

CAFFEINE AND RATINGS OF ALERTNESS IN THE EARLY MORNING

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Article Received on 07/01/2021

Article Revised on 27/01/2021

Article Accepted on 17/02/2021

ABSTRACT

Background: The effects of caffeine on alertness are well-documented. One established effect of caffeine is that it restores function when the person has a low level of alertness. This topic was examined here, with alertness being at a low level due to time of day (early morning). The effects of caffeine were assessed by measuring subjective alertness, hedonic tone, anxiety and a symptom checklist. The study also examined whether effects could be attributed to the reversal of caffeine withdrawal. **Methods:** Three groups of participants were recruited: non-consumers of caffeine (N=23); low consumers (<200mg/day; N=40) and high consumers (>300mg/day; N=33). After overnight caffeine abstinence participants visited the laboratory and rated their mood and current symptoms. They then consumed a fruit juice which had either caffeine (100 mg) or placebo added. Two hours later, they returned to the laboratory and repeated their subjective ratings. They repeated this procedure on five consecutive days. **Results:** Caffeine was associated with significantly higher alertness. This effect did not change over days. No effects of withdrawal were observed in the baseline ratings. The effect of caffeine on alertness was present in consumers and non-consumers. There were no significant effects of caffeine on hedonic tone, anxiety or a symptom checklist. **Conclusion:** These results demonstrate that caffeine is beneficial in low arousal situations, in this case when circadian alertness is increasing. This effect was reliable in that it did not change across the five day period. The results could not be attributed to the reversal of caffeine withdrawal, as no effects of withdrawal were present at baseline, and increased alertness after caffeine was observed in non-consumers and withdrawn consumers. The significant effects of caffeine were specific to alertness rather than mood or subjective ratings per se. These results have important implications for real-life situations involving low arousal states and show that caffeine is an effective countermeasure when circadian alertness is low.

KEYWORDS: Caffeine; Ratings of Alertness; Circadian Arousal; Caffeine Withdrawal.

INTRODUCTION

The alerting effects of caffeine are well-documented.^[1-7] Beneficial effects of caffeine are often most easily observed when alertness is low (e.g. after prolonged work,^[8] after lunch,^[9] when working at night,^[10] when sleep-deprived,^[11] and when the person has a cold^[12]). The present study continued this line of research by examining the effects of caffeine on ratings of alertness in the morning when circadian arousal was increasing.

The most plausible mechanism of caffeine, at doses reflecting normal usage, is the blockade of adenosine receptors.^[13] Adenosine inhibits physiological activity, and the blockade of adenosine receptors by caffeine leads to alerting effects.^[14] Adenosine inhibits the release of various neurotransmitters through their presynaptic receptors. One might expect therefore, that blockade of adenosine by caffeine would increase the release of these neurotransmitters. Caffeine can increase the synthesis and turnover of noradrenaline,^[15] and Smith et al.^[16] have

shown that caffeine counteracts the effects of clonidine, which at low doses leads to a state resembling sleep deprivation and acts pre-synaptically by binding to auto-receptors that reduce the turnover of central noradrenaline.

It has been suggested that caffeine has no direct benefits on behaviour, but that caffeine withdrawal leads to impairments, and caffeine removes these negative effects of withdrawal.^[17] However, this is unlikely to be generally correct,^[4,5] as caffeine influences the behaviour of animals and non-consumers,^[18] who are not experiencing withdrawal. The behavioural effects of caffeine have also been found after a seven-day washout period,^[19] when effects of withdrawal should be absent. Caffeine has also been shown to have effects after prior consumption (i.e., when the person is no longer deprived).^[20]

A search of Pubmed shows that there are over 400 studies that have investigated caffeine and alertness.

However, a much smaller number (< 50) specifically examined ratings of alertness without other measures (e.g. performance tasks or physiological measures) being taken. The increased workload of these extra tasks may in itself reduce alertness, and studies which have measured alertness at the start and end of a battery of testing lasting about 30 minutes show a drop in alertness of 10-15% due to performing the tasks. Measures of alertness taken after cognitive testing reliably show improvement after caffeine, reflecting the restoration of function.^[21] One line of research has provided support for the caffeine withdrawal hypothesis by investigating the effects of caffeine on drink acceptability.^[22-28] These studies have also included ratings of alertness without accompanying cognitive testing, and generally show that caffeine only increases alertness by removing the negative effect of caffeine withdrawal. Given the difficulties replicating effects of caffeine withdrawal in other laboratories, the present study examined the effects of caffeine in withdrawn volunteers, low consumers and non-consumers. If the reversal of withdrawal explanation is correct, effects of caffeine withdrawal should be observed after a night of caffeine abstinence (pre-caffeine drink), and there should be no effects of caffeine on the ratings of non-consumers.

Many studies have used coffee as a vehicle for caffeine. As well as caffeine, coffee contains many different compounds.^[29] which have the potential to have behavioural effects. In order to rule out effects of these other ingredients, the caffeine was given in another vehicle, namely fruit juice. Pre-experimental acceptability ratings were also used to ensure that the participants had a drink with a mid-range degree of acceptability.

In summary, the present study examined the effects of caffeine in fruit juice on ratings of subjective alertness in the early morning. The study also examined the effects of caffeine withdrawal by comparing non-consumers and withdrawn consumers. The reliability of effects was examined by testing over a five day period. In order to determine whether effects of caffeine were specific to alertness, ratings of hedonic tone, anxiety and a symptom checklist were also carried out.

MATERIALS AND METHODS

The studies described here were carried out with the approval of the ethics committee, School of Psychology, Cardiff University, and carried out with the informed consent of the volunteers.

Participants

Participants were selected if they were (1) high caffeine consumers (>300mg caffeine/day, N = 33), (2) low caffeine consumers (<200mg caffeine/day, N = 40), or (3) non-consumers (0mg caffeine/day, N=23). All participants were members of the Centre for

Occupational and Health Psychology's recruitment panel (N=96; male=33; female=66; mean age=25 years, range 18 to 53 years).

Design

Each consumer group was split so that approximately half received caffeine in their fruit juice and the others received placebo. The caffeine manipulation was double-blind.

Fruit juice

Fruit juices used were Cranberry and Raspberry (Ocean Spray), Orange, Apple and Passion Fruit (Del Monte), and Mango and Apple (Cape). To this was added either 100mg of caffeine in solution or placebo solution (water).

Procedure

Choice of fruit juice

Prior to the test days, each volunteer was asked to rate the three fruit juices on visual analogue scales for pleasantness, novelty, sweetness, strength, and sourness of the drink. The middle choice each time was then selected as their test drink. A questionnaire concerning normal drink consumption was also completed at this time.

Test days 1-5

Visit 1 (09:00)

Participants were told to abstain from caffeine overnight, and at 09.00 saliva samples were taken to assess compliance, and participants completed a questionnaire recording their sleep and breakfast. Pre-drink mood ratings and a symptom checklist were then completed (see Table 1). The mood ratings provide three factors: alertness, hedonic tone and anxiety, and these were used in the analyses. A total symptom score was used in the analyses. The fruit juice was then given, containing either 100mg of caffeine or placebo.

Table 1: Mood rating and symptom checklist.

MOOD QUESTIONNAIRE		
Number:	Time completed:	
On each of the following lines please draw a cross between the two extremes which best represents how you are feeling at this precise moment in time.		
Drowsy	-----	Alert
Relaxed	-----	Excited
Strong	-----	Feeble
Muzzy	-----	Clear-headed
Co-ordinated	-----	Clumsy
Lethargic	-----	Energetic
Contented	-----	Discontented
Troubled	-----	Tranquil
Mentally-slow	-----	Quick-witted
Tense	-----	Calm
Attentive	-----	Dreamy
Incompetent	-----	Proficient
Happy	-----	Sad
Antagonistic	-----	Friendly
Interested	-----	Bored
Withdrawn	-----	Sociable
Depressed	-----	Elated
Self-centred	-----	Outward-going

Symptom Checklist

Please tick the boxes next to any symptoms you are currently experiencing.

Physical weakness	Sensitive to noise
Excessive fatigue	Sensitive to light
Legs feeling heavy	Feeling hot/cold
Muscle pain	Sweating
Pain in the chest	Shivering
Painful joints	Swollen glands
Nausea	Racing heart
Indigestion	Insomnia
Bloated stomach	Depression
Wind	Anxiety/Panic
Headache	Loss of concentration
Ear ache	Memory problems
Sore eyes	Allergy
Sore throat	Other:

Visit 2 (11:00)

The volunteers repeated the mood rating and symptom checklist.

RESULTS

The first analysis examined the baseline scores to determine whether overnight caffeine deprivation had any effect. These results are shown in Table 2. There were no significant effects of the caffeine consumer group.

Table 2: Ratings of alertness at the pre-drink baseline by the three consumer groups (scores are the means, s.e.s in parentheses; higher scores = greater alertness).

Non-consumers	491.1 (24.6)
Low consumers	484.6 (18.6)
High consumers	489.9 (20.5)

Repeated measures analyses of variance were carried out on the mood and symptom checklist data. The post-drink scores were analysed in terms of the difference from baseline. In the analysis of alertness, there was a significant effect of caffeine ($F_{1, 90} = 7.14$ $p < 0.01$), with those given the caffeine reporting a greater increase in alertness (see Figure 1). There was also a significant effect of days ($F_{4, 360} = 2.72$ $P < 0.05$). None of the interactions involving caffeine were significant (Consumer group x caffeine: $F < 1$; Days x Caffeine: $p > 0.05$).

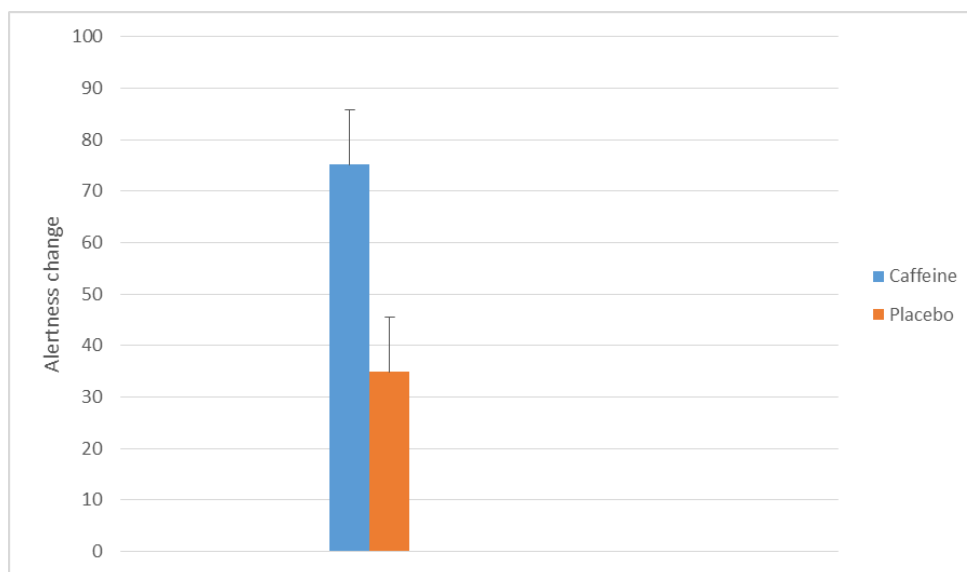


Figure 1: Changes in alertness from baseline after caffeine and placebo (scores are the means, s.e.s as bars; higher scores = a greater increase in alertness).

In the analysis of hedonic tone, the caffeine effect approached significance ($p=0.075$), with caffeine being associated with a more positive mood. The anxiety ratings showed a trend for the non-consumers being the most anxious, then the low consumers, and the high consumers being the least anxious. This effect did not interact with caffeine. Very few symptoms were reported (means < 2) and none of the factors in the analysis were significant.

DISCUSSION

The present study obtained no significant effects of caffeine withdrawal on early morning ratings of alertness, hedonic tone, anxiety, and the ratings of current symptoms. This confirms other studies which suggest that only some research groups have demonstrated significant effects of caffeine withdrawal. Caffeine given at 09.00 led to increased alertness at 11.00. This was a robust effect in that it was seen in non-consumers, low consumers and high consumers and was reliable over five days. There were no significant effects on the other subjective ratings, confirming that the major effect of caffeine is to increase alertness. The early morning is a time of day when circadian alertness is increasing, and the present results support prior findings showing that caffeine has beneficial effects when alertness is below the maximum. Another prediction based on this view is that caffeine should not increase ratings of alertness when these are at maximum values, for example, in the middle of the day. This view needs to be tested in further research using a methodology like the present one, as the combination of alertness ratings with cognitive testing is likely to put the person in a reduced alertness situation due to the workload related to the testing.

CONCLUSION

There is a large literature showing that caffeine increases alertness. Most of these studies have measured subjective alertness in the context of a battery of cognitive tasks, the performance of which can induce fatigue. Previous research shows that the clearest effects of caffeine on ratings of alertness can be observed when the ratings are carried out after the task battery. The present study examined another low alertness context, namely the early morning. In this study, there was no cognitive testing, just rating of alertness, other aspects of mood and a symptom checklist. Possible effects of caffeine withdrawal were examined by comparing non-consumers, low caffeine consumers and high consumers. The results showed no effects of caffeine withdrawal prior to consuming the drink. In contrast, caffeine increased alertness in all groups, and this effect was reliable over the five day test period. There were no effects of caffeine or caffeine withdrawal on hedonic tone, anxiety or reports of symptoms.

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