WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.084
Volume 12, Issue 7, 914-924. Research Article ISSN 2277– 7105

EFFECTS OF CAFFEINE IN TEA AND HOT WATER ON ALERTNESS, SIMPLE REACTION TIME AND ATTENTION

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Article Received on
17 March 2023,

Revised on 07 April 2023,
Accepted on 27 April 2023

DOI: 10.20959/wjpr20237-28051

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ABSTRACT

Background: Coffee and tea are major sources of caffeine and have often been used as the vehicle in which caffeine has been delivered in laboratory research. Instant coffee has been frequently used, but there are few studies on the behavioral effects of instant tea. There has been a great deal of research on the behavioural effects of caffeine, and sensitive tests have been identified. The present study compared the effects of tea and hot water, with and without caffeine added. **Methods:** Ninety-six university students participated in the research. There were twenty-four in each of the four groups formed by combining caffeine/placebo and tea/hot water conditions. The caffeine condition was double-blind, and 60mg of caffeine was added to the caffeine conditions. Instant tea, with added milk, was compared with hot water. Participants carried out a baseline test session, followed by drinks, and then a post-drink test session one hour later. The test battery included measures of alertness, simple reaction time, choice reaction time, sustained attention, episodic memory, working memory and semantic memory. **Results:** Significant beneficial effects of caffeine were observed for changes in alertness, simple reaction time and sustained attention. There were no significant main effects of tea nor caffeine x tea interactions. **Conclusion:** Caffeine was found to lead to the usual established behavioural changes. This was observed whether it was given in tea or hot water. There was no evidence of significant effects of drink type (tea v hot water), and the effects of caffeine were apparent in both types of drink.

KEYWORDS: Tea, Caffeine, Alertness, Simple reaction time, Sustained attention.

INTRODUCTION

Much of the research on the behavioural effects of coffee and tea has investigated caffeine. This approach was adopted in the early studies of our research programme[1-10] and has been continued in our recent publications.[11-20] The results of this type of research have been frequently reviewed.[21-27] and sensitive measures have been identified. Caffeine has frequently been shown to increase participants' alertness, especially when this is reduced by the prior performance of laboratory tasks. Performance of the variable fore-period simple reaction time task is also improved after consumption of caffeine, as is the ability to sustain attention.

Other research has shown that caffeine has effects when presented as pills or added to other beverages.[28] However, there is also research which shows that coffee and tea have other bioactive components such as theanine, polyphenols, theobromine and chlorogenic acid, which could lead to differences in the behavioural effects of these beverages.[30-35] Many of the studies of coffee have used soluble or instant coffee, whereas studies of tea have often used tea bags. Little is known about the effects of instant tea, and one of the aims of the present study was to examine the effects of tea made from granules. A major component of both coffee and tea is hot water. Another aim of the present study was to determine whether caffeine produced its established effects when delivered in hot water. Many studies have used large doses of caffeine, which are not representative of single drinking episodes. Other research has shown the effects of lower doses of caffeine, typical of the amounts found in single cups of instant tea or coffee.

The first hypothesis tested was that 60 mg of caffeine would improve participants' alertness, simple reaction time and sustained attention but have less effect on memory tasks and choice reaction time tasks. The second hypothesis was that the effects of caffeine would be observed for both instant tea and hot water. Comparison of the decaffeinated tea and hot water allowed for investigation of possible effects of other components of the tea.

METHOD

The ethics committee of the School of Psychology approved the research, and it was carried out with the informed consent of the participants. The study employed a between-participants design, with caffeine being one grouping factor and tea/hot water another. The caffeine/placebo manipulation was double-blind. Testing sessions lasted for three hours and were held between 10.00 and 13.00, 14.00 and 17 .00, and 17.00 and 20.00. The evening

before their test day, participants were instructed to refrain from drinking alcohol. Smoking and drinking caffeinated beverages were not allowed from two hours prior to the start of the study.

Participants

Ninety-six participants, all university students, took part in the research. All were non-smokers and regular caffeine consumers. Participants were paid £20 for participation in the research. Twenty-four participants were randomly assigned to the four groups formed by caffeine/placebo and tea/hot water conditions. Eight participants in each condition were tested in each of the three testing times.

Procedure

Upon arrival at the laboratory, the participants carried out a half-hour familiarisation study, during which time they were briefed about the procedures and familiarised with the test battery. A saliva sample to assess caffeine levels was taken at this time. A baseline test session was then carried out for approximately 40 minutes. The participants then had their drinks break and rated the acceptability of the drink. The post-drink test session occurred one hour later, followed by another saliva sample.

Drinks

All drinks (255 ml) were made with Highland Spring Water and served at 55^0C. In the tea condition, 235 ml of water (at 63^0C) was added to 0.87g of decaffeinated tea granules and 20 ml of refrigerated milk was added. A caffeine solution was added to give 60mg of caffeine. Distilled water was added to the decaffeinated conditions. Participants were instructed to drink at their own pace. Once they had completed their drinks, they completed acceptability ratings using a 10cm visual analogue scale with ratings ranging from 0 = Not at all acceptable to 100 = Extremely acceptable.

Measures of Mood and Performance

A) Mood

Mood was assessed both before and after each set of performance tests using 18 computerised visual analogue rating scales. Three main factors are derived from these - Alertness, Sociability and Tension. The difference in alertness before and after completing the test battery was the primary outcome variable.

B) Performance tests

The following performance tests were completed at each test session in the order shown below. The estimated length of time to complete the test is shown in brackets beside it.

1. Free recall (3 minutes)

The participants were shown a list of 20 words presented at a rate of one every 2 seconds. At the end of the list, the volunteer had 2 minutes to write down (in any order) as many of the words as possible on the sheet provided.

2. Verbal reasoning test (3 minutes)

The participants were shown statements about the order of the letters A and B followed by the letters AB or BA (e.g. A follows B: BA). The participants had to read the statement and decide whether it was a true description of the order of the letters. If it was, the participants pressed the T key on the keyboard; if it wasn't, they pressed the F key. The sentences ranged in syntactic complexity from simple active to passive negative (e.g. A is not followed by B).

3. Five-Choice serial reaction time test (3 minutes)

Five buttons around a central button were present on the response box. A light appeared in one of the peripheral buttons, and the participant had to press that button and then the light returned to the centre button, which also had to be pressed before the procedure would start again.

4. Focused attention (3 minutes)

Target letters appeared in upper case A's and B's. On each trial, three warning crosses were presented on the screen; the outside crosses were separated from the middle one by either 1.02 or 2.60 degrees. Participants were told to respond to the letter presented in the centre of the screen and ignore any distracters presented in the periphery. The crosses were on the screen for 500 ms and were then replaced by the target letter. The central letter was either accompanied by 1) nothing, 2) asterisks, 3) letters which were the same as the target or 4) letters which differed - the two distracters were identical, and the targets and accompanying letters were always A or B. The correct response to A was to press a key with the forefinger of the left hand, while the correct response to B was to press a different key with the forefinger of the right hand. Participants were given ten practice trials followed by three blocks of 64 trials. In each block, there were equal numbers of near/far conditions, A or B responses and equal numbers of the four distracter conditions. The nature of the previous trial was controlled.

5. Categoric search (3 minutes)

Each trial started with the appearance of two crosses in the positions occupied by the non-targets in the focused attention task (i.e. 2.04 or 5.20 degrees apart). Participants did not know, in this task, which of the crosses would be followed by the target. The letter A or B was presented alone on half the trials and was accompanied by a digit (1-7) on the other half. Again the number of near/far stimuli, A versus B responses and digit/blank conditions were controlled. Half of the trials led to compatible responses (i.e. the letter A on the left side of the screen or the letter B on the right), whereas the others were incompatible. The nature of the preceding trial was also controlled. In other respects (practice, number of trials, etc.), the task was identical to the focused attention task.

6. Semantic processing task (3 minutes)

This test measures the speed of retrieval of information from general knowledge. Participants were shown a sentence and had to decide whether it was true (e.g. canaries have wings) or false (e.g. dogs have wings). The number completed in the 3 minutes was recorded, as was the accuracy of responses.

7. Variable fore-period simple reaction time (3 minutes)

In this task, a box was displayed on the screen and at varying intervals (from 1 to 8 seconds), a square would appear in the box. Participants were required to press a response key as soon as they detected the square.

8. Repeated digits detection task (3 minutes)

Participants were shown three-digit numbers on the screen at the rate of 100 per minute. Each digit was normally different from the preceding one, but occasionally (8 times a minute), the same number was presented on successive trials. Participants had to detect these repetitions and respond as quickly as possible. The number of hits, reaction times for hits, and false alarms were recorded.

9. Recognition memory (2 minutes)

At the end of the test session, participants were shown 40 words which consisted of the 20 words shown at the start plus 20 distracters. The participants had to decide as quickly as possible whether each word had been shown in the original list or not.

RESULTS

Acceptability ratings

Both caffeinated and placebo teas were liked more than the hot water. Caffeine had no significant effect on acceptability (Mean ratings: Caffeinated tea: 48.2; Placebo tea: 57.0; caffeinated hot water: 18.5; Placebo hot water: 26.5).

Caffeine levels in saliva

The change in caffeine levels from baseline showed that those given caffeine had higher levels than at baseline (Caffeinated tea: 3.5 mmol/l; Caffeinated hot water: 2.8 mmol/l), whereas those given placebo showed a decrease from their baseline level (Placebo tea: -3.0 mmol/l; Placebo hot water: -2.5 mmol/l).

Mood and Performance

Analyses of covariance were carried out with the baseline variables as covariates and the post-drink variables as the dependent variables. The between-subject factors were caffeine/placebo and tea/hot water.

Significant effects of caffeine

The change in alertness over the test session showed a significant effect of caffeine, with the decline in alertness being less in the caffeine condition (see Table 1). The placebo groups showed a decrease of 11.3%, whereas the decline in the caffeine groups was 4.8%. There was no significant effect of drink type (tea v hot water) nor caffeine x drink type interaction.

The simple reaction time analysis also showed a significant effect of caffeine, with reaction times being faster in the caffeine conditions (see Table 1). Again, there was no significant effect of drink type nor caffeine x drink type interaction.

The analysis of the repeated digit task hits showed that significantly more targets were detected in the caffeine condition (see Table 1). Again, there were no significant effects of drink type nor caffeine x drink interaction.

Analyses of the other tasks showed no significant effects, although there was a numerical trend of faster performance in the caffeine conditions in the analyses of the focused attention, categoric search, logical reasoning and semantic processing tasks. There was no evidence of caffeine changing performance for the recall and recognition tasks.

Correlations between acceptability, saliva levels of caffeine and mood and performance Within the caffeine groups, there were no significant correlations between the behavioural changes and the ratings of drink acceptability or saliva caffeine levels.

Table 1: Effects of Caffeine and Drink type on alertness change, Simple reaction Time and Detection of targets in the repeated digits task (Scores are the adjusted means, s.e.s in parentheses).

Variable	Caffeine/ Tea	Caffeine/ hot water	Placebo/ tea	Placebo/ hot water	Significance of caffeine effect
Alertness change	-13 (7.5)	-11 (7.4)	-19.5 (7.5)	-37.1 (7.4)	F1,93 = 4.68 p <0.05
Simple RT (msec)	351 (9.0)	341 (9.2)	381 (9.0)	376 (9.2)	F1,93=12.55 p < 0.001
Repeated digits hits (maximum = 24)	13.7 (0.7)	14.4 (0.7)	12.7 (0.7)	13.2 (0.8)	F1,93 =2.88 P <0.05 1-tail

DISCUSSION

Many studies of the behavioural effects of caffeine have used tea or coffee as the vehicle for caffeine administration. In the case of coffee, instant or soluble coffee has often been used for convenience. In contrast, there has been little investigation into instant tea, and this was the first aim of the present study. Research suggests that the effects of low doses of caffeine are very similar in different vehicles (e.g. coffee, tea, soft drinks and water), and this was examined here. Studies with other types of coffee have examined the effects of other bioactive compounds (e.g. chlorogenic acid). Similarly, studies of tea have examined components such as theanine, sometimes in combination with caffeine. Another aim of the present study was to compare the effects of tea with those of hot water.

Research on caffeine has demonstrated that certain outcome measures are more sensitive than others. The established sensitive measures used here were changes in subjective alertness over the test battery, variable fore period simple reaction time and sustained attention. Other tasks (choice reaction time, episodic memory, working memory and semantic memory) have been shown to be less sensitive to the effects of low doses of caffeine, and it was predicted that they might not show significant effects in the present study.

The results confirmed that caffeine improved alertness, simple reaction time and sustained attention. There were no significant effects of caffeine for the other tasks. No significant differences were found between tea and hot water, and there were no significant interactions

between drink type and caffeine. These findings confirm previous research on sensitive indicators of caffeine effects[36] and that the effects of caffeine can be found in different beverages.[28] It is also important to note that the participants were only deprived of caffeine for two hours and that the effects of caffeine are unlikely to reflect the reversal of caffeine withdrawal. Saliva levels of caffeine showed no difference in metabolism as a function of drink type. In the caffeine groups, saliva levels of caffeine were not correlated with the behavioural changes confirming earlier findings.[37] The tea was liked more than the hot water but drink acceptability ratings were not significantly correlated with the behavioural effects. Finally, it should be noted that the tea differed from the hot water, not only in the presence of tea granules but also in the addition of milk. The results suggest that milk does not modify the behavioural effects of caffeine, although the use of a black tea condition would give more confidence in this conclusion.

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