

Chewing Gum Moderates Multi-Task Induced Shifts in Stress, Mood, and Alertness: A Re-Examination

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Abstract

The finding that chewing gum can moderate stress and mood changes following a multi-task cognitive stressor (Scholey, Haskell, Robertson, Kennedy, Milne, and Wetherell, 2009) was re-examined. In a repeated measures cross-over design, thirty participants completed a 20-minute multi-tasking stressor on consecutive days, both with and without chewing gum. Both prior to and post stressor, participants provided salivary cortisol samples and self-rated measures of stress, state anxiety, calmness, contentedness, and alertness. Contrary to Scholey et al. (2009), chewing gum failed to attenuate both salivary cortisol levels and the increase in self-rated stress. Self-rated anxiety, calmness, and contentedness were not impacted by chewing gum. This suggests that the stress effects reported by Scholey et al. may be constrained by particular features of that study (e.g. morning testing). However, consistent with Scholey et al. (2009), chewing gum was shown to increase alertness following the stressor. The mechanisms underpinning heightened alertness are unclear; however, such increases may be linked to greater cerebral activity following the chewing of gum (Fang Li, Lu, Gong, and Yew, 2005).

Keywords: chewing gum, multi-tasking stress, mood, alertness

Introduction

The effects of chewing gum on cognition and mood are variable. For instance, initial reports of facilitated memory performance following the chewing of gum (Wilkinson, Scholey, and Wesnes, 2002; Stephens and Tunney, 2004; Baker, Bezance, Zellaby, and Aggleton 2004) have proved difficult to replicate (e.g. Tucha, Mecklinger, Maier, Hammerl, and Lange, 2004; Johnson and Miles, 2007, 2008; Smith 2009a; 2010). Such variability is surprising given the compelling neurological evidence linking the chewing of gum to increased delivery of both glucose and oxygenated blood to the brain (Onozuka, Fujita, Watanabe, Hirano, Niwa, Nishiyama, and Saito, 2002; see also Stephens and Tunney, 2004), in addition to more general increases in cerebral activity (Fang, Li, Lu, Gong, and Yew, 2005).

Recently, Scholey, Haskell, Robertson, Kennedy, Milne, and Wetherell (2009) examined the effects of chewing gum on mood and stress, via both salivary cortisol and self-rated measures. Participants completed a 20-minute 4-component multi-task stressor both with and without chewing gum and results showed that salivary cortisol was reduced in the chewing gum condition compared to the no gum condition (in contrast, see Smith, 2010, where chewing gum increased cortisol concentrations). This physiological effect was mirrored by significant reductions in both self-rated stress and state anxiety in the chewing gum condition coupled with significantly higher levels of self-rated alertness (see also Smith 2009a, 2009b, and 2010 for effects on alertness). Furthermore, Smith's (2009c) survey data corroborate the self-rated data of Scholey et al., such that gum chewers (compared to non-chewers) reported significantly lower levels of extreme work stress, life stress, lifetime instances of high blood pressure, and lifetime incidences of high cholesterol.

Although the precise mechanism(s) underpinning these effects is unclear, Scholey et al. (2009) suggest that the act of chewing flavourless material (Tahara, Sakurai, Ando, Shimada, Miura, and Saito, 2007) and flavoured gum (Morinushi, Masumoto, Kawasaki, and Takigawa, 2000) each have distinct effects on stress and mood. Specifically, chewing per se acts to reduce stress, but flavour induces a state of relaxation. Indeed, it is possible, therefore, that the mint flavour enhanced alertness (see Norrish and Dwyer, 2005). With respect to stress, Scholey et al. highlight that

brief stress exposure can cause short-term reductions in vasodilatation. They argue that since chewing gum has been shown to increase cerebral blood flow (e.g. Onozuka et al., 2002) it may serve to minimize reductions in blood flow (and secondary decreases in oxygen and glucose delivery) resulting from blood vessel constriction.

An alternative explanation for the stress reduction associated with chewing gum suggests it is epiphenomenal to task facilitation, i.e. that improvements in mood and stress are secondary to a gum-induced benefit to task performance (as suggested also by Scholey et al., 2009). In this regard, Scholey et al. (2009) reported significantly higher task performance for the chewing gum condition compared to the no gum condition. It is possible then, that the observations on mood and stress were a consequence of the chewing gum-facilitated reduction in task difficulty. This proposition was examined directly by Torney, Johnson, and Miles (2009) who induced participant stress via an impossible task and then compared the extent of stress elevation in the chewing gum and no gum groups. Importantly, when changes in task performance were eliminated, Torney et al. (2009) showed that the increase in self-rated stress and mood were not moderated by chewing gum.

The Torney et al. (2009) data suggest that the effects of chewing gum on stress and mood may be analogous to the intermittent effects observed with memory (e.g. see Wilkinson et al., 2002; Tucha et al., 2004). Indeed, one proposition is that the attenuation of stress following gum chewing is limited to the stress induced when cognitive resources are inadequate to meet demands (i.e. Scholey et al. 2009) and is absent for social evaluative impasse stress (i.e. Torney et al. 2009). The current study examines this proposition via a partial replication of Scholey et al. To simplify the design of Scholey et al., and to limit effects of fatigue, participants (1) completed the stressor once on each day of testing, (2) were tested within a single time period (i.e. 11:00-13:00), and (3) only completed the medium intensity stressor (Scholey et al., 2009, reported similar effects of the stressor at low and medium intensities). If chewing gum does reliably reduce stress under conditions of multi-task cognitive stress, the present study should replicate the effects of Scholey et al. That is, we should observe an interaction between experimental stage and chewing gum, such that mood increases and stress decreases are apparent uniquely for the chewing gum condition but only following the stressor.

Method

Participants. Thirty (9 males, 21 females, mean age = 21.24 years) non-smoking Coventry University Psychology undergraduates participated in exchange for course credit. All participants were regular chewing gum users but did not chew more than ten times per week. All participants reported they were free from both concurrent medication and illicit drug use. Participants were instructed to refrain from caffeine, alcohol, and chewing gum on the morning of testing and asked to not consume food up to one hour prior to testing. Ethical approval was obtained from the Coventry University Ethics Committee.

Materials.

Defined Intensity Stressor Simulation (DISS)

The Defined Intensity Stressor Simulation (DISS) is a multi-tasking framework allowing both the number and intensity of tasks to be manipulated. The DISS involves the division of the computer screen into quarters, with separate tasks presented in each segment. The four tasks selected for this study were those employed by Wetherell and Sidgreaves (2005), Wetherell, Hyland, and Harris (2004), and Kennedy, Little, and Scholey (2004): i.e. auditory monitoring, visual tracking, memory search, and mental arithmetic. This configuration of tasks has been shown to increase S-IgA reactivity (Wetherell and Sidgreaves, 2005; Wetherell, Hyland, and Harris, 2004), increase perceived stress relative to workload (Wetherell and Sidgreaves, 2005) and reduce calmness (Kennedy et al., 2004). Each task is described below.

Auditory Monitoring Task: the participant is presented with individual tones separated by an inter-stimulus interval of approximately 5-seconds. Two tones are used which, relative to each other, are high or low. The participant is instructed to click on the '@' symbol when the higher of the two tones is presented. Ten points are awarded for the correct response and ten points are deducted for the incorrect response.

Visual Tracking Task: the participant is presented with six overlapping circles wherein the diameter of each circle is greater than that of the preceding circle. A small red dot drifts gradually out of the set of six circles, beginning in the centre of the

smallest circle. The participant is instructed to click on the 'reset' icon before the dot leaves the final circle. If 'reset' is clicked whilst the dot has passed the inner circle, 2 points are awarded. Two additional points are awarded for every subsequent circle that the dot passes through. If 'reset' is clicked whilst the dot is within the final circle, ten points are awarded. However, if the dot touches the outer rim, ten points are deducted for every 0.5 seconds until 'reset' is clicked.

Memory Search Task: the participant is presented with a series of four letters simultaneously for approximately 10-seconds, followed by a series of single test letters to which a 'new/old' judgement is required for each. Ten points are awarded for each correct response and ten points deducted for each incorrect response. Review of the original letter sequence results in a five point deduction.

Mental Arithmetic Task: the participant is presented with an addition sum comprising two 3-integer numbers and required to type their sum. Ten points are awarded for a correct response and ten points are deducted for an incorrect response.

Both the four concurrent tasks and the positional configuration of these tasks were identical across participants. The task was used at medium intensity.

Self-Rated Mood Scales

The Bond Lader Visual Analogue Mood Scales (VAMS) (Bond and Lader, 1974) was employed. It comprises 16 mood questions, with mood antonyms anchoring either end of a 100mm line. These produce overall scores of alertness, calmness, and contentedness. As described in Torney et al. (2009) the VAMS had an additional seventeenth imbedded stress question of: no stress at all-worst stress imaginable. The stress antonym is not presented separately in order to limit effects of social desirability. Participants are instructed to rate, via a mark on the line, with respect to each antonym pairing, how they are feeling at that precise moment.

The State-Trait Anxiety Inventory (STAI: Spielberger, Gorsuch, and Lushene, 1969) comprises separate measures for changing levels of anxiety (state) and fixed levels of anxiety (trait). The questionnaire comprises 20 questions each assessing state and trait anxiety. Each question contains a single statement to which the participants state the

extent to which they agree on a 4-point likert scale. A high score indicates greater anxiety levels. For the current study state anxiety was assessed.

Cortisol Measurement

All participants provided salivary samples through placing an Oral Swab (Salimetrics LLC) in their mouth until saturated. Samples were then placed in a conical polypropylene tube and immediately frozen at -20°C. Salivary samples were thawed to room temperature on the day of analysis and centrifuged. Analysis of the samples followed the instructions of the manufacturers (Salimetrics LLC).

Design. A 2x2 within-participants design was employed. The first factor refers to experimental stage (pre- or post-stressor) and the second factor refers to the chewing gum condition (chewing gum versus no chewing gum). The dependent measures were salivary cortisol concentration ($\mu\text{g/dL}$), self-rated measures of stress, state anxiety, alertness, contentedness, and calmness. The presentation order of these measures was counterbalanced.

Procedure. Participants were tested individually in a Psychology laboratory. Participants were tested on two consecutive days between the hours of 11:00 and 13:00 (in order to minimise diurnal variation effects reported by Scholey et al., 2009). Prior to entering the laboratory, participants were instructed to rinse their mouth thoroughly with water. Participants provided informed consent and completed a lifestyle questionnaire for screening purposes and then completed the STAI, Bond-Lader VAS, and provided a salivary sample. The administration order of the STAI and Bond-Lader VAS was counterbalanced. The STAI and Bond-Lader VAS were pencil-and-paper measures and the saliva sample was collected via an oral swab. Five minutes were allocated for the administration of these measures. If administration time was less than five minutes, a brief interval was introduced before the next stage.

Participants completed a 2-minute practice session on the 4-module version of the multi-tasking framework without feedback. The task constraints were identical to those during the main testing session. Following the practice session, participants were either administered chewing gum or not given chewing gum. In the chewing gum condition participants were instructed to chew throughout the 20-minute task and

participants in the no chewing gum condition were instructed not to chew. When performing the 20-minute multi-tasking framework, participants were instructed to complete each of the four tasks to an equivalent level. Participants were informed that their score would be recorded and that they should attempt to obtain as high a score as possible.

Following the 20-minute stressor, participants in the chewing gum condition removed their gum and completed the STAI, Bond-Lader VAS, and provided a salivary sample (again in a counterbalanced order).

This process was repeated on the second testing session, with the order in which participants received chewing gum counterbalanced. Following the final measures of stress and mood the participants were debriefed.

Results

The effects of task, gum intervention, and order of gum conditions on measures of both stress and mood were analysed via a series of 3-factor (2x2x2) mixed design ANOVAs. The first and second factors are within-participants and refer to experimental stage (pre- and post-stressor) and gum condition (gum versus no gum), and the third factor is between-participants and refers to the presentation order of gum conditions (gum/no gum versus no gum/gum).

Cortisol: The main effect of experimental stage was significant, demonstrating a decrease in cortisol concentration following task completion, $F(1,29)=5.70$, $p=0.02$, *partial eta squared* = 0.16 (mean pre-stressor = 0.36, mean post-stressor = 0.27). The main effect of gum condition was non-significant, $F(1,29)=0.002$, $p=0.96$, *partial eta squared* < 0.001, as was the predicted interaction, $F(1,29)=1.63$, $p=0.21$, *partial eta squared* = 0.05. There were no effects or interactions involving order of gum presentation.

Self-Rated Stress: The main effect of experimental stage was significant, demonstrating an increase in self-rated stress following task completion, $F(1,29)=4.75$, $p=0.04$, *partial eta squared* = 0.14 (mean pre-stressor = 48.78, mean

post-stressor = 54.87). The main effect of gum condition was non-significant, $F(1,29)=0.006$, $p=0.94$, *partial eta squared* < 0.001, as was the predicted interaction, $F(1,29)=0.60$, $p=0.44$, *partial eta squared* = 0.02. There was a main effect for order of gum presentation, $F(1,28)=5.12$, $p=0.03$, *partial eta squared* = 0.16 but, critically, interactions involving order of gum presentation were absent.

State Anxiety: The main effects of experimental stage, gum condition, and their interaction were non-significant (all $F_s < 1$). There was a main effect for order of gum presentation, $F(1,28)=4.01$, $p=0.05$, *partial eta squared* = 0.13, but, critically, interactions involving order of gum presentation were absent.

Self-Rated Mood Measures of Calmness and Contentedness: The main effects of experimental stage (both $F_s < 1$), gum condition ($F < 1$ and $F=2.74$), and their interaction ($F=1.77$ and $F=1.35$) were non-significant for both calmness and contentedness, respectively. Order of gum presentation interacted with gum condition for contentedness only, $F(1,28)=4.24$, $p=0.05$, *partial eta squared* = 0.13. Further analysis of the interaction demonstrated that contentedness declined in the no gum condition but only when it was the second testing condition (difference in contentedness between gum and no gum for gum/no gum and no gum/gum presentation orders = 5.37 and -1.62, respectively).

Self-Rated Alertness: ANOVA showed the effects of both experimental stage and gum condition to be non-significant, $F=1.1$ and < 1 , respectively. Importantly, the predicted interaction between experimental stage and gum condition was significant, $F(1,29)=5.96$, $p=0.021$, *partial eta squared* = 0.17. Planned pairwise comparisons revealed no differences between the gum and no gum conditions pre-stressor, $t(29)=0.19$, $p=0.85$. However, self-rated alertness was significantly greater in the chewing gum condition compared to the no chewing gum condition post stressor, $t(29)=2.17$, $p=0.04$. There were no effects or interactions involving order of gum presentation with the exception of the three way interaction between experimental stage, gum condition and order of gum presentation, $F(1,28)=5.91$, $p=0.02$, *partial eta squared* = 0.17. Further examination revealed that the effect of gum on alertness was more pronounced for the gum/no gum order (i.e. in the gum/no gum presentation order, the pre-post alertness shift for gum and no gum = 3.16 and -6.12, respectively;

in contrast, in the no gum/gum presentation order, the pre-post alertness shift for gum and no gum = 1.98 and 1.61, respectively).

To examine the possibility that chewing gum facilitated multi-task performance, mean DISS scores for each of the 4 tasks were compared via a series of two-tailed within-participants t-tests. There were no significant differences in DISS performance between the gum conditions for auditory monitoring (gum = 117.33; no gum = 98.00, $t = 1.12$), visual tracking (gum = 358.47; no gum = 383.20, $t < 1$), memory search (gum = 4979.17; no gum = 4654.17, $t = 1.02$), mental arithmetic (gum = 503.33; no gum = 614.33, $t < 1$), and aggregate DISS performance (gum = 5953.97; no gum = 5743.70, $t < 1$).

Discussion

The present study found that chewing gum, relative to the no chewing gum condition, increased self-rated alertness following the multi-tasking stressor. Although self-rated stress increased following task completion, cortisol excretion failed to do so, and neither measure was moderated by chewing gum. The measures of mood and state anxiety were immune to the potential effects of both the stressor task and chewing gum.

The increase in alertness for the chewing gum condition post-stressor is consistent with the findings of Scholey et al. (2009) and Smith (2009a; 2009b; 2010). In addition, this finding supports data from our laboratory (Johnson, Miles, Harrison, Haddrell, Osborne, Wilson, and Jenks, in preparation) showing that pupillary unrest (a physiological measure inversely associated with alertness, e.g. Norrish and Dwyer, 2005) is significantly reduced by a chewing gum condition compared to both sham and no chewing controls. The exact mechanism underpinning the increase in self-rated alertness is unclear but it may be driven by the mint flavour (e.g. see Norrish and Dwyer, 2005; Johnson and Miles, 2008). Alternatively, the proposed increase in cerebral activity following the chewing of gum (e.g. Fang et al., 2005) may serve to heighten alertness.

Contrary to our predictions, cortisol secretion dropped post- task completion and, crucially, this change was equivalent across the gum conditions. Our data therefore fail to replicate the reductive effects of chewing gum on salivary cortisol levels following the administration of a multi-tasking cognitive stressor (Scholey et al., 2009). Furthermore, despite broadly similar self-rated increases in stress for the present study relative to Scholey et al. (2009), (mean pre-post medium intensity DISS increases of 6.09 and 8.06, respectively) chewing gum failed to attenuate the increase for the current study: a finding consistent with that of Torney et al (2009).

There are a number of methodological differences between the present study and that of Scholey et al. (2009). These differences are potentially important with regard to their impact upon the outcomes for the two studies. First, for the current study, cortisol samples were taken between 11:00 hours and 13.00 hours. Heightened cortisol secretions following awakening have been shown to gradually decline over the subsequent six hours (Hucklebridge, Hussain, Evans, and Clow, 2005). It is, therefore, plausible that heightened baseline cortisol levels during our testing period attenuated the detection sensitivity for these stress-induced hormone effects (i.e. ceiling effects, see Kudielka, Schommer, Hellhammer, and Kirschbaum, 2004). Scholey et al. do not include time of day in their change from baseline analysis of gum effects and so one cannot dissociate the extent to which their data are time of day specific. That is, it remains a possibility that the ameliorating effect of gum on cortisol rises may be a function of afternoon testing only. Cortisol effect detection may have been further desensitised in the present study through including salivary samples within the counterbalancing of test administration. In Scholey et al. salivary samples were taken following the self-rated measures thus enabling more time for cortisol shifts.

Second, it should be noted that a different testing configuration was used to that described by Scholey et al. (2009); specifically an auditory monitoring task was used in place of the Stroop task. It is possible, therefore, that the gum effects on stress reported by Scholey et al. are limited to a specific configuration of tasks. However, it is important to note that the mean increase in self-rated stress across the two studies was not dramatically different (i.e. on a scale of 0-100, 8.06 for Scholey et al. and 6.09 for the present study, respectively). Furthermore, the configuration used in the

present study has precedence in affecting physiological and self-rated state (e.g. Kennedy et al., 2004; Wetherell and Sidgreaves, 2005; Wetherell et al., 2004).

Third, in Scholey et al. participants underwent a full day of training prior to the within-participants testing sessions. In contrast, a 2-minute training session was employed in the current study. Order of condition, however, was not found to interact with gum condition for either stress measure. This suggests that novelty-induced asymmetric transfer (Poulton, 1982) did not occur. Notwithstanding this analysis, sessions were longer in the Scholey et al. study indicating that the effects of gum on stress may be limited to more prolonged instances of stress (e.g. see the survey examination of chronic stress by Smith, 2009c). Furthermore, some evidence of asymmetric transfer was found for contentedness and alertness. These novelty effects may explain why the present study failed to observe the effects of gum on contentedness reported by Scholey et al. (2009). In addition, self-rated mood measures may also have been compromised through imbedding the stress scale within the VAMS. This minor modification was included to minimise social desirability effects; however, it is possible that this altered the psychometric properties and thus prevented replication.

Finally, it is possible that the present failure to demonstrate significantly elevated performance scores in the gum condition prevented an epiphenomenal fall in stress. Note, however, that in direct contradiction to this hypothesis, Smith (2010) reported significant gum-induced benefits for a series of cognitive tasks coupled with significant increases in cortisol secretion relative to the no-gum condition. Although it is unclear why our participants did not experience chewing gum-induced task benefits, a number of previous studies have shown that such cognitive facilitation is sporadic in the chewing gum literature (e.g. Wilkinson et al., 2002; Stephens and Tunney, 2004; Tucha et al., 2004). One possible explanation can be found in Stephens and Edelstyn (under review) who showed that digit span task performance declined as self-rated thirst increased for participants in the no gum condition. This relationship was not found in the chewing gum condition. One might speculate, therefore, that instructing our participants to thoroughly rinse their mouth prior to the study limited any debilitating effects of thirst that could subsequently be normalised via the chewing of gum.

In conclusion, we have shown that the moderating effects of chewing gum on cognitive stress are fragile (e.g. effects are not found following morning testing). The Scholey et al. findings are, however, compelling and further work is clearly required to ascertain the precise conditions under which such benefits are observed. Our findings do, though, contribute to the growing corpus of studies suggesting that chewing gum can improve alertness and further work is required to disambiguate the mechanism underpinning such an effect.

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