Paper:
Sands, H., Downey, L., Wilson, R., Abbott, L., Tysse, B. & Parrott, A. (2015). Mood and Psychomotor Tremor Changes following Acute Caffeine Consumption in Moderate and Minimal Caffeine Consumers. *Journal of Caffeine Research, 5*(1), 42-49.
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Abstract

Objective: The behavioural effects of caffeine have been well documented, with research reporting improvements in both mood and cognitive performance. There has been a paucity of research investigating the cumulative effects of caffeine over the working day, with few studies considering the effects of tea as a beverage. We looked at the cumulative effects of caffeine in male (n= 11) and female (n=13) healthcare workers who consumed different beverages (caffeinated and decaffeinated tea, coffee and Horlicks) over six working dayshifts. The aim of this study was to obtain psychodynamic profiles for caffeine and caffeine deprivation over the course of a working day. *Method:* This was a double-blind, within-subjects study. Twenty-four volunteers (11 males and 13 females) comprising healthcare assistants and nurses completed a mood questionnaire every hour throughout the day and a battery of computerised cognitive tasks at the start of their shift, 2-3rs and 4-5hrs into their shift. *Results:* With performance, no overall effects of caffeine were obtained. Consuming caffeinated Horlicks was found to improve accuracy on a number vigilance task, compared to when decaffeinated Horlicks was consumed (pre-post test). With mood, the consumption of caffeinated beverages led to higher levels of arousal over the day (compared to decaffeinated beverages) and the consumption of caffeinated tea led to lower levels of anxiety throughout the day (compared to decaffeinated tea). *Conclusions:* Caffeinated tea was found to promote a sense of well being and suggests that the psychoactive effects of tea should be further investigated.

Introduction

The contradictory findings when investigating the effects of caffeine upon performance and mood has been well documented (Smith, 2002). Caffeine has been found to enhance performance, using alertness, vigilance and information processing tasks (Bruce and Lader, 1986; Fagan, Swift and Tiplady, 1988 Johnson Spinweber, and Gomez, 1990; Smith Rusted, Eaton-Williams, Savory and Leathwood, 1990; Frewer and Lader, 1991; Mitchell and Redman, 1992; Fine, Kobrick, Lieberman, Marlowe, Riley and Tharion, 1994,; Smith, Kendrick, and Maben, 1992; Smith, Whitney, Thomas, Perry and Brockman, 1997; Warburton, 1995; Smit and Rogers, 2000, Brice and Smith, 2001), increase the speed of processing new stimuli (Smith, Clark and Gallagher, 1999, Smith, Sutherland and Christopher,2005) and remove the post-lunch dip in sustained attention (Smith, 1990, Smith, Rusted, Eaton-Williams, Savory, Eaton-Williams and Hall 1991, Smith and Phillips, 1993). However, other research refutes this (Svensson, Persson and Sjoberg, 1980; Loke, Hinrichs and Ghoneim 1985, Swift and Tiplady, 1988).

With mood, caffeine has been found to improve levels of alertness and counteract the effects of fatigue (Smith and Phillips 1993; Muehlbach and Walsh (1995); with deprivation leading to increases in feelings of irritability, anxiety (Loke et al, 1985; Stern, Chait and Johanson ; Lieberman, 1992; Green and Suls, 1996; Sicard et al, 1996) and depression (Griffiths and Woodson,1988; Smith, Kendrick and Maben,). However, it has been suggested that these effects have been obtained after ingesting large quantities of caffeine and similarly, these findings have been refuted (Svensson et al, 1980; Eaton and Mcleod, 1984; Swift and Tiplady, 1988).

Most studies examine acute changes after administering a single dose, with less known about regular consumption and there is considerable variation in methodology and measures used. In addition to this, previous studies have administered caffeine in coffee, dismissing any effects that might be obtained using tea (Gilbert, 1984) and it has been suggested that other compounds (e.g. flavonoids, tannins, catechins, theaflovins) may underlie these effects.

Previous studies investigating the effects of tea have found that some differences exist in the consumption of tea and coffee (Quinlan, Lane and Aspinall, 1997; Hindmarch, Rigney, Stanley, Quinlin, Rycroft and Lane, 2000; Steptoe et al, 2007). Haskell, Kennedy, Milne, Wesnes and Scholey (2008) suggest that beverages containing theanine and caffeine (such as tea) may have a different pharmacological profile to those containing caffeine alone, with theamine historically recognised as a relaxing agent (Lu et al, 2004; Nathan, Lu, Gray and Oliver, 2006; Kimura, Nagato, Aoi, Juneja and Ohira, 2007). However, in terms of cognitive performance, conflicting findings have been obtained, with negative or no effects being found (eg Haskell et al, 2008, James and Rogers, 2005). Rogers, Smith, Heatherley and Pleydell-Pearce (2008) investigated the subjective, behavioural and blood pressure effects of theanine and caffeine, administered alone and together, in doses relevant to the daily tea consumption of regular tea drinkers. They concluded that it remains unclear as to how theanine might explain perceived differences between the consumption of tea and coffee.

Improvements in performance and mood have been highlighted when consuming tea as a beverage. Hindmarch, Ouinlan, Moore and Parkin (1998) investigated the effects of black tea and other beverages on aspects of cognition and psychomotor performance and found

improvements when consuming tea (in terms of Critical Flicker Fusion), which was not affected by time of day. Over the day, the consumption of tea, and caffeinated compared to decaffeinated beverages, was found to prevent a decline in alertness and cognitive capacity. Hindmarch Rigney, Stanley, Quinlan, Rycroft and Lane (2000) investigated the effects of day-long consumption of tea, coffee and water on cognitive and psychomotor performance and sleep quality at night. They suggested that day long consumption of tea has similar alerting effects (using a psychometric battery of tests) to coffee, despite low caffeine levels; but that tea is less likely to disrupt sleep. De Bruin, Rowson, Van Buren, Rycroft and Owen (2011) found that the consumption of black tea as a beverage was found to enhance attention and alertness. In a more ecologically valid study, Bryan, Tuckey, Einother, Garczarek and Garrick (2012), using a naturalistic, cross-sectional study design of professional and academic staff, investigated the daily habitual consumption of tea and other beverages upon performance and mood, finding that the consumption of tea was associated with increased perceived work performance and reduced tiredness, most especially in the absence of milk and sugar. Tea and other caffeinated beverages were found to enhance the negative effects of evening recovery and morning mood on mindfulness during the day, with non caffeinated beverages leading to an increase in relaxation and recovery from work.

Therefore, there seems to be scope for definitive studies in this area. More specifically, it can be argued, that there has been a paucity of ecologically focused research investigating the cumulative effects of caffeine over the day and night, using a variety of beverages.

The aim of this present study was to obtain psychodynamic profiles for caffeine and caffeine deprivation, using a variety of beverages (tea, coffee, Horlicks) and to determine these profiles for change across a wide range of cognitive tests and mood states over the course of a working day.

Method

Participants

Twenty-four volunteers (11 males and 13 females) comprised healthcare assistants and qualified nurses (ages ranged from 21 to 55; mean 37, sd 29.8 years) who were all non-smokers and regular caffeine drinkers (who habitually consumed between 3-5 cups tea/coffee daily). Participants gave their written consent prior to commencement of the study and the protocol was approved by the University of East London Ethics Committee. Participants were paid a nominal fee for their participation.

Design

The study used a within-subjects design and all participants completed all six drug conditions comprising the consumption of caffeinated and decaffeinated tea, coffee and Horlicks. Participants were instructed to consume one beverage from each condition, every two hours, from the start of their shift until 17:00h over the course of six working days. Each "active" beverage contained 60mg caffeine. Participants were free to add their own milk and sugar if desired. The order in which the six conditions was administered was counterbalanced between volunteers and the study was double-blind (restricted to the caffeine and no caffeine conditions of the three beverages).

Assessment measures

A self-rating mood questionnaire (West and Russell, 1985[44], Jones and Parrott, 1997[45]) was completed every hour throughout the day. Participants were asked to rate levels of: depression, irritability, jittery, alertness, headache, anxiety, restlessness, stress, arousal and pleasure.

Cognitive performance was measured using a computerised package of assessment measures covering a range of functions; namely immediate and delayed word recall, picture presentation and recognition, simple reaction time, number vigilance and logical reasoning. The tasks have been described previously and have been found to be sensitive to various drug effects (Wesnes, Simpson and Kidd 1988; Preece, Wesnes and Iwi 1998; Parrott, Garnham, Wesnes and Pincock 1996, Parrott, Lees, Garnham, Jones and Wesnes, 1998; Wesnes and Parrott, 1992)

Procedure

Prior to testing, all participants received full training and practice sessions using the computerised battery of tasks and participants were instructed to refrain from drinking caffeine from when they awoke on test days, and also to refrain from consuming any other beverage throughout the day. Test sessions comprised six working day shifts, divided over two weeks. Participants completed the mood questionnaire and the battery of computerised tasks during a baseline session at the start of their shift, followed by two further computerised test sessions (2-3 hours into their shift and 4-5hrs into their shift). Mood questionnaires were completed every hour throughout the day until 17:00hrs.

Data Analysis

Data was analysed using repeated measures ANOVAs, with two factors (caffeine/No caffeine) and beverage (coffee, tea, Horlicks). Six conditions (caffeinated and decaffeinated tea, coffee and Horlicks) were compared over six working days. Cognitive data were analysed as differences in baseline from 2hrs and 4hrs post-drug. Mood data were analysed with 8 time periods over the day (0900-1700h). Post-hoc analysis was performed on performance data, using multiple-paired t-tests.

Results

Cognitive Performance

With the number vigilance task, a significant ANOVA effect was found with caffeine x drink interaction (differences between baseline and post-drug test one), in that accuracy (the number of correct detections) improved when participants consumed Horlicks containing caffeine, compared to when consuming caffeine free Horlicks $F=3.36$, $p<.0.05$, (means 2.41 and -4.63,). There were no significant mood differences found between types of beverage consumed and no overall caffeine effects were obtained with performance.

Mood

A significant effect was detected from the ANOVA with Caffeine, time and beverage was with arousal ($F=5.04$, $p<.05$; in that the consumption of caffeinated beverages led to higher levels of arousal throughout the day (compared to decaffeinated beverages). However, the consumption of caffeinated tea as a beverage led to lower levels of anxiety throughout the day (compared to decaffeinated tea) ($F=p<.05$, means 0.45 and 0.78).

Discussion

This study obtained psychodynamic profiles for caffeine and caffeine deprivation over the course of a working day and represents one of the few, ecologically relevant investigations of cognitive and mood effects of caffeine. Tea, coffee and Horlicks were consumed by participants in both caffeinated and decaffeinated forms. No other beverages were consumed over the day.

With performance, no overall effects of caffeine were obtained. However, accuracy improved on a number vigilance task (pre-post-drug one), when participants consumed Horlicks containing caffeine, compared to when consuming caffeine free Horlicks (Fig 1). No improvements in performance were found after the consumption of tea as a beverage. Therefore, the present findings do not agree with previous research suggesting an improvement in performance (De Bruin et al, 2011; Hindmarch et al, 1998).

Caffeine deprivation has been found to increase feelings of irritability, depression and anxiety (Lieberman, 1992; Sicard et al, 1996), with the consumption of tea as a beverage increasing feelings of alertness over the day, similar to when consuming coffee as a beverage (Hindmarch et al, 2000). The present study suggests that the consumption of caffeinated beverages, compared to decaffeinated beverages, led to higher levels of arousal throughout the day (fig 2). Therefore, this finding supports previous findings, in that the consumption of caffeinated beverages does lead to improved alertness and counteracts the effects of fatigue (Smith et al, 1993; Muelbach and Walsh, 1995), more specifically over the whole course of a working day and after consuming a variety of beverages.

Surprisingly, anxiety levels were found to be lower consuming caffeinated tea, compared to decaffeinated, throughout the course of a day (Fig 3). These findings promote the positive effects of drinking caffeinated tea over the day, over other beverages; suggesting that differences do exist between the consumption of tea and coffee (Quinlan et al, 1997; Hindmarch et al, 2000; Steptoe et al, 2007) and reinforce the suggestion that theamine found in tea has relaxing effects (Lu et al, 2004; Kimura et al, 2007). However, the present findings need to account for possible effects of other compounds, as participants were free to add milk and sugar to their beverages and this varied between participants according to individual preference. Previous studies have highlighted differences such as tea, when taken without sugar was related to lower ratings of tiredness and when taken without milk, sugar or both, was related to better work perceived work performance (Bryan et al, 2012) and the addition of milk to (de) caffeinated tea and coffee had

positive effects on mood and anxiety (Quinlan, lane and Aspinall, 1997). Therefore, it is suggested that future studies investigate these effects further.

The present study differed from most previous work, in that it provides an ecologically valid study investigating the cumulative effects of caffeine over a working day. This study highlights just why drinking tea is so beneficial, not just for those individuals that work within a healthcare setting, but also for psychiatric patients within hospital settings (i.e. drinking coffee has been found to impact negatively upon levels of anxiety whereas the present study suggests that tea has relaxing properties). A between subjects design was employed, with participants consuming a variety of beverages (each with exact does of caffeine), using an extensive battery of cognitive tasks and self-reported mood states. However, the addition of milk and sugar and the implications of this upon other compounds should not be ignored. It also remains unclear as to whether the presence of others when consuming beverages impacts upon possible effects found (eg workers drinking together on their breaks or when alone), in addition of other factors such as food consumption throughout the day. Therefore, the sense of well-being and positive effects found when consuming caffeinated tea as a beverage should be highlighted and further investigated.

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Gaylor Fig.1.

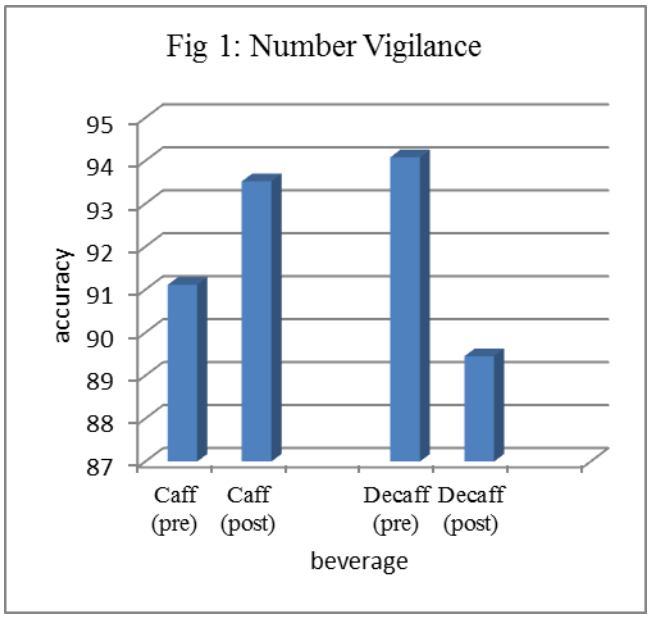
Fig 1: Number Vigilance
95
94
93
92
91
90
89
88
87
accuracy
Caff (pre)
Caff (post)
Decaff (pre)
Decaff (post)
beverage

Gaylor.Fig 2.

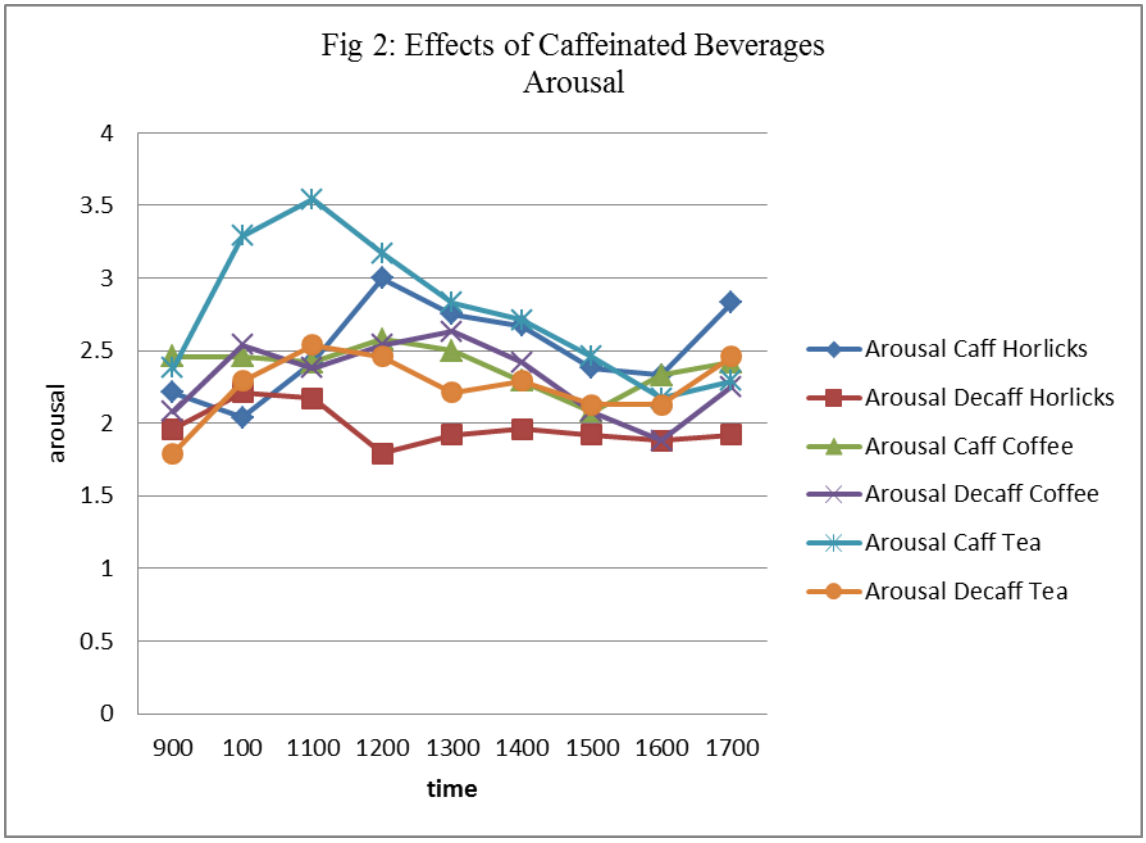
Fig 2: Effects of Caffeinated Beverages
Arousal
arousal
4
3.5
3
2.5
2
1.5
1
0.5
0
900
100
1100
1200
1300
1400
1500
1600
1700
time
Arousal Caff Horlicks
Arousal Decaff Horlicks
Arousal Caff Coffee
Arousal Decaff Coffee
Arousal Caff Tea
Arousal Decaff Tea

Gaylor Fig 3.

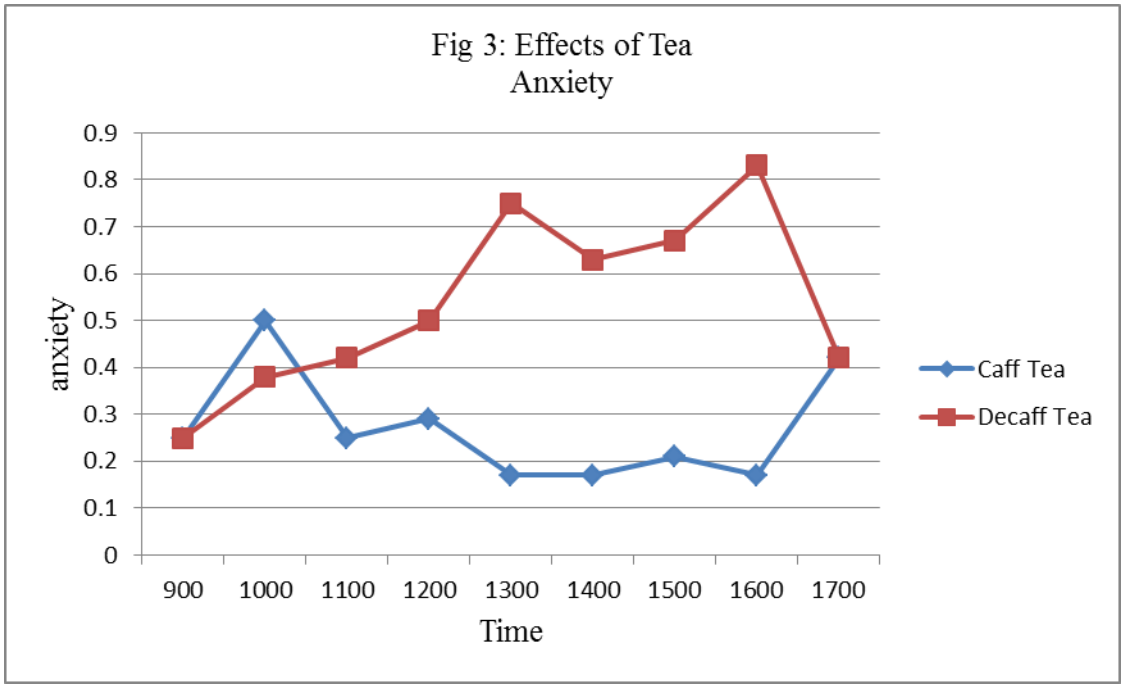
Fig 3: Effects of Tea
Anxiety
anxiety
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
900
1000
1100
1200
1300
1400
1500
1600
1700
Time
Caff Tea
Decaff Tea