wjpmr, 2021, 8(6), 114-118

SJIF Impact Factor: 5.922

WORLD JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.wjpmr.com

Research Article

ISSN 2455-3301

WJPMR

EFFECTS OF CAFFEINE IN CHEWING GUM ON MOOD AND PERFORMANCE AT DIFFERENT TIMES OF DAY

Andrew P. Smith PhD*

Professor, Centre for Occupational and Health Psychology, School of Psychology, Cardiff University, 63 Park Place, Cardiff CF10 3AS, UK.

***Corresponding Author: Dr. Andrew P. Smith PhD**

Professor, Centre for Occupational and Health Psychology, School of Psychology, Cardiff University, 63 Park Place, Cardiff CF10 3AS, UK.

Article Received on 16/04/2021 **Article Revised on 06/05/2021** **Article Accepted on 26/05/2021**

ABSTRACT

Background: Most research on caffeine has given it in beverages or capsules. Recently, caffeinated chewing gum has been produced and this leads to very rapid absorption and positive behavioural effects with a dose of 40mg. Caffeine often has its greatest benefit in low alertness states, and the present study examined this topic using caffeine in chewing gum. **Methods:** Volunteers (N=48) were randomly assigned to caffeinated gum, placebo gum or no gum conditions. Half of each group were sleep deprived and tested between 04.00 and 07.00, whereas the others were allowed normal sleep before testing between 09.00 and 12.00. Baseline measures of mood and performance were taken before chewing the gum. The gum was then chewed before repeating the tasks. **Results**: The results showed few differences between the placebo gum and no gum conditions and these groups were combined to form the control group. The results showed that caffeinated gum increased ratings of alertness and hedonic tone but not anxiety. The caffeinated gum group showed improved performance on the simple reaction time task, detection of repeated numbers task and five-choice serial response task. There were no significant effects of caffeine on the memory tasks. **Conclusion:** The results showed the profile of effects that one would expect from the caffeine literature. The changes seen after caffeine were not modified by level of fatigue induced by sleep deprivation. The magnitude of the caffeine effects were in the region of about half a standard deviation which is consistent with the size of effects seen in other studies, and are of a magnitude that may be of practical importance in real-life activities.

KEYWORDS: Caffeine; Chewing gum; Mood; Alertness; Simple reaction time; Sustained attention; Memory; Sleep deprivation; Time of day; Nightwork.

INTRODUCTION

The effects of caffeine on mood and cognitive function have been widely studied and frequently reviewed.[1-7] These reviews suggest that the effects of caffeine are often positive except when one considers very large doses of caffeine and certain types of task (e.g. episodic memory). Caffeine research has often involved manipulating the caffeine dosage in a cup of coffee or some other beverage. Research has examined the medium of consumption of the caffeine, comparing coffee with tea, diet cola, cola, tap water and sparkling water.[8] The results showed that the caffeine did not change as a function of the type of drink. Other research has given caffeine in capsules which allows ingestion of caffeine in situations where it may be impossible to drink a caffeinated beverage.

More recently research has focused on caffeinated gum, and it has been shown that caffeine is rapidly available from this, probably due to absorption through the buccal cavity. Caffeinated gum could, therefore, be advantageous in situations where alertness and performance have to be quickly restored,[9] Smith[10] examined effects of caffeinated chewing gum (40 mg caffeine) twenty minutes after chewing. Those in the caffeinated gum condition reported a more positive mood and showed better performance of sustained attention tasks.

The effects of caffeine are often clearest when alertness is low (e.g. at night,[11] when the person is sleep deprived,[12] after prolonged work,[13] after lunch,[14] or when the person has a cold,[15] Research has also examined effects of caffeinated chewing gum in low alertness situations, usually after many hours of sleep deprivation.[16] Such studies often use very large doses of caffeine (e.g. 800mg per night) which would not be recommended for normal use. The studies of smaller doses have been carried out when participants were generally alert (e.g. late afternoon), and it is now important to determine whether caffeinated chewing gum can improve mood and performance in low alertness situations (e.g. following sleep deprivation or in the early morning).

Chewing placebo gum has also been shown to increase alertness and improve attention,[17-20] although the effect sizes are smaller than those observed with caffeine. In the present study, the caffeinated gum condition was compared with placebo gum and with no chewing. The study tested two main hypotheses. The first was that the caffeinated gum would lead to a more positive mood and better sustained attention than the comparison conditions. Memory tasks were not expected to be affected by the caffeine. The second hypothesis was that the effects of caffeine would be greater in a group tested after sleep deprivation and being in the laboratory from 04.00-07.00 compared to a non-sleep deprived group tested between 09.00 and 12.00.

MATERIALS AND METHODS

This study was approved by the ethics committee, School of Psychology. All participants were required to sign an informed consent form which outlined the experiment, explained that they were free to withdraw at any time and confirmed the anonymity of all information collected.

Participants

Volunteers were recruited from the research unit's panel. All volunteers were young adults (mean age: 22 years; range: 18-32 years) and an equal number of males and females were assigned to each condition. Regular caffeine consumption was recorded (mean consumption = 100mg per day). Specific inclusion criteria were that the person was at least an occasional gum user and passed medical screening. Potential volunteers were excluded if they consumed in excess of twenty-five units of alcohol per week; smoked more than 5 cigarettes a day; had a serious medical conditions (e.g. phenylketonuria, diabetes, heart disease, kidney disease); were currently taking medication; had tempero-mandibular joint dysfunction; and were allergic to mint flavours. Upon completion of the study participants received a payment (£15 for the non-sleep deprived condition and £50 for the sleep-deprived group).

Design

Volunteers were randomly assigned to either the non-sleep deprived or the sleep deprived condition. The sleep-deprived group were in the laboratory from 04.00 to 07.00 am, whereas the non-sleep deprived group were in the laboratory from 9.00 am to 12.00. Apart from the sleep manipulation and time of testing the volunteers followed the same protocol. Forty- eight volunteers were tested in total, with sixteen randomly assigned to the caffeinated gum condition (eight sleep deprived, eight not), sixteen to the placebo gum condition (eight sleep deprived and eight not) and sixteen to the no gum condition (eight sleep deprived and eight not). The caffeine manipulation was double-blind.

Procedure

The evening before their test day participants were required to limit their alcohol consumption to a maximum of four units and to abstain from drinking caffeinated beverages. Upon arrival at the laboratory, participants filled out a questionnaire which recorded their alcohol consumption in the previous 24 hours, details of their sleep, and food and drink consumed that day. They then carried out a familiarisation session, where they were briefed about the study procedures and practised the test battery. The sleep deprived group carried out a baseline session at 04.40, and the non-sleep deprived group carried out their baseline session at 09.40. In the gum conditions, chewing occurred between 5.40-06.00 or 10.40-11.00. The post-chewing test session occurred between 06.00-07.00 and 11.00-12.00.

Nature of the gum

The gum used contained 20mg caffeine per pellet (or no caffeine in the placebo gum). The serving was two pellets at a time. The gum was mint flavoured.

Mood and Performance battery

Rationale behind choice of measuring instruments

Our previous studies of low doses of caffeine[8,10] showed significant changes in mood following caffeine and significant improvements in the sustained attention tasks. The other tests showed a trend towards greater improvement after caffeine and have given significant effects in other studies with higher doses and larger sample sizes. The battery of tests represents a wide range of mental functions, are sensitive measuring instruments that are well tolerated by the volunteers and were, therefore, most suitable to use in the present investigation.

Performance tests

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

1. Free recall task (3 minutes)

The volunteers were shown 20 words presented at a rate of one every 2 seconds. At the end of the list of words the person had 2 minutes to write down (in any order) as many of the words as possible on the sheet provided. Participants were shown a different list at each test session.

2. Variable fore-period simple reaction time (5 minutes)

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

3. Verbal reasoning test (3 minutes)

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

4. 5 Choice serial reaction time test (5 minutes)

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

5. Repeated digits detection task (5 minutes)

Volunteers 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. They had to detect these repetitions and respond as quickly as possible.

6. Semantic processing task (3 minutes)

This test measured speed of retrieval of information from general knowledge. Volunteers 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. Recognition memory (2 minutes)

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

Mood

Mood was assessed after the battery of performance tests using 18 visual analogue rating scales (e.g. Drowsy/Alert; Happy/Sad; Tense/Calm.). These yield three mood dimensions: Alertness, Hedonic tone and Anxiety. Post-task mood measures have been shown to be more sensitive to the effects of caffeine than measures taken before doing the tests.

Completion of the whole battery of tests took approximately 40 minutes.

Data analysis

Data were transferred directly from the test computer to the database with no manual intervention. Statistical analyses used the IBM SPSS 26 statistical package and ANOVAS were carried out on the percentage change from baseline scores. Initial analyses compared the placebo gum and no gum conditions to see whether they should be considered separately or combined as a single control group.

RESULTS

Comparison of placebo gum and no gum groups

There was little evidence of differences between the placebo gum and no gum conditions. The placebo gum and no gum conditions were, therefore, combined to make a single control group.

Effects of caffeinated gum

Mood

The results showed that caffeinated gum increased ratings of alertness ($F(1,44) = 6.10$ $p < 0.05$), hedonic tone ($F(1,44) = 6.47$ $p < 0.05$) but not anxiety ($F(1,44) = 2.44$ $p > 0.05$). These effects are shown in Table 1. There were no significant interactions between caffeine condition and sleep deprivation conditions.

Performance

The caffeinated gum group showed faster performance of the simple reaction time task ($F(1,44) = 4.26$ $p < 0.05$), more hits in the detection of repeated numbers task ($F(1,44) = 4.21$ $p < 0.05$, and greater accuracy in the five-choice serial response task ($F(1,44) = 4.24$ $p < 0.05$). These effects are shown in Table 1. There were no significant interactions between caffeine conditions and sleep deprivation conditions.

Table 1: Effects of caffeinated gum on mood and performance (scores are the mean percentage change from baseline, s.e.s in parentheses).

	Caffeinated gum	Control
Alertness (high scores = greater increase in alertness)	40.8 (7.7)	17.6 (5.4)
Hedonic tone (high scores = more positive mood)	24.1 (5.4)	7.4 (3.8)
Simple reaction time (low scores = faster RT)	-1.0 (3.0)	8.6 (2.1)
Hits in repeated digits (high scores = more accurate performance)	4.2 (2.1)	-1.2 (1.4)
Accuracy in five choice task (high scores = more accurate performance)	0.42 (0.47)	-0.76 (0.33)

DISCUSSION

The results from the study confirm that caffeine in chewing gum induces similar behavioural effects to those observed when the caffeine is given in other vehicles. The profile observed here was consistent with that seen in low alertness situations: increased alertness and attention but little effect on episodic, semantic processing and working memory. There was no difference in the effect of caffeine in the sleep deprived and non-sleep deprived groups. This may reflect several things. First, students often have a nocturnal lifestyle, and the short sleep deprivation may have had little effect.

This view is not supported by the baseline data, where the alertness levels of the sleep deprived group were only 60% of the alertness of the non-sleep deprived group. The second reason for similar effects in the two groups is that they both carried out a fatiguing battery of tests. What is likely and has been shown in other research on caffeine and sleep deprivation, is that caffeine leads to a certain degree of restoration of function but does not remove all the effects of extreme fatigue. Caffeine may, therefore, be a good countermeasure for acute less extreme fatigue but will not completely remove all the effects of extreme reductions in alertness due to many hours of sleep deprivation. The effects obtained here were in the region of half a standard deviation and may be of practical significance in real-life activities such as driving.[21] The subjective benefits of chewing the caffeinated gum were generally larger than those seen with the objective measures, suggesting that caffeine may increase subjective wellbeing.

This study did not show any effect of the caffeine on working memory or semantic processing tasks. These tasks have been shown to be sensitive to higher doses of caffeine,[22] and larger sample sizes may be required to demonstrate effects of smaller doses on these tasks. The study also found little difference between chewing placebo gum and no chewing. Again, this may reflect the small sample sizes and, possibly, the duration of the chewing period. Further research is required with different methodology to address these areas.

CONCLUSION

The present study showed that 40mg of caffeine in chewing gum increased alertness, led to a more positive mood, faster reaction times and a greater ability to sustain attention. These effects were general, being observed in a sleep deprived group tested between 04.00 -07.00 and a non-sleep deprived group tested between 09.00-12.00. Plausible biological mechanisms have been put forward to account for such effects of caffeine, and it has some utility as a countermeasure to real-life fatigue.

Dedication

This paper is dedicated to John Gallagher (deceased) who was my research assistant working on projects relating to caffeine. John was an important member of my research unit and a good friend and colleague.

REFERENCES

1. Lieberman HR. Caffeine. In: Handbook of Human Performance, Vol.2: Health and performance. (eds) A. P. Smith & D. M. Jones. London: Academic Press, 1992: 49-72.
2. Smith AP. Effects of caffeine on human behavior. Food Chem Toxicol, 2002; 40: 1243-55.
3. Smith AP. Caffeine. In: Nutritional Neuroscience. Edited by H. Lieberman, R. Kanarek and C Prasad, London: Taylor & Francis, 2005; 335-359.
4. Glade MJ. Caffeine – Not just a stimulant. Nutrition, 2010; 26: 932-938.
5. Smith AP. Caffeine: Practical implications. In: Diet, Brain, Behavior: Practical Implications. Eds: R.B. Kanarek & H.R. Lieberman. Taylor & Francis, 2011; 271-292.
6. Doepker C, Lieberman H, Smith AP, Peck J, El-Sohemy A, Welsh B. Caffeine: Friend or Foe? Annual Review of Food Science and Technology, 2016; 7: 6.1 – 6.22. doi: 10.1146/annurev-food-041715-033243.
7. Smith AP. The psychobiological processes underpinning the behavioural effects of caffeine. In: P. Murphy (ed), Routledge International Handbook of Psychobiology. London New York: Routledge. ISBN: 978-1-138-18800-6 (hbk) ISBN: 978-1-315-64276-5 (ebk), 2019; 239-250.
8. Smith AP, Sturgess W, Gallagher J. Effects of a low dose of caffeine given in different drinks on mood and performance. Human Psychopharmacology, 1999; 14: 473-482.
9. Kamimori GH, Karyekar CS, Otterstetter R, Cox DS, Balkin TJ, Belenky GL, Eddington ND. The rate of absorption and relative bioavailability of caffeine administered in chewing gum versus capsules to normal healthy volunteers. International Journal of Pharmaceutics, 2002; 234: 159-167.
10. Smith AP. Effects of caffeine in chewing gum on mood and attention. Human Psychopharmacology: Clinical and Experimental, 2009; 24(3): 239-247.
11. Smith AP, Brockman P, Flynn R, Maben A, Thomas M. An investigation of the effects of coffee on alertness and performance during the day and night. Neuropsychobiology, 1993; 27: 217-233.
12. Killgore WDS, Kamimori G. Multiple caffeine doses maintain vigilance, attention, complex motor expression, and manual dexterity during 77 hours of total sleep deprivation. Neurobiology of Sleep and Circadian Rhythms, 2020. doi.org/10.1016/j.nbscr.2020.100051
13. Smith AP. Caffeine and long hours of work: Effects on alertness and simple reaction time. World Journal of Pharmaceutical Research, 2021; 10(2): 79-89. DOI: 10.20959/wjpr20212-19694.
14. Smith AP, Rusted JM, Eaton-Williams P, Savory M. Leathwood, P. Effects of caffeine given before and after lunch on sustained attention. Neuropsychobiology, 1990; 23: 160 - 163.
15. Smith AP, Thomas M, Perry K, Whitney H. Caffeine and the common cold. Journal of Psychopharmacology, 1997; 11(4): 319-324.
16. Killgore WD, Kamimori GH. Multiple caffeine doses maintain vigilance, attention, complex motor sequence expression, and manual dexterity during 77 hours of total sleep deprivation. Neurobiol. Sleep Circ. Rhythms, 2020; 9: 100051. https://doi.org/10.1016/j.nbscr.2020.100051.
17. Smith AP. Effects of chewing gum on cognitive function, mood and physiology in stressed and non-stressed volunteers. Nutritional Neuroscience, 2010; 13: 7-16.

18. Allen AP, Smith AP. A review of the evidence that chewing gum affects stress, alertness and cognition. Journal of Behavioral and Neuroscience Research, 2011; 9(1): 7-23.
19. Allen AP, Smith AP. Effects of chewing gum and time on task on alertness and attention. Nutritional Neuroscience, 2012; 15(4): 176-185.
20. Allen AP, Smith AP. Chewing gum: cognitive performance, mood, well-being and associated physiology. Biomed Research International, 2015; 1: 1-16. DOI: 10.1155/2015/654806.
21. Aidman E, Johnson K, Paech GM, Della Vedova C, Pajcin M, Grant C, Kamimori G, Mitchelson E, Hoggan BL, Fidock J, Banks S. Caffeine reduces the impact of drowsiness on driving errors. Transport Research Part F, 2018; 54: 236-247.
22. Nguyen-van-Tam D., Smith AP. Caffeine and human memory: a literature review and some data. 19th International Scientific Colloquium on Coffee. Trieste. Association Scientifique Internationale du Café, 2001; P501. https://www.researchgate.net/publication/279764995_Caffeine_and_human_memory_a_literature_review_and_some_data.