Chewing Gum and Impasse-Induced Self-Reported Stress

Laura K. Torney[1], Andrew J. Johnson[1] and Christopher Miles[2]

[1]Department of Psychology
Coventry University
Priory Street
Coventry
CV1 5FB
UK

[2]School of Psychology
Cardiff University
Park Place
Cardiff
CF10 3AT
UK

Corresponding author: Andrew Johnson

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Abstract

An insoluble anagram task (Zellner et al., 2006) was used to investigate the proposition that chewing gum reduces self-rated stress (Scholey et al., 2009). Using a between-participants design, forty participants performed an insoluble anagram task followed by a soluble anagram task. These tasks were performed with or without chewing gum. Self-rated measures were taken at baseline, post-stressor, and post-recovery task. The insoluble anagram task was found to amplify stress in terms of increases in self-rated stress and reductions in both self-rated calmness and contentedness. However, chewing gum was found not to mediate the level of stress experienced. Furthermore, chewing gum did not result in superior performance on the soluble anagram task. The present study fails to generalise the findings of Scholey et al. to an impasse induced stress that has social components. The explanation for the discrepancy with Scholey et al. is unclear; however, it is suggested that the impossibility of the insoluble anagram task may negate any secondary stress reducing benefits arising from chewing gum-induced task improvement.

Keywords: chewing gum; impasse-induced self-rated stress.

Introduction

In a recent paper Scholey, Haskell, Robertson, Kennedy, Milne, and Wetherell (2009) investigated the effects of chewing gum on task-induced stress. Participants were exposed to a laboratory multi-task stressor with measures of both self-rated and physiological stress and self-rated mood taken before and after the stressor tasks. All participants completed the stressor tasks in both the gum and no gum conditions. Chewing gum was associated with significantly higher self-rated levels of alertness together with decreased levels of self-rated anxiety and stress, and a reduction in salivary cortisol concentrations. Furthermore, overall task performance was significantly higher in the chewing gum condition.

Although the mechanism underpinning stress reduction whilst chewing gum requires elucidation, Scholey et al. (2009) speculate that their findings may be linked to the increased heart rate (Farella, Bakke, Michelotti, Marotta, and Martina, 1999; Wilkinson, Scholey, and Wesnes, 2002) and increased cerebral blood flow (e.g. Sesay, Tanaka, Ueno, Lecaroz, and De Beaufort, 2000) associated with chewing gum. Additionally, Kern, Oakes, Stone, McAuliff, Kirschbaum, and Davidson (2008) have demonstrated that the increase in glucose metabolism in the rostral medial prefrontal cortex (areas BA9 and BA10) is associated with decreases in salivary cortisol concentrations following the Trier Social Stress task. On the basis of these findings, one might speculate that the increased cerebral blood flow (e.g. Sesay et al., 2000), and related accentuation of glucose delivery (Onozuka, Fujita, Watanabe, Hirano, Niwa, Nishiyama, and Saito, 2002; and suggested by Stephens and Tunney, 2004), act to reduce stress via an increase in the pre-frontal cortex glucose metabolism. Furthermore, numerous studies have reported increased cerebral activity following the chewing of gum (e.g. Fang, Li, Lu, Gong and Yew, 2005; Hirano, Obata, Kashikura, Nonaka, Tachibana, Ikehira, and Onozuka, 2008) and have shown that this effect is specific to the act of chewing gum rather than mimicry of the motion (Sakamoto, Nakata, and Kakigi, 2009; Takada and Miyamoto, 2004). One might argue, therefore, that the increased neural activation facilitates task performance, thereby reducing stress.

Notwithstanding the findings of stress reduction whilst chewing gum, to date, studies reporting the effects of chewing gum on cognition and physiology have proven controversial. For instance, the facilitative effects of chewing gum on memory (Wilkinson et al., 2002; Stephens and Tunney, 2004) have proved difficult to replicate (Tucha, Meckilinger, Maier,

Hammerl, and Lange, 2004) as have the accentuating effect of chewing gum on heart rate (Wilkinson et al., 2002; Tucha et al., 2004). In addition, a series of studies investigating chewing gum induced context-dependent memory effects have produced contradictory findings (see, Baker, Bezance, Zellaby, and Aggleton, 2004; Johnson and Miles, 2007, 2008; Miles and Johnson, 2007; Miles, Charig, and Eva, 2008).

The following study investigates further the effects of chewing gum on stress but extends previous work to impasse-induced, rather than multi-tasking induced stress. To this end, the present study utilises an anagram stressor task developed by Zellner, Loaiza, Gonzalez, Pita, Morales, Percora, and Wolf (2006), that has been demonstrated to increase self-rated measures of stress (Zellner et al., 2006; Zellner, Saito, and Gonzalez, 2007). The anagram stressor task differs from that employed by Scholey et al. (2009) in that it encompasses an emotional component: intuitively, one might predict a degree of frustration resulting from the inability to solve the anagrams, coupled with both social embarrassment and fear of negative appraisal from the experimenter. In this respect, the task has parallels with the Trier Social Stress Task (TSST, Kirschbaum, Pirke, and Hellhammer, 1993) in which social stress is elicited via participation in a mock interview. The present study, therefore, investigates the extent to which the attenuating effect of chewing gum on multi-task induced stress (Scholey et al., 2009) can be generalised to a more social-induced stress. Furthermore, acute stress has been shown to impair cognition (e.g. working memory, al'Absi, Hugdahl, Lovallo, 2002; long-term memory retrieval, Tollenaar, Elzinga, Spinhoven, and Everaerd, 2008). Following the stressor task, participants receive soluble anagrams enabling the assessment of chewing gum on task performance whilst recovering from stress. Given the improved task performance under stress reported by Scholey et al. (2009), coupled with the findings that chewing gum can facilitate working memory (Wilkinson et al., 2002; Stephens and Tunney, 2004), the study investigates the further hypothesis that chewing gum can facilitate task performance for participants recovering from stress.

For the present study both self-rated stress and mood are examined at baseline, post-insoluble anagram task, and post-soluble anagram task. If chewing gum acts to reduce the negative effects of the stressor task, then an interaction between anagram task and gum condition would be predicted. Specifically, post-insoluble anagram task, self-rated stress should be reduced and self-rated mood elevated in the gum group relative to the non-gum group. Furthermore, if chewing gum facilitates task performance when under conditions of stress,

we predict that for the post-stressor soluble anagrams participants chewing gum should complete significantly more anagrams.

Method

Participants. Forty (20 males, 20 females, mean age = 20 years and 11 months) Coventry University Psychology undergraduates participated in exchange for course credit. Participants were pseudo-randomly assigned in equal numbers to one of two experimental groups such that both groups comprised equal numbers of male and female participants.

Materials. 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. The antonyms are: alert-drowsy, calm-excited, strong-feeble, muzzy-clear headed, well coordinated-clumsy, lethargic-energetic, contented-discontented, troubled-tranquil, mentally slow-quick witted, tense- relaxed, attentive-dreamy, incompetent-proficient, happy-sad, antagonistic-amicable, interested-bored, and withdrawn-gregarious. The VAMS had an additional seventeenth imbedded stress question of: no stress at all-worst stress imaginable. Participants are instructed to rate, with respect to each antonym pairing, how they are feeling at that precise moment.

A set of ten soluble anagrams and ten insoluble anagrams (Zellner et al., 2006; 2007) was employed. Each anagram comprised a 1-2 syllable word of 5-letters. The insoluble anagram list included a single soluble anagram (exits − exist) intended to limit the possibility that participants believed the set to be impossible.

In the experimental condition all participants chewed a single pellet of Wrigley's spearmint sugar free gum.

Design. A mixed 2x3 design was adopted where the first factor was between-participants and refers to group (chewing gum versus no chewing gum) and the second within-participants factor refers to experimental stage (baseline, post-insoluble anagram task, and post-soluble anagram task). The dependent measures were self-rated mood (as measured by the Bond Lader VAMS and factored into 3 separate measures of calmness, contentedness, and

alertness) and self-rated stress. An additional dependent measure was the number of correctly completed anagrams.

Procedure. Participants were tested individually in a well-ventilated laboratory and sat at a desk facing the wall. Participants completed the Bond-Lader VAMS with imbedded stress scale and then received either a single pellet of gum or no gum. Participants in the chewing gum condition were instructed to chew throughout the duration of the experiment. Participants in the no chewing gum condition were instructed to conduct the tasks without chewing. Participants were then given the list of 10 insoluble anagrams and were instructed that they had five minutes to complete as many as possible. Following the anagram task participants completed a second Bond-Lader VAMS with imbedded stress scale. Participants were then given the list of 10 soluble anagrams and were instructed that they had five minutes to complete as many as possible. Upon completion of the second anagram task participants were given a final Bond-Lader VAMS with imbedded stress scale to complete.

Results

Self-rated Stress

Self-rated stress scores across the three experimental stages for the chewing gum and control conditions are shown in Figure 1. The effect of the task and intervention (chewing gum) on stress levels was examined via a two-factor (2x3) mixed design ANOVA. The ANOVA revealed a main effect of experimental stage, $F(2,76)=9.56$, $p<0.001$, partial eta squared = 0.20. Post-hoc Bonferroni t-test comparisons revealed that self-rated stress immediately following the stressor was significantly higher than baseline (mean stress = 33.4 and 44.3, for baseline and post-stressor task, respectively), $t(39)=4.40$, $p<0.001$. This finding shows that the insoluble anagrams increased self-rated stress levels. Furthermore, self-rated stress following the recovery task (mean stress = 38.4) was significantly lower than self-rated stress immediately post-stressor, (mean stress = 44.3 and 38.4, respectively), $t(39)=2.80$, $p=0.008$. This finding indicates that the recovery task (soluble anagrams) reduced stress levels in participants. There was a non-significant difference between baseline self-rated stress and post-recovery task self-rated stress (mean stress = 33.4 and 38.4, respectively), $t(39)=1.78$, $p=0.08$. This finding indicates that the effect of the stressor was acute, such that perceived stress levels normalised following the recovery task. The main effect of chewing gum condition was non-significant, $F(1,38)=0.004$, $p=0.95$, partial eta squared <0.001 (mean self-

rated stress in the chewing gum condition = 38.48; mean self-rated stress in the non-chewing gum condition = 38.92). The predicted interaction between experimental stage and chewing gum condition was also non-significant, $F(2,76)=0.52$, $p=0.59$, partial eta squared = 0.01.

Figure 1 about here please

Self-Rated Mood

The effect of the stress task and gum condition on mood measured by the Bond-Lader VAMS was also assessed. A series of two-way (2x3) mixed design ANOVAs were computed independently on the contentedness, calmness and alertness measures.

A main effect of experimental stage was found for self-rated contentedness ($F(2,72)=4.76$, $p=0.01$, partial eta squared =0.11) and calmness ($F(2.72)=4.18$, $p=.02$, partial eta squared = 0.10). Post-hoc Bonferroni t-tests showed that both measures were significantly reduced after the stressor (contentedness $t(39)=2.79$, $p=0.008$ and calmness $t(39)=2.70$, $p=0.01$). A borderline main effect of experimental stage was found for self-rated alertness, $F(2,72)=3.03$, $p=0.054$, partial eta squared = 0.07. Post-hoc Bonferroni t-tests showed that participants were more alert following the soluble anagram task (post-recovery task), $t(39)=2.55$, $p=0.015$.

There were no significant main effects of chewing gum for contentedness, calmness, and alertness, Fs<1. Furthermore, the predicted interaction between experimental stage and chewing gum condition was non-significant for self-rated contentedness ($F(2,76)=2.10$, $p=0.13$, partial eta squared = 0.052), calmness ($F<1$), and alertness ($F<1$).

Cognitive Task Performance (Post-Stressor)

Chewing gum was found to have no effect on the number of correct anagrams completed in the recovery-task (mean percentage correct anagrams in chewing gum condition = 69%; mean percentage correct anagrams in the no chewing gum condition = 63.5%), $t(38)=0.99$, $p=0.33$.

Discussion

The present study investigated the effects of chewing gum on impasse-induced stress. Consistent with the findings of Zellner and colleagues (Zellner et al., 2006; Zellner et al., 2007) the insoluble anagram task significantly increased participants' stress as evidenced by significant increases in self-rated stress and significant decreases in both calmness and contentedness. The insoluble anagram task had no effect on self-rated alertness. Crucially, chewing gum was found not to have an effect on self-rated stress. A significant interaction between experimental stage (baseline, post-stressor, post-recovery task) and gum condition (gum and no gum) was predicted, wherein the chewing gum conditions would differ post-stressor. This was not found for any of the measures suggesting that chewing gum does not reduce stress induced via an insoluble anagram task. Furthermore, there was no evidence of chewing gum improving the stressor-induced reductions in mood (i.e. calmness and contentedness), nor did chewing gum increase overall alertness. Finally, the act of chewing gum failed to significantly improve performance on the soluble anagrams task.

The present data contradict the findings of Scholey et al. (2009) who reported significant reductions in self-rated stress following a period of chewing gum. However, it should be noted that the 20 minute stressor employed by Scholey et al. was four times longer than the current stress task and it is, therefore, possible that a greater period of chewing is required in order to observe stress reductions. Scholey et al. also reported significant reductions in salivary cortisol concentrations. Indeed, it is a noted limitation of the present study that biological measures of stress are not included (furthermore, preliminary data from our laboratory supports the reduction in salivary cortisol concentrations for gum chewers following a multi-tasking stressor, Johnson, Jenks, Albert, Miles, and Cox, in preparation). However, it should be noted that the reliability of the association between physiological and self-rated stress has been questioned (Eck, Berkhof, Nicholson, and Sulon, 1996). Since self-rated and physiological stress may be underpinned by different mechanisms, the present study has focussed uniquely on the effect of chewing gum on perceived stress and does not assess the effect of chewing gum on cortisol levels.

Although it is unclear why the present data do not replicate the findings of Scholey et al., we have identified five possible explanations. First, the inability to find an effect may be an artefact of insufficient statistical power. Specifically, in Scholey et al. there is a within-

participants design using 40 participants, whereas, in the present study we employ two groups of 20 participants. However, the chewing gum effect size for the self-rated stress measure was extremely small (partial eta squared <0.001). To have an 80% chance of obtaining a significant difference with such an effect size would necessitate an extremely large sample size far beyond that employed by Scholey et al. We would argue, therefore, that insufficient statistical power is an inadequate explanation.

Second, as aforementioned, chewing throughout the five minute stressor may be an insufficient duration for chewing gum to reduce stress. Third, it is possible that a large increase in stress is required before chewing gum can induce attenuation. The possibility that the insoluble anagram task was insufficiently stressful to induce a stress increase of necessary magnitude was investigated by comparing our data with those of Scholey et al. (2009). Following the medium intensity stressor task used by Scholey et al., the authors report a mean increase of 10.61 in self-rated stress for the no gum condition. The present study used the same stress antonym but embedded it within the Bond Lader VAMS and for the no gum condition a mean increase of 10.3 in the self-rated stress measure was reported. A one sample t-test compared the stress increase in the present study with the mean stress increase in Scholey et al. and revealed a non-significant difference, $t<1$. Furthermore, there were not differences in proportional stress change as a one sample t-test revealed that baseline self-rated stress in the present study (33.4) did not significantly differ with the mean baseline self-rated stress in Scholey et al.'s medium intensity condition (28.01), $t(39)=1.41$, $p=0.17$. These analyses suggest that the inability to observe an effect of gum on stress was not due to the task inducing relatively weak changes in self-rated stress. Indeed, the substantial effect on stress of the insoluble anagram task is further supported by its impact upon dietary choices (Zellner et al., 2006; 2007).

A fourth explanation is that the effect of chewing gum on stress is restricted to certain types of stress. The present stressor arguably encompasses components of both social embarrassment and fear of negative appraisal. The association between chewing gum and stress reduction may, therefore, be limited to working load-induced stress and not generalised to social stress. Such a proposition requires further investigation.

A fifth explanation for the discrepancy between Scholey et al. and the present data may relate to the mechanisms underpinning stress reduction. As argued earlier, the reduction in stress

may be secondary to the facilitative effects of chewing gum on task performance (induced via increased cerebral activity, e.g. Onozuka et al., 2002). Scholey et al. observed significantly greater overall task performance in the chewing gum condition. Such superior task performance on the multi-tasking paradigm may have affected stress due to the perceived difficulty of the task. However, in the present study the task was impossible; consequently, chewing gum cannot facilitate performance and induce secondary benefits on stress. This hypothesis requires further investigation but is mired by the general unreliability of chewing gum effects on cognition. Indeed, irrespective of the mechanism underpinning non-replication, the present data further contribute to the general unreliability of associations between task performance and chewing gum reported in the literature (e.g. see chewing gum context-dependent memory studies; Baker et al., 2004; Johnson and Miles, 2007 etc). The failure to observe a difference between our gum and no gum groups in the post-stressor soluble anagram task generates further ambiguity with respect to the effect of chewing gum on cognitive performance (e.g. see Wilkinson et al., 2002; Stephens and Tunney, 2004; Tucha et al., 2004). Further research is therefore required to isolate the exact conditions under which beneficial effects of chewing gum can be observed.

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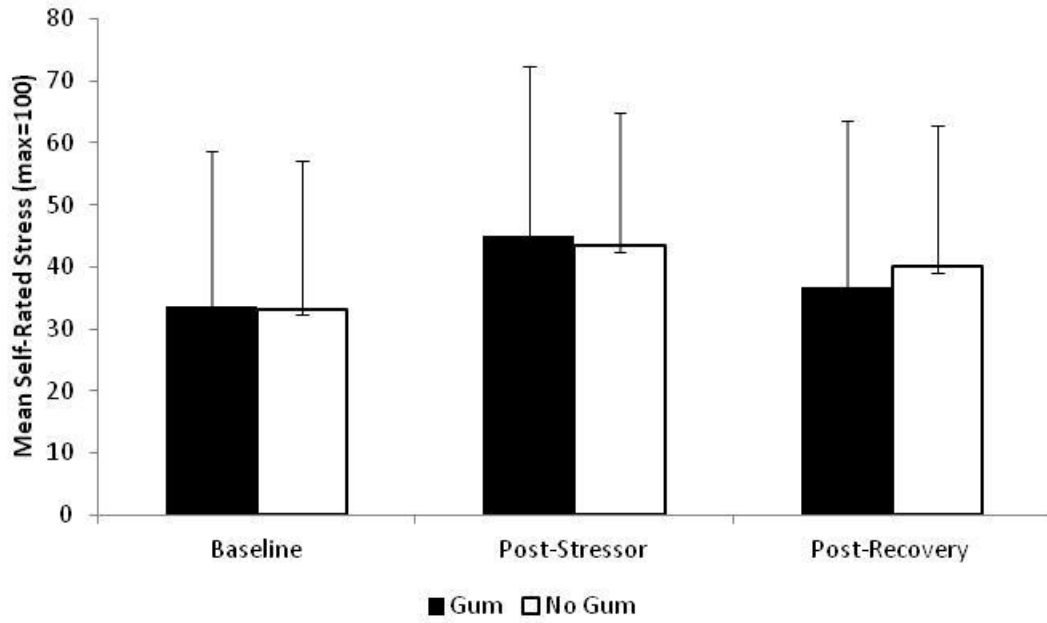
Figure 1: Mean self-rated stress at baseline, post stressor, and post recovery task for the chewing gum and control conditions. Error bars denote 1 standard deviation.