

Role of familiarity on effects of caffeine- and glucose-containing soft drinks [☆]

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Abstract

SMIT, H. J., M. L. GRADY, Y. E. FINNEGAN, S.-A. C. HUGHES, J. R. COTTON AND P. J. ROGERS. Role of familiarity on effects of caffeine- and glucose-containing soft drinks *PHYSIOL BEHAV* XX(X) 000-000, 200X. — Familiarity, through conditioned responses and expectations, may play a significant role in the expression of liking for, and mood and performance effects of, food and drink constituents. The role of familiarity and the effects of caffeine and glucose in Lucozade Energy were investigated by testing this familiar soft drink, and its non-caffeine/non-CHO placebo match, against novel coloured/flavoured full and placebo drinks. Both the familiar drink and its placebo improved alertness, mental energy and mental performance compared to baseline and compared to the novel placebo drink. After repeated exposure, that is, after having gained familiarity with the novel drinks in addition to the already existing familiarity with Lucozade Energy, only the full (caffeine and CHO containing) drinks showed sustained beneficial effects compared to placebo drinks and baseline measures, as well as an increase in liking compared to placebo drinks. Therefore, participants appeared to have learned that beneficial effects were mainly linked to the full products. The results illustrate the restorative combination of caffeine and CHO in the drink, and emphasises the need to implement the appropriate placebo(s) in any study design employing familiar foods or drinks.

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1. Introduction

Learning, including Pavlovian or classical conditioning, contributes significantly to an individual's responses to food and drinks. For example, unlike small children, many adults may have learnt to appreciate the strong (and somewhat bitter) taste of coffee through the negative reinforcing effects of caffeine [1,2]. Likewise, repeated consumption of a new drink containing caffeine and glucose is likely to increase the preference for the drink compared with its caffeine and glucose free sensory match (placebo). The relevance of this to the present research lies in two interrelated consequences of

associations formed between the oro-sensory and post-ingestive effects of drinking. First, we have to consider the reinforcement of liking (i.e., the individual's hedonic response to the drink's taste, flavour, aroma etc.) through beneficial physiological or psychological effects of the pharmacologically active constituents. We have demonstrated this most clearly for caffeine in studies showing that liking for a new drink is markedly increased after repeated exposure if the drink contains caffeine. This increase has been shown after only a few 'trials' or separate experiences of the drink [2]. Accordingly, the method developed in these so-called 'conditioned flavour preference' studies can be used to screen the reinforcing effects of a variety of existing and potential product constituents. Second, familiarity and expectations might play an important role in the expression of such effects. Expectations with regard to effects of the food or drink consumed (in this case, generally derived from familiarity with the product) can have a large impact on the effects of the food or drink tested [3,4]. Therefore, in flavour preference conditioning studies, a 'novel' flavour is typically utilised. But how does

[☆] Part of these results were presented at the 11th International Food Choice Conference in Philadelphia, USA, on 26th July, 2003, and published as an abstract in *Appetite* [31].

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this then allow us to test the effects of a familiar, commercially available drink? How important is this familiarity? How clearly are familiarity-related expectations linked to effects of any active ingredients of such a drink? And what impact does this have on the choice of placebo when testing such a drink?

The study presented here was designed to answer these questions by using a caffeine- and glucose containing soft drink with a typical ‘brand heritage’. Although in this study we do not discriminate between caffeine and glucose in their combined presence in the drinks tested, it is important to realise the potential of their effects on physiology and behaviour when discussing the results. The psycho-pharmacological effects of caffeine have been researched extensively and the status quo in this field has been reviewed regularly (e.g., [5–7]). Following oral administration, the uptake of caffeine is fairly rapid and complete, although other food constituents, for example sugars, may slow the absorption rate [8]. The maximum blood plasma concentration (peak plasma time is typically reached within at least an hour [9]. Indeed, one study found a peak plasma time of 30 min after oral administration of 72 mg caffeine [10], and in a different study, the same researchers found an onset of subjective effects of caffeine at around 21 min after oral administration in participants who successfully discriminated caffeine from placebo [11]. However, despite the large range of literature describing psychostimulant effects of caffeine in adult human beings for over 100 years, only very recently have significant numbers of studies reported using doses of caffeine within the ranges found in typical caffeine-containing drinks, including the many popular soft drinks, which contain amounts of caffeine in the range of 10 to 50 mg. Mumford et al [11] reported that six out of their seven participants were able to reliably discriminate 56 mg caffeine from placebo. Evidence of significant reinforcing effects of 70 mg caffeine have been found by [1]. In another study, all doses of caffeine tested, ranging from 32 to 256 mg, significantly improved visual reaction time and auditory vigilance, although no significant effects of caffeine on self-rated mood and alertness were found [12]. The latter study showed a flat dose-response relationship for psychomotor performance, findings that are in line with the conclusions of reference [13], where performance effects were of similar magnitude for all doses of caffeine tested (including 12.5 mg). In terms of mood and performance, caffeine mainly improves aspects of energetic mood [5], and performance on tasks requiring sustained attention [6].

Glucose has seen many fewer publications in terms of its effects on mood and performance. Effects have been found on memory [14,15], concentration [16] and reaction time [17], with glucose showing greater benefits on performance on more demanding tasks [18,19]. Note that in most of these studies participants were fasted overnight. Interestingly, the popular belief that consumption of carbohydrate (CHO), especially simple sugars, has an energising effect ties in with increasing plasma glucose levels as early as 5 min after consumption (post-treatment), peaking at 20 min post-treatment, and maintaining this increase beyond 75 min [20]. This is confirmed by other publications, quoting peak plasma glucose

times of 20–30 min [14,16,18]. However, by contrast, sucrose and high-CHO meals have been found to decrease energetic arousal [21,22], which was attributed to an elevation of blood plasma tryptophan [21] in line with the ‘serotonin hypothesis’ (originally proposed by Wurtman and Wurtman in the 1980s, and more recently very comprehensively reviewed [23,24]). Largely, although there is mixed evidence for either energising or fatiguing effects of CHO, and it has been concluded that “there is no enhancement of performance by glucose *per se*” [25], the balance of evidence seems to be skewed towards an improvement of performance efficiency. In summary, it appears that effects of glucose are more likely to be expressed in food-deprived participants subjected to cognitively demanding tasks.

Finally, in testing psychopharmacological effects of a well-known brand of soft-drink, the choice of placebo may be of particular importance to the outcome of the results. For example, although some investigations have used ‘nothing’ as a placebo for the active condition [26], this does not take into account the effect of the vehicle. Others [27] have used hot water versus tea and coffee to assess the effects on energetic arousal. In the pursuit of assessing effects of caffeine, some researchers have used caffeinated decaf coffee versus uncaffeinated decaf coffee (e.g., [28]), or cola vs. caffeine-free cola to assess the effects of caffeine in a cola drink [29]. We previously concluded that for demonstrating the practical benefits of the drinks tested, the choice of placebos was not particularly critical [30,31]. However, this was based on assessing psychopharmacological effects of drinks that were not familiar to the participants (‘novel’ drinks). Because familiarity and/or expected effects can play an important role in the effects of, e.g., a caffeine containing drink [4], this study aims to investigate the role of pre-existing familiarity (prior exposure) and gained familiarity (experimental or controlled exposure) on the effects of the test drink, and discusses the importance of the correct choice of placebo.

2. Methods

2.1. Participants

The study aimed to collect data of 20 participants per condition (80 participants in total). They were recruited through our recently set-up participant database, and through posters displayed in various Departments of Bristol University. They were healthy, native English speaking, 18–50 years of age, not diabetic, dyslexic, pregnant or breast-feeding. They habitually consumed breakfast with coffee or tea before 9 a.m., they were familiar with the taste of cola, orange juice, Lucozade Energy drink (original with golden colour), lemonade (e.g. 7 UP), and orange soda (e.g. Fanta), and they did not suffer from allergies for any foods, drinks or particular food or drink constituents.

The study was presented as investigating ‘The effects of repeated use of a mid-morning drink on mood and cognitive performance’, and no further explanation was provided, in order to prevent raising expectations about the drinks, their constituents or other aspects of the study under investigation

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