Effects of Chewing Gum on Heart Rate: 
A Physiological Stress Indicator

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Previous findings have concluded that chewing gum can reduce self-reported levels of stress and moderate physiological stress responses, including brain activity and salivary cortisol levels. This study aimed to establish whether similar findings for the stress alleviating property of chewing gum could be obtained by measuring participants' heart rate, pre- and post-stress inducing task, using a mixed experimental design. Participants were given 12 anagrams and 12 arithmetic problems to solve within a 5-minute period in order to elicit stress. During the task, half the participants chewed one piece of gum whilst the other half did not chew gum. It was hypothesised that those in the chewing gum condition would experience a smaller increase in heart rate. However, the findings suggested that chewing gum does not moderate an individual's heart rate increase in response to a stressful situation. Potential explanations for these findings are presented in this article and suggestions for further research are also discussed.

Keywords: physiological stress, stress-inducing task, heart rate, chewing gum, digital sphygmomanometer.

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Introduction

Stress is an inevitable feature of day-to-day life, but high levels of prolonged stress are detrimental to physical and mental health, being a significant risk factor for psychopathology (Schneiderman, Ironson and Siegel, 2005; Wang and Saudino, 2011; Steptoe and Kivimäki 2013; Kelly and Ismail 2015). A major source of stress that individuals face is work related or occupational stress. According to the Labour Force Survey commissioned by the Health and Safety Executive (2014), 40% of all work related illnesses in Great Britain between 2011 and 2012 were attributed to stress. The report also estimates that 11.3 million working days were taken off due to stress, depression or anxiety over a 12-month period in 2013-2014. As well as affecting productivity, high levels of occupational stress have been found to be associated with damaging health behaviours, including increased levels of smoking and drinking (Smith, 2000). Consequently, a substantial proportion of current health costs in the UK are attributable to stress (Chandola, 2010). Thus, research into cost effective methods of stress management and prevention is imperative.

One potential stress management method which has received renewed interest in the last decade is the chewing of gum. Over 70 years ago, Hollingworth (1939) was the first to investigate the benefits of chewing gum, reporting a 10-15% decrease in participants’ feelings of tension whilst chewing gum at the workplace. Recent studies have demonstrated similar findings. For example, Smith’s (2009) online survey involving 2,248 full-time workers concluded that perceived levels of stress were lower for self-reported chewers of gum. Furthermore, non-chewers were found to be nearly twice as likely to be extremely stressed, compared to levels reported by chewers. A recent intervention study (Smith, Chaplin and Wadsworth, 2012) has shown a linear relationship between the quantity of chewing and resultant stress moderating effect for perceived levels of stress. After the 14-day intervention, participants who chewed more than 64 pieces of gum, versus those who chewed less than 64 pieces (but a minimum of two pieces per day for at least a 20-minute time period), generally reported an increased reduction in stress and greater overall wellbeing (a more positive mood and mental health) as assessed by standardised questionnaires. Chewing gum was found to result in approximately a 10% reduction in reported levels of stress (Smith, Chaplin and Wadsworth, 2012), a similar effect size as previously found by Hollingworth (1939). Laboratory studies involving stress-inducing tasks have yielded similar self-report findings (Scholey et al., 2009). Physiological measurements have also provided supporting results. For example, whilst exposed to a loud noise and chewing gum, participants’ level of bilateral superior
temporal sulcus\(^1\) and left anterior insula\(^2\) activation (which was higher in noise versus no noise conditions and corresponded to self-reported stress) was found to be less increased in comparison to not chewing gum. Furthermore, these activations were positively correlated with participants self-reported feelings of stress (Yu et al., 2013). Salivary cortisol levels are widely used in stress research, as the hormone is secreted in response to stress (Kirschbuam and Hellhammer, 2000). Tahara, Sakurai and Ando (2007) found that salivary cortisol levels of individuals chewing paraffin wax after a stress eliciting arithmetic task were significantly reduced, in comparison to the control condition in which the individuals did not chew paraffin wax. Several studies thus support the anti-stress properties of chewing, using both subjective and objective measures.

However, Allen and Smith’s (2011) systematic review concluded that the evidence from a number of studies was mixed regarding whether chewing gum can alleviate self-reported levels of stress, with a general consensus yet to be established. Whilst the authors presented some evidence in support of chewing gum alleviating self-reported naturally occurring chronic stress, findings for the effects on acute self-reported stress have been far less apparent. Torney, Johnson and Miles (2009) found no significant effect of chewing gum on participants’ self-rated stress after attempting unsolvable and solvable anagrams. Johnson et al. (2011) also failed to replicate the moderating effects of chewing gum on salivary cortisol levels.

This study aimed to contribute to previous research by testing the effect of chewing gum on participants’ autonomic stress response measured via heart rate (HR) whilst completing a newly devised arithmetic and anagram task. It was decided to measure HR as it is an objective measure of acute stress, avoiding the subjective nature of self-report. Cardiac activity, and thus HR, increases in response to stress (Arora et al., 2010). Interestingly, some research has found increased HR for participants chewing gum compared to those not chewing gum, during a series of cognitive tasks that assessed aspects of attention, working memory and long-term memory (Wilkinson, Scholey and Wesnes, 2002). The authors posited that the increase in HR was attributable to the general circulatory effects associated with chewing gum as detailed by Farella et al. (1999).

This study compared changes in HR before and after the administration of a stress-inducing task in a group of individuals chewing gum and a group of individuals not chewing gum. The independent variable (IV) is thus the condition of chewing gum or no gum. The dependent variable (DV) is the change in HR from pre-task to post-task. It was hypothesised that

\(^1\) A region of the brain often associated with emotional awareness (Gu et al., 2013).
\(^2\) A region of the brain involved in aspects of social cognition and language processing (Redcay, 2008).
participants who chew gum during the stress-inducing task would have a smaller increase in HR than participants who do not chew gum.

Methods

Design

An independent measures experimental design was used to establish if chewing gum could reduce HR increase, elicited by a cognitive task. Participants were randomly allocated to either the chewing gum or no gum condition with half the participants in each group.

Participants

Thirty participants (mean age (M) = 19.4 years, range = 19-21, standard deviation (SD) = 0.56) participated without incentive.

Materials

A portable digital sphygmomanometer (blood pressure (BP) and heart rate monitoring device) manufactured by A and D Medical, model number UA-767 Plus 30, was used to automatically measure participants’ HR, both immediately before and after the stress-inducing task. The newly devised paper based stress-inducing task consisted of alternating anagrams and arithmetic problems, 12 each. Anagrams varied in length from four to ten letters. Various types of arithmetic problems including addition, subtraction, division, multiplication, percentages, fractions and square roots were incorporated (see Appendix 1 for the full task). During the task, half of the participants chewed one piece of sugar free chewing gum (Wrigley’s Extra, peppermint flavour) the other half simply completed the task.

Procedure

Before the study commenced, participants provided informed written consent. Ethical approval was given by a lecturer at the University of Surrey from the School of Psychology. Participants were tested individually. Prior to the stress-inducing task, their HR was measured using the sphygmomanometer to obtain a resting baseline parameter. Half of the participants, chosen at random, were asked to start to chew one piece of chewing gum and to continue to do so throughout the task. Participants then attempted to complete the 24-part, stress-inducing, mixed anagram and arithmetic task. They were instructed to attempt the task, to the best of their ability, in a 5-minute time period. A 5-minute time period was chosen in order to create a sense of time pressure. Participants received a 1-minute warning 4 minutes into the task. Regardless of task progression, after 5 minutes the task was terminated. During the task, the
researcher remained in the room and observed the participant. Participants’ HR was then measured immediately after the 5-minute period allowed for the task. The study lasted approximately 15 minutes and was conducted in various natural yet quiet settings, including participants’ homes and public libraries. Once complete, all participants were fully debriefed. (They had been naive to the nature of the study until this point). No task related behavioural data, for instance, the number of participants that completed the task in the given time, average completion rate and accuracy, were recorded.

**Data Analysis**

Before the initial analysis, the data were pre-screened. Whilst most adults have a resting HR of 60-100 beats per minute (bpm), a lower resting HR, for example, 40-60 bpm can be a sign of greater levels of fitness (National Health Service, 2015). The current sample population was relatively young, with a mean age of 19.4 years, thus, a lower range of 40-60 bpm was permitted. Generally an HR below 40 bpm can be a sign of ill-health and cause for concern (National Health Service, 2015); consequently, only volunteers with a resting HR of 40-100 bpm were included in the experiment to ensure homology between groups. One participant, from the no gum condition, exceeded this criterion, with a resting pulse of 108 bpm and was excluded from further analysis. Data analysis of HR was thus conducted on 29 participants, 15 in the gum condition and 14 in the no gum condition.

Data normality was checked before running inferential tests. Calculated skew and kurtosis z-scores for the pre-task and post-task HR measures within each group met the criteria for normal distribution that all values lie within the ± 1.96 confidence limit. For the purposes of this study, a p-value of ≤ 0.5 was regarded to indicate statistical significance.

An independent samples t-test was run to ensure that the pre-task HR for the two groups did not significantly differ from each other and thus can be assumed to be drawn from the same sample. Pre-task HR was found not to be significantly different between the chewing gum (M = 70.93 bpm, SD = 13.79) and no gum group (M = 73.14 bpm, SD = 12.64); t(27) = -0.45, p = 0.66. This baseline homology indicating no pre-task HR difference between the groups allowed for further investigation of the effect of chewing gum on HR during a stress-inducing task.

**Results**

Descriptive statistics revealed slightly different effects in HR occurring between the two conditions. For the chewing gum condition, HR after the task increased from a mean of 70.93
bpm (SD = 13.79) to 74.13 bpm (SD = 13.43) with a mean difference of +3.13 bpm. Yet in the no gum condition, HR decreased from a pre-task baseline mean of 73.14 bpm (SD = 12.64) to a post-task HR mean of 71.64 bpm (SD = 15.49) with a mean difference of -1.50 bpm (see Figures 1 and 2 for mean HR pre-task and post-task for both groups).

![Figure 1. Mean pre-task HR for gum and no gum group. Note: Error bars represent SD.](image)

![Figure 2. Mean post-task HR for gum and no gum group. Note: Error bars represent SD.](image)
In order to establish whether there was a significant difference in the change in HR between the two experimental groups, chewing gum and no gum, a second independent samples t-test was conducted on the calculated change in HR variable (post-task HR – pre-task HR). No significant difference was found for the change in HR between the chewing gum (M = 3.13, SD = 6.69) and no gum conditions (M = -1.50, SD = 9.14); t(27) = 1.57, p = 0.13, indicating that there was no significant difference in the change of HR between the groups.

Discussion

The aim of this study was to test the effect of chewing gum on HR whilst completing a newly devised arithmetic and anagram based cognitive task. Based on prior research, it was hypothesised that participants who chewed gum during the cognitive task would experience a diminished HR increase in comparison to those participants who did not chew gum. However, descriptive statistics in fact demonstrated that whilst those in the chewing gum condition showed an increase in HR from pre-task to post-task, participants in the no gum condition were found to show a decrease in HR. Further analysis, however, indicated that there was no significant difference for the change of HR between the chewing gum and no gum conditions (p = 0.13), indicating that the chewing gum did not moderate HR response. This study thus yielded no significant results in support of the initial hypothesis.

One potential reason for not finding a significant difference in the change of HR between the groups could be due to the task not eliciting a stress response (or at least not a significant one), since the validity of the cognitive task aimed to provoke stress was unknown. Further research should, therefore, investigate the validity of the task, for instance, comparing outcomes with reliable and validated tasks. Another proposal would be to re-run the experiment using a validated stress-inducing task, such as the Defined Intensity Stress Simulator as used by Scholey et al. (2009).

Aside from the validity of the task, HR may not have been an appropriate measure of acute stress in this particular study. Wilkinson et al. (2002), for example, found that as well as increased cognitive performance for participants chewing gum, HR was also found to be significantly higher than those in the no gum condition. Increased HR may thus be the result of an increased level of attention to the required task. Allen and Smith’s (2011) systematic review concluded that there are robust results for the enhancement of self-reported levels of attention whilst chewing gum. Whilst chewing gum, the brain has been found to exhibit increased alpha activity and decreased beta activity akin to simultaneous attention and relaxation, explained as ‘relaxed concentration’ (Morinushi et al., 2000, p. 649). It is feasible that participants in the current study may have felt less stressed whilst chewing gum, as...
previous studies have indicated (Smith, 2009; Scholey et al., 2009; Smith, Chaplin and Wadsworth, 2012), despite an increased HR. Thus, there may exist a discrepancy between subjective and objective indices of acute stress. Lower levels of perceived stress could be the result of enhanced attention and thus better cognitive performance (Wilkinson, Scholey and Wesnes, 2002).

To fully investigate whether enhanced attention and thus better cognitive performance are associated with lower levels of resulting perceived stress, future research could explore perceived levels of stress, HR, salivary cortisol levels, EEG recordings and task performance to delineate potential interactions. Obtaining a range of subjective and objective measures of stress in addition to cognitive task performance would enable a thorough investigation of the effects of chewing gum on both perceived and physiological stress, helping to clarify previous findings.

**Conclusion**

High levels of stress are detrimental to health and work productivity, consequently affecting health costs and the economy. Research into finding cost-effective and practical methods of stress management and prevention is of utmost importance. This study sought to investigate one such potential method - the chewing of gum. The current study used a physiological index of acute stress (HR) rather than a subjective rating of stress using a novel, un-validated cognitive task. Participants were given 12 anagrams and 12 arithmetic problems to solve within a 5-minute period in order to elicit stress, with half of participants chewing gum and the other half not chewing gum. The findings from 29 participants indicated that there was no benefit of chewing gum on moderating HR, however, this may be due to the task not effectively inducing stress in the participants. Furthermore, HR alone is perhaps not a sufficient index of stress. Mixed method research designs are thus suggested for future studies.

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References


Appendix 1: Anagram and Arithmetic Task

Anagrams and Mathematic Questions

You will have 5 minutes to complete the following anagrams (rearranging letters to form a word) and mathematic questions. Please attempt the tasks to the best of your ability, if you have any queries please ask the experimenter for clarification.

1. What is 99 divided by 2?

2. ERTE =

3. 25% of students in a school with 340 pupils have free school meals.
   How many students is this?

4. IISUNREITVY =

5. There are 350 pupils in a school. If 70 are female, what percentage of the pupils are male?

6. FOAMLING =

7. It is possible to seat 35 people in a row across the hall. How many rows are needed to seat 415?

8. BOILCROC =
9. After buying some erasers for £50.53, Ashley has £12.54 left. How much money did Ashley have to begin with?

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10. MOONSTARER =

……………………………………………………

11. There are 350 pupils in a school. 70 are female. What percentage of the pupils are male?

……………………………………………………

12. TALENIVEN =

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13. If one bridesmaid's dress costs £150, and there are five bridesmaids, how much will it cost for all of their dresses?

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14. HENCEAPONG =

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15. Two friends keep a record of their scores at ten-pin bowling. These are John’s scores for 6 games: 130, 104, 155, 160, 135, 108.

What is John’s mean score?

……………………………………………………

16. LSKBLATAEB =

……………………………………………………

17. What is the square root of 121?

……………………………………………………
18. Peter spends ½ his pocket money on a new toy. He spends 1/3 of his money on a pen. What fraction of his pocket money did he spend altogether?

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19. SDMBASOARA =

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20. 24 students took a maths test. If 18 students pass, what percentage did not pass?

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21. CSUELM =

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22. 1 box holds 6 bottles of water, each bottle contained 750ml of water. How many litres of water does 18 boxes hold?

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23. SDAEDSR =

……………………………………………………

24. What is: 63 + 72 + 12 + 59 + 108 = ?

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