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Acute impact of caffeinated alcoholic beverages on cognition: A systematic review

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ABSTRACT

Introduction: Energy drinks are popular beverages that are supposed to counteract sleepiness, increase energy, maintain alertness and reduce symptoms of hangover. Cognitive enhancing seems to be related to many compounds such as caffeine, taurine and vitamins. Currently, users mostly combine psychostimulant effects of energy drinks to counteract sedative effects of alcohol. However, recent literature suggests that this combination conducts to feel less intoxicated but still impaired. The goal of the present article is to review cognitive impact and subjective awareness in case of caffeinated alcoholic beverage (CAB) intoxication.

Method: PubMed (January 1960 to March 2016) database was searched using the following terms: cognitive impairments, alcohol, energy drinks; cognition, alcohol, caffeine.

Results: 99 papers were found but only 12 randomized controlled studies which explored cognitive disorders and subjective awareness associated with acute CAB or AED (alcohol associated with energy drinks) intoxication were included.

Discussion: The present literature review confirmed that energy drinks might counteract some cognitive deficits and adverse effects of alcohol i.e. dry mouth, fatigue, headache, weakness, and perception of intoxication due to alcohol alone. This effect depends on alcohol limb but disappears when the complexity of the task increases, when driving for example. Moreover, studies clearly showed that CAB/AEDs increase impulsivity which conducts to an overconsumption of alcohol and enhanced motivation to drink compared to alcohol alone, potentiating the risk of developing addictive behaviors. This is a huge problem in adolescents with high impulsivity and immature decision making processes.

Conclusion: Although energy drinks counteract some cognitive deficits due to alcohol alone, their association promotes the risk of developing alcohol addiction. As a consequence, it is necessary to better understand the neurobiological mechanisms underlying these interactions in order to better prevent the development of alcohol dependence.

1. Introduction

Energy drinks are popular beverages whose components are supposed to counteract sleepiness, increase energy, maintain alertness and reduce hangover symptoms. Companies claim that energy drinks can improve athletic performance by increasing physical endurance, and intellectual performance by enhancing reaction times, concentration, attention etc. The most common ingredients found in energy drinks are carbohydrates (e.g., glucose), amino acids (e.g., taurine, tyrosine, L-tryptophan, L-arginine, L-theanine), herbal extracts (e.g., guarana, yerba maté, green tea, Gingko biloba, ginseng, St. John's wort), vitamins (e.g., A, B, C, E) minerals (e.g., iron, calcium), and various other nutrients (e.g., carnitine, citicoline, creatine, 1,3-dimethylamylamine, malic acid, vinpocetine, yohimbine). Cognitive enhancement seems to be related to many compounds such as caffeine, taurine and vitamins (Alford et al., 2012; Horne and Reyner, 2001; Howard and Marczinski, 2010; Kennedy and Scholey, 2004; Smit et al., 2004). The literature shows that caffeine actually impacts many cognitive functions, and can

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improve psychomotor speed, serial subtraction, face recognition attention, reaction time, and visual searching (Hewlett and Smith, 2007; Lieberman et al., 2002; Ryan et al., 2002; Scholey and Kennedy, 2004; van Duinen et al., 2005). While students often report consuming around one energy drink per month to increase studying performance (Malinauskas et al., 2007), in reality they mostly use the psychostimulant effects of energy drinks to counteract the sedative effects of alcohol. In Messina, Italy, 56.9% of students reported to consume energy drinks and most of them (48.4%) associate energy drinks with alcohol (Oteri et al., 2007). In the US, many companies sell energy drinks mixed with alcohol. Even if caffeine's psychostimulant effects do counteract the sleepiness induced by alcohol, it is unlikely that they abate other cognitive impairments that result from excessive alcohol consumption. In fact, the literature shows that excessive and repetitive alcohol consumption leads to impairment of executive function, attention and memory (Lawrence et al., 2009a; Moriyama et al., 2002; Pitel et al., 2007, 2008, 2009), while binge drinking in particular is most often the cause of cognitive impairment and brain damage (Smith et al., 2015; Thayanukulvat and Harding, 2015). It is worrisome, then, that in young people binge drinking of alcohol is often associated with the consumption of energy drinks, which can lead to overconsumption of alcohol. As it was reported by Marczinski, when alcoholic beverages are combined with energy drinks, "*you feel less intoxicated but yet, you are still impaired*" (O'Brien et al., 2011). This state was also described by Arria and O'Brien, as a "wide-awake drunkenness" (Arria and O'Brien, 2011). The goal of the present article is to review the cognitive impact of energy drinks and subjective awareness associated with acute caffeinated alcoholic beverage (CAB) intoxication.

2. Method

2.1. Protocol and registration

This systematic review was executed according to the PRISMA guidelines (Moher et al., 2009, 2015).

2.2. Information sources

The PubMed (January 1959 to March 2016) database was searched to identify articles in English or in French assessing cognitive impairments in subjects consuming AED using the following terms: [cognitive impairments or cognition] AND [alcohol] AND [energy drinks or caffeine]. Supplemental references were generated through review of identified literature citations.

2.3. Eligibility criteria

Studies were included if they met the following criteria: (1) clinical studies in adults (2) studies were scientifically peer-reviewed; (3) they employed RCT methods (with no requirement for blinding); (4) subjects were tested with classical and validated cognitive assessments; (5) control conditions were defined as placebo drinks. Papers using only behavioral measures with analog scales were excluded.

2.4. Study selection

A data-base search yielded 91 articles for evaluation and 8 were found by checking the reference lists. After removing duplicates, 72 studies were screened for title or abstract fulfilling the inclusion criteria and 21 were excluded as not matching the study's centers of interest. Among the remaining 51 studies, we excluded case reports, commentaries, abstracts of conference, and interviews (n = 31). Moreover, full-text reports from 8 studies (published from 1959 to 1981, and reviewed in 1988 (Fudin and Nicastro, 1988)) that reported cognitive effects of sequential administration of high dosage of alcohol (from 0.5 to 1 g/kg) followed by high dosage of caffeine (from 0.5 to 1 g/kg) were excluded because (i) these studies were not controlled neither randomized, (ii) they did not include a comparison to placebo, alcohol and caffeinated beverage alone, and (iii) they did not use standard and updated neuropsychological tests. Finally, 12 studies were included in the review, assessing cognitive effects of alcohol caffeinated beverages compared to placebo beverage, caffeinated beverage and alcohol alone (or with a placebo of caffeinated beverage) and subjective awareness associated with acute CAB or AED (Table 1).

3. Results

3.1. Global results

Our review allowed us to make a timeline of the publications which explored cognitive impairments due to combination of caffeine and alcohol and to understand in what kind of context this research takes place. Indeed, the first paper analyzing the cognitive effects of a combination of caffeine and alcohol was published in 1959 (Carpenter, 1959). Eight papers followed in the eighties that examined the ability of caffeine to counteract cognitive decrements due to alcohol intake (Fudin and Nicastro, 1988). All these studies tested cognitive effects of sequential intake of various but high dosages of alcohol followed by high dosages of caffeine (from 200 to 300 mg for 70 kg): alcohol and caffeine intake were separated from 10 min to 2 h in the studies. The cognitive tests were centered on reaction time and attention, two cognitive functions that are of high importance for driving. Indeed, the goal of these studies was to examine the ability of caffeine to counteract the cognitive decrements due to alcohol on the ability of car driving. As mentioned above, we excluded these 8 studies for methodological reasons. Following these initial reports, there was a lack of interest for these questions until 2003, when worries emerged concerning student's use and misuse of energy drinks that were becoming commercially available in association with alcohol. Indeed, young populations use AED for binge drinking, which might impact their risky behaviors and cognitive performances at school, and promote the risk of developing addictive behaviors. Since the eighties, tools in cognition research have improved, and the importance of cognitive impairments in the initiation and the maintenance of addictive behaviors has been well acknowledged (Gould, 2010; Lalanne et al., 2016). Within this line, to examine the cognitive impact of AED on students, authors now use validated and standards neuropsychological tools that were elaborated since the nineties for cognitive examinations, such as the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS, see Randolph et al. (1998); Howieson et al. (2004), the Stroop test (see MacLeod (1991)), the Brief Stop-Signal Task (see Verbruggen and Logan (2008)), or the PRP task (see Pashler (1994); Strauss (2006)), among others. Moreover, these tools are regularly used in neuropsychology to explore the impact of alcohol on cognitive abilities (effect of alcohol on Stroop test, see Hallgren and BS (2013); on BSST, see Lawrence et al. (2009b); on PRP task and Purdue pegboard task, see Breckenridge and Berger (1990)). Finally, the examination of subjective awareness associated with acute CAB or AED was conducted most of the time with validated visual analogue scales (Alford et al., 2012; Marczinski et al., 2012; Bond and Lader, 1974). All the studies we examined in this review were published after 2003 in psychopharmacology journals (6 out of 12) and in alcoholism-related journals (6 out of 12), especially in the "Experimental and Clinical Psychopharmacology" Journal, and in "Alcoholism: Clinical and Experimental Research" Journal.

3.2. Acute impact of energy drinks associated with alcohol on neuropsychological measures

Curry and Stasio conducted a double blind study, in which 27 non-caffeine-deprived participants were randomly assigned to consume either a caffeinated energy drink (i.e. "Green Monster, 160 mg caffeine)