Impact of caffeine and information relating to caffeine on young adults' liking, healthiness perception and intended use of model energy drinks

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Abstract

Caffeine is added to energy drinks to boost energy levels however, there is little information on its impact on taste, healthiness image and how it impacts on intended use. The aim of this project was to understand the impact of caffeine and information relating to caffeine on young adults' perception of model energy drinks. A consumer panel of 107 young adults was recruited to assess one caffeinated and one caffeine free model drink in blind condition (no information about the presence of caffeine) and informed condition (with appropriate information about whether the drink contained caffeine or not). Energy drinks only contributed 5.2% to the participants' overall caffeine intake behind coffee and tea and their consumption appeared to be irregular rather than habitual. Caffeine in concentrations found in energy drinks could be detected by consumers and both caffeine presence and caffeine information had a small but significant detrimental effect on overall liking and liking of the bitterness level. Information relating to caffeine presence significantly decreased healthiness perception; however, it had a minimum impact on intended use. The most popular intended use for both the caffeine free and caffeinated model energy drinks was with alcohol.

Key words: sensory; alcohol; bitterness; sweetness

1. Introduction

There has recently been a lot of interest in the impact of energy drinks on teenagers and young adults (BBC News 2018a, 2018b, 2019), however, very little is known about the impact of the key ingredient of concern (caffeine) on taste and intended use. The aim of this study was to explore the role of caffeine on young adults' perception of model energy drinks.

In the European Union (EU), there is a statutory requirement to provide the warning "High caffeine content. Not recommended for children or pregnant or breast-feeding women" on drinks containing more than 150 mg/L (0.77 mmol/L) of caffeine. Recently, the UK Department of Health and Social Care launched a consultation on the ban of energy drink sales to children (Department of Health & Social Care, 2018). The Royal College of Paediatrics and Child Health's response has been to support the restriction of energy drink sales to under 16s (Viner, 2018). In the UK, the average caffeine concentration in energy drinks has remained fairly constant between 2015 and 2017 at around 310-320 mg/L (Hashem, He, & MacGregor, 2017) with cans typically containing 80 mg of caffeine; however, with the rapid growth in the caffeinated energy drink sales despite the recent introduction of the sugar levy in the United Kingdom (UK) (Mintel, 2019), there has been a lot of interest in their potential effects on health (Al-Shaar et al., 2017; Reissig, Strain, & Griffiths, 2009) including reviews of caffeine safety intake levels (EFSA, 2015a; EFSA, 2015b). It is estimated that in the EU, 68% of adolescents consume at least one energy drink per year, 12% of whom drinking 4-5 energy drinks per week or more (Zucconi et al., 2013). Energy drinks were found to be the 3rd source of caffeine intake after coffee and tea in Dutch students (Mackus, van de Loo, Benson, Scholey, & Verster, 2016). Children and adolescents consuming energy drinks are more likely to report issues such as headaches, sleep problems and depressive symptoms (Department of Health & Social Care, 2018). Moreover, although causality cannot be inferred, energy drink consumption has consistently been associated with sensation seeking, risk taking, smoking, substance and alcohol use and may represent a marker for other activities that may negatively affect adolescents (Arria et al., 2011; Azagba, Langille, & Asbridge, 2014; Miller, 2008; Scalese et al., 2017) although this is not exclusive to energy drinks as significant positive correlations between all sources of caffeine and smoking or alcohol intake have been reported (Hewlett & Smith, 2006). Risk taking behaviours in young people may stem from an underlying sense of invulnerability (Szabo, Piko, & Fitzpatrick, 2019) rather than a misperception of actual risks; this may partly explain why energy drinks remain popular even though they are generally seen as unhealthy by young people (Cormier, Reid, & Hammond, 2018; Kozirok, 2017; Mintel, 2019). Energy drinks were first introduced as a tool for athletes to enhance their physical performance (Corbo, Bevilacqua, Petruzzi, Casanova, & Sinigaglia, 2014; Duncan & Hankey, 2013). One of the key ingredients of energy drinks is caffeine, a mildly addictive psychoactive substance which deprivation in habitual users can trigger withdrawal symptoms (Evans & Griffiths, 1999; Schuh & Griffiths, 1997). It is also known to elicit a strong bitter taste (Calvino, Garciamedina, & Comettomuniz, 1990; Keast, Sayompark, Sacks, Swinburn, & Riddell, 2011) and is often added to soft drinks as a 'flavouring agent'. This can be easily understood when taking into account the fact that caffeine, even at reasonably low concentrations, has been consistently shown to increase liking of soft drinks over time (Dack & Reed, 2009; Keast, Swinburn, Sayompark, Whitelock, & Riddell, 2015; Temple et al., 2012; Tinley, Durlach, & Yeomans, 2004; Yeomans, Ripley, Lee, & Durlach, 2001; Yeomans, Pryke, & Durlach, 2002). More surprisingly, this effect was also observed when the caffeine is ingested as a capsule alongside the target drink rather than dissolved in the drink (Richardson, Rogers, & Elliman, 1996) or when the caffeine is consumed as a drink alongside the target food (Panek, Swoboda, Bendlin, & Temple, 2013), dissociating thus taste from liking or consumption pattern. The observed increased liking with exposure has therefore been explained by invoking learned associations between taste and alleviation of caffeine withdrawal symptoms. In this respect, the influence of caffeine on liking has been likened to a Pavlovian association (Yeomans, Durlach, & Tinley, 2005) and this has led to question the functional role of caffeine as a 'flavouring agent' (Griffiths & Vernotica, 2000). In spite of this, only a small number of studies (Table 1) have sought to test whether caffeine, at concentrations typically found in soft drinks, could be detected within a complex matrix (aroma compounds, sweeteners, acids and carbonation).

Table 1: impact of caffeine in soft carbonated drinks on taste, existing literature.

Article	**No. of panellists**	**Caffeine concentration***	**Results**	**Outcome**
Keast & Riddell, (2007)	30	0.333mmol/L in sucrose (64.7 mg/L), 0.467mmol/L (90.7 mg/L) in aspartame, 0.462 mmol/L (89.7	Caffeine could be detected in the sweet solutions ($p<0.001$) but was not detectable in cola solutions ($p=1.0$)	Caffeine not detected in complex system at concentrations

		mg/L) in sucralose, and 0.67mmol/L (130.1 mg/L) in cola beverages		lower than 150 mg/L
Griffiths & Vernotica, (2000)	25	50, 100, 200, 400, 800 and 1600 mg/L in cola beverages	Identification of the caffeinated sample for the 2 lower concentrations was not better than chance Ability to detect caffeine at higher concentration was significantly greater than chance	Caffeine not detected in complex system at concentrations lower than 150 mg/L
Keast, Swinburn, Sayompark, Whitelock & Riddell, (2015)	30	0.57mmol/L (110.7 mg/L) in soft carbonated drinks	Trained panellist found no flavour difference between the caffeine free and caffeinated samples (p>0.05)	Caffeine not detected in complex system at concentrations lower than 150 mg/L

** For reference, typical cola drinks contain 110 mg/L of caffeine and energy drinks 320 mg/L*

Although the amount of evidence is limited (only 3 studies with low participant numbers); the findings are consistent and it is therefore likely that caffeine, at concentrations generally found in carbonated soft drinks (typically 110 mg/L) and as part of a complex matrix cannot be easily detected by trained panellists or consumers. Only one study (Griffiths & Vernotica, 2000) investigated greater caffeine concentrations which resulted in improved detection rates. At concentrations of 200 mg/L and 400 mg/L; respectively 56% and 96% of participants correctly identified the samples containing caffeine. These are important findings, however, only 25 participants were used and the caffeine concentration most commonly used in energy drinks (320 mg/L) was not investigated; it is therefore important to address that gap.

In the light of the sustained growth in the market of energy drinks and paucity of evidence with respect to the sensory effect of caffeine; it is critical to understand better the impact of caffeine and information relating to caffeine on consumer perception of model energy drinks. Specifically, the study aimed to test whether 1) caffeine, at concentrations found in energy drinks, could be detected by consumers; 2) caffeine, at concentrations found in energy drinks, had an impact on consumer overall liking, liking of key tastes and flavour attributes and 3) information relating to caffeine presence (or absence) had an impact on liking, healthiness perception and intended use.

2. Materials and Methods

2.1. Participants

Participants were recruited by word of mouth. The inclusion / exclusion criteria were to be between 16 and 26 years of age, to be a regular consumer of carbonated drinks (at least once a month), not to be pregnant or breastfeeding and not to suffer from food allergies or a history of anxiety, caffeine hypersensitivity, Type I or Type II diabetes, heart disease, kidney disease, gastrointestinal problems or high blood pressure. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and was approved by the Faculty Research Ethics Committee of Sheffield Hallam University (SBS-254). Written informed consent was obtained from all participants.

One hundred and seven participants aged between 18 and 26 (average age 21.7 years) were recruited (26 males). Habitual caffeine intake was estimated using a method adapted from Dack & Reed (2009) whereby questions relating to consumption frequency of caffeine containing commercial products were asked once the participants had completed the sensory testing. Typical caffeine contents for different items were taken as: coffee 70 mg; tea 60 mg; caffeinated carbonated soft drink 30 mg; energy drinks 77 mg; hot chocolate 5 mg (Dack & Reed, 2009; Richardson et al., 1996; Tinley, Yeomans, & Durlach, 2003; Tinley et al., 2004). The energy drinks contribution to overall caffeine intake was estimated by dividing the estimated caffeine intake from energy drinks by the estimated caffeine intake from all sources for each participant. The average caffeine daily intake was estimated at 170 mg (standard deviation 148 mg) and ranged from 0.2 mg to 718 mg; 50% of participants had an average daily caffeine intake greater than 120 mg. There were no significant differences in discrimination ability or liking by either course type or habitual caffeine intake, therefore only the aggregated results, rather than the split analysis, are presented.

2.2. Samples

Two model carbonated drinks were prepared for this study. To ensure that participants would not have any preconceived idea as to whether the drinks would contain caffeine, an unfamiliar flavour was created using strawberry flavouring (Synergy, 2SX-74444, final concentration in test samples 150 ppm), garden mint flavouring (Synergy, 2SX-86580, final concentration in test samples 150 ppm) and a base of lemonade (Schweppes Lemonade, Coca-Cola European Partners). Although a lemon base is quite common for both caffeinated and caffeine free commercial soft drinks; the mint and strawberry flavourings made these model drinks completely unique and quite distinct from what is currently commercially available in the United Kingdom. In order to keep the carbonation levels identical between the drinks and between the sessions, fresh drinks were prepared hourly and both the caffeine free and caffeinated drinks were prepared from the same flavoured stock solution.

Briefly, the flavoured stock solution was mixed 50-50 with either regular (caffeine free) lemonade or lemonade to which caffeine had been added in concentration of 640 mg/L to produce a caffeine free drink and a caffeinated drink with caffeine concentration similar to that found in energy drinks (320 mg/L). All the drinks were served at room temperature.

2.3. Experimental design

The session was split in 2 stages to mirror the objectives.

Objective 1: In order to test whether caffeine, at concentrations found in energy drinks, could be detected by consumers, a triangle test was performed using the caffeine free and caffeinated drinks. Three samples (including 2 identical ones) were presented simultaneously and panellists were asked to identify the odd sample and explain the reason why they selected that sample. The 6 possible presentation orders were balanced between the panellists (BS EN ISO 4120, 2007).

Objectives 2 and 3: In order to test whether caffeine, at concentrations found in energy drinks, impacts on consumer overall liking and liking of key taste and flavour attributes and whether knowing that a drink contains caffeine impacts on liking, healthiness perception and intended use; the caffeine free and caffeinated drinks were presented monadically in blind conditions (labelled with 3 digit codes) and then again in informed conditions (labelled with 3 digit codes and either "caffeine free" or "contains caffeine" as appropriate). All the panellists tested the 2 samples (caffeinated / caffeine-free) in blind then informed condition; the presentation order was balanced between the caffeinated and caffeine-free drink within the test conditions. Panellists were asked to rate each sample for overall and flavour liking on a 9 point hedonic scale. They were also asked to rate their liking of the sweetness and bitterness levels on 5 point Just-About-Right scales. In order to test their perception of the drinks, panellists were also asked to rate how healthy they perceived the drink to be (9 point scale going from extremely unhealthy to extremely healthy) and in what occasion they would consume the drink using a Check All That Apply (CATA) scale with the following options: Breakfast; lunch; dinner; throughout the day (anytime); at night; when working and/or studying; when socialising; when driving; when tired; when feeling ill or sick; when exercising; for performance enhancement; mixed with alcohol; if on promotion; never; other (specify). Those options were derived from published information (Agoston et al., 2018; Attila & Cakir, 2011; Malinauskas, Aeby, Overton, Carpenter-Aeby, & Barber-Heidal, 2007) and internal focus groups with students.

All sensory testing took place in individual sensory booths under “northern daylight” lighting as specified in BS EN ISO 8589 (2014). The participants were instructed to cleanse their palates with water and crackers (Carr’s table water crackers) in between samples.

2.4. Data analysis

The triangle test results were analysed by comparing the number of correct answers required to reach statistical significance in the corresponding standard table (BS EN ISO 4120, 2007). The number of discriminators was estimated using Abbott's formula (Lawless and Heymann, 2010). The overall liking, flavour liking and healthiness ratings were analysed using a two-factor repeated measures ANOVA. The factors were caffeine (2 levels: absence and presence) and information (2 levels: blind and informed). Post-hoc, where appropriate, means were compared, and adjustment for multiple comparisons was performed using a Bonferroni test. The nature of the difference between caffeinated and caffeine free samples and the Just-About-Right data were analysed using chi square tests. The intended use data (blind vs. informed) was analysed using a McNemar test. Significance level was set at 0.05 for all statistical analyses. All analyses were performed using SPSS v24 (IBM Corp; Armonk, NY).

3. Results

3.1. Participants' intake of energy drinks: the energy drink consumption pattern and energy drink contribution to caffeine intake are presented in Table 2. Although energy drinks contribution to overall caffeine intake varied widely between participants; it remained fairly stable across high and low caffeine users.

Table 2: Energy drink consumption pattern for study participants (*N* = 107) and energy drink contribution to overall caffeine intake

Frequency of energy drink consumption	**Participants (%)**
At least once a day	3%
At least once a week but less often than once a day	8%
At least once a month but less often than once a week	12%
Less often than once a month	26%
Never	51%
Energy drinks contribution to overall caffeine intake (%)	
All participants	5.2% (range: 0.0% - 99.9%)
High caffeine users (>120 mg/day)	5.7%
Low caffeine users (<120 mg/day)	4.8%

3.2. Detection of caffeine (320 mg/L) in a model energy drink

An overall significant difference ($p = 0.01$) between the caffeine free and caffeinated samples was observed with 47 out of 107 participants correctly identifying the odd sample. Accounting for the correct answers obtained by chance, this yields that the number of discriminators must have been 17 (6% of participants).

The comments (Table 3) provided by the participants for the basis of their decision show that the sweetness level, the flavour quality and intensity as well as the bitterness level were the 3 most common reasons mentioned for the difference between the samples. Although "bitterness level" was cited more often by participants who correctly identified the odd sample; it did not reach statistical significance and overall, there were no significant differences in reasons cited by participants who could identify the odd sample and those who could not.

Table 3: reasons provided for selecting the odd sample in the triangle test by participants who correctly identified the odd sample (N = 47) and those who did not (N = 60)

Nature of the difference	**Participants correctly identifying the odd sample* (%)**	**Participants unable to identify the odd sample* (%)**	**Pearson chi square**
Sweetness level	51.1	46.5	$\chi^2(1, N = 107) = 0.186$ $p = 0.666$
Bitterness level	31.1	18.6	$\chi^2(1, N = 107) = 1.834$ $p = 0.176$
Flavour Intensity	26.7	25.6	$\chi^2(1, N = 107) = 0.130$ $p = 0.908$
Flavour quality**	15.6	20.9	$\chi^2(1, N = 107) = 0.427$ $p = 0.513$
Acidity level	11.1	9.3	$\chi^2(1, N = 107) = 0.078$ $p = 0.780$
Carbonation level	11.1	4.7	$\chi^2(1, N = 107) = 1.253$ $p = 0.263$
No perceivable difference	0.0	4.7	n/a

** sum of all values in column greater than 100% as some participants cited several reasons*
*** all attributes combined, for example "apple", "citrus flavour" or "floral notes"*

3.3. Impact of caffeine and information relating to caffeine

The overall liking, flavour liking and healthiness ratings for the caffeinated and caffeine free samples in blind and informed conditions are presented in Figure 1.

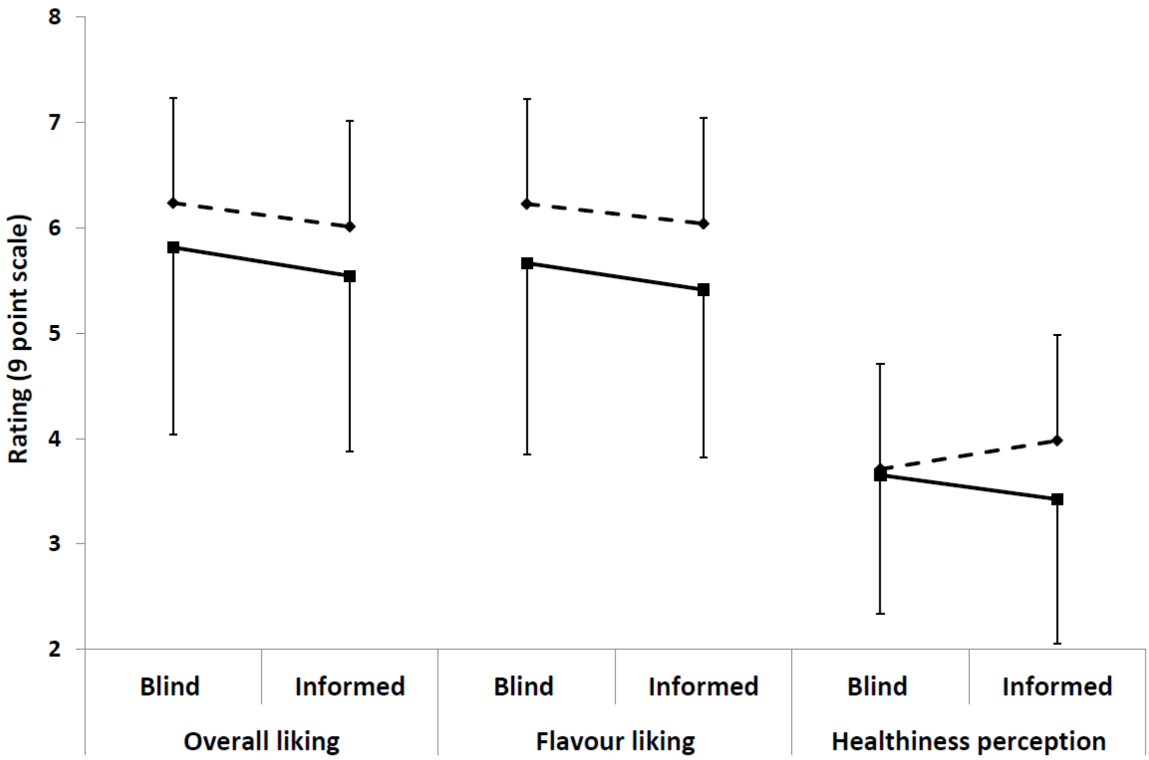

Figure 1: liking and healthiness perception of caffeinated (■) and caffeine free (◆) model energy drinks in blind and informed conditions ($N = 107$). Error bars represent one standard deviation.

Both the presence of caffeine and knowing that the drink contained caffeine had a significant negative impact on overall liking (respectively $F(1,106) = 8.320$, $p = 0.005$ and $F(1,106) = 4.825$, $p = 0.030$). The interaction was not significant ($F(1,106) = 0.038$, $p = 0.846$).

The presence of caffeine had a strong negative impact on flavour liking ($F(1,106) = 17.553$, $p < 0.001$); however, the impact of information relating to caffeine did not reach statistical significance ($F(1,106) = 2.972$, $p = 0.088$) and the interaction was not significant ($F(1,106) = 0.066$, $p = 0.797$).

With respect to healthiness perception, a strong interaction caffeine x information effect was observed ($F(1,104) = 7.918$, $p = 0.006$) with no difference observed between the caffeinated and caffeine free samples in blind conditions ($t(106) = -0.502$, $p = 0.617$) whilst it became strongly significant in informed conditions ($t(104) = -3.965$, $p < 0.001$).

In terms of taste quality, there was a significant interaction between sample (caffeinated / caffeine free) and condition (blind / informed); the impact of caffeine was amplified when participants were informed of its presence (Figure 2).

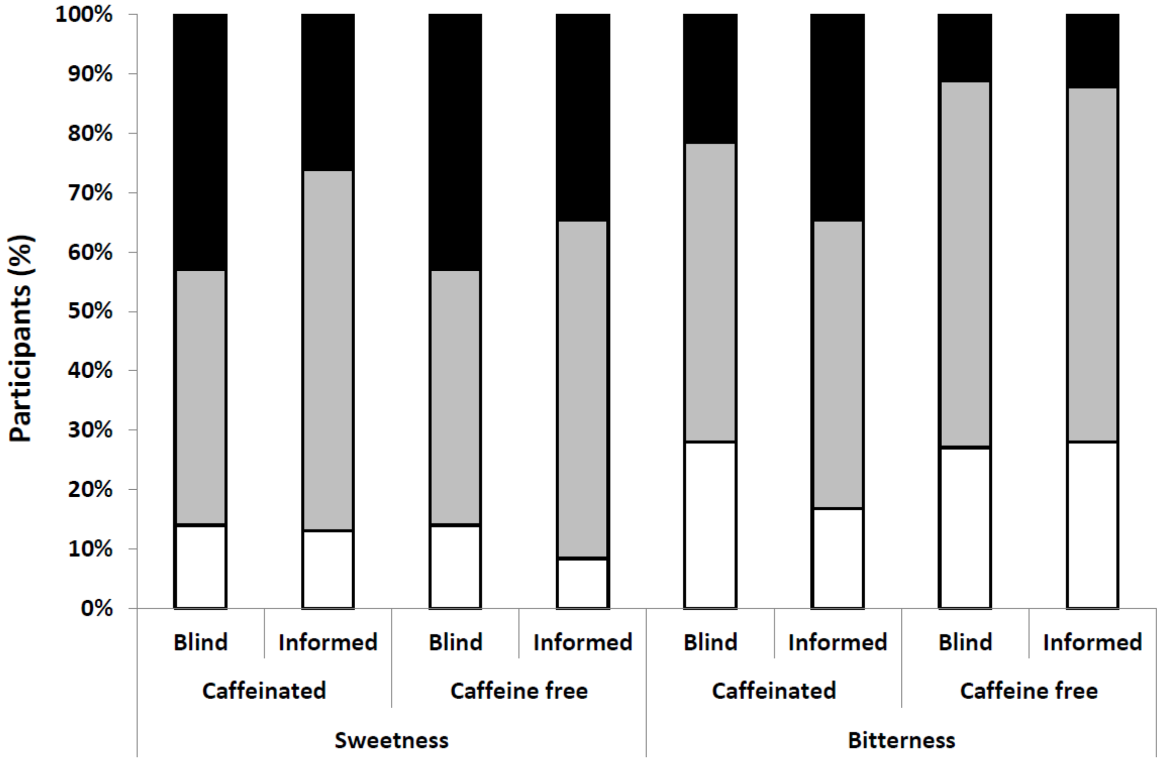

Figure 2: liking of key attributes for caffeinated and caffeine free model energy drinks in blind and informed conditions ($N = 107$). Too sweet/bitter (■); Just about right ( ); Not sweet/bitter enough (□).

In blind conditions, the presence of caffeine did not have a significant impact on the liking of sweetness level ($\chi^2(2, N = 107) = 0.000$, $p = 1.000$) and although slightly more participants felt that the caffeinated sample was "too bitter" compared to the caffeine free sample, this did not reach statistical significance ($\chi^2(2, N = 107) = 4.674$, $p = 0.097$). In contrast, in informed conditions, there was a strong significant difference in the bitterness level liking between the caffeinated and caffeine free samples (χ^2(2, N = 107) = 15.761, p < 0.001) which was not observed for the liking of sweetness level (χ^2(2, N = 107) = 2.460, p = 0.292). Although the condition (blind / informed) had no impact on the liking of sweetness level (χ^2(2, N = 107) = 4.579, p = 0.101) or bitterness level (χ^2(2, N = 107) = 0.088, p = 0.957) when the sample was caffeine free; it had an effect on the sweetness level liking (χ^2(2, N = 107) = 7.665, p = 0.022) for the caffeinated sample with fewer participants finding it "too sweet" in informed condition than blind condition. A condition effect was also observed for the liking of the bitterness level for the caffeinated sample (χ^2(2, N = 107) = 6.304, p = 0.043) with fewer participants rating the sample as "not bitter enough" and "too bitter" in informed condition than blind condition.

3.4. Impact of the information relating to caffeine presence on intended use

The data relating to occasions where less than 20% of participants indicated they would consume the drinks are not presented as those were deemed less relevant. The most popular intended use for both all drinks / condition was 'with alcohol' (Figure 3); this was the only occasion for which more than 30% of participants indicated they would consume the model energy drinks.

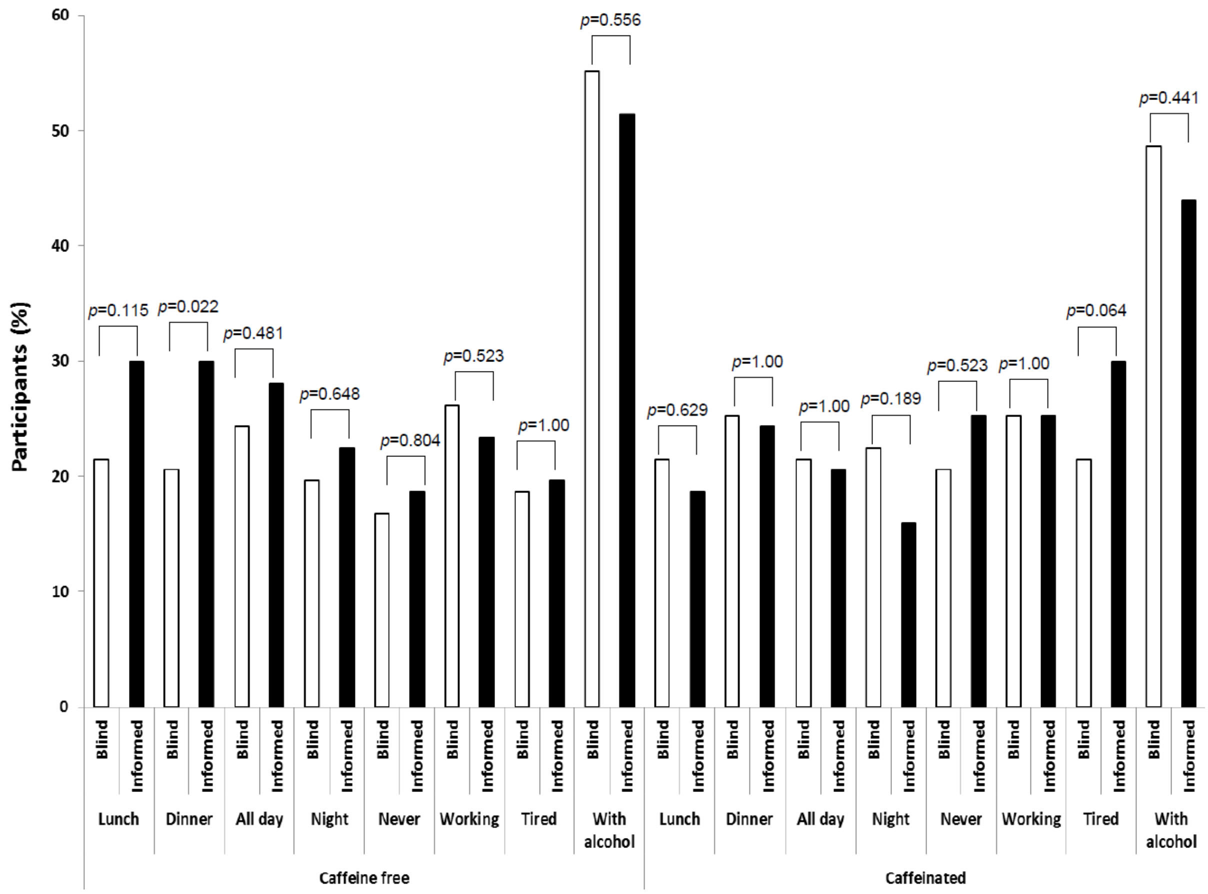

Figure 3: intended use for caffeine free and caffeinated model energy drinks on different occasions in blind (□) and informed (■) conditions (N = 107).

There were no significant differences in frequency of intended use between the blind and informed conditions for either sample on any of the occasions except for the caffeine free sample which was more likely to be consumed at dinner when participants were informed it was caffeine free than in blind condition (p = 0.022). Conversely; although it did not reach statistical significance (p = 0.064), participants were more likely to consume the caffeinated drink when tired if they knew that it contained caffeine than in blind condition.

4. Discussion

Considering the different recruitment strategies, target population and countries, the average caffeine intake and energy drink consumption pattern observed for this sample were similar to those reported elsewhere (Arria et al., 2011; Attila & Cakir, 2011; Azagba et al., 2014; Malinauskas et al., 2007; Miller, 2008; Mintel, 2019; Scalese et al., 2017): in general reports estimate that between 34% and 59% of the population studied never consume energy drinks and between 13% and 51% do so at least once a month. In this respect, as observed elsewhere, our study confirms irregular consumption patterns rather than habitual intake (Agoston et al., 2018; Kozirok, 2017); moreover, it provides further evidence that energy drinks remain low contributors to overall caffeine intake some way behind coffee and tea (Mackus et al., 2016).

Adding caffeine at a concentration typically found in energy drinks altered its sensory profile sufficiently to be detectable and impact on liking. This is not surprising as caffeine is known to not only elicit an intense bitter taste but also to suppress sweetness (Calvino et al., 1990; Keast et al., 2015). In this respect, caffeine does act as a flavouring agent when added in concentrations found in energy drinks even if this is not the case at lower concentrations typically found in colas (Griffiths & Vernotica, 2000; Keast & Riddell, 2007; Keast et al., 2015). In this instance, the high caffeine concentration had a significant detrimental impact on liking; however, the effect size was small and of borderline practical relevance as suggested by the low number of discriminators. Although there is currently no data available on caffeinated model energy drinks and liking; high caffeine concentrations (220 to 1034 mg/L) in model energy drinks have been shown to increase bitterness and decrease sweetness and fruity flavour perception in a trained panel (Tamamoto, Schmidt, & Lee, 2010). Notwithstanding the fact that this was not tested with a consumer panel, it is possible that these changes would decrease acceptance as bitterness generally reduces acceptance (Mennella & Bobowski, 2015). There are notable exceptions to this for specific product categories (Cavallo, Cicia, Del Giudice, Sacchi, & Vecchio, 2019) and coffee in particular (Geel, Kinnear, & de Kock, 2005), however, energy drinks do not tend to be associated with a pleasant bitter taste which may partly explain why sugar content tends to be slightly higher in energy drinks than in soft drinks with lower caffeine contents (Hashem, He, & MacGregor, 2017).

We found that information about the presence of caffeine had a significant effect on overall liking and bitterness perception. The fact that information can impact on liking is a well-known concept (Fernqvist & Ekelund, 2014) and information has been shown to impact on overall liking of coffees but not on bitterness perception although, this may be explained by the nature of the information provided which did not mention caffeine (Li, Streletskaya, & Gómez, 2019). Knowing that the model drink contained caffeine also significantly decreased its healthiness rating; the unhealthy image of caffeinated energy drinks has been observed before; for example, 33% of respondents stated that the reason why they do not drink energy drinks was because they contained too much caffeine (Mintel, 2019). Recently, in Canada, 76.2% of 12-24 year olds polled thought that energy drinks were either bad or very bad for your health (Cormier et al., 2018) and concerns around their impact on health were also noted with a sample of Polish consumers (Kozirok, 2017). In spite of this, younger participants (16 to 21 years old) felt that energy drinks must be safe to consume or they would not be sold (Bunting, Baggett, & Grigor, 2013). These results show that although the target consumers for these products perceive them as safe albeit unhealthy; this is not in itself, a deterrent to consumption. Indeed, it is well known that the relationship between healthiness perception and behaviours is a complex one at the best of times but especially in adolescents and young adults, this feature has been observed elsewhere in the context of children and young people's perception of energy drinks (Visram, Crossley, Cheetham, & Lake, 2017). Considering that young people use food and food rituals to facilitate integration and reinforce social ties (Neely, Walton, & Stephens, 2014), it is particularly pertinent to assess whether mentioning that a drink contains caffeine is likely to increase its use alongside alcohol compared to a non-caffeinated drink. The most popular intended use for our model drink was as a mixer, with alcohol. About 44% of our participants stated that they would consume the caffeinated model drink mixed with alcohol; that figure is reminiscent of data from different countries: about 40% of Turkish energy drink user students stated they mixed them with alcohol (Attila & Cakir, 2011); 56% of Italian adolescents who consume energy drinks mixed them with alcohol (Scalese et al., 2017) and 49.1% of Polish students polled stated that they combined energy drinks with alcohol (Kozirok, 2017). Consumers tend to have only one energy drink unless they are mixed with alcohol (Malinauskas et al., 2007) which in itself may be an issue as combining energy drinks with alcohol has been shown to increase the urge to carry on drinking compared to drinking alcohol alone (McKetin & Coen, 2014). Despite concerns over the prevalence of alcohol mixed with energy drinks consumption; it is the first time that the intended use of alcohol mixed with caffeinated mixers is compared to that for alcohol mixed with caffeine free mixers. Whether the model energy drink contained caffeine or not had no impact on intended use of young adults, this confirms recent findings from a meta-analysis showing that people did not consume more alcohol on occasions when they mixed it with energy drinks even though, people who tend to mix energy drinks with alcohol are more likely to have a higher alcohol intake than those who do not (Verster, Benson, Johnson, Alford, Benjereb Godefroy & Scholey, 2018). It is therefore likely that purposefully selecting mixers with high caffeine content to drink with alcohol is not a widespread practice in young adults; this is supported by recent findings which have shown that student alcohol intake was not greater when alcohol was consumed with energy drinks rather than with other caffeinated soft drinks such as colas (Johnson, Alford, Stewart & Verster, 2018). This is not entirely surprising as taste has consistently been highlighted as a key driver for choosing soft drinks (Agoston et al., 2018; Attila & Cakir, 2011; Bunting et al., 2013; Kozirok, 2017).

Study limitations and future work: although typical for sensory studies, the number of participants remains small and our participants were students, in this respect the results may not be generalisable to all young UK adults. Critically, there is a need to gather information with younger consumers, in particular where consumption patterns and intended use are concerned. Although the impact of caffeine, at concentrations found in energy drinks, ie increased bitterness and suppression of sweetness and fruity flavours is more likely to decrease acceptance (as observed here); the results could be confirmed with a broader range of flavour combinations.

5. Conclusions

Overall, this set of data shows that caffeine, at concentrations typically found in energy drinks, can be detected by consumers and impacts negatively, albeit moderately, on overall liking and taste profile of the drink. The information "contains caffeine" also has a negative impact both on liking and healthiness perception although it did not alter intended use notably. In a context where the consumption of energy drinks remains irregular rather than habitual and represents a small contribution to overall caffeine intake; these findings should partly assuage concerns with respect to young adults’ use of energy drinks and caffeine intake however, the trend to consume them in combination with alcohol may be seen as slightly more problematic.

Declarations of interest: none.

CRediT author statement:

Cecile Morris: conceptualization, methodology, investigation, formal analysis, data curation, writing - original draft, writing - review and editing, visualization, supervision, project administration. Jessica Elgar: investigation, resources, writing - original draft.

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