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Chewing gum alleviates negative mood and reduces cortisol during acute laboratory psychological stress

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ABSTRACT

The notion that chewing gum may relieve stress was investigated in a controlled setting. A multi-tasking framework which reliably evokes stress and also includes performance measures was used to induce acute stress in the laboratory. Using a randomised crossover design forty participants (mean age 21.98 years) performed on the multi-tasking framework at two intensities (on separate days) both while chewing and not chewing. Order of workload intensity and chewing conditions were counterbalanced. Before and after undergoing the platform participants completed the state portion of the State-Trait Anxiety Inventory, Bond–Lader visual analogue mood scales, a single Stress Visual Analogue Scale and provided saliva samples for cortisol measurement. Baseline measures showed that both levels of the multi-tasking framework were effective in significantly reducing self-rated alertness, calmness and contentment while increasing self-rated stress and state anxiety. Cortisol levels fell during both levels of the stressor during the morning, reflecting the predominance of a.m. diurnal changes, but this effect was reversed in the afternoon which may reflect a measurable stress response. Pre–post stressor changes (Δ) for each measure at baseline were subtracted from Δ scores under chewing and no chewing conditions. During both levels of stress the chewing gum condition was associated with significantly better alertness and reduced state anxiety, stress and salivary cortisol. Overall performance on the framework was also significantly better in the chewing condition. The mechanisms underlying these effects are unknown but may involve improved cerebral blood flow and/or effects secondary to performance improvement during gum chewing.

1. Introduction

People chew gum for a variety of reasons including to modulate psychological states, for example to aid concentration and to help relieve stress. This last possibility was first addressed in the 1930s by Hollingworth [1] who described a series of studies into the mood and performance effects of chewing gum, in the form of candy-coated chicle (the sap from the sapodilla tree) on aspects of stress and performance. Typically subjects were studied under three conditions: not chewing; chewing gum; sucking a candy. In one set of experiments subjects were asked to rate how they felt on a 20-point linear rating scale ranging from extreme strain to extreme relaxation. In all three experiments the subjects rated themselves as between 10% and 15% more relaxed in the chewing conditions compared with the other conditions.

Since these classic studies the impact of chewing on psychological function received scant attention until the last decade. Several controlled laboratory studies have identified that chewing gum can improve memory [2–4]. An effect which may be related to insulin-mediated glucose uptake [3] or the re-instatement of learning context [2]. The latter possibility has not gone unchallenged [5–7], and one study has reported effects on attention but not memory [8]. While there is evidence of cortical activation during chewing gum [9] any relationship to cognitive processing is not clear at present. Certainly the exact mechanisms underpinning any cognition-enhancing effects have been the subject of speculation but remain to be elucidated [10–13].

Measures of subjective state and aspects of performance have been included in studies into the effects of gum chewing during sleep deprivation. Subjects who were allowed to chew gum during an extended period without sleep were less sleepy than those who did not chew gum as measured using the Stanford Sleepiness Scale [14]. This effect may not be solely related to mastication since chewing an unflavoured, odourless substance (a strip of paraffin wax) had little effect on mood or performance during a night of sleep deprivation [15].

Thus while there are reports of beneficial effects of chewing gum on aspects of cognition and performance, there has been little research specifically addressing its effects on mood. This is despite the fact that

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chewing a flavoured gum may produce an electroencephalograph (EEG) pattern consistent with a state of relaxation [16]. A recent online study of 280 'heavy' gum chewers (>10 pieces per week) assessed the effects of abstaining from chewing in a two-way crossover study. Three-day chewing abstention resulted in significantly higher scores on the state portion of the Speilberger State-Trait Questionnaire. At the end of the study period 54% of the sample reported that chewing gum reduced stress (Zibell, personal communication). It was recently reported that chewing a neutral medium (paraffin wax) reduced salivary cortisol following an acute psychological stressor [17]. Such findings raise the possibility that chewing gum may have anti-stress properties which should be tested in more controlled conditions.

The aim of the proposed study was to identify if chewing gum can ameliorate both self-rated affective states and hormonal changes associated with acute, laboratory induced psychological stress. Mild but measurable stress can be induced in the laboratory in a variety of ways including via participants performing 'multi-tasking' activities. One such multi-tasking platform is the Multi-tasking Framework, also known as the Defined Intensity Stress Simulator (DISS), which has been developed as a platform for eliciting acute psychological stress via increases in cognitive workload. We have previously used a version of this framework in several randomised, double-blind, placebo-controlled studies examining anti-stress effects of herbal extracts [18–20]. The Multi-tasking Framework was chosen over other laboratory stressors (such as simulated public speaking), as it enables repeated testing of the same participant allowing a crossover design to be utilised. Additionally, unlike most other psychosocial stressors, performance measures are inherent in the task. Since the difficulty of the modules (cognitive tasks) making up the multi-tasking framework can be adjusted, the effects of chewing can be assessed at different workload intensities or stress levels. As elevated cortisol is associated with increased stress, salivary cortisol was measured as a physiological marker of stress. Given that chewing has been found to improve aspects of cognitive performance, and since each module produces a performance score, any positive or negative effects on psychomotor, memory or attentional performance were also examined. The present study therefore aimed to test the hypotheses that compared with a control, non-chewing condition, chewing gum would 1) reduce self-rated stress, 2) result in reduced cortisol levels, and 3) improve task performance.

2. Materials and methods

2.1. Design

The study followed a controlled, randomised, balanced crossover design. Due to the nature of the intervention neither double blinding nor placebo control was possible. The study followed a 2 (mild stress, moderate stress) × 2 (chewing, not chewing) design. In this way the effects of chewing gum on mild and moderate laboratory stress were assessed.

2.2. Participants

Forty healthy, non-smoking, young adults (8 male), mean age 21.98 years (±SD 4.79); BMI 23.80 (±4.32) took part in the study. The participant information sheet stated that the study examined the effects of chewing gum on mood and cognitive performance, during mentally demanding tasks. Volunteers were paid £90 for three visits to the laboratory.

Inclusion criteria included having chewed gum at least once in the previous week. Subjects had to show a willingness to use the assigned products according to instructions, be available for appointments, and be likely to complete the study. Other inclusion criteria included the presence of at least 18 natural teeth in a good state of repair with the ability to chew gum for at least 30 min at a time. Any subjects using concurrent medication (including over-the-counter medication) or a medical history which may have affected any experimental outcomes were not entered into the study. Screening also ensured that no subjects were admitted who had any type of negative opinion or feeling related to chewing gum — (e.g. it's a bad habit, it's unhealthy, it's impolite, it's rude, etc.). No volunteers were excluded based on these pre-determined criteria.

Ethical permission was granted from the Northumbria University School of Psychology and Sport Sciences Ethics committee and all procedures were carried out in accordance with the Declaration of Helsinki.

2.3. Multi-tasking framework

Participants were required to simultaneously perform four tasks presented via computer. The multi-tasking interface (Purple Research Solutions Ltd., UK) was presented on Dell Latitude laptops with high definition screens. The modules appeared as presented in Fig. 1. In the present study the participant performed the four computerised tasks simultaneously for 20 min. Participants were instructed to pay equal attention to all four modules and to perform as quickly and accurately as possible. Participants performed the tasks on two separate study visits. On one visit settings of 'low' intensity were used, on the other 'medium' intensity settings were used (with intensity defined according to the developers' definitions). The higher workload at medium intensity aims to produce higher levels of stress. The tasks are described in the following section.

2.3.1. Mental arithmetic

A series of arithmetic problems (additions) is presented (Fig. 1, top left quadrant). Using a number pad to the right of the sum, participants use the mouse to enter the answer. They are instructed that in the case of any error they should click on the digit that they wished to change and then use the number pad to select a new answer. When the volunteer is satisfied with the answer they click 'Done' whereupon a new sum appears. 10 points are awarded for each correct answer and 10 points subtracted for an incorrect answer. At the low intensity level the sums involve addition of two two-digit numbers and at medium intensity the addition of two three-digit numbers.

2.3.2. Stroop

The Stroop task [21] is a classic psychological test of selective attention and response inhibition. In the current form, four colour blocks (Blue, Yellow, Red and Green) appear on the right hand side of the task (Fig. 1, top right quadrant). At a given time interval, a colour name appears to the left of the colour blocks. The task is to click the colour block on the right related to the font colour, regardless of the colour it describes (e.g. the correct response would be the red block to the colour name 'blue' appearing in red font). 10 points are added for every colour word correctly identified, and 10 points subtracted for each incorrect answer, or for not making a response in the allotted time period (a 'timeout'). The frequency of stimulus presentation is higher in the medium than low intensity with 'timeouts' of 20 and 30 s respectively.

2.3.3. Memory search

This working memory task is adapted from Sternberg [22]. An array of letters appears for the participants to remember. After 4 s, the letters disappear but can be viewed again by clicking on "retrieve list" button (Fig. 1, bottom right quadrant). Approximately every 10 s, a single target letter appears. Participants indicate whether the target letter had appeared in the original list of four letters by clicking on the "yes" or "no" buttons. Ten points are awarded for a correct answer, 10 points deducted for an incorrect answer or no response within 15 s per stimulus. Five points are deducted every time the list is retrieved. There are two and four letters in the arrays displayed in the low and medium intensities respectively.