

Acute Effects of Energy Drinks on Behavioural Sanctions in Secondary School Children: A Preliminary Study

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Abstract

A large body of research suggests that diet can exert significant effects on behaviour, mood, and cognition. Of particular concern in recent years has been the rapid rise in popularity of highly caffeinated energy drinks, with some suggesting that they may negatively impact the performance, behaviour and health of schoolchildren. The current study aimed to assess whether these products exert acute effects on the likelihood of children receiving detentions. In addition, another known risk factor, the omission of breakfast, was also recorded. Participants in the current study came from a cohort of 3071 pupils attending three secondary schools in the South West of England. Those who were given a detention during a weeklong period of December 2013 ($N = 40$) were asked to state whether or not they had consumed an energy drink and eaten breakfast that day. The results were then compared to a control day later in the same week on which detentions had not been received. The children given detention were found to be more likely to habitually consume energy drinks and skip breakfast than other children in the cohort from which they came. The major difference between detention and control days was that on detention days there was an increase in both missing breakfast and consuming energy drinks. Though conclusions must be tentative due to the preliminary nature of the study, the results indicate that breakfast intervention programmes and restricting energy drink consumption may be effective methods for reducing problem behaviour in secondary schools.

Keywords: adolescent behavior, breakfast, caffeine, diet, diet and behaviour scale, energy drinks, nutrition, school meals

1. Introduction

The increasing popularity of highly caffeinated energy drinks in recent years has become a public health issue (Reissig, Strain, & Griffiths, 2009). Due to claims of boosting performance and endurance (Meadows-Oliver & Ryan-Krause, 2007) through positively affecting bodily functions, energy drinks are often marketed as 'functional foods' or dietary supplements (Finnegan, 2003), therefore bypassing legislation regarding caffeine content (McCusker, Goldberger, & Cone, 2006; Pomeranz, 2012). This could lead to problems, as large doses of caffeine (reportedly sometimes as high as 505mg per serving; Reissig et al., 2009) can put consumers at risk of intoxication (Seifert, Schaechter, Hershorin, & Lipschultz, 2011). In addition to this, energy drinks frequently contain a number of other, often under-studied and unregulated, ingredients that may be of potential harm.

The use of energy drinks has been associated with a number of short term benefits, such as improvements in aerobic endurance, anaerobic performance, reaction time, concentration and memory (Alford, Cox, & Westcott, 2001; Scholey & Kennedy, 2004), as well as reductions in driver sleepiness (Horne & Reyner, 2001; Mets et al., 2011; Reyner & Horne, 2002). McLellan and Lieberman (2012), however, have concluded that there is little evidence to attribute such effects to any contents other than caffeine. Regardless of what the causes of such positive effects may be, energy drink consumption has also been associated with serious health complaints, such as arrhythmias, tachycardia, strokes, psychotic symptoms/mania, seizures, and even death (Seifert et al., 2011).

Though serious adverse reactions to energy drinks are likely to be the result of extreme caffeine sensitivity and

overdose, it is important to consider that these products are often aggressively marketed at the young consumer (Reissig et al., 2009). Children aged 12-17 years make up the fastest growing population of caffeine users (Frary, Johnson, & Wang, 2005), with 30-50% of adolescents and young adults now being known to consume energy drinks (Seifert et al., 2011). This dangerous combination of highly caffeinated products and at-risk consumers is therefore of serious concern, and a topic which has so far received little attention (Smith, 2013).

Though a study of US college students (Malinauskas, Aeby, Overton, Carpenter-Aeby, & Barber-Heidal, 2007) found that 67% of participants consumed energy drinks to combat the effects of insufficient sleep, their use has also been associated with sleep problems themselves (e.g. daytime sleepiness and weekly 'jolt and crash' episodes; Kristjánsson, Sigfúsdóttir, Allegrante, & James, 2011; Malinauskas et al., 2007). Using structural equation modelling, James, Kristjánsson, and Sigfúsdóttir (2011) investigated the effects of caffeine, along with nicotine and alcohol, on academic performance in a large-scale study of Icelandic schoolchildren ($N = 7377$). A strong inverse relationship between caffeine use and academic attainment emerged, 32% of which was explained by mediating effects of daytime sleepiness and other licit substance use.

A pilot study of secondary school pupils from the South West of England aimed to investigate whether certain dietary practices are associated with disruptive in-class behaviour. The study determined that 1) children from disadvantaged backgrounds had relatively poor diets, consuming large quantities of high fat and high sugar foods, 2) pupils with high intakes of sugar throughout the day, those who consumed energy drinks, and those who did not regularly eat breakfast were more likely to behave poorly during school hours, and 3) those from higher socioeconomic backgrounds who ate good quality diets but also consumed energy drinks, behaved more poorly than similar children who did not consume energy drinks (N. Millward, personal communication, January, 2012).

So why do some schoolchildren choose to consume energy drinks? The findings of a qualitative focus group study of 12-15 year old Australians (Costa, Hayley, & Miller, 2014) suggest that adolescents use energy drinks for three main reasons: enjoyment, function, and social. The functional reasons cited were typically to relieve the effects of fatigue and tiredness. Specific examples for this included the need to stay awake when tired, and to help wake up in the morning after a late night. Coupling these observations with the finding of Calamaro, Mason, and Ratcliffe (2009), that children sometimes use caffeinated products to remain awake at night whilst using media-related technology, it may therefore be that energy drinks are used to help stay up late, leading to insufficient sleep, and that in turn this causes the child difficulties in waking up in time for school the next morning. This could then lead to breakfast being skipped, and further energy drinks being consumed as a substitute that can help increase alertness. If energy drinks are indeed sometimes used as a substitute for breakfast then it is considered important to also evaluate the behavioural effects of breakfast itself.

Eating breakfast has been associated with a number of acute benefits, such as improved mood, calmness, short-term recognition, spatial memory, free recall, and auditory attention (Mahoney, Taylor, Kanarek, & Samuel, 2005; Smith, Clark, & Gallagher, 1999; Smith, Kendrick, & Maben, 1992; Smith, Kendrick, Maben, & Salmon, 1994). Breakfast intervention programmes have also been demonstrated to improve academic performance (Rampersaud, Pereira, Girard, Adams, & Metz, 2005), school attendance (Huang, Lee, & Shanklin, 2006; Powell, Walker, Chang, & Grantham-McGregor, 1998), and psychosocial functioning (Murphy et al., 1998).

In order to address concerns that energy drink use may exert acute effects on problem behaviour, the current study investigated whether secondary school children in detention are more likely to have consumed an energy drink that day compared to a control day later in the same week. In addition to this, the study examined whether missing breakfast would be associated with more behavioural problems, and whether effects of this and consuming energy drinks would be additive. To assess whether such effects are related to insufficient sleep, associations between energy drink usage and average number of sleep hours were investigated in the cohort of schoolchildren that the detentions subsample came from.

2. Method

2.1 Participants

Forty secondary school children from three academies in the South West of England took part in the current study (Academy 1 $N = 20$, Academy 2 $N = 9$, Academy 3 $N = 11$). Several participants were given more than one detention within the same week (eight were given detention twice, one was given three detentions), and only data relating to the first detentions are included in the dataset. Thirty-five of the 40 participants were male, five were female, and an age range of 11-16 years was observed ($M = 13.53$, $SD = 1.19$). All participants were sourced from a cohort of 3071 secondary school pupils described elsewhere (see Richards, Malthouse, & Smith, 2015). Data relating to the rest of this sample are therefore used in the current paper to investigate how representative those who received a detention were of the larger population from which they came.

2.2 Materials & Apparatus

A short questionnaire was used to record whether or not participants had consumed an energy drink and eaten breakfast that day. Both questions were answered by ticking a box to indicate 'yes' or 'no'.

The Diet and Behaviour Scale (DABS; Richards et al., 2015) is a 29-item questionnaire designed to record the recent consumption of common foods and drinks. Eighteen items ask participants to state the frequency by which they consumed certain products, over the previous six months, on a five-point ordinal scale (1 = never, 2 = once a month, 3 = once or twice a week, 4 = most days [3-6], 5 = every day). The remaining 11 items are used to measure the amount by which certain food and drink products are consumed (either per week or per day). This measure, along with a question asking participants to state how many hours they typically spent asleep each night, had previously been administered to the participants as part of a larger study of the cohort from which they came (see Richards et al., 2015). Twenty-five of the 40 participants had responded to the measures in the earlier study, so these data are used here to provide an indication of the typical patterns of sleep, breakfast and energy drink consumption found in the detentions subsample.

2.3 Design

The current study utilised a within subjects design. The dependent variables were the consumption of energy drinks and breakfast, and the independent variable was the day on which the participants responded (either the day they received a detention or the control day on which they did not).

2.4 Procedure

All pupils from three academies in the South West of England who were given a detention during a weeklong period of December 2013 were asked by their schoolteachers to state whether or not they had consumed an energy drink and eaten breakfast that day. These pupils were then followed-up on a separate day later in the same week (on which they did not receive a detention) to answer the same questions again. Data relating to participants' backgrounds and school performance were subsequently collected through the School Information Management System and stored in an anonymised database at Cardiff University. This information included the participants' age, sex, academy attended, school year, ethnicity, school attendance, whether or not they were cared for by a non-parental guardian, the presence/absence of a special educational needs status, the eligibility/ineligibility to receive free school meals, the number of behavioural sanctions incurred throughout the school year, and their attainment at Key Stage 3/Key Stage 4 English and mathematics. Cardiff University's School of Psychology Ethics Committee granted ethical clearance, and informed consent was acquired from all participants prior to collection of data.

3. Results

3.1 Characteristics of the Sample

The forty pupils who received a detention during the week of data collection came from a large cohort ($N = 3071$) of secondary school pupils. It was found that the academy and school year that the pupils came from were related to their likelihood of receiving a detention. Significantly more than expected came from Academy 1, and significantly fewer than expected came from Academy 2, $\chi^2(2, N = 3071) = 9.194, p = .01$; more than expected came from Year 9, and fewer than expected came from Year 11, $\chi^2(4, N = 3040) = 12.867, p = .012$. Those who received detentions were also more likely to be male, $\chi^2(1, N = 3040) = 21.471, p < .001$, to be eligible to receive free school meals, $\chi^2(1, N = 3040) = 10.308, p = .001$, to have a special educational needs status, $\chi^2(1, N = 3068) = 26.19, p < .001$, and to not be White, $\chi^2(1, N = 3021) = 7.98, p = .005$. Furthermore, pupils in detention were significantly more likely to achieve below average school attendance, $\chi^2(1, N = 3040) = 4.947, p = .026$, and attainment at Key Stage 3/Key Stage 4 English, $\chi^2(1, N = 2941) = 15.818, p < .001$, and mathematics, $\chi^2(1, N = 2960) = 5.594, p = .018$. As would be expected, the sample of pupils in detention during the week of data collection were also found to receive more behavioural sanctions than average throughout the course of the school year, $\chi^2(1, N = 3040) = 87.624, p < .001$.

3.2 Detentions, Energy Drinks, and Breakfast Consumption

The mean number of energy drinks consumed per week was 2.67 ($SD = 5.11$) in the detention subsample and .97 ($SD = 1.88$) in the rest of the cohort. It should at this point be noted that response rates to these measures were relatively low in the detention subsample. This is likely because these data were collected at a different time from the detention/control days, and, as previously mentioned, those in the detention subsample achieved significantly lower school attendance than those from the rest of their cohort.

The frequency of consumption measures for breakfast and energy drinks were recoded into dichotomous

variables. Breakfast frequency was recoded as sometimes vs. never (answers 2, 3, 4, and 5 vs. answer 1), and energy drink consumption was recoded into three times per week or more vs. two times per week or less (answers 4, and 5, vs. answers 1, 2, and 3). Compared to the rest of the cohort, those in detention were significantly more likely to never eat breakfast, $\chi^2(1, N = 2022) = 7.717, p = .005$, and to consume energy drinks three times a week or more, $\chi^2(1, N = 2004) = 14.173, p < .001$. Though there was no relationship observed between energy drink consumption and sleep hours in the detention subsample, $\chi^2(1, N = 23) = .212, p = .645$, analysis of the rest of the cohort showed that those who consumed energy drinks three times per week or more were significantly more likely to achieve fewer than nine hours of sleep per night, $\chi^2(1, N = 1899) = 17.804, p < .001$. For the frequency of breakfast and energy drink consumption and the number of sleep hours for the detention subsample and the cohort as a whole, see Table 1.

3.3 Detention and Control Day Consumption

In order to examine the combined effects of breakfast and energy drink consumption, participants were organised into four groups: 1) breakfast/no energy drink, 2) breakfast/energy drink, 3) no breakfast/no energy drink, 4) no breakfast/energy drink. For distributions of these four groups on the detention day and control day, see Figure 1. An exact McNemar's test ($p = .006$) demonstrated that not eating breakfast combined with the consumption of an energy drink was significantly associated with being in detention.

Table 1. Frequency of breakfast and energy drink consumption and average number of sleep hours for the detention subsample and the rest of the cohort

		Detentions subsample		Rest of cohort	
		<i>N</i>	%	<i>N</i>	%
Breakfast	Never	6	24%	167	8.4%
	Once a month	0	0%	95	4.8%
	Once or twice a week	4	16%	313	15.7%
	Most days (3-6)	4	16%	413	20.7%
	Every day	11	44%	1009	50.5%
Energy drinks	Never	9	39.1%	874	44.1%
	Once a month	4	17.4%	576	29.1%
	Once or twice a week	2	8.7%	325	16.4%
	Most days (3-6)	5	21.7%	152	7.7%
	Every day	3	13%	54	2.7%
Sleep	< 7 hours	3	12%	147	7.7%
	7 hours	2	8%	207	10.8%
	8 hours	6	24%	518	26.9%
	9 hours	6	24%	520	27%
	10 hours	4	16%	378	19.7%
	> 10 hours	4	16%	153	7.9%

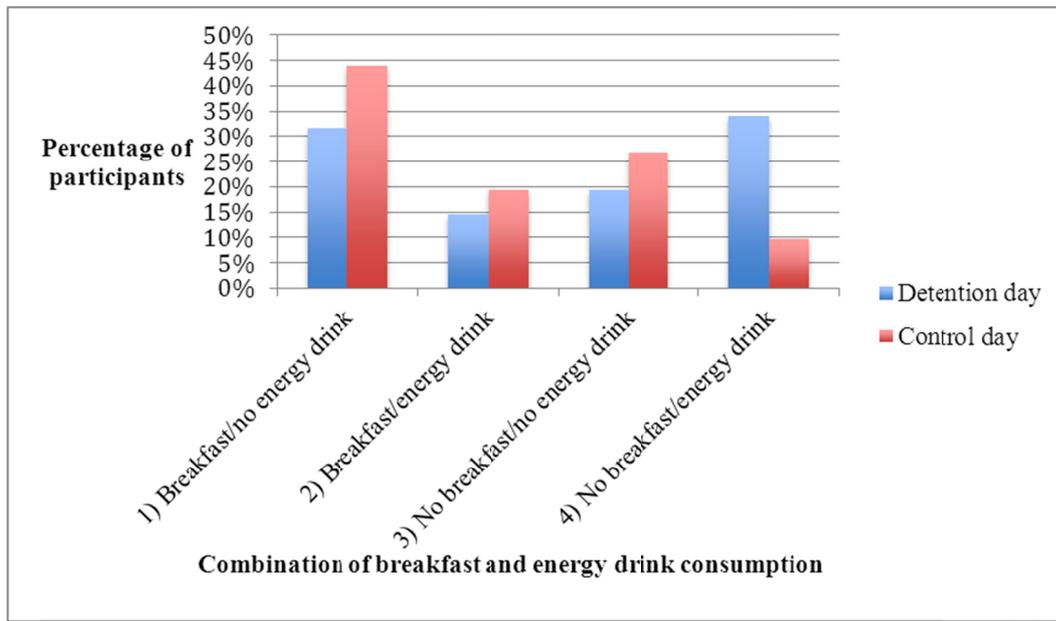


Figure 1. Distribution of breakfast and energy drink consumption combinations on the detention day and control day

4. Discussion

The current study set out to assess whether consuming energy drinks can exert acute effects on problem behaviour in the school environment. In order to investigate this, all children from three academies in the South West of England who were given a detention during a weeklong period of December 2013 were asked to state whether or not they had consumed an energy drink that day. In addition, the consumption/omission of breakfast was also recorded. The pupils were then followed-up and asked the same questions on a control day in which they had not received a detention.

When in detention, pupils were significantly more likely to have consumed an energy drink compared to on the control day. Being that it appears to be the main psychoactive component (McLellan & Lieberman, 2012), caffeine may be responsible, at least in part, for behavioural changes that lead to disruptive and problematic incidents resulting in detention. However, as caffeine is also known to have acute positive effects on attention and memory (Smith, 2002), it may be that the consumption of energy drinks actually increases as a direct compensation for having skipped breakfast. This idea is supported by the observation that breakfast omission combined with energy drink consumption was significantly more frequent on detention than control days. Equally, missing breakfast may also be the result of waking up late due to insufficient sleep. Subsequent energy drink consumption might therefore reflect a compensatory effect for having achieving poor sleep, an idea supported by the fact that frequent energy drink use in the cohort that the detentions subsample came from was associated with below average sleep hours.

Previous research has generally demonstrated that eating breakfast exerts positive effects on memory and attention (Cooper, Bandelow, & Nevill, 2011; Pivik, Tennal, Chapman, & Gu, 2012; Wesnes, Pincock, Richardson, Helm, & Hails, 2003; Wesnes, Pincock, & Scholey, 2012; Widenhorn-Müller, Hille, Klenk, & Weiland, 2008). It may therefore be proposed that breakfast omission can lead to behavioural problems caused by a reduced capacity to attend during class, and possibly also due to pupils getting off-task through inability to retain relevant information. Such cognitive effects of breakfast consumption/omission might therefore partly explain the efficacy of breakfast intervention programmes in improving academic performance (Rampersaud et al., 2005) and psychosocial functioning (Murphy et al., 1998). Considering the observation of James et al. (2011) that academic performance is inversely related to caffeine consumption, and that this relationship is mediated by daytime sleepiness, the following cycle can be proposed to explain the relationships observed between missing breakfast, consuming energy drinks, and receiving detentions: 1) poor sleep leads to inability to wake up with sufficient time to eat breakfast, 2) energy drinks are consumed as a compensation for missing breakfast, and as a means to remain awake at school, 3) behavioural problems occur due to daytime sleepiness and inability to pay attention and retain information during class, 4) high caffeine intake causes sleep disturbances the following night, 5) the sequence is repeated. Furthermore, if energy drinks are indeed sometimes consumed as a substitute

for breakfast, it is considered likely that the effects encountered will be stronger due to consumption occurring on an empty stomach.

Although the results suggest that energy drink consumption takes place in the mornings to counteract the effects of poor sleep and breakfast omission, the results can only be considered correlational rather than causal. It could be, for instance, that energy drink consumption at night causes sleep disturbances, which are in turn responsible for behavioural problems observed the following day. Support for this idea is provided by Calamaro et al. (2009), who observed that middle school and high school children often use caffeinated products to stay awake into the night when using media-related technology, inevitably resulting in sleep loss. This study also reported that 33% of teenagers admitted to having fallen asleep at school, and that the caffeine consumption of these individuals was 76% higher than that of those who did not fall asleep at school. Due to such findings, research into the timing, as well as the frequency, of energy drink consumption is necessary in order to better understand the relationships observed in the current study.

It should at this point be reiterated that the present study is necessarily preliminary in nature, and aims to form the basis for further research. Some methodological weaknesses therefore need to be acknowledged, and should be taken into account when interpreting the findings. Firstly, the study is limited as the sample size is relatively small. However, from three academies, together consisting of 3071 pupils, it was realistically unfeasible to acquire more data during a weeklong period of collection. Furthermore, as made obvious by the fact that 22.5% of the sample received more than one detention during this week, it is highly likely that further data collection would have yielded considerable amounts of data from these same individuals.

Another issue encountered is that the detention sample population cannot be deemed fully representative of the schools from which it came. However, intuition would deem this to be expected. Variation in the amount of detentions accrued by each academy and school year are likely to reflect different policies and teaching styles, and sex differences in problem behaviour are already well established in the literature (e.g. Lahey et al., 2000). What is of greater interest to the current study is that children receiving free school meals (a proxy indication of socioeconomic status; Shuttleworth, 1995), those with special educational needs, and those that were not White, were more likely to receive detentions. Although low socioeconomic status and special educational needs are already known to be indicators of problem school behaviour, given that the current study utilised a within-subjects design it is considered that, though the detentions subsample may have been at greater risk in the first place, these were not the only factors in play. What is possible therefore is that those receiving detentions in the current study represent a subgroup of children who exert antecedents of problem behaviour, and that the omission of breakfast and consumption of energy drinks can act as a catalyst for its manifestation.

Though the current study found that consuming energy drinks three times per week or more was associated with fewer than nine hours of sleep in the rest of the cohort, no such association was observed within the detentions subsample itself. A potential reason for this is that the instrument used to measure sleep duration may not have been sensitive enough. It is noted, for instance, that the study by James et al. (2011) used Chan et al.'s (2009) modified version of the Epworth Sleepiness Scale, an eight-item questionnaire to assess daytime sleepiness, whereas the current study used a single item to measure the average number of hours slept per night. Not only is the scale used by James et al. (2011) likely to be more sensitive, but it is in fact also used to measure a different, though related, concept: daytime sleepiness rather than average sleep hours. It is therefore proposed that future work examining links between energy drink usage and problem behaviour should investigate the effects of sleep in greater detail, as well as assess whether acute sleep loss can lead to subsequent behavioural problems.

A further methodological weakness of the current study is that the design did not allow for the use of a placebo control. In addition to this, the control condition (i.e. the day on which pupils did not receive detention) was preceded by the experimental condition (i.e. the day on which pupils did receive detention). It is therefore possible that pupils may have changed their in-class behaviour and/or dietary practices due to having been questioned by their teachers about their consumption of breakfast and energy drinks on the day that they received detention. As the design of the study could not accommodate double-blinding procedures, it is also possible that teachers may have acted differently towards pupils after knowing that they were enrolled in the study. This could potentially have altered the pupils' chances of receiving another detention later that week.

Due to the limitations encountered, it is proposed that future research should investigate energy drink use and problem behaviour longitudinally, and in a larger population. It may be, for instance, that energy drinks exert long-term consequences as well as those acute effects observed in the current study. Another possibility is that energy drink use exacerbates problem behaviour in an already at-risk subgroup of the population, but might otherwise be relatively harmless. If further research can demonstrate energy drinks to be a consistent predictor of

disruptive behaviour, within this sensitive subgroup or the school population as a whole, intervention programmes may be posited.

5. Conclusions

The current study provides preliminary evidence to suggest that the omission of breakfast in combination with consuming energy drinks may exert an acute effect on the likelihood of secondary school children receiving detentions, and that this dietary behavioural pattern might be encouraged by failure to achieve sufficient sleep. Though the sample was not fully representative of the schools from which it came, utilising a within-subjects design controlled for the issue. As the children in detention were also found to underperform regarding school attendance, attainment, and behavioural sanctions throughout the rest of the school year, it is considered plausible that they represent a subgroup of problem children whose disruptive in-class behaviour is likely to reoccur. However, due to methodological limitations, such as the study design not permitting the use of a placebo control or double-blinding procedures, the conclusions must remain tentative. The current study therefore aims to provide the basis for future work in the area, with larger-scale longitudinal studies into the relationships between energy drink consumption, breakfast omission, sleep, and problem behaviour being required in order for firm conclusions to be drawn.

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