings indicate that consuming AmED should be considered "high-risk drinking" for university students and efforts should be made to discourage combined consumption. These efforts could include specific regulation of the sale and promotion of pre-mixed alcoholic energy drinks—and possibly outright prohibition. Such efforts appear to be underway in the United States where health regulators, the Food and Drug Administration, have requested proof of product safety from makers of caffeinated alcoholic beverages (Seetharaman, 2009). Under some pressure, several beverage makers have discontinued their caffeinated alcoholic drink production. Subsequently, the Food and Drug Administration came to a decision that the addition of caffeine to alcoholic beverages is not 'generally recognized as safe' and has warned makers of caffeinated alcoholic beverages that they are in violation if the Federal Food, Drug, and Cosmetic Act (U.S. Food and Drug Administration, 2010). In Canada, new regulatory guidelines imposed by provincial liquor control boards have successfully reduced the caffeine content in pre-mixed alcoholic energy drinks. On the other hand, in British Columbia, Canada, caffeinated alcoholic beverages entered the market in 2007 and sales have continued to rise ever since (BC Liquor Distribution Branch, 2009). In Canada and other countries regulations require warning labels on non-alcoholic energy drinks against combining with alcohol. The European Union requires that energy drinks have warning labels noting "high caffeine content" (Reissig et al., 2009). Norway has limited sales of energy drinks to drug stores and France and Denmark have, at one time, banned the drinks all together (Simon & Mosher, 2007). Despite this, there appears to be continued debate in the European Union on the use of warning labels on energy drinks and the negative effects on health from combining them with alcohol (European Commission, 2010). Although some research to date has investigated the health effects of AmED (Wiklund, Karlsson, Ostrom, & Messner, 2009), most has focused on the physical and health effects of energy drinks alone (Finnegan, 2003; Ragsdale et al., 2010; Steinke, Lanfear, Dhanapal, & Kalus, 2009), therefore, more research should investigate the health effects of AmED consumption. Efforts should also be made to educate alcohol and energy drink consumers about the physical vs. subjective effects of AmED in an attempt to reduce drinking and driving, injury, conflict, and other risk behaviors. The development of prevention measures, such as energy drink awareness programs, is already underway (Dunlap, 2008; Woolsey & Kensinger, 2009). These efforts need to go beyond regulation of alcohol advertising and take into account pricing, distribution, use of social media, and consumer co-creation of brand image (Jones & Barrie, 2009). Finally, advertising for, and free distribution of, energy drinks on campus, which is common in North America, should be reconsidered.

#### 4.1. Limitations

This study used cross-sectional data, which limits our ability to assess causal relationships. The data were self reported and may therefore underestimate the prevalence of more risky or negative behaviors, however efforts were made to minimize this as the survey

was anonymous and web-based so the participants could complete it in private. The sample cannot be ensured to be a random sample due to biases in response to the email and poster recruitment, but the study did permit comparisons between drinkers who did or did not use AmED as well as allowed us to look in depth at drinkers who engaged in both behaviors. Precise prevalence estimates are not possible, but it is encouraging that our prevalence of AmED is similar to that of other studies (Miller, 2008a; O'Brian et al., 2008). Frequency of AmED use was limited to frequency in the past 30 days and lifetime use. This measure was used in order to limit recall bias, but future research should investigate frequency of use over a longer period. The current research only investigated the association between AmED and stimulant drug use due to interest in the combined use of alcohol and various stimulants. Future research should also investigate possible associations between AmED and other drugs. Graduate students were more highly represented in this sample, compared to the university student population, which limits the generalizability of our results. This may have been due to an unintended sampling bias in email recruitment or a bias where underage drinkers could have been less likely to complete the survey. To address the possible differences, age was controlled for in the analyses. Furthermore, the use of multiple recruitment methods with the potential to reach all university students ensured a high degree of heterogeneity of exposure (Rothman & Greenland, 1998) which limited the possibility of significant bias in our analysis of comparisons between the two groups of interest – AmED and non AmED drinkers. The current findings may not be readily generalizable to non-university samples.

Despite being used and validated in other international studies, the intrinsic risk taking measure used in this study may not fully measure intrinsic risk-taking propensity in our Canadian sample, as some of the question may have less relevance to Canadian populations (i.e. Have you ever gone scuba diving?). In addition, the internal consistency of the risk taking scale was relatively low. However, it was similar to previous research using this scale where researchers concluded that the scale appears sound given face validity and results from factor analysis (McLeod et al., 2003). The reliability of the scale is similar to what has previously been reported for other scales attempting to predict risk taking tendency such as the use of Zuckerman's Sensation Seeking scale in college students (Arria et al., 2010, p76). Also, as seen in previous analyses by McLeod et al. (2003), it appears that this scale which measures intrinsic risk taking tendency can be conceptualized as measuring a number of different aspects of this risk taking tendency (i.e. health risk taking and adventurous risk taking). Therefore, it is expected that there may be some degree of heterogeneity among the items contributing to the lower alpha. As a result, a higher alpha may not always be better, particularly when measuring a construct that can be conceptualized as having a number of different aspects (Streiner, 2003). Our current analyses add to the literature by investigating risk taking tendency as a third variable, although, other third variables were not investigated such as inhibitory control and executive functioning. Our analyses are also limited as we used frequency of past 30 day AmED use to predict negative outcomes ever experienced. It is unknown whether the negative outcomes occurred within the same 30-day window as the reported frequency of AmED use. Finally, the low rates of some stimulant substance use and alcohol-related consequences are encouraging, although we were unable to conduct statistical analyses or draw conclusions on these measures. Future research should collect a larger sample in order to increase power and the ability to conduct analyses on these important variables. Future research should also control for drinking setting.

#### 4.2. Conclusions

Mixing alcohol with energy drinks is common in university student drinkers. Students who partake in this drinking behavior are at

increased risk for alcohol and energy drink related consequences, even after adjusting for the amount of alcohol consumed and risk taking tendency. They are also at increased risk of heavy drinking. A range of interventions may be needed to reduce risk in this population, likely including regulatory controls on sale and promotion of AmED. Future research which systematically assesses motives for AmED use will likely inform the development of effective interventions.

#### Role of funding sources

Funding for this study was provided by the Canadian Institute for Health Research–New Emerging Team Grant #33496-53750. The Canadian Institute for Health Research had no role in the study design, collection, analysis or interpretation of the data, writing the manuscript, or the decision to submit a paper for publication. Graduate student funding was provided by Social Sciences and Humanities Research Council, Michael Smith Foundation for Health Research Junior Graduate Studentship #ST-JGS-01209-(07-1)POP, and Intersections of Mental Health Perspectives in Addictions Research Training Fellowship. They had no role in the study design, collection, analysis or interpretation of the data, writing the manuscript, or the decision to submit a paper for publication.

#### Contributors

Ms. Brache and Dr. Stockwell both contributed to the study design, collection, analysis and interpretation of the data, writing the manuscript, and in the decisions to submit the manuscript for publication.

#### Conflict of interest

All authors declare that they have no conflict of interest.

#### References

- Arria, A. M., Caldeira, K. M., Kasperski, S. J., O'Grady, K. E., Vincent, K. B., Griffiths, R. R., et al. (2010). Increased alcohol consumption, nonmedical prescription drug use, and illicit drug use are associated with energy drink consumption among college students. *Journal of Addiction Medicine*, 4(2), 74–80.
- BC Liquor Distribution Branch (2009). *Sales data for alcoholic energy drink "Rockstar with Vodka."*
- Brache, K. (2009). Alcohol and cocaine simultaneous polysubstance use: A qualitative investigation. Masters Thesis. Accessed on April 20, 2010 at <http://hdl.handle.net/1828/1436>.
- Brache, K., & Stockwell, T. (2008). Patterns, settings, and functions of simultaneous use of alcohol and psychostimulants: a literature review. Paper presented at the 34th Annual Alcohol Epidemiology Symposium of the Kettil Bruun Society for Social and Epidemiological Research on Alcohol, Victoria, Canada.
- Cherpitel, C. J. (1999). Substance use, injury, and risk-taking dispositions in the general population. *Alcoholism, Clinical and Experimental Research*, 23(1), 121–126.
- Curry, K., & Stasio, M. J. (2009). The effects of energy drinks alone and with alcohol on neuropsychological functioning. *Human Psychopharmacology*, 24, 473–481.
- Dunlap, L. (2008, March/April). Wake up to the facts: Energy drinks & alcohol don't mix. *The Journal of the Air and Mobility Command's Magazine*, 20–21.
- European Commission (2010). Standing committee on the food chain and animal health section on general food law: Summary of record of meeting of April 26, 2010. Accessed on July 25, 2010 at: [http://ec.europa.eu/food/committees/regulatory/scfcah/general\\_food/sum\\_26042010\\_en.pdf](http://ec.europa.eu/food/committees/regulatory/scfcah/general_food/sum_26042010_en.pdf).
- Ferreira, S. E., de Mello, M. T., Pompeia, S., & de Souza-Formigoni, M. L. O. (2006). Effects of energy drink ingestion on alcohol intoxication. *Alcoholism, Clinical and Experimental Research*, 30(4), 598–605.
- Ferreira, S. E., Quadros, I. M. H., Trindade, A. A., Takahashi, S., Koyama, R. G., II, & Souza-Formigoni, M. L. O. (2004). Can energy drinks reduce the depressor effect of ethanol? An experimental study in mice. *Physiology and Behavior*, 82, 841–847.
- Ferreira, S. E., de Mello, M. T., Rossi, M. V., & Souza-Formigoni, M. L. O. (2004). Does an energy drink modify the effects of alcohol in a maximal effort test? *Alcoholism, Clinical and Experimental Research*, 28(9), 1408–1412.
- Finnegan, D. (2003). The health effects of stimulant drinks. *Nutrition Bulletin*, 28, 147–155.
- Health Canada (2005). Safe use of energy drinks. Accessed on January 27, 2010 at [http://www.hc-sc.gc.ca/hl-vs/alt\\_formats/pacrb-dgapcr/pdf/iyh-vsv/prod/energy-energie-eng.pdf](http://www.hc-sc.gc.ca/hl-vs/alt_formats/pacrb-dgapcr/pdf/iyh-vsv/prod/energy-energie-eng.pdf).
- Jones, S. C., & Barrie, L. (2009). Alcohol-energy drinks: Engaging young consumers in co-creation of alcohol related harm. *Proceedings of the Australian and New Zealand Marketing Academy Conference (ANZMAC)* (pp. 1–8) Accessed on June 14, 2011 from [http://uow.academia.edu/LanceBarrie/Papers/221182/Alcohol-Energy\\_Drinks\\_Engaging\\_Young\\_Consumers\\_In\\_Co-Creation\\_of\\_Alcohol-Related\\_Harm](http://uow.academia.edu/LanceBarrie/Papers/221182/Alcohol-Energy_Drinks_Engaging_Young_Consumers_In_Co-Creation_of_Alcohol-Related_Harm)
- Kunin, D., Gaskin, S., Rogan, F., Smith, B. R., & Amit, Z. (2000). Caffeine promotes ethanol drinking in rats: Examination using a limited-access free choice paradigm. *Alcohol*, 21, 271–277.
- Levy, G., & Tapsell, L. (2007). Shifts in purchasing patterns of non-alcoholic, water-based beverages in Australia, 1997–2006. *Nutrition and Dietetics*, 64, 268–279.
- Malinauskas, B. M., Aeby, V. G., Overton, R. F., Carpenter-Aeby, T., & Barber-Heidal, K. (2007). A survey of energy drink consumption patterns among college students. *Nutrition Journal*, 6(35), 1–7.

- Marczinski, C. A., & Fillmore, M. T. (2006). Clubgoers and their trendy cocktails: Implications of mixing caffeine into alcohol on information processing and subjective reports of intoxication. *Experimental and Clinical Psychopharmacology*, 14(4), 450–458.
- Marczinski, C. A., & Fillmore, M. T. (2003). Dissociative antagonistic effects of caffeine on alcohol-induced impairment of behavioral control. *Experimental and Clinical Psychopharmacology*, 11(3), 228–236.
- McLeod, R., Stockwell, T., Rooney, R., Stevens, M., Phillips, M., & Jelinek, G. (2003). The influence of extrinsic and intrinsic factors on the probability of sustaining an injury. *Accident Analysis and Prevention*, 35, 71–80.
- Miller, K. E. (2008). Wired: Energy drinks, jock identity, masculine norms, and risk taking. *Journal of American College Health*, 56(5), 481–489.
- Miller, K. E. (2008). Energy drinks, race, and problem behaviors among college students. *Journal of Adolescent Health*, 43, 490–497.
- O'Brien, M. C., McCoy, T. P., Rhodes, S. D., Wagoner, A., & Wolfson, M. (2008). Caffeinated cocktails: Energy drink consumption, high-risk drinking, and alcohol-related consequences among college students. *Academic Emergency Medicine*, 15(5), 453–460.
- Oteri, A., Salvo, F., Caputi, A. P., & Calapi, G. (2007). Intake of energy drinks in association with Alcoholic beverages in a cohort of students of the school of medicine of the University of Messina. *Alcoholism, Clinical and Experimental Research*, 31(10), 1677–1680.
- Ragsdale, F. R., Gronli, T. D., Batool, N., Haight, N., Mehaffey, A., McMahon, E. C., et al. (2010). Effect of Red Bull energy drink on cardiovascular and renal function. *Amino Acids*, 38(4), 1193–1200.
- Reissig, C. J., Strain, E. C., & Griffiths, R. R. (2009). Caffeinated energy drinks—A growing problem. *Drug and Alcohol Dependence*, 99, 1–10.
- Rothman, K. J., & Greenland, S. (1998). *Modern epidemiology* (Second Edition). Philadelphia: Lippincott-Raven Publishers.
- Seetharaman, D. (2009). FDA killing buzz on alcohol and energy drinks. *National Post* Accessed on April 18, 2010 at <http://www.nationalpost.com/life/health/story.html?id=ac50aba2-6b6e-4135-a333-cf6ed75cfcdb>.
- Simon, M., & Mosher, J. (2007). Alcohol, energy drinks, and youth: A dangerous mix. *Marin Institute: Alcohol Industry Watchdog*, 1–18.
- Steinke, L., Lanfear, D. E., Dhanapal, V., & Kalus, J. S. (2009). Effect of “Energy Drink” consumption on hemodynamic and electrocardiographic parameters in healthy young adults. *The Annals of Pharmacotherapy*, 43, 596–602.
- Streiner, D. L. (2003). Starting at the beginning: An introduction to coefficient alpha and internal consistency. *Journal of Personality Assessment*, 80(1), 99–103.
- Thombs, D. L., O'Mara, R. J., Tsukamoto, M., Rossheim, M. E., Weiler, R. M., Merves, M. L., et al. (2010). Event-level analyses of energy drink consumption and alcohol intoxication in bar patrons. *Addictive Behaviors*, 35, 325–330.
- Thorson, J. A., & Powell, F. C. (1987). Factor structure of a lethal behaviors scale. *Psychological Reports*, 61, 807–810.
- U.S. Food and Drug Administration (2010, November 17). FDA warning letters issued to four makers of caffeinated alcoholic beverages. *FDA News Release* Retrieved from <http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm234109.htm>.
- Wiklund, U., Karlsson, M., Ostrom, M., & Messner, T. (2009). Influence of energy drinks and alcohol on post-exercise heart rate recovery and heart rate variability. *Clinical Physiological and Functional Imaging*, 29, 74–80.
- Woolsey, C. L., & Kensinger, W. S. (2009). Energy drinks: The new gateway drug. Accessed on January 30, 2010 at: [http://aahperd.confex.com/aahperd/2010/preliminaryprogram/abstract\\_14631.htm](http://aahperd.confex.com/aahperd/2010/preliminaryprogram/abstract_14631.htm).