Effects of chewing gum on cognitive function, mood and physiology in stressed and non-stressed volunteers

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Rationale: Recent research suggests that chewing gum may improve aspects of cognitive function and mood. There is also evidence suggesting that chewing gum reduces stress. It is important, therefore, to examine these two areas and to determine whether contextual factors (chewing habit, type of gum, and personality) modify such effects.

Objectives: The aims of the present study were: (i) to determine whether chewing gum improved mood and mental performance; (ii) to determine whether chewing gum had benefits in stressed individuals; and (iii) to determine whether chewing habit, type of gum and level of anxiety modified the effects of gum.

Subjects and methods: A cross-over study involving 133 volunteers was carried out. Each volunteer carried out a test session when they were chewing gum and without gum, with order of gum conditions counterbalanced across subjects. Baseline sessions were conducted prior to each test session. Approximately half of the volunteers were tested in 75 dBA noise (the stress condition) and the rest in quiet. Volunteers were stratified on chewing habit and anxiety level. Approximately, half of the volunteers were given mint gum and half fruit gum. The volunteers rated their mood at the start and end of each session and had their heart rate monitored over the session. Saliva samples were taken to allow cortisol levels (good indicator of alertness and stress) to be assayed. During the session, volunteers carried out tasks measuring a range of cognitive functions (aspects of memory, selective and sustained attention, psychomotor speed and accuracy).

Results: Chewing gum was associated with greater alertness and a more positive mood. Reaction times were quicker in the gum condition, and this effect became bigger as the task became more difficult. Chewing gum also improved selective and sustained attention. Heart rate and cortisol levels were higher when chewing which confirms the alerting effect of chewing gum.

Conclusions: Overall, the results suggest that chewing gum produces a number of benefits that are generally observed and not context-dependent. In contrast to some previous research, chewing gum failed to improve memory. Further research is now required to increase our knowledge of the behavioral effects of chewing gum and to identify the underlying mechanisms.

Keywords: chewing gum, mood, cognition, stress

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Introduction

There has been growing recent interest in the effects of chewing gum on cognitive functioning. Smith has reviewed the area and shown that many of the studies have methodological problems which mean that these prior results require replication and extension. In addition, few studies investigating the effects of chewing gum have examined cognition, mood and physiology in the same study so little is known about the comparative magnitude of different outcomes. The first aim of the present study was to investigate effects of chewing gum on aspects of cognition.

A second issue examined was whether chewing habit also has an effect (i.e. will regular gum chewers differ from irregular chewers in a ‘no-gum’ condition). Mood and physiological functioning (cardiovascular function, cortisol levels) were also recorded to determine whether changes in these underlie any effects on cognition. Similarly, it was important to determine whether the acute effects of chewing gum were modified by regular chewing habit. In addition, it was important to determine whether effects of gum generalize across gum types (in this case mint and fruit flavors) as some studies suggest that it is the flavor of the gum that is important. Smith has found that high consumers of gum are more anxious.

There is considerable anecdotal evidence that individuals who are stressed or anxious often chew gum. Smith has recently investigated the personality characteristics associated with chewing gum and found that high consumers of gum are more anxious. A secondary analysis of the placebo gum condition in a previous study also suggested that chewing gum reduced anxiety in those who have above average levels of anxiety. Other research has also shown that chewing gum is associated with lower stress levels. These studies have often examined regular chewing and chronic stress. One must now consider whether chewing gum reduces the impact of acute stress and a study of effects of chewing gum while carrying out demanding tasks suggests that it may influence physiology, subjective reports and performance.

There are many ways to induce stress; and one successful method is to have the person perform in noise. This may lead to an increase in negative mood, increased blood pressure and impaired performance. Another aim of the present research was to examine the effects of noise on volunteers who either chewed gum or nothing, were high or low consumers of gum, and had high or low levels of trait anxiety. One prediction was that chewing gum would reduce the impact of the noise in all groups. Alternatively, it may only be beneficial for those already high in anxiety or those who routinely chew gum regularly.

Subjects and methods

Ethical committee approval

The study was approved by the Ethical Committee of the School of Psychology, Cardiff University and carried out with the informed consent of the volunteers. Volunteers were recruited from the student population of Cardiff University and were informed that the study was investigating effects of chewing gum and noise on mood, cognitive function and physiology.

Design

The design of the study is shown in Table 1. Volunteers were familiarized with the tasks in an initial session. They then carried out two sessions of tests one week apart.

Within subject factors

In each session, volunteers carried out a pre-gum (pre-no gum) session (these were always ‘no noise, no chewing’) and measures from this were used as co-variates to adjust for any individual differences present at this time. Following this, the volunteers then completed another set of tests during which they either chewed gum or were given no gum.

Between subject factors

1. Order of gum conditions

The gum manipulation involved a cross-over design with half the volunteers starting in the ‘gum’ condition and then the ‘no gum’ condition, and the others having the conditions in the reverse order.

2. Noise conditions

Noise was a between subject factor as previous studies of effects of noise frequently show strong transfer effects in

Table 1 Design of study

<table>
<thead>
<tr>
<th>A: Within subject gum manipulation</th>
<th>Pre-gum test</th>
<th>Gum test</th>
<th>Pre-no gum test</th>
<th>No gum test</th>
</tr>
</thead>
<tbody>
<tr>
<td>B: Between subject factors</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Order of gum conditions</td>
<td>ABCD: Gum (week 1) No gum (week 2) n = 67</td>
<td>CDAB: No gum (week 1) Gum (week 2) n = 66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise conditions</td>
<td>Noise n = 65</td>
<td>Quiet n = 68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trait anxiety</td>
<td>High anxiety n = 69</td>
<td>Low anxiety n = 64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Habitual gum use</td>
<td>Frequent n = 62</td>
<td>Infrequent n = 71</td>
<td></td>
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</tr>
</tbody>
</table>
within subject designs. Half of the volunteers carried out both tests in quiet and half in noise. Volunteers were randomly assigned to these conditions.

3. Regular gum usage
Volunteers were sub-divided into regular and irregular gum chewers on the basis of questionnaire information collected prior to the study.

4. Anxiety levels
Information on anxiety levels (both general and at testing) was also available to assess whether gum chewing and anxiety interact.

Equal numbers of regular/irregular chewers and high/low anxious volunteers were assigned to each condition (high anxiety was defined as above 40 on the Spielberger Trait Anxiety Scale. Regular consumers = more than one pack of gum per week).

The above design allows one to assess whether chewing gum has an effect in both low- and high-stress conditions, and whether it reduces effects of stress. Similarly, it allows consideration of the impact of gum habit and anxiety levels on the effects of gum. In the gum condition, volunteers were allocated to either mint or fruit gum. This procedure allows one to generalize findings to both gum types, although it does not provide a test of equivalence of the two types of gum.

Sample
Sample size calculation
Sample size considerations are complicated in this type of study where one is considering multiple outcome measures and using different parts of the database to address different hypotheses. In general, it is important to have sample sizes that will be able to detect significant effects in the region of 0.5 SD. Two examples show that the study had an appropriate sample size to do this. First, in order to be able to demonstrate that gum reduces the effects of stress, one needs to be able to produce an effect in the first place. Previous research suggests that the effects of noise are in the region of 0.5–0.8 SD and, conservatively setting effect size at 0.5 SD, with power set to 0.8 and \( P < 0.05 \) one needs a sample size of 63 per group to show this effect. As the intention was to recruit at least 64 volunteers in the noise and quiet conditions this sample size was appropriate, especially as the effect size was likely to be much bigger than that used in the calculations.

In the case of gum, mood and cognitive performance, one is making a within-subject comparison. For such sample size calculations, one needs to know the SD of the difference scores of gum and no gum conditions. With \( n = 64 \), power set to 0.8 and \( P < 0.05 \), then one should be able to detect an effect size of 0.35 SD.

Inclusion/exclusion criteria
Participants were excluded if they: (i) were unable to chew gum for a period of approximately 40 min; (ii) were younger than 18 years or older than 40 years; (iii) consumed more than 40 units of alcohol per week; (iv) smoked more than 10 cigarettes a day; (v) were currently taking medication; (vi) were currently experiencing any medical problems (including dental problems) or had any serious medical conditions (including phenylketonuria [inability to tolerate phenylalanine, i.e. additives in foods], diabetes, heart or kidney disease); (vii) had a Spielberger anxiety score of less than 21 or greater than 70; and (viii) suffered allergic reactions to mint or fruit flavours.

Final sample
A total of 133 volunteers (64 male, 69 female; mean age 22.6 years, SD 4.4 years, range 19–39 years) completed the study.

Gum
The gum was Wrigley’s Spearmint gum or Wrigley’s Juicy Fruit gum.

Performance tests/mood ratings/physiological recording
These tests were selected because they measure a variety of cognitive functions, are known to be sensitive measuring instruments and are in a form which is easy to administer and carry out. They represent many of the tasks used in previous studies of the effects of gum and are also known to be sensitive to effects of noise. The mood and performance tasks were given in the order shown below.

Mood
This was measured using 18 bi-polar visual analogue scales (e.g. Drowsy–Alert, Tense–Calm; after Herbert, Johns and Dore(5)) presented on the screen of an IBM-compatible computer. Mood was rated at the start of each session (as soon as the volunteer started chewing) and at the end. This provides information about initial and longer term effects of the manipulations. Three scores were derived from the mood scales: alertness, hedonic tone and anxiety.

Performance tasks
A battery of tests were used that measure a range of functions. All of these tests were presented on an IBM-compatible PC. These tests are known to be sensitive to changes in state.16
Memory tasks

1. **Immediate Free Recall Task** – A list of 20 words were presented on the PC screen at a rate of one every 2 s. At the end of the list, the participant has 2 min to write down (in any order) as many of the words as possible.

2. **Delayed Free Recall Task** – At the end of the test session, the participant had 2 min to write down (in any order) as many of the words as possible from the list shown at the start of the study.

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

4. **Logical Reasoning Task** (a measure of working memory) – In this task 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 the sentence was a true description of the order of the letters. If it was, the participant pressed the T key on the keyboard; if it was not, they pressed the F key. The sentences ranged in syntactic complexity from simple active to passive negative (e.g. A is not followed by B). Volunteers carried out the task for 3 min.

5. **Spatial memory task** – This task was designed to investigate the visuo-spatial scratch pad described in Baddeley's working memory model. Volunteers were asked to concentrate on eight circles arranged on the screen. The circles lit up in a randomized sequence. Participants were required to observe the sequence and memorize the order in which the buttons lit up. Having observed the light sequence, they had to reproduce the sequence by pressing appropriate keys on the keyboard. This was repeated five times.

6. **Semantic Processing Task** – This test measured speed of retrieval of information from general knowledge. Participants were shown a sentence and had to decide whether it was true (e.g. canaries have wings) or false (e.g. dogs have wings). This task lasted for 3 min.

Psychomotor tasks

1. **Simple Reaction Time Tasks** – Two simple reaction time tasks were performed. One of them had a variable fore-period (1–8 s), whereas in the other the time between the warning signal and presentation of the target was fixed (2 s). In both tasks, a box was displayed on the screen and this was followed by a square (the target) being presented in the middle of the box. The participant had to press a key as soon as the square was detected, and following this another box was presented. These tasks lasted for 3 min each.

Selective attention choice reaction time tasks

1. **Focused attention task** – This choice reaction time task, developed by Broadbent et al.\textsuperscript{17,18} measured various aspects of performance. In this task, target letters appeared as upper case As and Bs in the centre of the screen. Participants were required to respond as quickly and as accurately as possible to the target letter presented in the centre of the screen, ignoring any distracters presented in the periphery. 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. Prior to each target presentation, three warning crosses were presented on the screen, the outside crosses were separated from the middle one by either 1.02º or 2.60º. The crosses were on the screen for 500 ms and were then replaced by the target letter. The central letter was either accompanied by: (i) nothing; (ii) asterisks; (iii) letters that were the same as the target; or (iv) letters which differed from the target. The two distracters presented were always identical and the targets and accompanying letters were always A or B. Participants were given 10 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 distracter conditions. The nature of the previous trial was controlled. This test lasted approximately 6 min.

In this task, several aspects of choice responses to a target were measured. The global measures of choice reaction time were mean reaction time and accuracy of response (percentage correct) when the target was presented alone or when distracters were present. Long response times (> 800 ms) were also recorded. In addition, a measure of selective attention was recorded (the Eriksen effect). This provided a measure of focusing of attention, describing the effect of spatial interference caused by disagreeing stimuli placed near to or far from the target upon reaction time and accuracy of response to the target. A more specific aspect of choice response was measured recording choice
reaction time and accuracy with which new information was encoded, e.g. alternations and repetitions of responses to the target.

2. Categoric search task – This task was also developed by Broadbent et al.17,18 and was similar to the focused attention task previously outlined. Each trial started with the appearance of two crosses either in the central positions occupied by the non-targets in the focused attention task, i.e. 2.04° or 5.20° apart or further apart, located towards either left and right extremes of the screen. The target letter then appeared in place of one of these crosses. However, in this task, participants did not know where the target would appear. On half the trials, the target letter A or B was presented alone and on the other half it was accompanied by a distracter; in this task a digit (1–7). 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. This task also lasted approximately 6 min. As in the focused attention task, several aspects of choice responses to a target were measured. The global measures recorded were choice reaction time and accuracy of response when the target was presented alone in either near/far locations. Long response times (> 1000 ms) were also recorded. A more specific aspect of choice response was measured, recording choice reaction time and accuracy with which new information was encoded. In addition, specific aspects of selective attention were measured. A measure of response organisation was recorded. This refers to the effect of compatibility of the target position and the response key upon reaction time and accuracy. A further measure of place repetition was taken which refers to the effect of target location (i.e. the target appearing in the same or a different place on successive trials). A measure of spatial uncertainty was also taken which describes the extent to which not knowing the location of the target (in near or far locations) hinders both reaction time and accuracy.

**Sustained Attention Task**

1. Repeated-digits Vigilance Task – Three-digit numbers were shown on the screen at the rate of 100 per minute. Each was normally different from the preceding one but occasionally (8 times a minute) the same number was presented on successive trials. Participants had to detect these repetitions and respond as quickly as possible. The number of hits, reaction times for hits, and false alarms were recorded. The task lasted for 3 min.

**Physiological recording**

Heart rate was recorded at minute intervals during each test session using a Polar S610 heart rate monitor. Saliva samples were also taken at the start and end of each session to measure cortisol, which is often considered a good indicator of stress.

**Nature of the noise**

A recording of industrial noise was played over headphones at a level of 75 dBA.

**Testing day schedule**

Prior to the test days, volunteers completed a familiarization session to ensure they understood the procedure. On test days, testing occurred in the late morning (start time 10.00 or 11.30), the afternoon (start time 15.00 or 16.30) or early evening (18.00 or 19.30) to avoid periods of low circadian alertness. Volunteers completed a baseline session on each day (no noise, no gum). Half of the volunteers then completed a session (lasting approximately 1.5 h) in noise, the other half in quiet. On one test day, volunteers chewed gum during the second session whereas on the other day they had no gum (order of gum conditions was counterbalanced across subjects). At the end of the tests, the volunteers rated the acceptability of the gum on a 10-point scale and those in the noise also rated how annoying it had been (on a 10-point scale).

**Statistical analysis**

In all of the analyses, normality was tested using Shapiro and Wilk’s W-statistic. When normality was rejected, an appropriate transformation was used based on Box–Cox diagnostics. Given the number of statistical tests carried out, a correction was made for multiple testing and only analyses with $P < 0.002$ were considered significant.

Analysis of the pre-chewing (pre-no chewing) data involved analyses of variance to determine whether regular gum chewing and trait anxiety levels influence cognition, mood and physiology. The acute effects of gum were examined using analyses of co-variance with the corresponding pre-chewing (pre-no chewing) measures as co-variates. This statistical technique removes any unwanted individual differences that were present at baseline. The following factors and their
interactions were included in the analyses: gum vs no gum; stress vs no stress; regular gum use; anxiety, and order of gum conditions. Order of gum conditions was included to remove any practice effects or asymmetric transfer effects. While it is important to remove these effects of order of treatments from the error term in the analyses, their significance (or lack of significance) is of no relevance and they are not discussed in the following sections.

Results

Missing and excluded data
The majority of the tasks had complete sets of data. The amount of missing data (not saved correctly) was: (i) pre-task mood ($n = 1$); (ii) repeated digits task ($n = 1$); and (iii) variable fore-period simple reaction time task ($n = 14$).

With the exception of the variable fore-period task, where a set of data was inadvertently over-written, very little data was lost.

Some data were excluded because the tasks were not performed correctly. Again, this was minimal except for the verbal reasoning task where 12 volunteers were excluded because they were performing at chance level.

Effects of chewing gum
The following sections consider the significant main effects of gum. In these analyses there were no significant interactions between gum and noise which shows that the effects of gum generalize to both quiet and noise conditions.

Mood
Chewing gum was associated with greater alertness both before completing the tasks ($P < 0.0005$) and after the tests ($P < 0.0001$). These effects are shown in Figure 1.

The non-significant effects of gum on hedonic tone and anxiety are shown in Table 2.

Performance tasks
Simple reaction time
Table 2 shows the results from the fixed and variable fore-period simple reaction time tasks. Neither of the tasks showed a significant effect of gum which suggests that basic sensory and motor functions are not altered by chewing gum.

Focused attention choice reaction time
Chewing gum was associated ($P < 0.0001$) with faster encoding of new information (a bigger difference between reaction times to new stimuli compared to repeated stimuli). This effect is often seen when individuals have increased alertness due, for example, to caffeine. The Eriksen effect, is a measure of whether attention is focused on central stimuli (the higher the score the greater the focusing of attention) or set to a wider angle. The effect of gum was to reduce the funnel vision ($P < 0.0001$), something that is again seen in alert individuals. These two effects are shown in Figure 2.

Non-significant effects of gum on other task parameters are shown in Table 2.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Effects of chewing gum on mood and performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gum</td>
<td>No gum</td>
</tr>
<tr>
<td>1. Pre-task hedonic tone</td>
<td>182.2 (3.7)</td>
</tr>
<tr>
<td>2. Pre-task anxiety</td>
<td>83.5 (1.7)</td>
</tr>
<tr>
<td>3. Post-task hedonic tone</td>
<td>175.6 (3.4)</td>
</tr>
<tr>
<td>4. Post-task anxiety</td>
<td>83.1 (1.8)</td>
</tr>
<tr>
<td>5. Variable fore-period simple RT (ms)</td>
<td>325 (4)</td>
</tr>
<tr>
<td>6. Fixed fore-period simple RT (ms)</td>
<td>233 (4)</td>
</tr>
<tr>
<td>7. Focused attention RT (ms)</td>
<td>380 (3)</td>
</tr>
<tr>
<td>8. Focused attention errors</td>
<td>1.0 (1.1)</td>
</tr>
<tr>
<td>9. Focused attention long responses</td>
<td>1.4 (0.2)</td>
</tr>
<tr>
<td>10. Categoric search errors</td>
<td>1.0 (1.1)</td>
</tr>
<tr>
<td>11. Categoric search long responses</td>
<td>6.5 (0.4)</td>
</tr>
<tr>
<td>12. Categoric search – spatial uncertainty (ms)</td>
<td>77.5 (2.6)</td>
</tr>
<tr>
<td>13. Categoric search S-R compatibility (ms)</td>
<td>16.1 (1.7)</td>
</tr>
<tr>
<td>14. Categoric search place repetition (ms)</td>
<td>15.9 (1.9)</td>
</tr>
<tr>
<td>15. Sustained attention false alarms</td>
<td>10.6 (1.3)</td>
</tr>
<tr>
<td>16. Sustained attention hit RT (ms)</td>
<td>668 (8.0)</td>
</tr>
<tr>
<td>17. Immediate recall</td>
<td>9.3 (0.3)</td>
</tr>
<tr>
<td>18. Delayed recall</td>
<td>6.2 (0.3)</td>
</tr>
<tr>
<td>19. Recognition memory hits</td>
<td>14.6 (0.3)</td>
</tr>
<tr>
<td>20. Semantic memory number done</td>
<td>67.1 (1.0)</td>
</tr>
<tr>
<td>21. Semantic memory number correct</td>
<td>62.0 (1.1)</td>
</tr>
<tr>
<td>22. Verbal reasoning number done</td>
<td>50.2 (1.5)</td>
</tr>
<tr>
<td>23. Verbal reasoning percent correct</td>
<td>88.6 (1.3)</td>
</tr>
<tr>
<td>24. Spatial memory percentage correct</td>
<td>66.3 (2.3)</td>
</tr>
</tbody>
</table>

RT, response time.
Scores are the adjusted mean values, SE shown in parentheses.
Categoric search choice reaction time
Reaction times were faster in the gum condition than the no gum condition ($P < 0.0005$). This is shown in Figure 3. The non-significant effect of gum on the other task parameters is shown in Table 2.

Sustained attention
More hits were detected when chewing gum ($P < 0.001$) and, again, this is a typical feature of high alertness situations. This is shown in Figure 4. Non-significant effects of gum on other task parameters are shown in Table 2.

Episodic memory
Immediate/delayed recall and recognition memory
Chewing gum reduced the immediate recall of the words but had no effect on the delayed recall. Similarly, it reduced the number of words correctly recognized. These effects are shown in Table 2.

Semantic memory
Chewing gum reduced both the speed and accuracy of performing the task. These effects are shown in Table 2.

Verbal reasoning
Chewing gum led to slower performance on this task but had no effect on accuracy (see Table 2).

Spatial memory
Table 2 shows the results from the spatial memory task. There was no difference between gum and no gum conditions.

Physiological measures
Figure 5 shows the heart rate and cortisol data. There

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**Figure 1** (A) Pre-performance alertness and (B) post-performance alertness. Higher scores = greater alertness. Maximum score = 400. Scores are the adjusted mean values, SE shown as bars

**Figure 2** (A) Effects of chewing gum on the speed of encoding of new information in the focused attention task (scores are adjusted mean values with SE shown as bars; the scores are difference between alternations and repetitions; low scores = faster encoding of new information). (B) Effects of chewing gum on the Eriksen effect (scores are the adjusted mean values, SE shown as bars. High scores = greater funnel vision)

**Figure 3** Effect of chewing gum on reaction time in the categoric search task (scores are the adjusted mean values, SE shown as bars)
were significantly higher values in the gum condition (mean heart rate, \( P < 0.001 \); mean cortisol, \( P < 0.0001 \)) which again is compatible with the view that chewing gum leads to an increase in alertness.

**Interactions between gum conditions, noise, regular chewing habit and anxiety**

The previous analyses have not only examined the effects of gum but analysed the level of significance of the interactions between gum and noise, anxiety and chewing habit. Only 4 out of over 100 of these effects were significant, which is about the level one would expect by chance. In other words, the effects of gum generalize across both quiet and noise conditions, regular and irregular chewers and low/high anxious individuals.

**Effects of type of gum**

The above analyses were repeated including type of gum as a factor. Again, this had no more effect than one would expect by chance.

**Effects of regular chewing habit**

In order to investigate possible long-term effects of chewing habits analyses of the baseline data were carried out to determine whether there were any significant differences between regular chewers and occasional chewers. The results showed no evidence of differences.

**Effects of the noise**

The analyses described already showed that noise increased stress and led to some impairment of performance. For example, anxiety was greater in noise (pre-task anxiety [low scores = greater anxiety]: noise: 77.4 quiet: 88.1, \( P < 0.0001 \); post-task anxiety: noise: 77.9 quiet: 87.8, \( P < 0.001 \)) and simple reaction time slower (noise mean: 236 ms; quiet mean: 226 ms).

The rating of the liking of the gum was also significantly higher (\( P < 0.05 \)) in the noise condition (mean = 7.5) than in the quiet condition (mean = 6.7). Similarly, there was a non-significant trend for the annoyance due to the noise to be lower in the gum condition (mean = 5.9) than in the no gum condition (mean = 6.3).

**Discussion**

The first point to emerge from this study was that the effects of chewing gum could be demonstrated in a range of contexts: in quiet, in noise, with regular or occasional chewers, and high or low anxious people. Similarly, the majority of effects were apparent with both fruit and mint gum. Many of the effects were extremely significant and remained so even when adjustments for multiple testing were made. Other effects were smaller and clearly require replication in future studies.

What were the benefits of chewing gum? First, if one considers mood, the results showed that it makes one feel more alert (as described using the adjectives strong, well co-ordinated, energetic, interested, quick-witted, attentive, proficient – these are all sub-
components of the alertness factor). These effects of chewing gum were present at both the start and end of the session.

Chewing gum improved speed of reactions in a number of contexts: (i) it improved the person’s speed of reactions when they were distracted; (ii) it helped respond quickly to targets in unknown locations; and (iii) it helped when the person had to make difficult responses.

Chewing gum also reduced lapses of attention and aided concentration. Similarly, chewing gum was associated with setting attention to a wide angle. Such effects are consistent with an arousing effect of chewing gum, which is consistent with the physiological changes. The beneficial effects of chewing gum would seem to suggest that many real-life activities, such as driving, may be improved. This can easily be examined using simulations and survey data.

All of the above represent potential benefits of chewing gum. Are there any costs? In the choice reaction time tasks, the faster response times in the gum condition were associated with a higher error rate. This change in the speed–error trade-off is often observed when alertness is increased. Unlike some of the previous studies, the memory tasks (immediate recall, semantic memory and verbal reasoning) showed impairments while chewing gum. This may either reflect the increased alertness or, more likely, be an effect of chewing on sub-vocal rehearsal. Folkard found that increased alertness, due to increased muscle tension, was associated with impaired immediate recall. This was found to be due to a reduction of sub-vocal rehearsal in the induced muscle tension condition. In the present study, gum was chewed throughout the test battery which represents a long time chewing. Previous studies have only involved shorter periods and the different results may reflect this. However, this appears unlikely as both beneficial effects of gum (pre-test mood) and impairments (immediate free recall) were found at the very start of the session. Another study has also found that chewing gum at learning significantly impaired recall which is in agreement with the present findings. These memory impairments also require further investigation and it may be appropriate to examine effects of chewing gum when different strategies are used to remember information.

How consistent are the present results with previous findings and effects observed in other paradigms? Hollingsworth first described the beneficial effects of chewing gum on mood and performance. Chewing gum has also been shown to increase alertness, both in those working at night and in the day. EEG studies also suggest that chewing gum may increase alertness and it has been suggested that chewing gum activates at least two types of mechanism, one related to the chewing and the other to the flavour of the gum. In addition, studies measuring EMG confirm that EMG activity, in particular facial muscles, is related to the mobilization of energetic resources. Mastication also has effects on both sympathetic and parasympathetic activity. Studies of brain imaging also confirm that chewing activates wide-spread regions of the brain. Other research has demonstrated that chewing gum influences neurotransmitter function, specifically the 5-HT descending inhibitory pathway.

The present results showed that chewing gum was beneficial in both the quiet and noise conditions. This result is similar to the finding that caffeine had beneficial effects in both stressful and non-stressful conditions. Caffeine produces CNS changes in many different ways and the literature on chewing gum suggests that it also influences different mechanisms. It is not unreasonable, therefore, to think of the state induced by chewing gum as being ‘alert and calm’. The increased alertness may reflect the chewing and/or sensory properties of the gum. In contrast, the relaxing effect of the gum may reflect changes in vagal stimulation, which are thought to underlie some of the other benefits of chewing gum (e.g. prevention of certain gastric disorders).

Conclusions

Overall, the findings from the present study suggest that chewing gum has wide-spread benefits that are observed across a range of functions in different contexts. Further research is now required to elucidate the mechanisms that underlie such effects and to determine the real-life implications of these benefits.

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References


