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BEHAVIOURAL EFFECTS OF CAFFEINE: CONSIDERATION OF CONTEXTUAL FACTORS

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ABSTRACT

Background: There has been extensive laboratory research on the behavioural effects of caffeine. There is still a need to determine whether such effects are obtained with realistic doses, when sugar is added to the drink, and when participants vary in age and personality. The relationship between acceptability and behavioural effects of caffeine also requires further study. **Methods:** One hundred and twenty-eight participants completed a separate groups, double-blind study examining the effects of 60mg caffeine in coffee and sugar on mood and performance. Associations of the behavioural effects of caffeine and sugar with acceptability, habitual level of caffeine consumption, age and personality were examined. **Results**: Caffeine was associated with a more positive mood and faster simple reaction time and encoding of new information. These effects did not vary with drink acceptability, time of day, level of habitual caffeine use, age or personality. Sugar had little effect on mood or performance. **Conclusion:** These results demonstrate that the behavioural effects of caffeine are largely unaffected by contextual factors related to the nature of the drink, regular caffeine usage and individual characteristics of the person.

KEYWORDS: Caffeine; Sugar; Acceptability; Regular Consumption of Caffeine; Personality; Mood; Performance.

INTRODUCTION

There has been extensive fundamental research on the behavioural effects of caffeine,[1-7] and there are plausible underlying biological mechanisms for them.[8-10] A large number of studies have shown that caffeine leads to a more positive mood, an increase in psychomotor speed

and faster encoding of new information. Other tasks, such as episodic or working memory tasks, show less reliable effects of caffeine. While many studies have demonstrated the effects of these substances on mood and performance, there is a question as to whether such effects occur in real-life situations. Much of the earlier research has suffered from important conceptual and methodological weaknesses, and it is clear that there is a need to continue to develop and refine the methods used in this area.

The need to consider conditions more closely resembling those encountered in real life can be illustrated by considering the effects of caffeine on mood and performance. Sweeping generalisations are made about the effects of caffeine, based mainly on studies that have used very large doses (compared to the amounts of caffeine obtained from drinking coffee, tea, or cola), used students as participants, and tested them in the early morning only. It is clearly desirable to examine the effects of the doses of caffeine more frequently consumed, to do this in a representative sample of the population at several times of day, and to consider the possible modifying effects of habitual caffeine consumption and individual differences.

Problems in interpreting the literature also arise due to poor design and lack of statistical power. Previous studies can be criticised on three grounds. First, the measures used have been purely descriptive and not linked to the sophisticated models of performance and mood developed by experimental psychologists. Secondly, many tasks have been based on poor technology. For example, reaction times have only been measured to the nearest 20 ms, which is often less than the magnitude of the effect of the independent variable being studied. Finally, many of the tasks used have not been appropriate to study short-lived sensory effects, which may be very important in influencing food choice and acceptability.

There is considerable commercial interest in the relationships between consumption of certain foods and beverages and changes in mood and cognitive performance. The main reasons for this interest are as follows. Firstly, such information may be important in the development of new products which are not only beneficial to health but which also produce positive effects with regards to mood and performance efficiency. Secondly, it is important to substantiate existing claims concerning the functional properties of certain snacks and beverages. Finally, it is essential to understand the factors influencing food choice and acceptability, and a much-neglected area is the behavioural changes produced by the food or drink. Indeed, positive shifts in mood accompanying ingestion may play a direct role in

reinforcing liking for the food or beverage consumed. Furthermore, certain foods and drinks may be selected when the person is in a particular mental state.

Given this background to previous research, the aims of the study were

1. To validate the sensitivity of the methods of mood and performance assessment using low doses of caffeine and sugar.
2. To examine these effects in a sample of volunteers from the general population to determine if they are constant or vary across age or different personality types.
3. To consider the importance of other contextual factors, such as the level of regular use of the products, in modifying the effects of the experimental substances.

The rationale behind the selection of the present outcome measures is given below. First, self-report questionnaires provide the most appropriate method for the assessment of mood effects of foods and beverages. Such instruments (e.g., the visual-analogue scales) provide good measures of alertness, hedonic tone and anxiety. In order to collect data on product enjoyment, recent developments from the food acceptability area were incorporated in the present study.

Two major areas of cognitive performance were considered in detail, namely selective attention and working memory. In addition, other traditional tests measuring such functions as psychomotor speed were used in order to provide a comparison with these more focused tests, which formed the core of the assessment battery for the project. The reasons for selecting these tests were

1. There are well-established theoretical models of working memory and selective attention.
2. The tasks are known to be sensitive measuring instruments that have been shown to be valid indicators of changes of state induced in a variety of ways (e.g., pharmacological manipulations, circadian variation, viral infections).
3. Minimal practice effects with these tasks make them particularly suitable for repeated presentations in the longitudinal assessment of functioning.
4. The tests allow detailed dissociations of mental functions, which can be linked to specific neurotransmitter systems.
5. The tests are in a form that eliminates the technological problems outlined earlier (e.g. reaction times are measured to the nearest millisecond). In addition, they can be transferred relatively easily to portable computers for use in the field.

This research described here involved assessment of the sensitivity of the tests to the effects of low doses of caffeine and sugar, considering both immediate sensory effects and those present for a long time after consumption of the drinks. Examination of the importance of contextual factors (e.g. characteristics of the person, regular use of the product, time of day at which consumption and testing occur) was also carried out. Caffeine was chosen as a model substance since it is known or can be expected to have definite behavioural effects. Caffeine can also be manipulated 'double blind', whereby neither the experimenter nor the participant knows the dose received. The sensitivity of the methods can be examined conveniently by testing whether low doses (e.g. those in everyday drinks) reliably alter mood and performance.

METHOD

The study was carried out with the approval of the School of Psychology Ethics Committee and the informed consent of the volunteers.

Sample: A general population sample (N = 128 per study) was recruited with approximately even numbers being drawn from the following age bands: 18 - 30, 31 - 40, 41 - 50 and 51 – 65 years. Demographic factors (e.g., age and gender), personality (e.g., introversion-extraversion and anxiety) and frequency of use of caffeine and sugar were included in the analyses. Such a sample gave considerable statistical power and allowed investigation into the extent to which relationships between the effects of caffeine and sugar generalised across participants. Forty-two per cent were single, almost as many were married, and sixteen per cent were divorced or separated. Thirty-six per cent had been educated at university, a further forty-seven per cent had completed ‘A’ or ‘O' Levels, and only seventeen per cent were unqualified. All but five participants were white. Thirty-three per cent were engaged in either full or part-time employment, and thirty-five per cent were unemployed. Of the remainder, almost half were retired and the rest students. Less than one-third of the participants were smokers. Of these, twenty-nine per cent smoked less than ten cigarettes per day, whilst the majority smoked ten to twenty per day. For smokers, the average number of cigarettes smoked each day was twelve. Over ninety per cent consumed alcohol. On average, they drank approximately nine units per week, with males consuming significantly ($p<0.01$) more units each week than females (eleven as opposed to seven). Nearly twenty per cent only drank at weekends. Ninety-seven per cent of the sample regularly consumed caffeinated

beverages. Overall, the average daily caffeine consumption was 243 mg (SD 164.49) with a range of 0 to 1375 mg. Participants were paid £25 upon completion of the study.

Exclusion Criteria

Volunteers were not selected for the study if they consumed more than twenty-five units of alcohol per week or if they smoked more than ten cigarettes in the daytime. This was to eliminate the possible effects of alcohol or nicotine withdrawal.

Participant Categorisation

Each person's daily caffeine consumption was calculated from the number of cups of caffeinated tea and/or coffee consumed. They were then designated as either high or low habitual caffeine consumers on the basis of a median split of total daily caffeine consumption. Median daily caffeine consumption was 230mg. They were further split into those who usually sweetened their coffee, either with sugar or other sweeteners, and those who usually drank their coffee unsweetened. Participants were also classified as either high or low personality types on measures of trait anxiety, obsessional personality and extraversion, following a median split of the sample for each dimension. These personality scales were selected as they were the best examples of three personality dimensions that emerged from factor analysis of a variety of personality measures.[11]

Experimental design

The study was based on a between-subjects design. Participants were allocated to receive either caffeinated or decaffeinated coffee, which either contained sugar or was sugar-free. Each subject participated in either a morning or afternoon test session. These conditions were balanced across usual caffeine and sugar intake and age band. Prior to testing, participants were given practice at the tasks to achieve stable levels of performance. This again is a major methodological improvement over much of the previous research where practice effects, even when these are relatively small, make the interpretation of results difficult. Baseline measurements were taken immediately before consumption of the experimental drinks, and these data were used as covariates in the analyses of the dependent variables to remove the effects of any unwanted differences in performance. The manipulation of caffeine was carried out double-blind. Mood and performance were then assessed immediately following consumption of the experimental drinks and then at regular intervals over the next 2 hours. This enabled both short-lived sensory effects and longer-term post-digestive effects to be detected. Testing was carried out at different times of day, which enabled investigation into

the extent to which effects may interact with background factors such as circadian variations in alertness. Testing sessions were held in the morning between 9.30 am and 12.30 pm and in the afternoon between 1.30 and 4.30 pm.

Nature of the drink

Participants received one rounded teaspoon of either caffeinated or decaffeinated Nescafe instant coffee (coded X and Y) in a 150ml mug of boiling water. One teaspoon of sugar was also added for those allocated to receive a sweetened drink. Milk in the drink was added in accordance with usual preference and was recorded. The participants, therefore, received realistic drinks, although neither they nor the experimenters knew the caffeine content of their drink.

Mood and performance battery

Mood was rated using standard visual-analogue scales (presented on the computer) labelled with pairs of bipolar adjectives (e.g., drowsy-alert). Similar ratings to assess drink acceptability were also included. Three factors were extracted from the mood ratings: alertness, sociability or hedonic tone, and anxiety.

Two selective attention tasks were used. Briefly, these measure a number of different aspects of attention (e.g. susceptibility to distraction and funnel vision), provide global measures of choice reaction time performance (mean reaction time and per cent correct), allow assessment of speed of encoding and response organisation and are known to be sensitive measuring instruments. Working memory tasks measuring the function of the articulatory loop, central executive and visuospatial scratchpad were also used. In addition, simple reaction time was measured since earlier research suggests that this task is influenced by caffeine. The performance tasks are shown below:

a) Variable fore-period simple reaction time task

In this task, designed to measure psychomotor speed, a box was displayed on the screen, and at varying intervals (from 1-8 secs), a square would appear in the box. Participants were required to press a response key with the index finger of the dominant hand as soon as they detected the square. (duration 3 minutes)

b) Focused attention task

In this selective attention task, 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 distractors presented in the periphery. The crosses were on the screen for 500 msec and were then replaced by the target letter. The central letter was either accompanied by 1) nothing, 2) asterisks, 3) letters that were the same as the target, or 4) letters that differed. The two distractors 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 fore-finger of the left hand, while the correct response to B was to press a different key with the fore-finger 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 distractor conditions. The nature of the previous trial was controlled. (duration = 5 minutes)

c) Categoric search task

In this task, again measuring aspects of selective attention, 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 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. (duration = 5 minutes)

d) Serial recall task

In this task, which primarily investigates the articulatory loop of the working memory model, eight single-digit numbers were consecutively presented on the screen at a rate of one per second. Participants were required to observe the eight numbers and then write down as many as they could remember in the order in which they were shown. If they were unsure about a

number, they were encouraged to guess. This process was repeated three times, and their responses were recorded on a sheet of paper. (duration = 3 minutes)

e) Running memory task

This task was very similar to the previous one but is thought to examine the central executive of the working memory model. The difference was that the sequence of numbers was of variable length, and the person did not, therefore, know when the sequence would end. They were still required to write down as many of the last eight numbers as they could remember in the order in which they were shown. Again if they were unsure of a number, they were encouraged to guess. There were three trials, and the responses were recorded on a response sheet. (duration = 3 minutes)

f) Mental Rotation task

In this task, examining the visuospatial scratchpad of the working memory model, either an 'R' or a reversed 'R' was presented on this screen. This was presented either in an upright position, upside down or at 270 degrees. The task was to decide whether the letter would be an 'R' or a reversed 'R' when returned to the upright position. The correct response to an 'R' was to press a key with the fore-finger of the left hand, while the correct response to a reversed 'R' was to press a different key with the fore-finger of the right hand. (duration = 3 minutes).

Questionnaires

Over the course of the experiment, several questionnaires were completed, and these are listed below:

At recruitment

General recruitment (Education / Ethnicity / Job / Health)

Health-related behaviours (smoking/caffeine/alcohol)

Eysenck Personality Inventory

Obsessional Personality

Trait Anxiety

Morningness

On the test day

Previous night's sleep, breakfast and lunch questionnaire.

Drink acceptability rating questionnaire.

Statistical Analysis

The data were collected into a form compatible with the major statistical packages and were collated immediately for analysis. The analyses consisted of analyses of covariance and multiple regression, which not only allowed determination of the effects of the experimental substances (with demographics etc., as control variables) but also enabled possible interactions between the substances and between them and contextual factors to be investigated.

Schedule of testing

Familiarisation

A one-hour familiarisation session was held prior to the test day, during which volunteers were weighed (to check this was comparable across the groups), briefed about the study and mastered the test battery.

Testing Prerequisites

The evening before their test day, volunteers were required to limit their alcohol consumption to a maximum of four units. On their test day, they were required to abstain from drinking any alcohol. They also had to have refrained from doing any strenuous physical exercise or, for 2 hours before coming to the unit, smoking or drinking any caffeinated beverages.

Test day

Eight participants attended each testing session, which was held in a purpose-built laboratory. Upon arrival at the unit, they were required to fill out a 'sleeping and eating' questionnaire to record details of the previous night's sleep and food and drink consumed that day. The test day schedule was then as shown in Table 1. When given their cup of coffee, participants were instructed to consume the drink at their normal rate, to refrain from commenting on their drink and to complete the drink rating scales only once they had consumed all of their drink. They were then required to immediately commence the test 1 mood scales. All participants completed the baseline, test 2 and test 3 sessions at times shown below. Effects of the coffee were therefore measured immediately after consumption of the drink, half an hour later and one and a half hours later.

Table 1: Testing day schedule.

9.30am / 1.30pm	BASELINE SESSION (BASELINE)
10.10am / 2.10pm	Drink coffee, rate acceptability and comparison to normal drink.
10.30am / 2.30pm(Approximately)	COMPLETE MOOD SCALES (TEST 1)
10.40am / 2.40pm	TESTING SESSION (TEST 2)
11.20am / 3.20pm	BREAK
11.40am / 3.40pm	TESTING SESSION (TEST 3)
12.20pm / 4.20pm	PAYMENT

RESULTS

Comparability of the different groups at baseline

Analyses were performed comparing the demographics, health-related behaviours, personality, pre-test activities and baseline performance of the four drink groups (caffeinated-sugar, caffeinated-no sugar, decaffeinated-sugar and decaffeinated-no sugar). Very few significant differences between the groups were found.

Drink acceptability

Ratings of drink acceptability were recorded on two visual analogue scales measuring enjoyment of the drink and difference from the usual drink. A correlational analysis was performed to establish whether there was a relationship between these two scales. There was a significant negative correlation between the drink enjoyment scale and the difference from the usual drink scale (-0.63), such that the more different the drink was from the usual drink, the less it was enjoyed.

The effects of the different combinations of caffeine and sugar in the experimental drink on the ratings of drink acceptability were examined using two-way Analyses of Variance: Caffeine condition (2 levels) X Sugar condition (2 levels). Neither the caffeine nor the sugar content of the drink affected the overall ratings of drink enjoyment or difference from the usual drink.

Effects of factors that could modify the drinks acceptability, such as usual caffeine and sugar consumption, were then investigated using three-way Analyses of Variance: Caffeine condition (2 levels) X Sugar condition (2 levels) X Modifying factor (n levels). Enjoyment of sweetened or unsweetened drinks was not moderated by the habitual amount of caffeine consumption, gender or personality. As expected, the interaction of sugar in the experimental drink and the usual preference for sugar in coffee was significant for the enjoyment of the

drink ratings (F(1, 120) = 20.84, p = 0.001 – see Figure 1). Age also influenced the enjoyment of the drink, with younger participants generally preferring sweetened drinks and the older ones generally preferring unsweetened drinks.

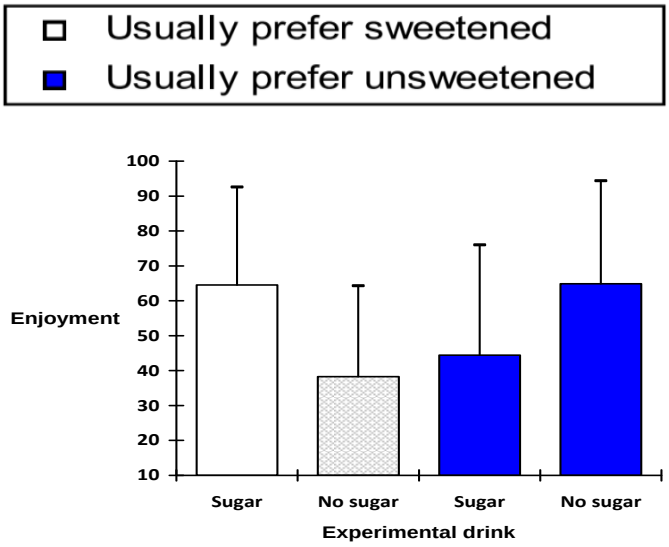

Figure 1: Influence of usual preference to sweeten coffee on the enjoyment of the experimental drink.

Effects of caffeine and sugar on mood and performance

Main effects of caffeine

a) Mood

There was a main effect of caffeine on the sociability factor and specific items in that factor, namely Friendly - Antagonistic (F(1,123) = 4.02, p = 0.0472), Sociable - Withdrawn (F(1, 123) = 4.04, p = 0.0467) and Interested - Bored (F(1, 123) = 8.33, p = 0.0046). Those in the caffeine condition reported a more positive mood (see Figure 2).

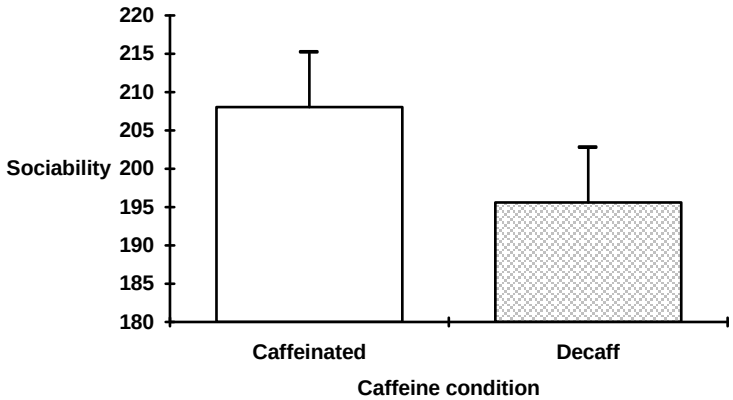

Figure 2: Effect of caffeine on sociability.

b) Performance

Caffeine had an effect on simple reaction time and also on two of the reaction time measures of stimulus encoding in the selective attention tasks. Those participants who received caffeinated coffee had significantly faster ($F(1, 123) = 5.02$, $p = 0.027$) simple reaction times (322 ms) than those who received decaffeinated coffee (345 ms). Caffeine also affected the speed of stimulus encoding and response in the selective attention tasks. In the categoric search task, speed of response to an alternated stimulus (one different from the previous trial) was significantly faster ($F(1, 123) = 5.93$, $p = 0.0163$) if the person had received caffeinated coffee than if they had received a decaffeinated drink (see Figure 3).

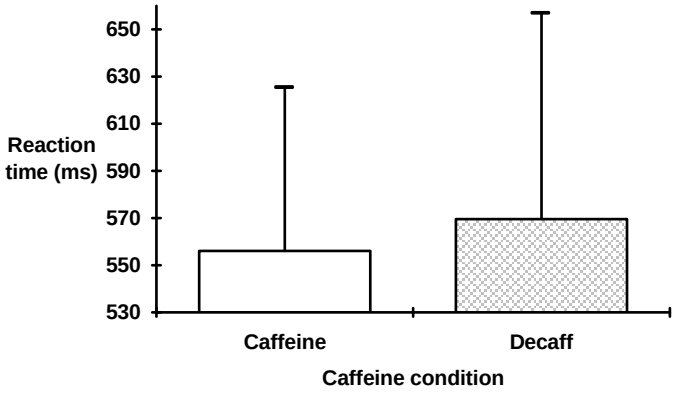

Figure 3: Effect of caffeine on reaction times to alternated stimuli in the search task.

This effect appeared to be robust in that it was also apparent numerically in the focussed attention task, although it just missed significance ($p = 0.057$). In this task, however, the effect of caffeine on the difference score measuring reaction time to alternations as opposed to repetitions did reach significance ($F(1, 123) = 8.39$, $p = 0.0045$). Those who received a decaffeinated drink had a greater difference score (32 ms) than those who had received a caffeinated drink (21 ms), confirming that they were indeed slower at responding to alternations. These findings indicate that caffeine increases the speed of encoding and response to a novel (i.e. alternated) stimulus.

There were no significant main effects of caffeine in the working memory tasks.

Main effects of sugar

There were no main effects of sugar on either the mood or performance measures.

Interaction of caffeine and sugar

There was only one significant interaction of caffeine and sugar, and given the number of analyses conducted, this could be a chance effect.

Drink Acceptability: relationship with Mood and Performance

Correlations between the baseline measures of mood and performance and measures of drink acceptability were examined to establish whether there was a relationship between how the participants were feeling and performing before they received their drink and their subsequent ratings of drink acceptability. There were significant positive correlations between drink enjoyment and baseline sociability scores both prior to ($r = 0.23$) and upon completion of the performance tests ($r = 0.18$) and also between drink enjoyment and baseline anxiety scores prior to the tests ($r = 0.21$), such that those who rated themselves as more sociable and calm also rated their drinks as more enjoyable. These findings may simply reflect a bias towards positive ratings. The majority of the baseline performance measures were not significantly correlated with acceptability.

Difference scores were then calculated for each variable representing the change in mood or performance from baseline to each of the testing sessions. Correlational analyses were then carried out to identify relationships between the acceptability measures of the drink and subsequent changes in mood and performance. The only significant correlation between acceptability and mood was found in the ratings taken immediately after the drink, with high drink enjoyment being related to greater sociability ($r = 0.19$). However, drink enjoyment did appear to be related to a change in the amount of distraction by near distractors, especially in the accuracy scores. These correlations were positive (e.g. confusion by disagreeing stimuli, test 2, $r = 0.23$), showing that higher acceptability was associated with less distraction from near irrelevant letters.

Factors modifying the effects of the experimental substances

These analyses were carried out for several reasons. First, it is possible that some of the effects of caffeine or sugar would disappear when other factors such as demographics, personality or habits were considered (i.e. the effects attributed to the experimental substances were due to confounders). Secondly, when other factors are added to the analyses, it is possible that new effects of experimental substances may emerge due to a reduction in error variance. Finally, effects may depend on a particular combination of factors, being present in some contexts but not others.

Many analyses were conducted to examine the effects of modifying factors. This produces problems in that one would expect a certain number of effects to occur by chance. One solution to this is to report only those which are highly significant. Another, which was adopted here, is to look for consistent patterns of results that either replicate previous findings or general views put forward in the literature. In other words, do any general trends emerge which can be readily interpreted.

Three-way Analyses of Covariance were performed: Caffeine condition (2 levels) X Sugar condition (2 levels) X Contextual factor (n levels), again with the baseline measures as the covariates and the testing measures as the dependent variables. The factors investigated were usual caffeine consumption (2 levels), usual sugar consumption (2 levels), time of day (2 levels), age band (4 levels), sex (2 levels) and the personality dimensions of extraversion (2 levels), anxiety (2 levels) and obsessionality (2 levels).

Mood prior to performance tasks

Analysis of the alertness factor showed a significant interaction between caffeine and sugar in the majority of the analyses (e.g. $F(1, 119) = 4.33$, $p = 0.0395$). Caffeine increased alertness in the no sugar condition, but this reversed in the sugar condition (see Figure 4).

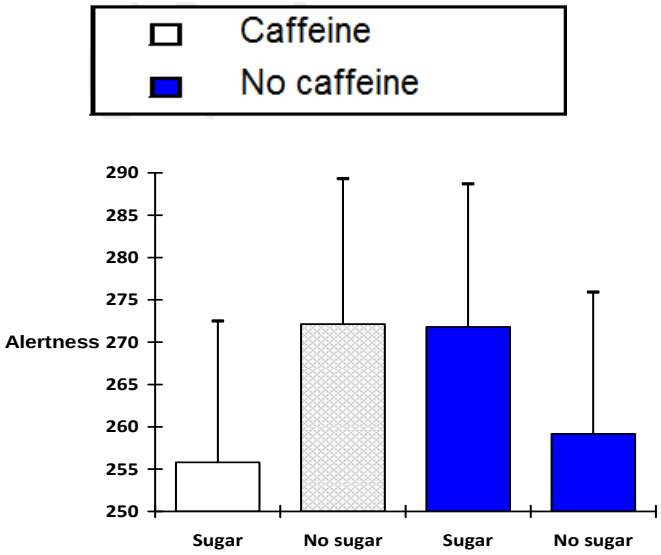

Figure 4: Interaction between caffeine and sugar on alertness.

Significant interactions between caffeine and test session were found in the analysis of the sociability factor, with the caffeine group reporting comparable levels at all sessions but those

given the decaffeinated coffee feeling less sociable as the experiment progressed. These results are shown in Table 1.

Table 1: Interaction of caffeine and session on sociability (Standard errors shown in brackets).

	Caffeine	No caffeine
Session 1	209.28 (7.30)	212.56 (7.30)
Session 2	211.48 (7.30)	206.98 (7.30)
Session 3	209.83 (7.30)	196.27 (7.30)

There was little evidence of personality, age, gender or usual caffeine or sugar usage modifying the mood effects.

Mood after completing the tests

The main effect of caffeine on sociability was confirmed in the majority of analyses. No other effects were significant.

Simple reaction time and encoding of new information

No interactions between caffeine and other factors were significant.

DISCUSSION

The aims of this study were

1. To validate the sensitivity of the methods of mood and performance assessment using low doses of caffeine and sugar,
2. To examine these effects in a general population sample to determine whether any effects generalise across age and personality types,
3. To consider the importance of other contextual factors, such as level of regular use of the products, and
4. To examine whether there is any relationship between enjoyment of the drink and mood and performance.

The above features of the experiment make it a unique study, which is more relevant to real-life consumption of coffee and sugar than most previous ones.

The results from this study lead to the following conclusions

1) Effects of low doses of caffeine and sugar on performance and mood.

Those given caffeine become more sociable than those in the decaffeinated group. Caffeine decreased the effects of boredom that were increasingly apparent in those in the decaffeinated group (who become more antagonistic, bored and withdrawn over time). Caffeine also had beneficial effects on some aspects of performance, namely simple reaction time and speed of encoding and response to an alternated stimulus. These performance effects confirm other findings.[12]

2) Modifying effects of other factors

More effects of caffeine and sugar became apparent when other factors (demographics, personality, usual caffeine/sugar consumption) were added to the analysis. These interactions were often were restricted to one or two measures and could have been chance effects. This provides support for the view that the behavioural effects of these low doses of caffeine and sugar will depend on the characteristics of the person, the nature of the tasks and the type of mental functions being measured. Indeed, these contextual factors are probably more relevant when low doses are used than in studies where high doses produce more global effects. The finding that the nature of the drink containing caffeine had little effect on performance supports results from other research.[13] Similarly, the absence of interactions between caffeine and the level of regular usage confirms the findings of previous studies.[12,14-15] The restriction of the alerting effect of the caffeine to the non-sweetened drink requires replication and extension to identify underlying mechanisms.

3) Acceptability

There was a significant negative correlation between the drink enjoyment scale and the 'difference from usual drink' scale, such that the more different the drink was from the usual drink, the less it was enjoyed. Acceptability of the drink was not affected by the caffeine or sugar content of the drink per se, and indeed there were no changes in the acceptability ratings of caffeinated as opposed to decaffeinated drinks even when modifying factors such as habitual caffeine consumption were included in the analysis.

Acceptability of the sugar content of the drink was, however, influenced by modifying factors. The usual preference to sweeten coffee significantly influenced the acceptability of the drink, with those who received their drink sweetened in accordance with their usual preference enjoying it much more than those who received the opposite of their preference, as would be expected. Age also influenced the enjoyment of the drink, with younger participants

generally preferring sweetened drinks and the older ones generally preferring unsweetened drinks.

4) Relationship between acceptability and behavioural effects.

Those who felt good prior to having a drink tend to find it more enjoyable. The majority of the baseline performance measures were not related to subsequent acceptability. When changes in performance and mood were correlated with acceptability, there were few significant effects. However, measures from the focussed attention tasks did appear to be associated with acceptability, and this needs to be examined in future research.

CONCLUSION

Overall, the present results suggest that an appropriate methodology and instrumentation was selected to examine the effects of low doses of caffeine and sugar. Some of the modifying effects of contextual factors (e.g. the combined effects of caffeine and sugar on alertness) need to be replicated in future research. Other effects of caffeine, for example, the significant performance changes, were largely independent of the contextual factors. Furthermore, some links between acceptability and behavioural effects have been established, which now need to be examined in other paradigms and with other dietary factors.

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