Why do people drink tea? An important reason, besides taste and habit, is the stimulating effect of tea. In the last decade scientists have started research on the beneficial cognitive effects of tea, with a focus on ‘attention’. Attention is an important prerequisite for memory, complex tasks and reasoning. If your attention is low, being smart doesn’t help you much.

Tea (prepared from Camellia sinensis leaves) contains two compounds, which are thought to be relevant for attention (Bryan, 2008): caffeine and L-theanine. The combination of these compounds has been reported to be effective in promoting alertness and attention: L-theanine is nearly universally consumed in tea, whereas caffeine is also present in coffee (albeit at a higher level).

There is a general consensus that caffeine can improve basic aspects of attention (e.g. simple reaction times). However, more recent evidence indicates that a level of caffeine equivalent to that present in 2 to 3 cups of tea, can also improve complex aspects of attention. Furthermore, L-theanine has been repeatedly demonstrated to influence brain activity and in particular to stimulate alpha brain waves at rest. Alpha waves are associated with relaxation.

Together with a number of external experts in the field, Unilever pioneered in the area of the effects of tea and tea ingredients on attention, and reported the findings in 11 peer-reviewed publications.

In this newsletter, we present a selection of findings that demonstrate that black tea and the tea ingredients caffeine and L-theanine help to improve attention scores and that black tea improves self-perceived work performance.
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1. **Introduction**

**What is Attention and Why is it Important?**

The human brain has limited information processing capacity. Therefore it is never able to deal with all the input that is continuously received through its sensory systems (e.g. vision, audition) and cognitive processes (e.g. memory).

Attention is an essential aspect of cognitive functioning in that it allows us to effectively deal with the continuous and very complex input in combination with our limited capacity to process information. As such, it is an important prerequisite for many other cognitive processes, such as memory and reasoning. Consequently, when attention is disrupted, this has profound consequences for everyday functioning (e.g., in complex tasks, such as driving; Wang, Knipling, and Goodman, 1996).

**How do we measure attention?**

In cognitive psychology, a variety of attention tests have been developed. Attention is generally measured in terms of test performance; usually speed of response and number of correct responses.

A concept which is closely related to attention is alertness. This refers to the subjective feeling, which is associated with superior performance in situations requiring attention. Thus, when people are attentive and focused, they often experience that they feel more alert. Alertness can be measured subjectively by means of self-report questionnaires. A number of mood questionnaires provide subjective ratings of alertness. For example the Bond-Lader Visual Analogues Scale (Bond & Lader, 1974), a scale that is used frequently in pharmacological research, measures an Alertness factor.
BLANK TEA HELPS TO IMPROVE ATTENTION

Tea is the second most widely consumed beverage in the world only being surpassed by water, and has been historically associated with mental clarity and enhanced concentration. Until a decade ago, the alleged mental benefits of tea were solely based on anecdotal evidence. Recently, scientists have started to underpin the relationship between tea and attention scientifically by means of objective measures of attention.

The cognitive effects of tea have been attributed to caffeine, a trimethylxanthine derivative and the non-proteinic amino acid L-theanine (Bryan, 2008), which are naturally occurring ingredients in tea. Caffeine is naturally found in a large variety of foods (e.g. coffee, tea, chocolate) and is the most widely consumed psychoactive ingredient. A typical serving of black tea (200ml) naturally contains approximately 35 to 61mg caffeine. L-theanine is an amino acid almost exclusively found in the tea plant. A typical serving of black tea will deliver between 4.5 mg and 22.5 mg theanine, depending upon the variety used, time of infusion, and amount of tea leaves used.

There is plenty of scientific evidence showing that caffeine and L-theanine have effects on the brain. For instance, theanine has been repeatedly demonstrated to stimulate alpha brain waves at rest, which are associated with relaxation (Kobayashi et al., 1998; Nobre et al., 2008). Furthermore, the psychostimulant effects of caffeine have been frequently demonstrated (for a review, see Ruxton, 2008). Specifically, caffeine has been shown to increase self-reported alertness, improve mood, and enhance psychomotor activity and attention (Smith, 2002; Rogers & Dernoncourt, 1998).

The effects of tea on attention were originally investigated in two studies comparing the effects of tea with coffee and water (Hindmarch et al., 1998, 2000). These studies demonstrated that black tea consumed over the course of the day leads to improved attention performance as compared to water. Since then, more research has been conducted on the mental benefits of tea. This research will be discussed in the next chapter.

CONTENT OF THE NEWSLETTER

For this newsletter, we have selected a number of recent scientific papers which have looked into the role of black tea and tea ingredients theanine and caffeine in attention. These will be discussed in Chapter 2. In section 2.1, we address a paper that demonstrated effects of black tea on attention. Section 2.2 discusses a recent paper on caffeine in relation to attention, while Section 2.3 shows the effects of L-theanine and caffeine in combination in an iced-tea drink. Section 2.4 shows recent data on the bioavailability of L-theanine. Finally, section 2.5 presents a very recent study, which investigated the influence of tea consumption on self-reported work performance under normal conditions.
2. SOME RECENT DEVELOPMENTS IN THE AREA OF TEA AND ATTENTION

2.1 TEA AND ATTENTION


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.
**SUMMARY:**
Two separate studies, each with a different tea, were carried out to test whether black tea can improve attention as measured with standardized and validated tests. In the first study, participants received two cups of PG Tips tea on one occasion and two cups of placebo tea on the other. In the second study, another group of participants received three cups of Lipton Yellow Label black tea and three cups of placebo tea. The order of the conditions was counterbalanced between participants in both studies. On each study day, the participants were asked to perform a series of attention tests before and after consumption of each cup of tea. The participants gave more correct answers on the switch task and reported to feel more alert after black tea in either study. Moreover, in the first study participants also gave more correct answers on a second attention test after black tea (trend in the same direction in study 2). Caffeine and theanine plasma levels were not measured in this study but were estimated using a kinetic model. This model indicated that plasma levels of caffeine and theanine were likely to be higher in the first study, which may explain why the tea effects on attention were slightly stronger in the first study.

**INTERPRETATION:**
These two studies were the first to compare the effects of black tea to a proper control drink that was indistinguishable from real black tea. With this placebo, administered in a double-blind fashion, expectancy effects that participants in the study may have had about the effects of caffeinated drinks on attention, were minimised.

Although both studies showed positive effects of black tea on attention, effects were stronger in the first study. One of the differences between studies was the timing of the drinks relative to each other. Modelling of caffeine and theanine kinetics in plasma over time suggested that the cumulative plasma levels of caffeine and theanine may have been higher in the first study. Higher plasma levels in combination with stronger effects in the first study, suggests that a dose-response relationship between black tea strength and attention effects may exist.

The size of the improvements in attention were relatively small (in the range of a few percent) but statistically very significant, which was surprising given that the participants were well-rested and already quite alert at the start of the study. Moreover, the fact that participants reported that they felt more alert after consuming black tea as compared to after the placebo strengthens the relevance of the attention benefits reported after black tea in everyday life.
2.2 CAFFEINE AND ATTENTION


ABSTRACT
The present work investigated the effects of caffeine (0 mg, 100 mg, 200 mg, 400 mg) on a flanker task designed to test Posner’s three visual attention network functions: alerting, orienting, and executive control (Posner, 2004). In a placebo-controlled, double-blind study using a repeated-measures design, we found that the effects of caffeine on visual attention vary as a function of dose and the attention network under examination. Caffeine improved alerting and executive control function in a dose–response manner, asymptoting at 200 mg; this effect is congruent with caffeine’s adenosine-mediated effects on dopamine-rich areas of brain, and the involvement of these areas in alerting and the executive control of visual attention. Higher doses of caffeine also led to a marginally less efficient allocation of visual attention towards cued regions during task performance (i.e., orienting). Taken together, results of this study demonstrate that caffeine has differential effects on visual attention networks as a function of dose, and such effects have implications for hypothesized interactions of caffeine, adenosine and dopamine in brain areas mediating visual attention.
SUMMARY:
In this study, 36 students visited the lab on four occasions. On each occasion they received one of four treatments (placebo, 100 mg, 200 mg, or 400 mg of caffeine) and completed a complex task of attention, namely the Attention Network Task (ANT), before and after consumption. The result showed that caffeine improved performance on two out of three attention measures in this task. Furthermore, it appeared that although all caffeine doses improved performance, the largest effect of caffeine was found at the 200mg dose. From this study it can be concluded that caffeine can affect a complex attention task, and that a very high dose of caffeine is not necessarily more effective in improving attention.

INTERPRETATION:
It is generally accepted that attention can be characterised in terms of simple or complex information-processing. Simple information-processing pertains to processes that are sensitive to the arousal or psychomotor components of attention, while complex processing pertains to higher order processing. Whereas there is a general consensus that caffeine can improve more basic aspects of attention (e.g., simple reaction time) via its role in increasing arousal, the evidence for its effects on more complex attention tasks is equivocal. The ANT is a complex attention task which measures three aspects of attention in a single task, called ‘attention networks’. The current study thus supports that caffeine can in fact improve more complex attention processes. The current study also supports that a dose of 100mg caffeine, which is regularly consumed in 2 to 3 cups of tea, can improve complex attention.
2.3 THEANINE, CAFFEINE AND ATTENTION


ABSTRACT
The non-proteinic amino acid L-theanine and caffeine, a methyl xanthine derivative, are naturally occurring ingredients in tea. The present study investigated the effect of a combination of 97 mg L-theanine and 40 mg caffeine as compared to placebo treatment on cognitive performance, alertness, blood pressure, and heart rate in a sample of young adults (n = 44). Cognitive performance, self-reported mood, blood pressure, and heart rate were measured before L-theanine and caffeine administration (i.e. at baseline) and 20 min and 70 min thereafter. The combination of moderate levels of L-theanine and caffeine significantly improved accuracy during task switching and self-reported alertness (both P < 0.01) and reduced self-reported tiredness (P < 0.05). There were no significant effects on other cognitive tasks, such as visual search, choice reaction times, or mental rotation. The present results suggest that 97 mg of L-theanine in combination with 40 mg of caffeine helps to focus attention during a demanding cognitive task.

SUMMARY:
The study consisted of males and females, aged 18 to 34. On one occasion, participants received an ice tea drink containing 97 mg L-theanine and 40 mg caffeine. On another occasion, they received an ice tea drink without L-theanine or caffeine (i.e., placebo). Both drinks were identical in taste and appearance. Before and after consuming the ice tea, participants completed cognitive tests and rated how difficult and tiring they found them. When participants had drunk the combination of L-theanine and caffeine, they were more accurate on a cognitive task measuring attention. During this task, they had to switch between two sets of instructions depending on the colour of letter word combination. In addition, they felt more alert and less tired. The L-theanine and caffeine combination did not affect performance on other cognitive tasks.

INTERPRETATION:
The findings of this study concur with previous findings and suggest that L-theanine in combination with caffeine improve performance on cognitive tasks measuring attention (Einother et al., 2010; Owen et al., 2008). Together, these studies corroborate the idea that L-theanine and caffeine may be the ingredients in black tea, which together are responsible for the positive effect on attention.
2.4 BIOAVAILABILITY OF L-THEANINE


ABSTRACT
After consumption of tea, L-theanine enters systemic circulation and is assumed to enter the brain. Several human studies indicate that L-theanine influences brain functioning. Knowledge about the pharmacokinetics of L-theanine facilitates further study of this health effect. Volunteers received 25–100 mg of L-theanine as tea, as L-theanine-enriched tea, and as biosynthetic L-theanine in aqueous solutions. Plasma was analysed for L-theanine content after which data were fitted with a 1-compartment model. For all interventions, the lag time was approximately 10 min and half-lives of absorption and elimination were approximately 15 and 65 min respectively. After approximately 50 min, maximum plasma concentrations of between 1.0 and 4.4 mg/L were achieved. Maximum plasma concentration and area under the plasma-concentration–time curve were dose-proportional. This knowledge allows prediction of plasma concentrations for various dose regimens supporting further study of a health benefit of L-theanine.

SUMMARY:
In this study, 15 males consumed one of five beverages on each study day: hot water with 25, 50, or 100 mg biosynthetic L-theanine dissolved, or Lipton Yellow Label black tea naturally containing 25 mg of L-theanine with 0, and 25 mg L-theanine derived from green tea added. Blood samples were collected at 0, 15, 30, 45, 60, 90, 180, 240, 360 and 480 min relative to the consumption of the beverage. No attention tests were performed in this study. L-theanine was absorbed quickly and resulted in maximum plasma concentrations of up to 5 mg/L L-theanine. Plasma concentrations could be described with a first-order kinetic model. Half lives of absorption and elimination were 15 and 65 min respectively.

INTERPRETATION:
Whereas the kinetics of caffeine have been studied numerous times, this is the first study to investigate the kinetics of L-theanine in humans. Interestingly, the kinetics of theanine were very similar for the various sources of theanine (as naturally present in black tea, pure L-theanine derived from green tea, or biosynthetic L-theanine) and across the matrices (hot water or black tea) used in this study. Knowledge on the kinetics of L-theanine and caffeine were instrumental in understanding differences in effect size between studies (e.g. the two black tea studies by De Bruin et al. (2011) and will be helpful in designing future intervention studies. However, the final missing piece crucial to understanding the relationship between L-theanine intake and attention performance is the bioavailability of L-theanine in the brain. At present it is unknown whether L-theanine arrives in the brain in relevant concentrations and whether it has a direct effect on brain function. It is also possible that L-theanine has an indirect effect on the brain, e.g. via its main metabolite ethylamine. The only way to assess effects of L-theanine on brain function directly would be to measure neurotransmitter concentrations in the human brain following consumption of L-theanine or placebo with Positron Emission Tomography (PET). To our knowledge this study has not been performed yet.
2.5 TAKING THE TEA OUT OF THE LAB – TEA AND SELF-PERCEIVED WORK PERFORMANCE


ABSTRACT
The aim of this research was to examine relationships between tea, coffee and other beverage consumption and associates of work performance and mood among individuals in relatively stressful and cognitively demanding workplace settings. Using a naturalistic, cross-sectional study design, 95 professional and academic staff logged their beverage intake and completed self-reports of associates of work performance (fatigue/exhaustion, mindfulness, work engagement), subjective work performance, mood, work-related strain and recovery four times daily during ten working days. Data were analysed using multilevel modeling in keeping with the hierarchical structure of the data. Tea consumption was associated with increased perceived work performance and reduced tiredness, especially when consumed without milk or sugar. Consumption of non-caffeinated beverages was associated with increased relaxation and recovery from work. In contrast, tea and other caffeinated beverages were found to enhance the negative effects of evening recovery and morning mood on mindfulness during the day. The findings suggest that beverage intake may have a role in optimizing work-related psychological states and performance.
SUMMARY:
Participants in the study were males and females, (mean age 36.96), who were working at different universities in Australia. Throughout ten working days, participants completed a diary. Four times a day, they reported their beverage consumption. They also answered questions about their subjective work performance and how they felt at a number of times throughout the day and just before bedtime. The outcomes reflected the everyday cognitive and emotional challenges faced by individuals in relatively stressful and cognitively demanding work-place settings.
Results showed that participants consumed one cup of tea per day on average. However, there was big variation in the numbers of cups. Interestingly, participants who consumed more tea felt less tired and reported higher levels of subjective work performance.

INTERPRETATION:
This is the first study to show positive effects of tea consumption on subjective work performance. Up to this point, most studies investigating the effects of tea on performance have investigated laboratory conditions, in which specifically designed computer tests of attention were administered. Studies such the Bryan et al. (2011) study are important as they give credibility to the idea that tea consumption has real-life performance benefits, e.g. in a demanding work setting.
Moreover, the findings from this very recent study demonstrate the validity of findings from earlier controlled studies, such as the study from Hindmarch et al. (1998) who demonstrated the positive effects of three servings of 400ml of black tea on measures of attention when taken throughout the day, as well as self-reported alertness.
FROM THIS SCIENCE OVERVIEW, THE TAKE AWAY MESSAGES FOR THE CONTRIBUTION OF TEA TO ATTENTION ARE:

In the preceding paragraphs, we presented five very different studies, which all in their specific way provide credence to the idea that black tea consumption is beneficial for attention performance. These studies investigated the attention effects of tea and its ingredients caffeine and theanine, the bioavailability of the amino acid theanine, which is unique to tea, and the effects of tea on self-perceived work performance.

In sum, these studies clearly demonstrate that black tea helps to improve attention.
4. References


