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# EFFECTS OF CHEWING GUM AND CAFFEINE CONSUMPTION ON THE PERFORMANCE OF FOCUSED ATTENTION AND CATEGORIC SEARCH CHOICE REACTION TIME TASKS

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## ABSTRACT

**Background:** There has been extensive research on caffeine and behaviour, and most studies have considered the effects of acute ingestion rather than regular consumption. The same applies to research on chewing gum. The aim of the present research was to examine associations between the level of caffeine consumption, chewing gum, and performance of focused attention and categoric search choice reaction time tasks. The effects of age and time of testing were also investigated. **Method:** Two hundred and seventy students and staff (159 females, 113 males; mean age 35.4 years, age range 17-65 years) from Cardiff University participated in the research. They completed the tasks between either 11.00-13.00 or 16.00-18.00. Participants carried out focused attention and categoric search two-choice reaction time tasks. They also completed psychosocial questionnaires to determine whether caffeine and chewing gum were associated with these measures. **Results:** Chewing gum and level of caffeine consumption did not have significant effects on the psychosocial measures. Chewing gum was associated with faster reaction times on both tasks. Caffeine was associated with a speed error trade-off, with high consumers responding more slowly but more accurately. Those who chewed gum were younger than the non-chewers, and high-caffeine consumers were older than low consumers. Older participants responded more slowly but more accurately, and responses were faster later in the day. The effects of chewing gum and level of caffeine consumption were no longer significant when age and time of day were included in the analyses. **Conclusion:** Gum chewing and level of caffeine consumption were not significantly associated with psychosocial measures. Chewing gum was associated with faster response times and high caffeine consumers responded more slowly but more accurately than low consumers. Both the effects of chewing gum and the level of consumption of caffeine could be accounted for by age differences in the groups. This demonstrates the importance of controlling for age and time of testing in studies using these choice reaction time tasks.

**KEYWORDS**: Age; Gender; Time of day; Chewing gum; Caffeine; Focused attention; Categoric search; Choice reaction time; Errors; Lapses of attention.

## INTRODUCTION

The literature on the effects of caffeine on performance has been frequently reviewed.[1-7] Most of the studies have investigated the acute effects of caffeine, although there have been studies which have examined the effects of habitual consumption.[8-11] A similar profile is observed when one examines the effects of chewing gum on performance,[12] although there are far fewer studies on the effects of habitual use, and these have focused on stress rather than performance. The aim of the present study was to determine whether regular chewers and caffeine consumers had a different psychosocial profile from non-consumers and whether they differed in the performance of choice reaction time tasks. This research is important from a theoretical point of view, and also has practical implications. Furthermore, it has implications for methodology in that significant effects of chewing gum and consuming caffeine would suggest that they should be controlled in between subject designs.

There has been extensive research using focused attention and categoric search tasks. The focused attention task involves the identification of stimuli in known locations (What is the stimulus?). Categoric search involves identifying the location of the stimulus, followed by its identification (Where is the stimulus? What is the stimulus?). These two types of attention have been measured in choice reaction time tasks.[13,14] Three main measures of attention were derived from these tasks. The first was the difference in reaction time between the two tasks (Spatial uncertainty little: SPUL). The second measured the focusing of attention (the Eriksen effect, ERIK). The final one measured the effects of stimuli occurring in the same or different locations (the place repetition effect, PREP). Initial research with these tasks focused on the correlations between attention measures and obsessional personality and cognitive failures.[13] These measures were also shown to be sensitive to testing at different times of day.[14]

Global outcomes of choice reaction time tasks, namely mean reaction time, errors, and lapses of attention (occasional very long reaction times), can be derived from these tasks. They also measure stages of processing, such as the encoding of new information and response organisation.[15] The global outcomes and those reflecting different stages of processing have been shown to be sensitive to time of day,[16,17] noise,[18] shiftwork,[19] sleep deprivation,[20] ingestion of food,[21-26] minor illnesses[27-31] aromas,[32] alcohol,[33,34] cholinergic drugs,[35] noradrenergic drugs,[36,37] chronic fatigue syndrome,[38] and cognitive failures.[39] Of particular relevance to the present study is that the tasks have also been shown to be sensitive to the acute effects of caffeine,[40-48] and chewing gum.[49,50] The tasks have also been shown to be sensitive to the effects of age[51] and time of testing.[51] In a recent analysis,[51] effects attributed to extraversion, social support, and anxiety/depression were no longer significant when age and time of testing were included in the analyses.

## METHOD

The study was approved by the ethics committee, School of Psychology, Cardiff University, and carried out with the informed consent of the participants.

### *Design*

A between-subjects design was used, with volunteers being randomly allocated to two times of testing (11.00-13.00 or 16.00-18.00). Prior to the test session, the volunteers were familiarised with the tasks, completed the psychosocial questionnaires, and provided information on chewing gum and consumption of caffeinated beverages. On the day of testing, volunteers abstained from consuming caffeinated beverages or chewing gum.

### *Participants*

Two hundred and seventy-two volunteers (159 females; 113 males; mean age 35.4 years, age range 17-65 years) were recruited from the university staff and students. The following analyses were based on the complete data of two hundred and fifty-two participants.

### *Details of the tasks*

#### *Focussed Attention Task*

This task was developed by Broadbent et al.[13,14]. Target letters were upper case A's and B's. On each trial, three warning crosses were presented on the screen, with the outside crosses being separated from the middle one by either 1.02 or 2.60 degrees. Volunteers 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 msec 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 differ - 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.

Volunteers were given ten practice trials followed by five 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.

The task gives three main types of outcome measures.
1. Global indicators of speed, accuracy, and lapses of attention.
2. Speed of encoding of stimuli
3. Resistance to distraction and focusing of attention.

#### *Categoric search task*

This task was also developed by Broadbent et al.[13,14]. 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). Volunteers 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.

The task gives four types of measures.
1. Global indicators of speed, accuracy, and lapses of attention.
2. Speed of encoding of stimuli
3. Speed of response organisation
4. Measures of spatial attention.

### *Questionnaires*

The participants completed the following questionnaires at the familiarisation session.

- The Cognitive Failures Questionnaire.[52]
- Obsessional personality.[13]
- Daily hassles.[53]
- The Interpersonal Self-Evaluation List (ISEL).[54]
- The UCLA Loneliness Scale.[55]
- The Hospital Anxiety and Depression Scale.[56]
- Positive and negative mood.[57]
- Profile of fatigue-related symptoms.[58]
- Trait anxiety.[59]
- The Eysenck Personality Inventory.[60]

**RESULTS**

Analysis was carried out using IBM SPSS version 27. Gum chewing was measured by a Yes/No question. Caffeine intake was calculated from coffee, tea, energy drinks and soft drink consumption. There were 132 gum chewers and 120 non-chewers. Caffeine consumption was divided at the median (median = 128 mg/day; range 0-525; 62 non-consumers). Gum chewers had higher caffeine consumption, but this difference was not significant (non-chewers: daily mean = 136 mg se =11.1; chewers: mean = 159 mg se=11.8). The data from the psychosocial questionnaires and performance tasks were then analysed with a MANOVA.

***Psychosocial Questionnaires***

There were no significant effects of chewing gum (Wilks Lambda =0.87 p = 0.27) nor caffeine consumption (Wilks Lambda = 0.96 p =0.52). These results are shown in Tables 1 and 2.

**Table 1: Psychosocial scores for those who did and did not chew gum.**

| | Chew Gum | Mean | Std. Deviation |
|---|---|---|---|
| Cognitive failures | Non-chewers | 42.63 | 13.79 |
| | Chewers | 41.00 | 13.63 |
| Obsessional personality | Non-chewers | 2.41 | 1.44 |
| | Chewers | 2.72 | 1.38 |
| Hassles cumulative severity | Non-chewers | 61.09 | 50.12 |
| | Chewers | 61.29 | 46.55 |
| Hassles frequency | Non-chewers | 41.49 | 28.17 |
| | Chewers | 39.48 | 23.89 |
| Hassles Intensity | Non-chewers | 1.35 | 0.33 |
| | Chewers | 1.45 | 0.40 |
| Perceived Stress | Non-chewers | 21.81 | 7.75 |
| | Chewers | 22.35 | 7.94 |
| ISEL Total | Non-chewers | 128.04 | 15.89 |
| | Chewers | 129.22 | 14.42 |
| UCLA Loneliness | Non-chewers | 27.67 | 12.74 |
| | Chewers | 26.60 | 12.32 |
| Anxiety | Non-chewers | 13.02 | 3.80 |
| | Chewers | 13.89 | 4.02 |
| Depression | Non-chewers | 10.58 | 3.11 |
| | Chewers | 10.43 | 2.89 |
| Positive Mood | Non-chewers | 33.92 | 8.49 |
| | Chewers | 33.75 | 9.32 |
| Negative Mood | Non-chewers | 15.16 | 10.23 |
| | Chewers | 15.66 | 10.63 |
| PFRS Emotional Distress | Non-chewers | 33.46 | 19.38 |
| | Chewers | 35.06 | 18.56 |
| PFRS Fatigue | Non-chewers | 26.44 | 13.44 |
| | Chewers | 29.04 | 15.26 |
| PFRS Somatic Symptoms | Non-chewers | 25.73 | 12.63 |
| | Chewers | 26.10 | 9.42 |
| Trait Anxiety | Non-chewers | 39.53 | 9.41 |
| | Chewers | 40.30 | 9.71 |
| Extraversion | Non-chewers | 10.75 | 4.30 |
| | Chewers | 11.76 | 4.63 |

**Table 2: Psychosocial scores for low and high caffeine consumers.**

| | Caffeine | Mean | Std. Deviation |
|---|---|---|---|
| Cognitive Failures | Low | 41.31 | 13.76 |
| | High | 41.61 | 13.29 |
| Obsessional Personality | Low | 2.57 | 1.29 |
| | High | 2.61 | 1.50 |

| | | | |
|---|---|---|---|
| Hassles cumulative severity | Low | 64.74 | 50.48 |
| | High | 56.90 | 45.16 |
| Hassles frequency | Low | 42.07 | 26.68 |
| | High | 38.44 | 25.09 |
| Hassles intensity | Low | 1.42 | 0.37 |
| | High | 1.37 | 0.36 |
| Perceived Stress | Low | 21.95 | 7.35 |
| | High | 21.95 | 8.34 |
| ISEL total | Low | 128.25 | 15.53 |
| | High | 129.34 | 14.57 |
| UCLA loneliness | Low | 27.49 | 12.18 |
| | High | 26.44 | 12.87 |
| Anxiety | Low | 13.38 | 3.77 |
| | High | 13.48 | 4.03 |
| Depression | Low | 10.55 | 3.18 |
| | High | 10.41 | 2.76 |
| Positive mood | Low | 33.25 | 8.69 |
| | High | 34.39 | 9.21 |
| Negative Mood | Low | 15.12 | 9.86 |
| | High | 15.33 | 10.93 |
| PFRS Emotional distress | Low | 33.21 | 17.59 |
| | High | 34.96 | 20.12 |
| PFRS fatigue | Low | 28.46 | 15.23 |
| | High | 26.84 | 13.75 |
| PFRS Cognitive difficulty | Low | 24.29 | 12.97 |
| | High | 23.44 | 11.66 |
| PFRS Somatic symptoms | Low | 27.44 | 12.31 |
| | High | 24.21 | 10.60 |
| Trait anxiety | Low | 40.01 | 9.53 |
| | High | 39.69 | 9.47 |
| Extraversion | Low | 11.33 | 4.59 |
| | High | 11.30 | 4.45 |

***Gum chewing, caffeine and performance***

Gum chewers had faster reaction times in both the focused attention and categoric search tasks. These results are shown in Table 3.

**Table 3: Effects of chewing gum on performance.**

| Chewing gum | Task | Mean | SD | Significance |
|---|---|---|---|---|
| | | | | |
| Non-chewer | Focused RT. | 450 msec | 78 | p<0.01 |
| Chewer | Focused RT | 425 | 72 | |
| | | | | |
| Non-chewer | Categoric RT | 572 msec | 77 | p<0.05 |
| Older | Categoric RT | 551 | 72 | |
| | | | | |

Higher caffeine consumption was associated with slower but more accurate performance on both tasks. These results are shown in Table 4.

**Table 4: Effects of level of regular caffeine consumption on performance.**

| Caffeine | Task | Mean | SD | Significance |
|---|---|---|---|---|
| | | | | |
| Low | Focused RT. | 429 msec | 71 | p<0.05 |
| High | Focused RT | 446 | 80 | |
| | | | | |

| | | | | |
|---|---|---|---|---|
| Low | Focused errors | 11.7 | 23.2 | p<0.05 |
| High | Focused errors | 7.4 | 9.8 | |
| | | | | |
| Low | Categoric RT | 553 msec | 72 | p<0.05 |
| High | Categoric RT | 569 | 77 | |
| | | | | |
| Low | Categoric errors | 13.6 | 22.6 | p<0.05 |
| High | Categoric errors | 9.4 | 8.8 | |

*Effects of chewing gum and caffeine consumption when age was included in the analyses.*

Non-chewers were significantly older than gum chewers (non-chewers: mean age = 38.7 sd =14.4; chewers: mean age =32.2 sd=13.1; p <0.001). High caffeine consumers were significantly older than low caffeine consumers (High consumers: mean =40.0 sd = 14.5; low consumers: mean = 30.7 sd= 12.1; p < 0.001). Older participants performed the tasks significantly more slowly but more accurately. When age was included in the MANOVA, the effects of chewing gum and caffeine consumption were no longer significant.

## DISCUSSION

The first aim of the present research was to examine associations between some psychosocial factors, whether individuals had high or low levels of caffeine consumption, and whether they chewed gum or not. There were no significant effects of caffeine or gum chewing on psychosocial measures, which meant that psychosocial factors did not need to be statistically controlled in the analysis of performance data. The performance tasks used were focused attention and categoric search choice reaction time tasks, which have been shown to be sensitive measuring instruments. Time of testing and age were also investigated, as these can have significant effects on the performance of choice reaction time tasks. The outcome measures used were mean reaction times, errors, and lapses of attention (occasional very long reaction times) for the two tasks. In addition, measures of selective attention (SPUL; ERIK; and PREP) were derived from the tasks. The speed of encoding new information and response organisation were also recorded.

Those who chewed gum had faster reaction times on both tasks. High-caffeine consumers responded more slowly on both tasks but were more accurate than those who consumed less caffeine. The older participants were slower but more accurate than the younger ones, and reaction times were faster when testing was later in the day. When age and time of testing were covaried, the effects of chewing gum and caffeine were no longer significant. This demonstrates the importance of controlling for age and time of day when using between-subject designs with choice reaction time tasks. Further research is now required to examine the effects of other types of individual differences, such as mood at the time of testing, on the performance of these tasks. Similarly, the current approach can be applied to study individual differences in other aspects of performance (e.g. memory and sustained attention). In terms of theory and the implications for real-life activities, the current results show that age and time of day are important variables to focus on. Effects observed in the laboratory may translate into reduced efficiency and safety in work, education, and other contexts.

## CONCLUSION

Most of the extensive research on caffeine and behaviour has considered the effects of acute ingestion rather than regular consumption. The same applies to less extensive research on chewing gum. The first aim of the present research was to examine associations between the level of caffeine consumption, chewing gum, and psychosocial factors. This was done in order to consider covariates in analyses examining the effects of the level of regular caffeine consumption and gum chewing on the performance of focused attention and categoric search choice reaction time tasks. The effects of age and time of testing were also investigated, as these are known to influence the performance of choice reaction time tasks. Two hundred and fifty two participants completed focused attention and categoric search two-choice reaction time tasks between either 11.00-13.00 or 16.00-18.00. At familiarisation, they also completed psychosocial questionnaires and recorded their use of caffeine and chewing gum. The results showed that chewing gum and level of caffeine consumption did not have significant effects on the psychosocial measures. Chewing gum was associated with faster reaction times on both of the tasks, whereas higher caffeine consumers responded more slowly but more accurately than lower consumers. High caffeine consumers were older than low consumers, and those who chewed gum were younger than the non-chewers. The older participants responded more slowly but more accurately, and responses were faster when participants were tested later in the day. The effects of chewing gum and level of caffeine consumption were no longer significant when age and time of day were covaried. In conclusion, the level of caffeine consumption and chewing gum were not significantly associated with psychosocial measures. Chewing gum was associated with faster response times and high caffeine consumers responded more slowly but more accurately than low consumers. Both the effects of chewing gum and the level of consumption of caffeine could be accounted for by age differences in the groups. This demonstrates the importance of controlling for age and time of testing in studies using these choice reaction time tasks.

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