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HABITUAL CAFFEINE CONSUMPTION, GENDER AND SELECTIVITY IN ATTENTION AND MEMORY, MOOD, AND CARDIOVASCULAR FUNCTION

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ABSTRACT

Background: The acute effects of caffeine have been widely studied, but less is known about the effects of habitual consumption, with the limited literature showing conflicting results. Research has investigated associations between habitual caffeine consumption and physical and mental health. The present study examined whether the level of habitual caffeine consumption modified selectivity in memory and attention, mood and cardiovascular function. The effects of gender were also investigated, and the effects of smoking and alcohol consumption covaried. **Method:** One hundred and twenty university students (50% female) participated in the study. Measurements were taken in the morning between 9.30 and 11.30 am, and questionnaires measuring health-related behaviours were completed. Blood pressure and heart rate were recorded, mood was rated before and after the battery of performance tasks, and tests measuring selectivity memory and attention were performed. **Results:** The multivariate effects of gender and high/low caffeine consumption (based on a median split of 125mg) were significant. There were no significant multivariate effects of smoking and alcohol consumption, and the gender x caffeine interaction was not significant. Systolic blood pressure was greater in males. Females showed more Stroop colour-word interference. High caffeine consumption was also associated with a smaller recall priority effect. **Conclusion:** The present analyses showed that both gender and caffeine consumption had little effect on mood. Systolic blood pressure was greater in males, whereas females showed greater distraction from an irrelevant colour word. Caffeine consumption did not have a significant effect on most of the measures. The exception was the recall priority task, which measures resource allocation to high and low-priority components in memory.

High caffeine consumption was associated with a reduced priority effect, which is often found in low alertness states. These results need to be extended by examining a more detailed profile of caffeine consumers and other measures of selective attention and memory.

KEYWORDS: Caffeine; University students; Heart rate; Blood pressure; Mood; Selective Attention; Biased probability choice reaction time; Stroop Task; Task priority; Category Instances.

INTRODUCTION

Much of the research on the effects of caffeine has examined acute effects. This area of research has been reviewed several times[1-7] and has been the main area of focus of studies in our laboratory.[8-52] Other research has considered the habitual effects of caffeine in real-life situations such as the workplace. Results from these surveys show that higher caffeine consumption is associated with fewer cognitive failures and a reduced risk of accidents.[53] Similar effects have been found with non-working samples[54] and the elderly.[55] The interpretation of these results has been in terms of higher habitual consumers being more likely to have benefited from the more frequent consumption of caffeine.

Other research has compared the effects of different levels of habitual consumption at times, which are not related to the acute effects of ingestion. There are a relatively small number of these studies, and the results are mixed.[56-64] Many studies of habitual caffeine consumption have investigated the acute effects of caffeine in those with different levels of consumption. One frequent comparison has been between non-consumers and withdrawn consumers. Results from our laboratory and from others often fail to show differences between these groups.

The present study

The present research examined associations between habitual caffeine consumption and the performance of tasks involving selectivity in memory and attention. Mood and cardiovascular parameters were also recorded. A secondary analysis of the baseline data from a study investigating time of day, lunch and selectivity in attention and memory was carried out. Initial analysis showed that time of day and lunch did not change the performance of tasks involving the selective processing of information in memory and attention. Further analyses showed that most of the baseline measures of selectivity in attention and memory were not

associated with personality dimensions or hunger. Smoking and regular alcohol consumption influenced resource allocation in memory but not the other selectivity indices.

The performance tasks used here were developed in noise research.[66-69] Noise can reduce the effect of a distracting colour name in the Stroop Colour-Word test,[70] and this task was used in the present study. Noise also improves recall of high-priority information at the expense of information with a lower priority, and this task was also included here.[71] Selectivity in memory can be measured using a category instances task.[72] This task was used here, and a category name was presented (e.g. Animal) followed by either a good example of that category (e.g., Dog) or a weaker example (e.g., a Stoat). The stronger example is responded to more quickly, and this effect was greater when the person performed in noise. A biased probability choice reaction time task, where one stimulus was more probable than the others, was also used. Reaction times to the more probable stimulus are faster than the less probable ones, and this effect was greater in noise.[73]

In summary, the present research examined whether there were any differences in the selectivity in memory and attention of participants with different levels of caffeine consumption and used tasks known to be sensitive to changes of state induced by exposure to noise. Previous analyses of the data had shown that significant indicators of selectivity in memory and attention were observed.[74] The majority of the selective attention and memory measures were not significantly changed by lunch, time of day, personality,[75] or hunger.[76] Smoking and alcohol consumption had a significant effect on resource allocation in memory but no significant effect on the other selectivity measures. Effects of habitual caffeine consumption might reflect differences in arousal, distraction from task-irrelevant thoughts or resource allocation. Cardiovascular measures and mood have been shown to be sensitive to acute caffeine ingestion and were also included here to determine whether habitual caffeine consumption influenced these outcomes.

METHOD

A detailed description of the methodology has been given in an earlier paper,[74] and a summary is given below. The study was carried out with the approval of the Psychology Ethics Committee and the informed consent of the volunteers.

Study design

Participants carried out a familiarisation session a few days before the test session. The test session started at either 09.30 or 10.30 and lasted about an hour.

Participants

120 students participated in the study (half male; mean age of 20.4 +/- 2.4 years).

Measurement of blood Pressure and Heart rate

Blood pressure and heart rate were measured before the test battery.

Mood rating

Mood was rated both before and after the cognitive tasks using bi-polar visual analogue rating scales (e.g. Tense-Calm, Drowsy-Alert, Happy-Sad). These ratings gave three factors: alertness, hedonic tone, and anxiety.

Stroop task

This task had four conditions

- Respond to the colour of a square shown in the centre of the screen.
- Respond to the colour name presented in black in the centre of the screen.
- Respond to the colour of the ink with a distracting colour word (RED – correct response blue)
- Respond to the word and ignore the colour (RED – correct response red)

The participant pressed the appropriate keys on a response box corresponding to the colours red, blue, yellow, and green. Reaction times were measured to the nearest milli-second using a timer card.

Four-choice biased probability reaction time task

This involved pressing the appropriate key on a response box when one of the letters A, B, C or D was presented on the computer screen. The letters were presented in the four corners of the computer screen. Three of the letters (B, C, and D) were presented 50 times, and the other (A) 100 times. Reaction times were measured to the nearest milli-second using a timer card.

Category instances task

A category name (e.g. Animal) was shown on the screen, followed by either a dominant instance of that category (e.g. Cat), a non-dominant instance (e.g. Otter) or a non-instance

(e.g. Chair). The person had to respond "True" if the word was an instance and "False" if it was not an instance of the category. Reaction times were measured to the nearest milli-second using a timer card.

Memory for high/low priority information

Eight words were presented in one of the four corners of the computer screen (two per corner). The high-priority task was to recall the order of presentation of the words, and the low-priority task was to recall the location of the words. At the end of the presentation, they were given the list of 8 words and had to re-arrange them in order of presentation and then put them in the location where they were shown.

Questionnaires

The volunteers also completed a series of questionnaires, including one asking about the consumption of caffeinated beverages (Cups of caffeinated tea, coffee and soft drinks).

RESULTS

Caffeine consumption

Caffeine consumption was divided into low and high groups based on a median split (median daily caffeine consumption = 125mg).

Multivariate analysis of variance (Manova)

The between-subject factors were gender and caffeine groups. Smoking and alcohol consumption were included as covariates. The dependent variables were heart rate, systolic blood pressure, diastolic blood pressure, the three mood factors (Alertness, hedonic tone and anxiety), priority recall effect (Order-location recall), category instance dominance effect (RT non-dominant-RT dominant), Stroop interference (CI-C; WI-W), and the biased probability effect (Lower probability RT- higher probability RT). The multivariate tests showed significant effects of gender (Wilks' Lambda = 0.799 F =2.15 $p < 0.005$ partial eta squared = 0.201) and caffeine (Wilks' Lambda = 0.774 F =2.50 $p < 0.01$ partial eta squared = 0.226). The multivariate tests for smoking and alcohol were not significant, nor was the interaction between gender and caffeine.

Univariate analyses showed that the males had higher systolic blood pressure ($F = 10.07$, $p < 0.005$; females mean = 119.1 mm/hg; males mean =126 mm/hg). Females also showed significantly more interference from a distracting colour word (F 3.97 $P < 0.05$; Females:

mean = 192ms; Males mean = 148 ms). The priority effect in the recall task was significantly smaller in the high caffeine consumption group ($F = 7.15$, $p < 0.01$; low caffeine mean = 1.42; high caffeine mean = 0.30). None of the other variables showed a significant difference between males and females, or low and high caffeine consumers.

DISCUSSION

The present analyses showed very few differences between high and low-caffeine consumers in cardiovascular functioning, mood and selectivity in memory and attention. Similarly, there were few differences between males and females. The only significant task in the caffeine analyses of the attention and memory battery was the memory task with components with different priorities. Higher caffeine consumption was associated with a reduced priority effect. Such an effect is usually associated with reduced alertness, and the alertness ratings did show that scores were lower in the high consumption group, but not significantly different from the lower caffeine consumers. Females had lower systolic blood pressure, which could reflect BMI, lower alcohol consumption and fewer smokers in the female group. Stroop interference was higher in the females, and it is unclear what underlies this effect.

There are plausible reasons, based on animal research, to expect habitual caffeine consumption to influence the brain and behaviour. It has been shown in animal models that long-term administration of caffeine causes both physiological changes (e.g. increasing the density of adenosine receptors)[78,79] and changes in behaviour.[80] Animal studies have generally used experimental manipulation of long-term caffeine consumption and very high doses, far more than the levels consumed by humans, so it is unknown to what extent the results can be generalised to consumers of commercial products. The results from our earlier analyses[74] revealed that the selective effects of task parameters were present in all the tasks. Alcohol and smoking were covaried, and gender was also included in the analyses. The absence of more extensive effects of caffeine consumption probably reflects the relatively short duration and magnitude of consumption. Future studies could look at more extreme groups or focus on sensitive groups such as adolescents, some of whom may consume large amounts of caffeine in energy drinks. Other types of tasks should also be used as the present battery does not appear to be very sensitive to changes in state.

CONCLUSION

The acute effects of caffeine have been widely studied, but less is known about the effects of habitual consumption, with the limited literature often showing conflicting results. The

present study examined whether the level of habitual caffeine consumption modified selectivity in attention and memory, mood, and cardiovascular function. The effects of gender were also investigated, and the effects of smoking and alcohol consumption were statistically covaried. Measurements were taken between 9.30 and 11.30 am, and questionnaires measuring health-related behaviours were completed. Heart rate and blood pressure were recorded, mood was rated, and tests measuring selectivity in attention and memory were carried out. The analyses showed that the multivariate effects of gender and high/low caffeine consumption (based on a median split of 125mg) were significant. There were no significant effects of smoking and alcohol consumption, and the gender x caffeine interaction did not reach significance. Systolic blood pressure was significantly greater in males. Females showed significantly more Stroop colour-word interference. Higher caffeine consumption was associated with a smaller recall priority effect, which is often found in low alertness states. These results need to be extended by examining a more detailed profile of caffeine consumption and other measures of selective attention and memory.

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