Appetite 56 (2011) 235–240

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Research report

# Black tea improves attention and self-reported alertness☆

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ARTICLE INFO

*Article history:*
Received 3 August 2010
Received in revised form 30 November 2010
Accepted 13 December 2010
Available online 21 December 2010

*Keywords:*
Attention
Alertness
Mood
Tea
Caffeine
Theanine
Plasma levels

ABSTRACT

Tea has previously been demonstrated to better help sustain alertness throughout the day in open-label studies. We investigated whether tea improves attention and self-reported alertness in two double-blind, randomised, placebo-controlled, crossover studies. Participants received black tea (made from commercially available tea bags) in one condition and placebo tea (hot water with food colours and flavours) similar in taste and appearance to real tea in the other condition. Attention was measured objectively with attention tests (the switch task and the intersensory-attention test) and subjectively with a self-report questionnaire (Bond–Lader visual analogue scales). In both studies, black tea significantly enhanced accuracy on the switch task (study 1 $p < .002$, study 2 $p = .007$) and self-reported alertness on the Bond–Lader questionnaire (study 1 $p < .001$, study 2 $p = .021$). The first study also demonstrated better auditory ($p < .001$) and visual ($p = .030$) intersensory attention after black tea compared to placebo. Simulation of theanine and caffeine plasma time–concentration curves indicated higher levels in the first study compared to the second, which supports the finding that tea effects on attention were strongest in the first study. Being the second most widely consumed beverage in the world after water, tea is a relevant contributor to our daily cognitive functioning.



## Introduction

Being able to concentrate and attend to the job at hand are important in our everyday life, whether at work, in your car driving home, or helping the kids with their homework in the evening. In this context, simple actions that could help sustain cognitive abilities throughout the day are welcome. Tea is the second most frequently consumed beverage in the world being only surpassed by water, and is often credited with cognitive benefits by consumers. A decade ago, scientists have started exploring the cognitive effects of tea. In these intial open-label studies, it was demonstrated that having a few cups of tea during the day increased subjective alertness and helped sustain arousal (Hindmarch, Quinlan, Moore, & Parkin, 1998; Hindmarch et al., 2000; Quinlan et al., 2000). Specifically, performance on the critical flicker fusion task was improved after tea as compared to water indicating higher levels of arousal (Hindmarch et al., 1998, 2000). In addition, tea consumption was associated with faster choice reaction time performance (Hindmarch et al., 2000) and higher levels of self-reported alertness (Quinlan et al., 2000).

The effects of tea on arousal and alertness may be due to its natural ingredients such as caffeine. Many studies have reported that caffeine improves performance on attention tests (e.g., Brice & Smith, 2002; Horne & Reyner, 1996; Lieberman, Tharion, Shukitt-Hale, Speckman, & Tulley, 2002; Rogers et al., 2005), even at levels comparable to those in a cup of tea (35–60 mg; Durlach, 1998; Lieberman, Wurtman, Emde, Roberts, & Coviella, 1987; Smit & Rogers, 2000; Smith, 2009; Smith, Sturgess, & Gallagher, 1999). As tea is one of the main dietary sources of caffeine globally, it may thus significantly contribute to improved cognitive function in many people (Bryan, 2008; Ruxton, 2008).

In addition to caffeine, a cup of tea naturally contains 5–23 mg theanine (γ-N-ethylglutamine), an amino acid virtually exclusive to tea. Theanine when ingested on its own increases calmness and relaxation (e.g., Abdou et al., 2006; Lu et al., 2004; Nobre, Rao, & Owen, 2008). *In vitro* work suggests that theanine interacts with the effects of caffeine (Kimura & Murata, 1986), which is supported by EEG studies showing that theanine alone significantly synchronises brain activity related to attentional processing (Gomez-Ramirez et al., 2007; Gomez-Ramirez, Kelly, Montesi, & Foxe, 2009), but in combination with caffeine induces even greater synchronisation (Kelly, Gomez-Ramirez, Montesi, & Foxe, 2008). Behavioural studies confirmed the positive effects of theanine and caffeine on attention (Einother, Martens, Rycroft, & de Bruin, 2010;

☆ The authors would like to thank Nick Tyrrell, Mano Pillai, Suzanne Einöther, Vanessa Martens, Kay Budd-Fletcher, Daniel Rycroft, Nelly van der Meer, Selina Hira, Solene Naveos, and Timo Giesbrecht for their support. The studies were sponsored by Unilever.

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doi:10.1016/j.appet.2010.12.011

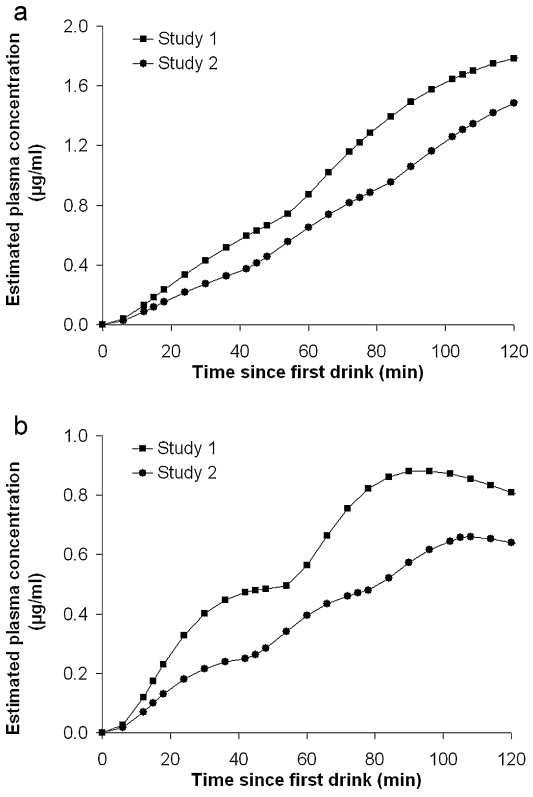


**Fig. 1.** Plasma time–concentration profiles of caffeine (a) and theanine (b) based on the dosing regime in study 1 (boxes) and 2 (circles).

Giesbrecht, Rycroft, Rowson, & de Bruin, 2010; Owen, Parnell, de Bruin, & Rycroft, 2008). Moreover, tea is associated with more consistent levels of alertness throughout the day than coffee, even when matched for caffeine content (Hindmarch et al., 1998), suggesting that tea ingredients such as theanine may modify the alerting effect of caffeine. Besides caffeine and theanine, preliminary evidence indicates that flavonoids may also improve cognitive performance (Macready et al., 2009), and there may be other tea ingredients with a positive impact on attention yet to be discovered.

Thus, tea may be a likely candidate for improving attention in everyday life. In the two systematic studies described in the present paper we investigated the effects of two commercially available black tea blends on attention and self-reported alertness using a double-blind, randomised placebo-controlled, cross-over design. In the first study, a relatively strong tea blend containing 2.6 g/L tea solids (PG Tips tea) was used as this was the first randomised and placebo-controlled study on tea and attention. As the results were positive, the study was repeated with a slightly less strong tea (Lipton Yellow Label tea; 1.9 g/L tea solids) to find out whether the effects were dose-dependent. Plasma curves were simulated based on the dosing regime and population characteristics of the two current studies and pharmacokinetic data on caffeine and theanine from previous studies (see Van der Pijl, Chen, & Mulder, 2010 for theanine; caffeine data unpublished) in a physiologically based pharmacokinetic model (GastroPlus; Parrot and Lavé, 2008). These simulations indicated that the caffeine and theanine peak plasma levels in the second study were very likely to be slightly lower than those in the first study (see Fig. 1a for caffeine and b for theanine) thus allowing for first indications of dose dependency.

## Methods

Twenty-six volunteers (20 females) aged on average 30.7 years (*SD* = 11.2) took part in study 1, and 32 volunteers (15 females) aged on average 30.3 years (*SD* = 10.1) participated in study 2. The sample size of study 1 was loosely based on the observational tea studies by Hindmarch et al. (1998, 2000) and Quinlan et al. (2000). The sample size required for study 2 was calculated to be 36 based on the first study, taking a smaller effect size and an anticipated drop-out rate of 20% into account. Participants were regular caffeine consumers (average caffeine intake 306.4 mg/day (*SD* = 148.6) in study 1 mg/day and 280.1 mg/day (*SD* = 142.2) in study 2), and had a body mass index (BMI) between 18 and 32. Exclusion criteria were allergies to caffeine or herbal supplements, colour blindness, dyslexia, pregnancy, breastfeeding, and use of recreational drugs and medication with the exception of the contraceptive pill. The studies were approved by the Unilever Colworth Research Ethics Committee and were carried out in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. Participants provided written informed consent prior to inclusion in the study and were paid for their participation.

A crossover, double-blind, randomised, placebo-controlled design was used in both studies. In study 1, participants received two servings of placebo tea in one condition and two servings of black tea in the other condition over the course of 60 min. In study 2, participants received three servings of placebo tea in one condition and three servings of black tea in the other condition over the course of 90 min. Treatments were allocated using a Latin square design such that the order of treatments was counterbalanced across participants. Visits were separated by at least 6 days and at most 14 days.

For study 1, the tea was prepared by pouring 235 ml of boiled, de-ionised water onto a PG Tips tea bag. The tea was passively infused for 60 s after which the tea bag was removed and allowed to drip over the cup for 3 s. 200 ml of the infusion was then poured and served in a fresh cup. The placebo was prepared by adding 10 mg caramel colour 602, 10 µl red food colour, 7 mg tea flavour 502840, 150 mg oak tannin, and 150 mg grape seed tannin powders to 200 ml boiled, de-ionized water.

For study 2, the tea was prepared by pouring 190 ml of boiled, de-ionised water onto a Lipton Yellow Label tea bag. The tea was passively infused for 90 s, after which the tea bag was removed and allowed to drip over the cup for 3 s. Ten milliliter water at room temperature was added. The placebo was prepared by adding 190 ml boiled, de-ionized water to a 10-ml aliquot at room temperature containing 20 mg caramel colour 602, 4 µl red food colour, 3 mg tea flavour 502840, and 120 mg oak tannin.

See Table 1 for the amount of tea solids, caffeine, and theanine in each study. The tea flavours and colours used have no known

**Table 1**
Amount of tea solids and caffeine and theanine content per serving and in total per visit for each study.

| | Tea solids | Caffeine | Theanine | Servings | Tea solids | Caffeine | Theanine |
|---|---|---|---|---|---|---|---|
| | Per 200-ml serving (mg) | | | Per visit (ml) | In total per visit (mg) | | |
| Study 1 | 520 | 50 | 23 | 2 × 200 | 1040 | 100 | 46 |
| Study 2 | 380 | 30 | 12 | 3 × 200 | 1140 | 90 | 36 |