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Nature versus intensity of intoxication: Co-ingestion of alcohol and energy drinks and the effect on objective and subjective intoxication

Jessica Forward[a], Jane Akhurst[a], Raimondo Bruno[a], Xiao Leong[a], Amelia VanderNiet[a], Holly Bromfield[a], Jacqueline Erny[a], Tessa Bellamy[a], Amy Peacock[a,b,*]

[a] School of Medicine (Psychology), University of Tasmania, Private Bag 30, Hobart, TAS 7001, Australia
[b] National Drug and Alcohol Research Centre, University of New South Wales, Randwick, Sydney, NSW 2052, Australia

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ABSTRACT

Background: We report a series of studies examining the effect of alcohol mixed with energy drinks (AmEDs) versus alcohol on objective intoxication (breath alcohol concentration; BrAC), intensity, and nature of intoxication. We also aimed to disentangle the role of energy drink (ED) ingredients in any effects.
Method: Three within-subject double-blind placebo-controlled studies measured BrAC, subjective intoxication and impairment ('intensity of intoxication'), stimulation and sedation ('nature of intoxication') following administration of ED, Cola, Caffeine + Sugar, and Placebo with alcohol (Study 1, n = 18); ED, Caffeine-only, Sugar-only and Placebo with alcohol (Study 2, n = 20); and ED and Placebo with alcohol (Study 3, n = 27).
Results: Significant moderate-to-large magnitude BrAC decrements and delayed time to peak BrAC were observed after ED administration versus Placebo. However, no meaningful BrAC differences between ED and other active conditions were observed in Study 1 and 2. After BrAC adjustment, moderate-to-large magnitude reductions in intoxication and impairment ratings were observed after ED versus Placebo on the ascending limb in all studies and at peak in Study 2 and 3. No meaningful differences were observed in intoxication and impairment ratings between ED and Caffeine + Sugar and Cola conditions (Study 1); ratings were lower after ED versus Sugar-only (Study 2). Stimulation and sedation ratings did not differ between ED and Placebo.
Conclusion: Reductions in objective intoxication and perceived intensity of intoxication, but not nature of intoxication, were observed after AmED consumption. However, effects may be common to alcohol mixers containing sugars (objective intoxication) and caffeine (intensity of intoxication) and specific to a laboratory setting.

1. Introduction

Consumption of alcohol mixed with energy drinks (AmED) is a popular practice among young people (O'Brien et al., 2011; Pennay et al., 2015). However, the stimulant effects of caffeinated energy drinks (EDs) may attenuate the sedative effects of alcohol, masking important intoxication cues (Peacock et al., 2014). It is hypothesised that consumers experience 'wide-awake drunkenness' as a consequence. Specifically, consumers may underestimate the intensity of intoxication despite evidencing similar objective intoxication (i.e., breath alcohol concentration; BrAC) relative to when consuming the same quantity of alcohol alone (Marczinski et al., 2011). This state is thought to lead to negative outcomes, including longer drinking sessions, heavier alcohol consumption and greater risk-taking (Ferreira et al., 2006).

The notion of AmED-induced underestimation of intoxication is cited in most publications regarding this consumption trend. This is despite the majority of experimental studies showing negligible differences in perceived intoxication ratings following AmED versus alcohol-only administration (Alford et al., 2012; Benson and Scholey, 2014; Irwin et al., 2014; Marczinski et al., 2011, 2012, 2013; Peacock et al., 2013b). Two alternative hypotheses are proposed. The first is that co-consumption changes the nature (i.e., experience of stimulation/sedation), as opposed to the intensity, of intoxication (Attwood et al., 2012), based on a growing body of evidence showing increased stimulation post-AmED consumption (Marczinski et al., 2012; Peacock et al., 2013b). The second hypothesis is that EDs may be no different to other alcohol mixers in terms of their core ingredients and how they alter subjective and objective intoxication (Verster and Alford, 2011).

However, the existing literature cannot provide definitive support for these propositions. The aforementioned experimental studies have typically delivered a single low ED dose (250 mL) relative to AmED consumer self-reported intake (500–750 mL), neglecting dose-

* Corresponding author at: National Drug and Alcohol Research Centre, University of New South Wales, Randwick, Sydney 2052, Australia.
E-mail address: Amy.Peacock@utas.edu (A. Peacock).

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dependent changes at real-world consumption levels (Lubman et al., 2013; Peacock et al., 2012). Further, there has been no systematic assessment of the role of ED constituents in objective and subjective intoxication, despite evidence of lower BrAC with higher sugar content (Marczinski and Stamates, 2013). Finally, these studies have typically assessed subjective intoxication on the ascending limb and at peak intoxication, neglecting important changes in subjective intoxication on the descending limb of the BrAC curve (Martin et al., 1993).

Exploration of limb, dose and ingredient-dependent changes in subjective intoxication are critical to enhance methodological rigour in testing these hypotheses, and to increase generalisability of findings to real world consumption. Using doses equivalent to those ingested in real-world contexts and exploring the role of primary psychoactive ED constituents (caffeine and sugar), this series of three studies aimed to provide a body of evidence regarding potential differential effects of AmED versus alcohol on:

1 Objective intoxication (BrAC);
2 Subjective intensity of intoxication; and
3 Subjective nature of intoxication (stimulation and sedation).

2. Study 1: the effects of alcohol mixed with caffeinated drinks on objective and subjective intoxication

2.1. Aim

Study 1 was conceived to study the differences in subjective and objective intoxication after AmED versus alcohol administration by: i.) using a high ED dose (750 mL) to reflect intake in the real world, ii.) looking across ascending and descending limb to reflect the whole intoxication experience, and iii.) including two additional administration conditions (cola and caffeine + sugar with alcohol) to determine whether there were any differences between the complete ED beverage versus various constituents.

2.2. Method

2.2.1. Design and participants

In this double-blind, placebo-controlled, multi-dose within-subjects study, participants (n = 18; 4 female) aged 18–35 years attended four counterbalanced sessions in which they consumed alcohol (target 0.080% BrAC) with i.) ED, ii.) placebo, iii.) caffeine, and iv.) cola. Participants were reimbursed $AUD160.

Participants were recruited via advertisements on university noticeboards and social media. Inclusion criteria included completion of pre-tertiary education (Year 12), normal sleep patterns (≥6 h/night), normal or corrected-to-normal vision, and normal body mass index (18.5–29.9) to minimise changes in absorption rate with body mass (Dubowski, 1985). Participants were regular consumers of EDs (1–30 250 mL EDs in the past month), alcohol (≥two standard drinks per session in the past fortnight), and caffeine (≥five caffeinated drinks in the past week). Exclusion criteria included pregnancy or lactation; history of chronic health, psychiatric or neurological disorders; current psychological distress (Kessler-10 Psychological Distress Scale score ≥30; K10; Kessler et al., 2002); intellectual disorder (Wechsler Test of Adult Reading score < 70; WTAR; Wechsler, 2001); alcohol dependence (Alcohol Use Disorders Identification Test score ≥16; Saunders et al., 1993); weekly or more frequent tobacco use; and past six-month illicit drug use. Participants received $AUD160 reimbursement. Ethics approval was granted by the Tasmanian Health and Medical Human Research Ethics Committee. Participant demographics for each study are available in Appendix 1 in Supplementary material.

2.2.2. Measures and apparatus

2.2.2.1. Alcolizer HH-2. BrAC was monitored using an Alcolizer HH-2, certified to Australian standard AS3547.

2.2.2.2. Subjective effects scale (SES). Participants used 100 mm visual analogue scales with anchors 'not at all' (0) and 'very much' (100) to rate the level to which they perceived themselves to be 'intoxicated' and 'impaired'.

2.2.2.3. Biphasic alcohol effects scale (BAES). The BAES (Martin et al., 1993) consists of 14 items rated on an 11-point Likert scale (anchors 0 'not at all' and 10 'extremely'), scored to create two subscales: 'Stimulation' (e.g., 'energised', 'talkative'), and 'Sedation' (e.g., 'sedated', 'sluggish'). Higher scores indicate greater stimulation/sedation.

2.2.2.4. Beverage rating scale (BRS). The BRS (Fillmore and Vogel-Sprott, 2000) was used to ensure successful blinding of treatment conditions. Participants reported the perceived number of standard alcoholic beverages (unit = 10 g alcohol) and standard EDs (unit = 250 mL containing 80 mg caffeine) consumed, to the nearest 0.5 standard drinks.

2.2.3. Preparation and treatment doses

2.2.3.1. Preparation. Participants attended a 60-min familiarisation session (including briefing and written consent) and four 270-min experimental sessions. Sessions commenced at 9am or 1pm, 4–14 days apart, to ensure task familiarisation and no carryover effects. Participants abstained from alcohol, nicotine, and non-prescription medication for 24 h, caffeinated beverages for eight hours, and food and exercise for four hours prior to sessions, and illicit drugs for the study duration. Given the duration of fasting and testing and to standardised intake, participants ingested a standardised meal (two slices of toast) 60 min before session commencement in line with prior research protocols (9).

2.2.3.2. Treatment doses. Doses comprised a dose of 37.5% a/v Smirnoff Red Label No. 21 vodka mixed with ED, placebo, caffeine, or cola (Table 1). The ED dose (750 mL) contained 240 mg caffeine, 82.5 g sugar, as well as taurine, glucuronolactone, and b-vitamins. The Caffeine + Sugar condition contained only the caffeine (240 mg) and sugar (82.5 g) content of the ED, while the Cola condition (750 mL) contained caffeine (60 mg) and sugar (79.5 g) equivalent to commercial products.

Treatment order was counterbalanced using a completely balanced Latin-square process (Kim and Kim, 2010). Conditions were matched for taste, colour, and smell using sugar-free syrup, using a blinding procedure deemed as effective in previous research and the current study (32; see Appendices 2–4 in Supplementary material for BRS results for each study). Alcohol dose was calculated using the Widmark formula (Dry et al., 2012) to achieve target 0.050% and 0.080% BrAC (Table 1).

2.2.4. Procedure

Baseline testing and a BrAC reading to ensure 0.000% BrAC were completed at session commencement. Treatments were consumed in two doses: one immediately after baseline testing (target 0.050% BrAC), and a second at 60 min post initial beverage administration (target 0.080% BrAC). Participants had 15 min for consumption and 5 min for absorption of each dose. They completed six test batteries from 20 to 190 min post-administration (Fig. 1), including the SES, BAES, BRS, and BrAC measurement. At 120 min, they consumed a light meal and observed a 50-min detoxification period (ending at 170 min). Participants were released after two consecutive readings ≤ 0.030% BrAC.

2.2.5. Analysis

Participant withdrawal from the study resulted in missing data from a single session. Technical malfunction resulted in a further 13 missing BrAC data points and two missing data points for each subjective