

The Subjective Physiological, Psychological, and Behavioural Risk-Taking

Consequences of Alcohol and Energy Drink Co-Ingestion

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Abstract

Background: The increasingly popular practice amongst adolescents and young adults of consuming alcohol mixed with energy drinks (AmED) has raised concern regarding potential increases in maladaptive drinking practices, negative psychological and physiological intoxication side-effects, and risky behavioural outcomes. Comparison of user types has revealed that AmED users report engaging in more risk-taking behaviour relative to alcohol users. However, the comparative likelihood of risk-taking according to session type (i.e., AmED versus alcohol session) remains relatively unknown. Thus, the current study was designed with the aim of establishing the subjective physiological, psychological, and behavioural risk-taking outcomes of AmED consumption relative to alcohol consumption for AmED users drawn from the community.

Method: Between May and June 2011, 403 Australians aged 18-35 who had consumed AmED and alcohol only in the preceding six months completed a 10-30 minute online survey about their use of these substances.

Results: Despite participants consuming a significantly greater quantity of alcohol in AmED sessions compared to alcohol sessions, the odds of participants experiencing disinhibition and engaging in 26 risk behaviours were significantly lower during AmED sessions relative to alcohol sessions. Similarly, the odds of experiencing several physiological (i.e., speech and walking difficulties, nausea, and slurred speech) and psychological (i.e., confusion, exhaustion, sadness) sedation outcomes were less during AmED sessions compared to alcohol sessions. However, the odds of enduring physiological (i.e., heart palpitations, sleep difficulties, agitation, tremors, jolt and crash episodes, and increased speech speed) and psychological (i.e., irritability, tension) outcomes potentially related to over-stimulation were significantly greater during AmED sessions than alcohol sessions.

Conclusions: Co-ingestion may provide a double-edged effect. The increased stimulation from energy drinks may negate some intoxication-related sedation side-effects by increasing alertness. However, it could also lead to negative physiological side-effects associated with over-stimulation. Notwithstanding any stimulatory effects of energy drinks, risk and negative effects of excessive alcohol consumption were present in both session types. However, the odds of engaging in risk-taking were less during AmED sessions relative to alcohol sessions. Objective measurement of behavioural risk-taking via laboratory-based measures could confirm the causal relationship between AmED and risk-taking.

Key words: Energy Drink, Alcohol, Caffeine, Risk, Harm

Introduction

Market size demographics and estimates of use indicate increasingly widespread energy drink (ED) consumption, particularly amongst the adolescent and young adult demographic (Heckman et al., 2010; Levy and Tapsell, 2007; Reissig et al., 2009). However, over the last decade a new ED consumption pattern has become increasingly popular: alcohol mixed with ED (AmED). AmED use prevalence estimates have generally been based on regional non-probability sampling of college student populations, with 24% of an American college sample reporting AmED consumption in the preceding month (O'Brien et al., 2008), and 48% of an Italian college student sample reporting lifetime AmED use (Oteri et al., 2007).

The use of AmED may be based on a perceived improvement in alcohol-induced physical and cognitive impairment (Ferreira et al., 2006; Weldy, 2010). The presumed interaction of alcohol and EDs is based on the premise of an antagonistic relationship, whereby the stimulatory nature of the ED is thought to negate alcohol's depressant effects (Ferreira et al., 2006). Objective measurement of AmED's effects on performance generally contradict this hypothesis, with the majority of research yielding no significant reduction of alcohol-induced impairment in performance after co-ingestion relative to alcohol only (Ferreira et al., 2006; Marczynski et al., 2011a; Marczynski et al., 2011b). Only Marczynski et al. (2011a) have reported AmED attenuation of alcohol-induced impairment during measurement of response execution in a Cued Go/No-Go task.

Indeed, research on the subjective psychological, physiological, and behavioural risk-taking outcomes of AmED use present a divergent pattern of alcohol and EDs' interactive effects. Measurement of perceived psychological outcomes has generally been restricted to mood state ratings of stimulation (e.g., 'elated', 'energised') and sedation (e.g., 'down', 'sedated'). However, the lack of significant difference in mood states recorded following

AmED and alcohol ingestion suggest no interactive effect of EDs on alcohol-induced psychological changes (Marczinski et al., 2011a). In contrast, support for EDs' antagonistic effect on alcohol-induced impairment is evident from measurement of perceived physiological side-effects, with participants reporting reduced headache, weakness, and dry mouth sensation intensity after AmED relative to alcohol ingestion (Ferreira et al., 2006). These results suggest that co-ingestion of EDs with alcohol may result in reduced perception of alcohol-induced physiological side-effects, despite generally similar outcomes on objective performance measures.

The discrepancy between objective and subjective measures of intoxication could reflect a reduced ability to accurately detect level of impairment after AmED, which may result in continued consumption of alcohol and/or an increased likelihood of engaging in risk-taking behaviours (O'Brien et al., 2008; Oteri et al., 2007). For example, Canadian college students who identified as ED users reported consuming significantly more alcohol in AmED drinking sessions compared to alcohol sessions (Price et al., 2010; however, note Woolsey et al. (2010) have identified effects in the opposite direction in a study of American college athletes). Additionally, O'Brien et al. (2008) found that American college students who reported using AmED had a significantly higher prevalence of engaging in six alcohol-related consequences, including being taken or taking advantage of another sexually, riding in a vehicle with the driver under the influence of alcohol, or being hurt, injured, or requiring medical treatment.

However, individuals who choose to consume AmED may systematically differ from alcohol users in their level of risk-taking propensity. Thus, although O'Brien et al.'s (2008) findings imply greater risk-taking by AmED users, a causal link between co-ingestion and behavioural outcomes cannot be inferred as reporting was not session-specific (i.e., risk-taking in AmED sessions versus alcohol sessions). However, few researchers have examined

subjective behavioural risk-taking according to session type. This is particularly concerning considering ED marketing and cross-promotional strategies, whereby product branding and extreme sport sponsorship bolsters the adrenaline-charged, thrill-seeking connotations of ED consumption, allowing users to vicariously partake in risky, extreme behaviour through their own consumption (Heckman et al., 2010; Miller, 2008). These ED marketing strategies target a high risk, sensation-seeking demographic. Berger et al. (2011) reported that hazardous alcohol drinkers had almost four-fold increased odds of reporting AmED use relative to nonhazardous drinkers. Similarly, Brache and Stockwell (2011) found in a survey of Canadian college students that frequent AmED consumers had almost twice the odds of driving while intoxicated, being a passenger of an intoxicated driver, or being hurt or injured compared to less frequent AmED consumers after controlling for individual differences (i.e., risk-taking propensity and drinking behaviour). However, a causal relationship between AmED and risk-taking cannot be inferred from these results, as a comparison of risk-taking while under the influence of AmED relative to alcohol only was not undertaken. Field research by Thombs et al. (2010) has showed that bar patrons who have consumed AmED had a four-fold increased likelihood of reporting an intention to drive a motor vehicle while intoxicated than those who had not consumed AmED. Furthermore, Woolsey et al. (2010) found that American college athletes who used AmED were significantly more likely to expect to act aggressively, and drive a motor vehicle during AmED sessions compared to alcohol sessions. However, Woolsey et al. (2010) did not find a significant difference between session types in regards to AmED users' expectation of taking risks and engaging in physical violence.

Thus, the existing research generally suggests that risk-taking related to aggressive behaviour, risky driving practices, and physical injury may be greater in AmED consumers compared to alcohol consumers, and after co-ingestion relative to independent alcohol

consumption. However, the comparative likelihood of risk-taking behaviour by AmED users during alcohol-only and AmED sessions across a broader array of specific risk-behaviours remains relatively unknown. Additionally, the current paucity of data regarding the psychological, physiological, and behavioural risk-taking outcomes of AmED ingestion for other than college student users suggests that this also requires investigation, as alcohol users within this demographic generally display a unique drinking pattern relative to those in the community (Ham and Hope, 2003). As the nature of the outcomes under investigation (e.g., risk-taking behaviours related to sexual practices, illicit drug use, illegal driving practices) may be sensitive for participants and thus subject to under-reporting, a self-administered anonymous web-based survey was proposed to increase the likelihood of accurate reporting (Kreuter et al., 2008). Thus, the aim of the present study was to determine the subjective psychological, physiological, and behavioural risk-taking consequences of AmED and alcohol only ingestion in a sample of AmED users recruited from the community.

Materials and Methods

Participants and Procedure

Between May and July 2011, 1113 participants aged 18 years or older completed a self-administered online Internet-based survey on independent and combined ED and alcohol consumption patterns. Participants were invited to complete the survey regardless of their history of alcohol or ED use and were recruited via posters displayed in the greater Hobart (Tasmania, Australia) area in cafes, bars, nightclubs, and university campuses, as well as media reports and posts on internet forums and social networking sites. Survey completion time was dependent on the participants' history of alcohol and ED use, varying between 10 and 30 minutes. After submitting their responses, participants could redirect to a secure

webpage and enter a prize draw to win an Apple iPad 2. The project was granted ethics approval by the Human Research Ethics (Tasmania) Network.

Following exclusion of data from participants with 50% or more responses missing ($n=3$); those who reported an international residential status ($n=9$); and those outside the age range of the target ED market (18 to 35 years; Heckman et al., 2010) ($n=138$), the full sample comprised 963 Australian males and females aged 18 to 35 years.

Two-fifths (42%) of the full sample were identified as AmED users, as they reported: (i) consuming alcohol and EDs in the same drinking session in the preceding six months, and (ii) typically consuming the two constituents simultaneously (i.e., mixed within a single beverage) rather than successively (i.e., as separate beverages within the one drinking session). As the current analyses were restricted to AmED users, all references to the sample henceforth will refer to this 42% of the sample, that is, AmED users only ($N=403$).

Survey Design and Content

Following an exhaustive review of the literature, potential items and response options were devised based on the literature, standardised questionnaires (i.e, physiological items: visual analogue scales (Ferreira et al., 2006); psychological items: Profile of Mood States (McNair et al., 1971) and Biphasic Alcohol Effects Scale (Martin, 1993)), and extraction of recurrent themes apparent in two 30-minute focus group sessions with six AmED users and four alcohol users aged between 21 and 47 ($M=26.4$; $SD=7.6$). Item refinement was achieved via iterative application of the Question Appraisal System (Willis and Lessler, 1999). The online format of the survey was pilot-tested by three volunteers. The final survey consisted of 303 items assessing (i) patterns of independent and combined ED and alcohol use, (ii) motivations for AmED use, (iii) physiological, psychological, and behavioural outcomes of acute alcohol and AmED intoxication, (iv) licit and illicit drug use, (v) demographics, and

(vi) trait impulsivity. The current analyses were limited to the patterns of independent and combined use, as well as AmED use outcomes.

In relation to the current analyses, participants who identified as AmED users were asked to indicate: (i) the typical frequency of ED, alcohol, and AmED consumption, and (ii) the quantity of alcohol and/or EDs consumed in typical alcohol, ED, and AmED drinking sessions. Participants were then asked to indicate on a 5-point Likert scale (ranging from 'never' to 'all the time') how frequently they had experienced 17 physiological side-effects (e.g., 'I had heart palpitations') and 21 mood states in the previous six months during: (i) AmED drinking sessions and (ii) alcohol drinking sessions. The mood states selected for inclusion represented several themes areas: stimulation (e.g., 'I felt alert'), contentment/sociability (e.g., 'I felt friendly'), sedation (e.g., 'I felt exhausted'), anti-sociability (e.g., 'I felt irritable'), and impulsivity (e.g., 'I felt daring').

Finally, AmED users were asked to report using a dichotomous response format (yes, no) whether they had engaged in 26 risk-behaviours in the preceding six months during: (i) AmED drinking sessions, and (ii) alcohol drinking sessions. Risk behaviours selected represented several theme areas: licit and illicit drug use (e.g., 'I drank more alcohol than I planned to'), sexual practices (e.g., 'I had sex with someone I had only recently met'), motor vehicle behaviour (e.g., 'I did not wear a seatbelt while I/someone else was driving a vehicle'), financial outcomes (e.g., 'I gambled'), aggressive behaviour (e.g., 'I grabbed, pushed, slapped, punched and/or shoved someone'), mental and physical distress, injury, or harm (e.g., 'I acted in a way that resulted in me experiencing humiliation or embarrassment'), and other antisocial behaviour (e.g., 'I was asked to leave or kicked out of a club/bar/pub'). AmED users who endorsed each risk behaviour during an AmED session indicated the degree to which they attributed engagement in the behaviour to ingestion of EDs with alcohol

on a 4-point Likert scale ranging from 'not at all' to 'all'. A copy of the survey can be made available on request from the corresponding author.

Data analysis

Frequencies and means for categorical and continuous demographic data were calculated using SPSS Statistics Version 19 (IBM, Somers, NY). Responses to physiological and psychological AmED and alcohol outcome items were clustered into 'side-effect absent' ('never' and 'less than half the time') and 'side-effect present' ('half the time', 'more than half the time', and 'all the time') to provide 2 x 2 contingency tables (AmED Side-Effect: Present/Absent; Alcohol Side-Effect: Present/Absent). Odds ratios were calculated using Comprehensive Meta-Analysis Version 2 (Biostat, Englewood, NJ) to determine the relative likelihood of each behavioural, psychological and physiological outcome during AmED and alcohol sessions, with alcohol sessions functioning as the reference category. Participants who reported using only AmED in the preceding six months (i.e., no alcohol only sessions) ($n=18$) were excluded from odds ratio analyses. Responses to the AmED session attribution item were grouped into attribution absent ('not at all' and 'somewhat') and attribution present ('mostly' and 'all').

Results

Demographics

The majority of the sample were female (61%), with a mean age of 23.1 years ($SD=3.8$, range 18-35). Participants were relatively well-educated, with reported Year 12 attainment considerably higher than national indicator data (96% and 78% respectively) (Australian Bureau of Statistics, 2011). The majority of participants had completed (52%) or were currently completing (43%) post-secondary school qualification(s) and were engaged in

full-time (39%) or part-time/causal employment involving 30 hours or less of paid work per week (45%).

Alcohol, ED, and AmED Use: Frequency and Quantity

As evident in Figure 1, the frequency of combined ingestion was generally less than independent alcohol and ED ingestion. While AmED was typically ingested on a monthly or less basis, EDs were generally consumed on a weekly to monthly basis and alcohol was generally consumed on a fortnightly to thrice weekly basis.

*** Figure 1 approximately here***

Independent ED use was generally quite judicious, with the majority of participants (85%) reporting typical consumption of one or two EDs per session; only 16% of participants reported consumption in excess of the Australian recommended daily intake guidelines (i.e., maximum consumption of two 250ml ED beverages each containing 80mg caffeine) (Australia New Zealand Food Authority, 2001). Participants reported an average consumption of 2.4 ($SD=1.7$, range=1-10) standard EDs in AmED sessions. While comparison of ED quantities between session type was not possible, a one-sample t -test revealed that the quantity of ED ingested in AmED sessions significantly exceeded the aforementioned recommended daily intake, $t(389)=4.15$, $p<.001$, 95% CI [.19, .52], with 33% reporting typical consumption of three or more EDs during AmED sessions.

The typical number of standard alcoholic drinks was greater in the case of co-ingestion relative to independent ingestion, with a paired samples t -test revealing that a significantly greater quantity of alcohol was consumed in AmED sessions ($M=7.1$, $SD=5.6$) compared to alcohol sessions ($M=6.5$, $SD=4.8$), $t(386)=2.53$, $p=.012$, 95% CI [-1.16, -0.15]. However, these results should be interpreted judiciously as, given the lower frequency of AmED sessions, estimates of alcohol quantities are based on slightly different time reference

periods (i.e., one month reference period for use in alcohol sessions and six month reference period for use in AmED sessions). One-sample *t*-tests revealed that the recommended threshold for alcohol-related injury risk-reduction in a drinking session (i.e., one to four standard drinks) (National Health and Medical Research Council, 2009) was exceeded in alcohol, $t(394)=10.20$, $p<.001$, 95% CI [1.99, 2.94], and AmED sessions, $t(394)=10.94$, $p<.001$, 95% CI [2.51, 3.61], with 61% and 63% of participants consuming five or more drinks per typical alcohol and AmED session respectively.

AmED and Alcohol Behavioural Risk-Taking Outcomes

Table 1 presents the relative likelihood of engagement in risk-behaviours during AmED and alcohol sessions based on the reported intoxicated risk-taking behaviour by participants in the preceding six months. Overall, risk-taking behaviour was higher across all categories in alcohol sessions relative to AmED sessions. This was supported by examination of the odds ratios, which indicated that participants had significantly lower odds of engaging in all 26 risk behaviours in AmED sessions relative to alcohol sessions. However, as evident in Table 1, these results do not imply the complete absence of risk-taking in AmED sessions, with the reported rate of risk-taking by participants during AmED session typically within 25 percentage points of alcohol sessions.

Table 1 also displays the percentage of participants who attributed their engagement in the risk behaviour during an AmED session to consuming EDs with alcohol. Where inferences regarding attributions were not hampered by small sample sizes, less than one-fifth attributed their risk-taking behaviour during AmED sessions as due to co-ingestion of EDs with alcohol.

*** Table 1 approximately here ***

Physiological Outcomes

Physiological outcome data analyses indicated several negative outcomes of AmED consumption potentially associated with EDs' stimulatory properties (Table 2). AmED users recorded six times higher odds of experiencing heart palpitations and four times higher odds of enduring sleep difficulties during AmED sessions relative to alcohol sessions. Heightened stimulation was also evident via significantly increased odds of tremors, general psychomotor agitation, jolt and crash episodes (a period of increased stimulation followed by a sharp, sudden drop in energy), and increased speech speed during AmED sessions relative to alcohol only sessions. However, AmED ingestion also appeared to be associated with some negation of alcohol-induced sedation, as the odds of experiencing nausea, slurred speech, and impairment of walking and vision were significantly less in AmED sessions relative to alcohol sessions.

*** Table 2 approximately here ***

Psychological Outcomes

Similar to physiological outcomes, psychological data analyses yielded contrary outcomes of AmED ingestion relative to alcohol consumption (Table 3). The odds of experiencing stimulatory mood states were significantly higher, and sedation states significantly lower, in AmED sessions relative to alcohol sessions. However, there were significantly higher odds of feeling 'on edge' and irritable, and significantly lower odds of feeling sociable and content, during AmED sessions compared to alcohol sessions. More extreme antisocial moods (i.e., aggression) evidenced equivalent odds across session type. Similarly, feelings of impulsivity and novelty-seeking were generally reported at a consistently high rate regardless of session type. However, AmED users did have significantly lower odds of experiencing disinhibition in AmED sessions relative to alcohol sessions.

*** Table 3 approximately here***

Discussion

The aim of the present study was to determine the subjective psychological, physiological, and behavioural risk-taking consequences of AmED and alcohol ingestion in a sample of AmED users recruited from the community. The results revealed that co-ingestion yielded a double-edged effect in regards to the physical and psychological manifestation of intoxication. In addition to demonstrating lower odds of physiological (e.g., nausea, walking and speech difficulties) and psychological (e.g., confusion, sadness) sedation side-effects, AmED users reported significantly higher odds of experiencing stimulatory mood states, such as increased energy and alertness. Surprisingly, while risk-taking outcomes were present during both session types, the odds of engaging in all assessed risk behaviours were significantly lower during AmED sessions relative to alcohol sessions. While a greater quantity of alcohol was typically consumed in AmED sessions, the difference in quantity was equivalent to approximately half a standard alcoholic drink. Additionally, participants reported significantly lower odds of experiencing disinhibition during AmED sessions. However, co-ingestion was also associated with several negative outcomes potentially related to over-stimulation, as AmED users had significantly higher odds of experiencing negative physiological (e.g., heart palpitations, agitation, tremors, sleep difficulties, jolt and crash episodes) and psychological (e.g., tension, irritability) outcomes.

The existing proposal of increased risk-taking post-AmED consumption was based on the premise that AmED may compromise the accurate assessment of intoxication, consequently resulting in increased alcohol consumption and/or increased engagement in other risk-taking (Ferreira et al., 2006; Weldy, 2010). This hypothesis has gained preliminary support from findings of equivalent impairment on objective measures, despite lower ratings of intoxication on some subjective measures following AmED consumption (Ferreira et al., 2006; Marczinski et al., 2011a; Marczinski et al., 2011b). However, participants in the

current study also reported lower odds of experiencing disinhibition during AmED sessions relative to alcohol sessions. The current behavioural risk-taking outcomes contradict those of Thombs et al. (2010), who found that bar patrons who had consumed AmED were more likely to report an intention to drive intoxicated compared to those who had not consumed AmED. Thombs et al.'s (2010) research has the advantage of increased ecological validity due to the setting for testing. However, inferences regarding risk-taking by AmED users are limited as participants were reporting an intention – an intention which may not necessarily translate into action. The results of the current study are based on retrospective reporting of actual engagement in a range of behaviours which vary in type and level of risk. This element of the design may also explain the inconsistency between the present findings and those of Woolsey et al. (2010), who examined American college athletes' expectancies regarding risk-taking outcomes of AmED and alcohol sessions. Further objective measurement of risk-taking via laboratory-based instruments across a range of dosages which may be consumed in 'real world' scenarios is necessary to explore this tentative hypothesis. Use of psychophysiological measurement techniques (i.e., electroencephalographic measurement) may also clarify the specific cognitive processes impacted by AmED ingestion relative to alcohol only.

However, the increased stimulation and alertness associated with co-ingestion may result in several negative outcomes. While current research now suggests that EDs' performance-enhancing effects cannot be attributed solely to caffeine (Marczinski et al., 2011a; Scholey and Kennedy, 2004), the stimulation-related negative psychological and physiological side-effects reported during AmED sessions are in all likelihood a function of EDs' caffeine content. The increased odds of tension, irritability, tremors, agitation, heart palpitations, sleeping difficulties, and jolt and crash episodes reported by participants during AmED sessions are common side-effects of caffeine overconsumption (Reissig et al., 2009).

This is not to say that the caffeine content of a standard ED will necessarily result in such side-effects. The average ED intake during AmED sessions was significantly higher than the Australian recommended daily intake (Department of Health and Ageing, 2009), with some users reporting consumption of 10 standard EDs per session (equivalent to 800mg caffeine). Investigation of AmED users' knowledge regarding caffeine intoxication side-effects, ED caffeine content, and ED recommended intake may elucidate whether this excess consumption is intentional or prompted by a lack of awareness. If the latter is true, then this may be an important focus of health education interventions.

The results of the present study should be interpreted with caution as the data were self-reported to maintain confidentiality and is thus subject to potential bias, particularly as no 'lie' questions were embedded within the survey to assess the consistency of responses. However, certain considerations were implemented to minimise this bias, including the use of a web-based survey to allow participants to complete the survey independently, collection of non-identifying information to assure anonymity, and entry of contact details for prize draw entry on a secure, independent webpage. An advantage of this study was recruitment beyond the university student population, in that data was also provided by a range of AmED users outside of the university student drinking culture. However, we cannot assume the sample is fully representative of the community, as participants were self-selected in response to recruitment advertisements. Furthermore, examination of the demographic data indicates that the AmED sample primarily consisted of females in their early to middle twenties who had completed further post-secondary qualifications and were employed on a part-time to full-time basis. Longitudinal studies on alcohol use trajectories suggest that a decline in alcohol use becomes apparent by the mid-twenties, when users are generally transitioning into adult roles (e.g., worker, parent, spouse) (Maggs and Schulenberg, 2004). Thus, the current study may have captured predominantly older AmED users in the midst of altering their general

alcohol consumption practices. Closer examination of the sample age composition revealed that only 28% were aged 18 to 20. Thus, whilst the current study provides a picture of AmED use by young Australian adults, more purposive sampling of individuals who have recently reached the legal drinking age limit (18 years in Australia) and who are undergoing the transition from high school to university or workforce may yield divergent findings.

Additionally, there has been limited investigation of adolescent AmED use, despite evidence to suggest the primary ED user type may be shifting to a younger demographic. For example, the proportion of young females aged 14 to 17 among the ED user cohort increased from 9% in 2004 to 16% in 2006 (Levy and Tapsell, 2007). Thus, investigation of AmED use within this age group may be warranted, particularly in light of the later-life impact of alcohol consumption within this critical period (Grant et al., 2006).

In summary, co-ingestion of EDs with alcohol appears to offer a reduction in the experience of sedation outcomes but amplification of adverse stimulation outcomes. The lower odds of disinhibition and behavioural risk-taking in AmED sessions may be attributable to enhanced arousal post-ED consumption, consequently increasing attentional resources for information processing. However, overconsumption of EDs when co-ingesting may counteract any possible benefits of increased stimulation, with increased odds of negative physiological and psychological side-effects potentially related to caffeine intoxication.

References

- Australia New Zealand Food Authority (2001) Inquiry report: Formulated caffeinated beverages, Australia New Zealand Food Authority.
- Australian Bureau of Statistics (2011) Australian Social Trends March 2011: Year 12 Attainment, Australian Bureau of Statistics.
- Berger LK, Fendrich M, Chen HY, Arria AM, Cisler RA (2011) Sociodemographic correlates of energy drink consumption with and without alcohol: results of a community survey. *Addict Behav* 36:516-519.
- Brache K, Stockwell T (2011) Drinking patterns and risk behaviors associated with combined alcohol and energy drink consumption in college drinkers. *Addictive Behaviors* 36:1133-1140.
- Department of Health and Ageing (2009) Australia New Zealand Food Standards Code: Standard 2.6.4 Formulated caffeinated beverages, Department of Health and Ageing.
- Ferreira SE, de Mello MT, Pompeia S, Souza-Formigoni MLO (2006) Effects of energy drink ingestion on alcohol intoxication. *Alcoholism: Clinical and Experimental Research* 30:598-605.
- Grant JD, Scherrer JF, Lynskey MT, Lyons MJ, Eisen SA, Tsuang MT, True WR, Bucholz KK (2006) Adolescent alcohol use is a risk factor for adult alcohol and drug dependence: Evidence from a twin design. *Psychological Medicine* 36:109-118.
- Ham LS, Hope DA (2003) College students and problematic drinking: A review of the literature. *Clinical Psychology Review* 23:719-759.
- Heckman MA, Sherry K, de Mejia EG (2010) Energy drinks: An assessment of their market size, consumer demographics, ingredient profile, functionality, and regulations in the United States. *Comprehensive Reviews in Food Science and Food Safety* 9:303-317.

- Kreuter F, Presser S, Tourangeau R (2008) Social desirability bias in CATI, IVR, and Web surveys: The effects of mode and question sensitivity. *Public Opinion Quarterly* 72:847-865.
- Levy G, Tapsell L (2007) Shifts in purchasing patterns of non-alcoholic, water-based beverages in Australia, 1997-2006. *Nutrition & Dietetics* 64:268-279.
- Maggs JL, Schulenberg JE (2004) Trajectories of alcohol use during the transition to adulthood. *Alcohol Research and Health* 28:195-201.
- Marczinski CA, Fillmore MT, Bardgett ME, Howard MA (2011a) Effect of energy drinks mixed with alcohol on behavioral control: Risks for college students consuming trendy cocktails. *Alcoholism: Clinical and Experimental Research* 35:1282-1292.
- Marczinski CA, Fillmore MT, Henges AL, Ramsey MA, Young CR (2011b) Effects of energy drinks mixed with alcohol on information processing, motor coordination and subjective reports of intoxication. *Experimental and Clinical Psychopharmacology* Advance online publication.
- Martin CS, Earleywin, M., Musty, R. E., Perrine, M. W., & Swift, R. M. (1993) Development and validation of the Biphase Alcohol Effects Scale. *Alcoholism: Clinical and Experimental Research* 17:140-146.
- McNair DM, Lorr M, Droppleman LF (1971) Profile of Mood States (POMS), Multi-Health Systems.
- Miller KE (2008) Wired: Energy drinks, jock identity, masculine norms, and risk taking. *Journal of American College Health* 56:481-489.
- National Health and Medical Research Council (2009) Australian guidelines to reduce health risks from drinking alcohol, National Health and Medical Research Council.

- O'Brien MC, McCoy TP, Rhodes SD, Wagoner A, Wolfson M (2008) Caffeinated cocktails: Energy drink consumption, high-risk driving, and alcohol related consequences among college students. *Academic Emergency Medicine* 15:453-460.
- Oteri A, Salvo F, Caputi AP, Calapai 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* 31:1677-1680.
- Price SR, Hilchey CA, Darredeau C, Fulton HG, Barrett SP (2010) Energy drink co-administration is associated with increased reported alcohol ingestion. *Drug and Alcohol Review* 29:331-333.
- Reissig CJ, Strain EC, Griffiths RR (2009) Caffeinated energy drinks - A growing problem. *Drug and Alcohol Dependence* 99:1-10.
- Scholey AB, Kennedy DO (2004) Cognitive and physiological effects of an "energy drink": An evaluation of the whole drink and of glucose, caffeine and herbal flavouring fractions. *Psychopharmacology* 176:320-330.
- Weldy DL (2010) Risks of alcoholic energy drinks for youth. *Journal of American Board of Family Medicine* 23:555-558.
- Willis GB, Lessler JT (1999) Question Appraisal System, Research Triangle Institute, Rockville MD.
- Woolsey C, Waigandt A, Beck NC (2010) Athletes and energy drinks: Reported risk-taking and consequences from the combined use of alcohol and energy drinks. *Journal of Applied Sport Psychology* 22:65-71.

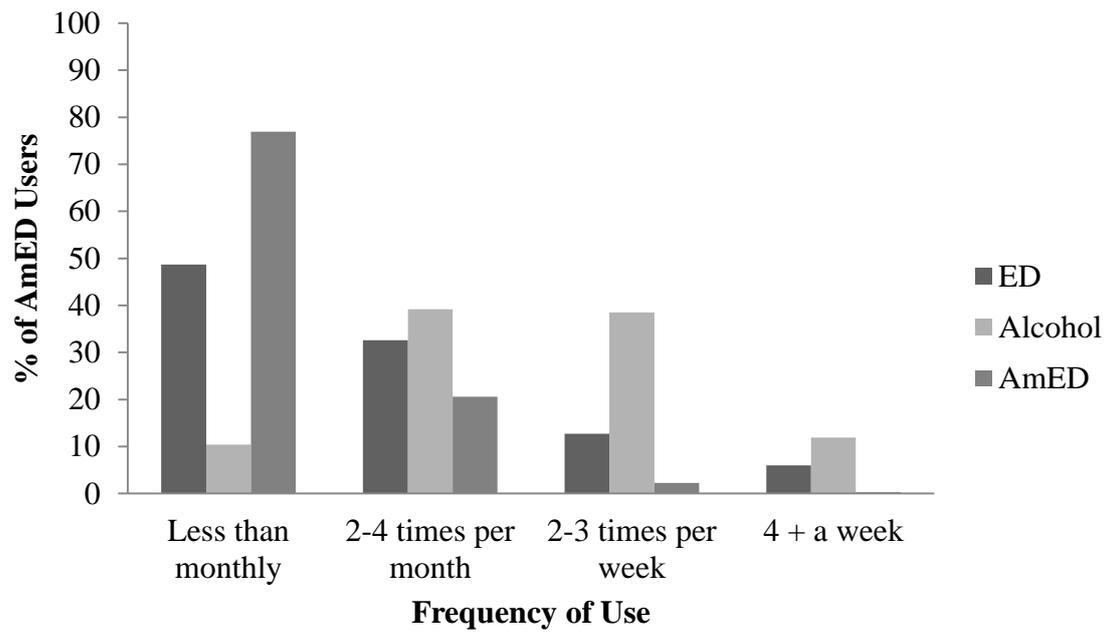


Figure 1. Typical frequency of ED (energy drink), alcohol, and AmED (alcohol mixed with energy drink)

Table 1

Percentage (%) and Odds Ratio for Engagement in Risk Behaviours in AmED Sessions Relative to Alcohol Sessions

Risk Behaviour	<i>N</i>	% Alcohol Session ^a	% AmED Session ^a	Odds Ratio ^b (95% CI)	% Attribute to ED ^c
Licit and illicit drug use:					
Smoked cigarettes	380	45	32	0.59 (0.51, 0.69)***	12
Drank more alcohol than planned	374	75	62	0.54 (0.43, 0.68)***	16
Used legal drugs for recreational purposes	377	14	8	0.56 (0.44, 0.72)***	0
Used illegal drugs	376	29	15	0.42 (0.34, 0.53)***	2
Sexual practices:					
Had sex with someone recently met	374	33	19	0.47 (0.38, 0.58)***	10
Did not use contraception	373	27	16	0.51 (0.41, 0.62)***	5
Was touched in an unwanted sexual way	378	15	7	0.41 (0.29, 0.57)***	#
Touched someone in an unwanted sexual way	380	6	3	0.56 (0.37, 0.85)***	8
Driving behaviour:					
Drove while over legal alcohol limit	375	15	4	0.21 (0.13, 0.34)***	15
Passenger while driver over the legal alcohol limit	370	20	5	0.24 (0.16, 0.36)***	10
Seatbelt omission	378	9	4	0.38 (0.25, 0.58)***	0
In a vehicle with an illegal passenger number	380	25	10	0.34 (0.26, 0.46)***	5
In a vehicle exceeding speed limit by at least 10%	380	8	5	0.58 (0.42, 0.81)**	22
Financial outcomes:					
Spent more money than planned	376	75	59	0.47 (0.37, 0.60)***	15
Gambled	377	24	10	0.34 (0.25, 0.46)***	6
Aggressive behaviour:					
Verbally fought	378	32	16	0.41 (0.33, 0.51)***	5
Physically fought	375	14	8	0.50 (0.38, 0.67)***	15

Mental and physical injury, distress, or harm:					
Acted in a way that resulted in me experiencing guilt	380	49	26	0.36 (0.30, 0.44)***	14
Acted in a way that resulted in me experiencing humiliation	377	46	30	0.51 (0.42, 0.60)***	16
Passed out	380	32	18	0.47 (0.38, 0.59)***	19
Physically hurt or injured	375	27	14	0.46 (0.36, 0.58)***	17
Required emergency medical treatment	379	3	1	0.24 (0.82, 0.73)*	25^
Antisocial behaviour:					
Acted on a dare which could cause harm to myself and/or others	377	15	9	0.53 (0.40, 0.71)***	16
Asked to leave and/or kicked out of a drinking establishment	383	21	11	0.45 (0.34, 0.60)***	0
Vandalised	379	5	2	0.29 (0.13, 0.65)**	67^
Cautioned, restrained, charged, and/or fined by the police	379	4	2	0.37 (0.17, 0.78)*	33^

Note. ^a Indicates the percentage of participants who endorsed the event as present in an alcohol mixed with energy drink (AmED) session/alcohol session; ^b An odds ratio of 1 indicates the event is equiprobable in each session, > 1 indicates the event is more likely to occur in AmED sessions relative to alcohol sessions, and <1 indicates the event is less likely to occur in AmED sessions relative to alcohol sessions; ^c This percentage reflects the number of AmED users who had engaged in the risk behaviour in an AmED session and reported that they attributed 'most' or 'all' of their behaviour to ingesting energy drinks (EDs) with alcohol, compared to those who attribute 'none' or 'some' of their behaviour to co-ingestion; ^ indicates small sample size ($n \leq 10$); # indicates that the attribution item was not measured for this risk behaviour due to the sensitivity of the question; * $p < .050$; ** $p < .010$; *** $p < .001$.

Table 2

*Percentage (%) and Odds Ratio for Physiological Outcomes of Intoxication in AmED**Sessions Relative to Alcohol Sessions*

Physiological Outcome	<i>N</i>	% Alcohol Session ^a	% AmED Session ^a	Odds Ratio ^b (95% CI)
Headache	379	39	38	0.94 (0.80, 1.10)
Heart palpitation	377	6	27	5.79 (3.84, 8.73)***
Dizziness	381	35	34	0.93 (0.81, 1.07)
Tremors	379	10	22	2.48 (1.88, 3.27)***
Nausea	378	32	28	0.82 (0.69, 0.97)*
Vomiting	377	14	13	0.93 (0.74, 1.17)
Increased saliva	350	12	14	1.14 (0.93, 1.39)
Increased sweating	359	16	18	1.15 (0.97, 1.37)
Vision difficulty	369	20	17	0.85 (0.73, 0.99)*
Difficulty breathing	369	4	5	1.32 (0.90, 1.95)
Difficulty walking	376	34	29	0.78 (0.68, 0.90)**
Jolt and crash episode	373	15	22	1.64 (1.29, 2.08)***
Agitation	372	10	19	2.06 (1.54, 2.76)***
Hearing disturbance	375	11	13	1.17 (0.97, 1.41)
Slurred speech	379	31	24	0.68 (0.58, 0.80)***
Increased speed of speech	375	21	26	1.33 (1.11, 1.59)**
Inability to sleep	381	11	34	4.13 (3.08, 5.54)***

Note. ^a Indicates the percentage of participants who endorsed the event as present in an alcohol mixed with energy drink (AmED) session/alcohol session; ^b An odds ratio of 1 indicates the event is equiprobable in each group, > 1 indicates the event is more likely to occur in AmED sessions relative to alcohol sessions, and <1 indicates the event is less likely to occur in AmED sessions relative to alcohol sessions; * $p < .050$, ** $p < .010$, *** $p < .001$.

Table 3

*Percentage (%) and Odds Ratio for Psychological Outcomes of Intoxication in AmED**Sessions Relative to Alcohol Sessions*

Psychological Outcome	<i>N</i>	% Alcohol Session ^a	% AmED Session ^a	Odds Ratio ^b (95% CI)
Stimulatory mood state:				
Alert	365	49	69	2.34 (1.94-2.84)***
Energetic	371	74	83	1.79 (1.42-2.26)***
Stimulated	368	62	70	1.42 (1.22-1.66)***
Active	369	77	80	1.16 (0.99-1.35)
Sedation mood state:				
Confused	372	23	17	0.68 (0.57-0.80)***
Exhausted	373	31	16	0.43 (0.34-0.54)***
Sad	368	10	5	0.53 (0.38-0.74)***
Antisocial mood state:				
On edge	370	9	15	1.73 (1.33-2.24)***
Irritable	372	9	12	1.30 (1.03-1.64)*
Annoyed	371	16	14	0.90 (0.73-1.12)
Aggressive	372	10	12	1.22 (0.95-1.57)
Contentment/sociability mood state:				
Calm	367	65	48	0.50 (0.42, 0.59)***
Carefree	372	82	77	0.73 (0.63, 0.84)***
Outgoing	372	88	85	0.77 (0.63, 0.95)*
Friendly	372	94	90	0.58 (0.44, 0.78)***
Sociable	373	94	91	0.67(0.51, 0.88)**
Impulsive mood state:				
Daring	371	54	54	1.01 (0.93, 1.10)
Adventuresome	369	75	73	0.92 (0.81, 1.04)
Headstrong	364	62	61	0.96 (0.88, 1.03)
Impulsive	372	55	53	0.92 (0.83, 1.01)
Disinhibited	370	64	60	0.83 (0.75, 0.92)**

Note. ^a Indicates the percentage of participants who endorsed the event as present in an AmED session/alcohol session; ^b An odds ratio of 1 indicates the event is equally probable in each group, > 1 indicates the event is more likely to occur in AmED sessions relative to alcohol sessions, and <1 indicates the event is less likely to occur in AmED sessions relative to alcohol sessions; * $p < .050$, ** $p < .010$, *** $p < .001$.