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The contrasting physiological and subjective effects of chewing gum on social stress ☆

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ABSTRACT

Uncertainty exists with respect to the extent to which chewing gum may attenuate stress-induced rises in cortisol secretion (Johnson, Jenks, Miles, Albert, & Cox, 2011; Scholey et al., 2009; Smith, 2010). The present study used the Trier Social Stress Task (TSST: Kirschbaum, Pirke, & Hellhammer, 1993), a task known to elevate cortisol secretion (Kudielka, Schommer, Hellhammer, & Kirschbaum, 2004), in order to examine the moderating physiological and subjective effects of chewing gum on social stress. Forty participants completed the TSST either with or without chewing gum. As expected, completion of the TSST elevated both cortisol and subjective stress levels, whilst impairing mood. Although gum moderated the perception of stress, cortisol concentrations were higher following the chewing of gum. The findings are consistent with Smith (2010) who argued that elevations in cortisol following the chewing of gum reflect heightened arousal. The findings suggest that chewing gum only benefits subjective measures of stress. The mechanism remains unclear; however, this may reflect increased cerebral blood flow, cognitive distraction, and/or effects secondary to task facilitation.

Introduction

In a recent study, Sketchley-Kaye, Jenks, Miles, and Johnson (2011) examined the moderating effect of chewing gum on both anxiety and mood following exposure to the Trier Social Stress Task (TSST: Kirschbaum et al., 1993). The task, involving an oral presentation and mental arithmetic test, induced a decrease in both self-rated calmness and contentedness and increases in state-anxiety. Chewing gum acted to moderate this increase in state-anxiety whilst elevating self-rated alertness. This pattern of findings complements an earlier study (Scholey et al., 2009) in which chewing gum moderated the rise in both self-rated stress (see also Smith, 2009a, 2010) and state anxiety, and significantly decreased cortisol concentrations following a cognitive-load stressor.

The reduction in stress levels, both physiologically and subjectively, following the chewing of gum can be interpreted via the mastication-induced changes in cerebral blood flow (e.g. Fang, Li, Lu, Gong, & Yew, 2005). Indeed, heightened delivery of both oxygen and glucose to fronto–temporal regions (Onozuka et al., 2002) can act to increase metabolic rate, a post-stress process (in areas BA9 and BA10) associated with a reduction in salivary cortisol concentrations (Kern et al., 2008).

Notwithstanding the above proposed mechanism, in a similar design, Johnson et al. (2011) failed to replicate Scholey et al. (2009) in that chewing gum did not attenuate the rise in cortisol. Furthermore, Smith (2010) reported that chewing gum elevated cortisol concentrations under conditions of acute (noise-induced) stress: a finding taken to reflect the heightened alertness/arousal following the chewing of gum (see also Johnson et al., 2011; Onyper, Carr, Fararr, & Floyd, 2011; Scholey et al., 2009; Smith, 2009b, for alertness effects). These studies suggest a degree of unreliability in respect to the effects of gum on cortisol. One possibility for such unreliability is the diurnal variation in cortisol excretion. For instance, Johnson et al. (2011) tested participants in the morning when cortisol levels are typically high (Hucklebridge, Hussain, Evans, & Clow, 2005) and such elevation may have masked the effects of chewing and/or the stressful task. Indeed, in Scholey et al. (2009), cortisol levels fell following the stressor when participants were tested in the morning (corroborating the Johnson et al. (2011) data). However, since Scholey et al. (2009) did not include time of day in their analysis of gum effects, it is unclear the extent to which the reductive effects of chewing gum on cortisol were confined to the afternoon. Similarly, in Smith (2010), despite testing taking place at intervals across the day, time of day was not included as a variable in

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his analysis. It is, therefore, unclear whether time of day differentially influenced the cortisol excretion. Additionally, Smith (2010) does not report whether there was a main effect of the noise stressor on cortisol excretion. That is, we do not know if the noise was 'physiologically' stressful. If not, then the scenario is quite different to that of Scholey et al. (2009), in which the rise in cognitive-load induced cortisol excretion was mediated via the chewing of gum.

The present study examines the extent to which increases in cortisol excretion are moderated by chewing gum with a task known to produce established and reliable effects on cortisol excretion (TSST: Kirschbaum et al., 1993; see also Kudielka et al., 2004). The presentation and mental arithmetic components of the TSST, in particular, have been shown to increase both cortisol excretion (Kudielka et al., 2004) and state-anxiety (Sketchley-Kaye et al., 2011), and decrease subjective mood state (Kudielka et al., 2004; Sketchley-Kaye et al., 2011). As aforementioned, Sketchley-Kaye et al. (2011) found that chewing gum attenuated the rise in self-rated anxiety following the TSST. In the present study we examine the extent to which this mediating effect of gum following the TSST can be extended to cortisol and self-rated stress.

The TSST comprises a social evaluative stress task where participants deliver a presentation and perform a mental arithmetic task in front of a panel. There are four stages to the task: baseline measures, preparation for the presentation, presentation/mental arithmetic stressor, and post-task recovery. To the extent that chewing gum affects cortisol excretion under conditions of acute physiological stress (Scholey et al., 2009), we predict an interaction between the experimental stage and chewing gum condition. That is, we expect differences between the gum and no gum groups at specific points in the stressor protocol. One might expect increases in stress immediately prior to the TSST (anticipatory stress) and immediately following the TSST. If chewing gum attenuates the rise in cortisol production under conditions of acute stress (Scholey et al., 2009), lower cortisol levels should be reported in the gum group at these stages. Furthermore, since a temporal delay exists in respect to stress exposure and salivary cortisol peak (Kudielka et al., 2004), one might predict differences between the gum and no gum groups following the recovery phase due to a delay in cortisol returning to normal levels. Additionally, if chewing gum moderates the stress induced changes in self-rated stress and mood (e.g. Scholey et al., 2009; Sketchley-Kaye et al., 2011), we predict an interaction between chewing gum and experimental stage such that increases in stress and decreases in mood are both attenuated in the chewing gum condition.

Method

Participants

Forty (20 males, 20 females, mean age = 20 years and 3 months) non-smoking Coventry University Psychology undergraduates participated in exchange for course credit. All participants reported that they were free from both concurrent medication (including the contraceptive pill) and illicit drug use. Participants were instructed to refrain from caffeine, alcohol, and chewing gum on the day of testing and asked to not consume food for up to 1 h prior to testing. Participants were assigned at random to either the chewing gum or no chewing gum condition ($n = 20$ per group: chewing gum group comprised 12 males and 8 females, mean age = 20.55 years, SEM = 0.48; no gum group comprised 8 males and 12 females, mean age = 20.00 years, SEM = 0.27). Ethical approval was obtained from the Coventry University Ethics Committee.

Materials

Participants completed both the Bond–Lader Visual Analogue Mood Scale (VAMS: Bond & Lader, 1974), a single-item stress scale (modelled on the scale described by Scholey et al., 2009) and the State-Trait Anxiety Inventory (STAI: Speilberger, Gorsuch, & Lushene, 1969). The Bond–Lader VAMS comprises 16 mood questions, with mood antonyms anchoring either end of a 100 mm line. It provides scores for alertness, contentedness, and calmness. Participants are instructed to rate, via a mark on each antonym-paired line, how they are feeling at that moment. On a separate sheet the same single-item scale was used to measure self-rated stress and comprised the single antonym: no stress at all/worst stress imaginable. This single scale was modelled on Scholey et al. (2009) but employed a different antonym. The STAI comprises 40 statements each assessing either state or trait-anxiety. For each statement participants respond on a four-point likert scale indicating the extent to which they agree with each statement.

Salivary samples were obtained through participants 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 manufacturer's instructions (Salimetrics LLC).

At three distinct task stages in the study (immediately following baseline measures, immediately prior to the presentation, and at the start of the recovery period), participants in the chewing gum condition were provided with a single pellet of Wrigley's Extra, spearmint-flavoured, sugar-free gum.

Design

A (2×4) mixed design was employed where the first factor is between-participants and refers to chewing gum condition (gum or no gum) and the second factor is within-participants and refers to experimental stage (baseline, pre-TSST, post-TSST, and recovery). The dependent variables measured at each experimental stage were salivary cortisol concentration (μg/dL), self-rated measures of stress, state-anxiety, alertness, contentedness, and calmness.

Procedure

Participants were tested between 15:00 h and 17:00 h in order to minimise the possibility of diurnal variations in cortisol excretion masking physiological responsiveness (Hucklebridge et al., 2005). The stressor task was based upon the Trier Social Stress Task (TSST) as described by Kirschbaum et al. (1993); this incorporates a videoed mock interview and mental arithmetic task performed to a panel. Participants were tested individually, with the experimental start time (15:00 h or 16:00 h) counterbalanced across gum conditions.

Participants entered the laboratory and completed the self-rated measures (trait-anxiety was measured at baseline only) and provided a salivary sample. The presentation order of the self-rated measures was counterbalanced with the salivary cortisol sample always taken last. Following completion of the baseline measures, participants were informed that the study required them to participate in a video-recorded presentation to a panel of two psychologists. Participants were informed that the psychologists were experts in both verbal and non-verbal communication. At this juncture participants were given the option to withdraw their participation.

Participants were allotted 10-min to prepare for the 5-min presentation. Participants were required to present an argument in support of their suitability for a graduate position of their choice. Following the preparation phase, self-rated and physiological mea-