



# Chewing gum, stress and health

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## Summary

*Hollingworth described chewing gum as 'a technique of relaxation'. Recent research has examined this issue and there is evidence that chewing gum can prevent the adverse effects of acute stress. There are also plausible biological mechanisms that could explain such effects. It is now important to examine chewing gum and chronic stress and the present study involved a survey of this topic. The survey covered the 'stress process', collecting data on exposure to stressful events, levels of perceived stress and health outcomes. Frequency of chewing gum was also recorded. Potential confounding factors (demographics, personality and health-related behaviours) were also recorded. The web-based survey was completed by a community sample of 2,248 full-time workers (68% female. Mean age: 35 years, range 18–74 years). Sixty-one per cent of the sample were gum chewers. The results showed that chewing gum was associated with lower levels of perceived stress (both at work and life in general). Gum chewers were also less likely to be depressed and to have seen their doctor for high blood pressure or high cholesterol. Chewing gum was associated with lower levels of alcohol consumption and with cigarette smoking. Gum chewers were also more likely to be neurotic extraverts. Those who chewed gum were also more likely to be exposed to negative factors at work. Logistic regression analyses showed that the effects of chewing gum on stress and health remained significant when these confounding factors were controlled for. These results suggest that chewing gum may be a simple way of preventing stress and the negative health outcomes that are often associated with it. Intervention studies are now required and the mechanisms underlying the effects reported here need further investigation. Copyright © 2009 John Wiley & Sons, Ltd.*

## Key Words

*Chewing gum; Stress; Health*

## Introduction

Recent research has suggested that chewing gum may increase alertness and improve aspects of performance (Baker, Bezance, Zellaby, &

Aggleton, 2004; Hirano et al., 2008; Masumoto et al., 1999; Momose et al., 1997; Morinushi, Masumoto, Kawasaki, & Takigawa, 2000; Onozuka et al., 2002; Smith, 2009a,b; Smith, in press; Takada & Miyamoto, 2004; Tucha, Mecklinger, Maier, Hammerl, & Lange, 2004; Wilkinson, Scholey, & Wesnes, 2002; Yagyū et al., 1997, 1998). Some areas, such as the effects of chewing gum on memory, show conflicting results (see Smith, 2009b for a review), with some studies (e.g. Johnson & Miles, 2007; Tucha et al., 2004) reporting impaired performance when chewing. Hollingworth (1939) described chewing gum as 'a technique of relaxation'.

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Recent research has examined this issue and there is evidence that chewing gum can prevent the adverse effects of acute stress. For example, Smith (in press) found that chewing gum improved performance and mood when participants were exposed to noise (a method frequently used to study the effects of stress). A cross-over study involving 133 volunteers was carried out. Each volunteer carried out a test session when they were chewing gum and without gum, with order of gum conditions counterbalanced across subjects. Baseline sessions were conducted prior to each test session. Approximately half of the volunteers were tested in 75dBA noise (the stress condition) and the rest in quiet. Volunteers were stratified on chewing habit and anxiety level. Approximately, half of the volunteers were given mint gum and half were given fruit gum. The volunteers rated their mood at the start and end of each session and had their heart rate monitored over the session. Saliva samples were taken to allow cortisol levels (good indicators of alertness and stress) to be assayed. During the session, volunteers carried out tasks measuring a range of cognitive functions (aspects of memory, selective and sustained attention, psychomotor speed and accuracy). The results showed that chewing gum was associated with greater alertness and a more positive mood. Reaction times were quicker in the gum condition, and this effect became bigger as the task became more difficult. Chewing gum also improved selective and sustained attention. Heart rate and cortisol levels were higher when chewing which confirms the alerting effect of chewing gum.

Scholey et al. (2009) showed chewing gum reduced anxiety and stress when individuals performed a series of multi-tasking activities designed to induce stress. In this study, 40 volunteers performed on the Defined Intensity Stressor Simulation (DISS), a multi-tasking platform which reliably induces stress and also includes performance measures, while chewing and not chewing gum. Anxiety, alertness and stress levels were measured before and after participants completed the DISS. When chewing gum, participants under stress reported a reduction in anxiety as compared with non-gum chewers. Similarly, gum chewers under stress showed improvement in alertness over non-gum chewers. Stress levels were lower in participants who chewed gum. Levels of salivary cortisol (a physiological stress marker) in gum chewers were lower than those of non-gum chewers. Chewing gum resulted in a

significant improvement in overall performance on multi-tasking activities.

Electrophysiological studies also suggest that chewing gum may increase relaxation (Masumoto, Morinushi, Kawasaki, Ogura, & Takigawa, 1999). Research also shows effects of chewing on the vagus nerve (Shiba, Nitta, Hirono, Sugita, & Iwasa, 2002) which may lead to increased relaxation due to vagal stimulation of the CNS. In addition, chewing gum may change serotonergic functioning (Mohri, Fumoto, Sato-Suzuki, Umino, & Arita, 2005) which again provides a plausible mechanism for chewing gum reducing stress.

Another method of examining factors that influence stress is to use surveys. One study (Princeton Review and Wrigley, 2005) has examined chewing gum and stress associated with exams in a sample of 8,930 university students. Over 85% of the sample reported stress and tension at exam times and 41% reported that they chewed gum while studying to reduce stress. Another study (FRC Research Corporation, 2006) found that in a sample of 280 participants, chewing gum reduced stress, and that stress levels increased in heavy chewers who abstained from chewing for 3 days. Indeed, more than half of the sample agreed that they chewed gum to help them cope with everyday stress.

It is important that research on stress uses accepted models of the stress process (see Cohen, Tyrrell, & Smith, 1991, for an example of this). Models of stress must consider (1) stress as a stimulus, (2) perceived stress, and (3) outcomes of stress (acutely physiological changes, changes in affect; longer term—mental health problems, increase risk of cardiovascular and other chronic diseases). Potential confounders and mediating/moderating factors (e.g. individual differences) must also be taken into account (see Mark & Smith, 2008).

Work-related stress has recently become a major occupational health issue. Work-related stress accounts for over a third of all new incidences of ill health. Each case of work-related stress, depression or anxiety leads to an average of 30.2 working days lost. A total of 13.8 million days were lost to work-related stress, depression and anxiety in 2006/2007 (Health and Safety Executive, 2008). Prevention and management of stress at work involves both organizational interventions and individual approaches (e.g. relaxation). Chewing gum may therefore be an important method of dealing with stress at work.

One method of examining this issue is to look at associations between gum chewing habits and perceived levels of stress at work. Stress at work is also associated with negative health outcomes (e.g. increased anxiety and depression; high blood pressure, etc.) and the effects of gum on these also need to be examined. Stress at work is influenced by many factors (see Smith, 2000) and these need to be controlled for when examining effects of gum. The most obvious are job characteristics—jobs with high demands (and other negative features) are associated with more stress. Demographic factors also need to be controlled for as they are likely to be associated with both stress (Smith, 2001) and gum chewing habits. In addition, chewing gum is likely to be associated with other factors such as personality and health-related behaviours (e.g. smoking). These need to be co-varied in any studies examining chewing gum and stress. It is also the case that stress at work may be related to stress outside of the workplace. ‘Stress in life generally’ can be examined using a similar approach.

The present study represents a preliminary investigation of possible associations between chewing gum and the stress process using a web-based survey of a community sample.

## Method

### Survey

The study was carried out with the approval of the School of Psychology Ethical Committee and the informed consent of the participants. The survey was carried out using a web-based questionnaire (using SurveyTracker software). Gum chewing was measured using a five-point scale from ‘Never’ to ‘Very often’. Perceived stress at work and stress in life generally were measured using a five-point scale from ‘Not at all’ to ‘Extremely stressed’. Stress in life generally was also measured using a similar scale. Anxiety and depression were measured using the Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983). Reports (Yes/No) of ever having to see a doctor for high blood pressure and high cholesterol were recorded. Demographics (age, gender, marital status, ethnicity, and socio-economic status), personality (measured by the ‘Big 5 scale’—Goldberg, 1990) and health-related behaviours (smoking and alcohol consumption) were recorded. In addition, negative job charac-

teristics were measured using the questions shown in Table I.

### Sample

A community sample of 2,248 workers (68% female. Mean age: 35 years, range 18–74 years) completed the survey. They were recruited from the clients of an insurance firm and, by participating, were offered a chance to win one of five prizes of £100. They were informed that the study was investigating associations between work, lifestyle and health.

### Method of analysis

Gum chewing was dichotomized (non-chewers versus chewers). This was because the accuracy of the frequency of chewing ratings was unknown (i.e. one person who chewed a pack of gum a week may describe this as ‘sometimes’ whereas another person may describe chewing the same amount as ‘often’). Thirty-nine per cent of the sample never chewed gum, 44.7% fell in the ‘sometimes’ category, and 9.7% ‘often’ chewed gum and 6.6% ‘very often’.

Outcome variables were also dichotomized and cross-tabulations between chewing and the outcomes were performed. These univariate analyses were followed by logistic regressions which provided odds ratios for any effects. Subsequent multi-variate analyses included demographics, personality, job characteristics and health-related behaviours in the logistic regressions to control for the influence of these factors.

## Results

### Possible confounders

Chewing gum and demographics. Those who chewed gum were more likely to be female, single, younger age, earning a lower salary and lower educational attainment. All of these differences were significant and are shown in Table II.

Chewing gum and personality. The Big 5 personality inventory measures the five major dimensions of personality. Chewers and non-chewers were found to differ on extraversion and neuroticism scales, with chewers being more likely to

Table I. Negative job characteristics.

The following questions are designed to give a quick overview of your job characteristics. Please tick the appropriate box. (Items marked with an \* are reverse scored. The items are summed to give a total negative characteristics score).

<b>Do you work long or unsociable hours (shiftwork, at night, on call, unpredictable hours)?</b>				
Never <input type="checkbox"/> <sub>0</sub>	Rarely <input type="checkbox"/> <sub>1</sub>	Sometimes <input type="checkbox"/> <sub>2</sub>	Often <input type="checkbox"/> <sub>3</sub>	Very often <input type="checkbox"/> <sub>4</sub>
<b>How often are you exposed to noise at work?</b>				
Never <input type="checkbox"/> <sub>0</sub>	Rarely <input type="checkbox"/> <sub>1</sub>	Sometimes <input type="checkbox"/> <sub>2</sub>	Often <input type="checkbox"/> <sub>3</sub>	Very often <input type="checkbox"/> <sub>4</sub>
<b>Do you have a demanding job (have to work fast, intensively etc)?</b>				
Never <input type="checkbox"/> <sub>0</sub>	Rarely <input type="checkbox"/> <sub>1</sub>	Sometimes <input type="checkbox"/> <sub>2</sub>	Often <input type="checkbox"/> <sub>3</sub>	Very often <input type="checkbox"/> <sub>4</sub>
<b>* Do you have a choice in what you do or how you do your job?</b>				
Never <input type="checkbox"/> <sub>0</sub>	Rarely <input type="checkbox"/> <sub>1</sub>	Sometimes <input type="checkbox"/> <sub>2</sub>	Often <input type="checkbox"/> <sub>3</sub>	Very often <input type="checkbox"/> <sub>4</sub>
<b>* Do you have a great deal of say in decisions at work?</b>				
Never <input type="checkbox"/> <sub>0</sub>	Rarely <input type="checkbox"/> <sub>1</sub>	Sometimes <input type="checkbox"/> <sub>2</sub>	Often <input type="checkbox"/> <sub>3</sub>	Very often <input type="checkbox"/> <sub>4</sub>
<b>* Do you have a lot of support at work (from colleagues and superiors)?</b>				
Never <input type="checkbox"/> <sub>0</sub>	Rarely <input type="checkbox"/> <sub>1</sub>	Sometimes <input type="checkbox"/> <sub>2</sub>	Often <input type="checkbox"/> <sub>3</sub>	Very often <input type="checkbox"/> <sub>4</sub>
<b>Do you have constant pressure due to a heavy workload?</b>				
Never <input type="checkbox"/> <sub>0</sub>	Rarely <input type="checkbox"/> <sub>1</sub>	Sometimes <input type="checkbox"/> <sub>2</sub>	Often <input type="checkbox"/> <sub>3</sub>	Very often <input type="checkbox"/> <sub>4</sub>
<b>Work rarely lets me go, it is still on my mind when I go home</b>				
Never <input type="checkbox"/> <sub>0</sub>	Rarely <input type="checkbox"/> <sub>1</sub>	Sometimes <input type="checkbox"/> <sub>2</sub>	Often <input type="checkbox"/> <sub>3</sub>	Very often <input type="checkbox"/> <sub>4</sub>
<b>* Do you receive the respect you deserve from superiors and colleagues?</b>				
Never <input type="checkbox"/> <sub>0</sub>	Rarely <input type="checkbox"/> <sub>1</sub>	Sometimes <input type="checkbox"/> <sub>2</sub>	Often <input type="checkbox"/> <sub>3</sub>	Very often <input type="checkbox"/> <sub>4</sub>
<b>* Do you feel your efforts and achievements at work are appropriately rewarded?</b>				
Never <input type="checkbox"/> <sub>0</sub>	Rarely <input type="checkbox"/> <sub>1</sub>	Sometimes <input type="checkbox"/> <sub>2</sub>	Often <input type="checkbox"/> <sub>3</sub>	Very often <input type="checkbox"/> <sub>4</sub>
<b>* Are you satisfied with your job?</b>				
Never <input type="checkbox"/> <sub>0</sub>	Rarely <input type="checkbox"/> <sub>1</sub>	Sometimes <input type="checkbox"/> <sub>2</sub>	Often <input type="checkbox"/> <sub>3</sub>	Very often <input type="checkbox"/> <sub>4</sub>
<b>Does your job interfere with family life or other activities outside work?</b>				
Never <input type="checkbox"/> <sub>0</sub>	Rarely <input type="checkbox"/> <sub>1</sub>	Sometimes <input type="checkbox"/> <sub>2</sub>	Often <input type="checkbox"/> <sub>3</sub>	Very often <input type="checkbox"/> <sub>4</sub>

be neurotic extraverts (see Table II). There were no significant effects of chewing status for the other personality dimensions.

#### Chewing gum and health-related behaviours.

Chewers were more likely to smoke than non-chewers (see Table II). However, they were less likely to consume moderate to high levels of alcohol (>20 units a week—see Table II).

#### Chewing gum and negative job characteristics.

One possible explanation of any differences in levels of occupational stress reported by chewers is that they may be exposed to different job demands than non-chewers. Analyses showed that gum chewers were actually exposed to more negative characteristics at work (see Table II).

The mentioned confounders were included in the logistic regressions to determine whether

Table II. Associations between gum chewing and (1) demographics, (2) personality, (3) health-related behaviours, and (4) negative job characteristics.

	Non-Chewers ( <i>n</i> = 867)	Chewers ( <i>n</i> = 1381)
<b>Gender</b> (chi square = 35.6, <i>p</i> < 0.0001)	61% female	73% female
<b>Marital status</b> (chi square = 65.8, <i>p</i> < 0.0001)	25% single	38% single
<b>Age</b> ( <i>F</i> = 167.6, <i>p</i> < 0.0001)	Mean = 39.4 years, range 19–74 years	Mean = 33.6 years, range = 18–73 years
<b>Education</b> (chi square = 26.1, <i>p</i> < 0.0001)	61% educated to degree level	51% educated to degree level
<b>Salary</b> (chi square = 23.5, <i>p</i> < 0.0001)	58% earning >£25,000 p.a.	48% earning >£25,000 p.a.
<b>Personality</b>		
Extraversion ( <i>F</i> = 17.4, <i>p</i> < 0.0001)	Mean = 20.2 s.e. = 0.1	Mean = 21.1 s.e. = 0.1
Neuroticism ( <i>F</i> = 8.25, <i>p</i> < 0.001)	Mean = 12.1 s.e. = 0.1	Mean = 12.7 s.e. = 0.1
<b>Smokers</b> (chi square = 4.3, <i>p</i> < 0.001)	13.6%	17.4%
<b>Alcohol consumption</b> (>20 units per week) (chi square = 6.3, <i>p</i> < 0.001)	4.5%	1.9%
<b>Negative work characteristics</b> ( <i>F</i> = 5.06, <i>p</i> < 0.005)	Mean = 16.6 s.e. = 0.2	Mean = 17.2 s.e. = 0.1

associations between chewing gum, stress and health remained when these were statistically controlled.

#### *Chewing gum and perceived occupational stress*

Of the non-chewers, 3.2% reported that they were extremely stressed at work compared with 1.8% of the chewers. This effect was significant (chi square = 10.9, *p* < 0.05) and was confirmed in the logistic regression analysis which showed that non-chewers were nearly twice as likely to be extremely stressed as chewers (OR = 1.96, CI = 1.17, 3.28). This effect remained significant when demographics, personality, job characteristics and health-related behaviours were included in the model, with the other significant influences being job characteristics and neuroticism.

#### *Chewing gum and perceptions of life stress*

Of the non-chewers, 9.2% reported high levels of life stress (ratings of 'very' or 'extremely' stressed)

compared with 6.5% of the chewers. This effect was significant (chi square = 12.2, *p* < 0.01) and was confirmed in the logistic regression analysis which showed that non-chewers were over one and a half as likely to be extremely stressed as chewers (OR = 1.65, CI = 1.22, 2.24). This effect remained significant when demographics, personality, job characteristics and health-related behaviours were included in the model, with the other significant influences being job characteristics and neuroticism.

#### *Chewing gum and depression*

Of the non-chewers, 27.3% reported that they had moderate to high levels of depression (scores of >5 on the HAD depression scale) compared with 23.6% of the chewers. This effect was significant (chi square = 5.2, *p* < 0.05) and was confirmed in the logistic regression analysis which showed that non-chewers were more likely to be depressed than chewers (OR = 1.31, CI = 1.08, 1.59). This effect remained significant when demographics, personality, job characteristics and health-related behaviours were included in

the model, with the other significant influences being neuroticism, introversion, high job demands, marital status and being less well educated.

### *Chewing gum and high blood pressure*

Of the non-chewers, 16.2% reported a lifetime incidence of high blood pressure compared with 10.6% of the chewers. This effect was significant (chi square = 12.6,  $p < 0.0001$ ) and was confirmed in the logistic regression analysis which showed that chewers were half as likely as non-chewers to have suffered from high blood pressure (OR = 0.61, CI = 0.49, 0.77). This effect remained significant when demographics, personality, job characteristics and health-related behaviours were included in the model, with the other significant influence being age.

### *Chewing gum and high cholesterol*

Of the non-chewers, 11.1% reported a lifetime incidence of high cholesterol compared with 5.1% of the chewers. This effect was significant (chi square = 22.3,  $p < 0.0001$ ) and was confirmed in the logistic regression analysis which showed that chewers were half as likely to have suffered from high cholesterol as non-chewers (OR = 0.43, CI = 0.33, 0.58). This effect remained significant when demographics, personality, job characteristics and health-related behaviours were included in the model, with the other significant influences being age and being male.

## **Discussion**

Chewing gum was associated with a reduced likelihood of feeling extremely stressed at work, feeling stressed in life generally, being depressed, having high blood pressure and having high cholesterol. Chewing gum was associated with greater exposure to negative characteristics at work, being a neurotic extravert and being more likely to be a smoker. The association between chewing gum and these characteristics may explain why some individuals are more likely to be chewers. For example, neurotic individuals may chew gum to relax and extraverts may chew gum to increase arousal. Changes in relaxation and alertness may also explain the association between chewing and smoking. All of the effects of gum on stress and

health remained significant when these factors were controlled for in the logistic regression models.

The first question one must ask is whether the study is methodologically sound. The main weaknesses of the study can be summarized as follows. First, any cross-sectional study can only identify associations, not cause and effect. Indeed, associations between chewing and stress may be bi-directional. Intervention studies provide a better view of causality and such research examining chewing gum and occupational stress and health is in progress. Most of the measures used in the study are validated instruments that have been used before to study occupational stress and health (see Smith, 2001). One exception was the measure of chewing frequency and future research will aim to quantify how much gum is chewed and the context in which it is chewed (e.g. at work, while driving, at home, etc.). In addition, it is important to ask whether the present effects are reliable. Another study is in progress to examine this and to evaluate the new measure of gum chewing. This new research will allow analysis of thresholds and dose response. The new studies will also recruit the sample in a different way (through collaboration with local organizations) and it will be possible to determine whether effects are observed across a more diverse sample where some of the selection biases seen here (e.g. more females) are eliminated. One of the major strengths of the present studies was controlling for a wide range of possible confounders. Chewing gum was associated with demographic characteristics, personality, smoking and drinking and negative job features. These correlated attributes of chewing gum are of interest in their own right and may provide reasons why some people chew gum and others do not. A second strength of the study was that it considered the 'stress process' and has not only identified reduced stress in gum chewers but a reduced risk of major health problems. In summary, this initial study has provided a clear description of associations between chewing gum and stress.

A second important consideration is whether there are plausible mechanisms that could account for reduced stress in gum chewers. The literature reviewed in the introduction showed that there are a number of plausible mechanisms ranging from peripheral nerve effects through to Central Nervous System (CNS) effects (at the structural and chemical level) that could provide a basis for the effects described here. A detailed investigation

of these potential mechanisms is also now high on the research agenda.

Finally, one must ask whether the results are of practical importance. Again, the literature reviewed in the introduction showed that stress is common and widespread. While stress is often thought of in terms of reduced quality of life, the long-term health consequences can be life threatening. Stress clearly needs to be prevented and managed in a number of different ways (as do high blood pressure/cholesterol). Chewing gum may be a readily available (and relatively cheap) method of addressing these issues. The results of the present study suggest that further research on this topic is warranted.

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#### References

- Baker, J.R., Bezance, J.B., Zellaby, E., & Aggleton, J.P. (2004). Chewing gum can produce context-dependent effects upon memory. *Appetite*, 43(2), 207–210.
- Cohen, S., Tyrrell, D.A.J., & Smith, A.P. (1991). Psychological stress in humans and susceptibility to the common cold. *New England Journal of Medicine*, 325, 606–612.
- FRC Research Corporation (2006). *Impact of chewing gum on consumers' stress levels*. New York: FRC.
- Goldberg, L.R. (1990). An alternative description of personality: The big-five factor structure. *Journal of Personality and Social Psychology*, 59, 1216–1229.
- Health and Safety Executive (2008). *Self-reported work-related illness and workplace injuries in 2006/07: Results from the Labour Force Survey*. Office of National Statistics: Newport.
- Hirano, Y., Obata, T., Kashikura, K., Nonaka, H., Tachibana, A., Ikehira, H., & Onozuka, M. (2008). Effects of chewing in working memory processing. *Neuroscience Letters*, 436, 189–192.
- Hollingworth, H. (1939). Chewing as a technique of relaxation. *Science*, 90, 385–387.
- Johnson, A.J., & Miles, C. (2007). Evidence against memorial facilitation and context-dependent memory effects through the chewing of gum. *Appetite*, 48, 394–396.
- Mark, G.M., & Smith, A.P. (2008). Stress models: A review and suggested new direction. Vol 3. *EA-OHP Series*, Edited by J. Houdmont & S. Leka. Nottingham University Press, 111–144.
- Masumoto, Y., Morinushi, T., Kawasaki, H., Ogura, T., & Takigawa, M. (1999). Effects of three principal constituents in chewing gum on electroencephalographic activity. *Psychiatry Clinical Neuroscience*, 53, 17–23.
- Mohri, Y., Fumoto, M., Sato-Suzuki, I., Umino, M., & Arita, H. (2005). Prolonged rhythmic gum chewing suppresses nociceptive response via serotonergic descending inhibitory pathways in humans. *Pain*, 118, 35–42.
- Momose, I., Nishikawa, J., Watanabe, T., Sasaki, Y., Senda, M., Kubota, K., Sata, Y., Funakoshi, M., & Minakuchi, S. (1997). Effect of mastication on regional cerebral blood flow in humans examined by positron-emission tomography with 150-labelled water and magnetic resonance imaging. *Archives of Oral Biology*, 42, 57–61.
- Morinushi, T., Masumoto, Y., Kawasaki, H., & Takigawa, M. (2000). Effect on electroencephalogram of chewing flavored gum. 2000. *Psychiatry Clinical Neuroscience*, 54, 645–651.
- Onozuka, M., Fujita, M., Watanabe, K., Hirano, Y., Niwa, M., Nishiyama, K., & Saito, S. (2002). Mapping brain region activity during chewing: A functional magnetic resonance imaging study. *Journal of Dental Research*, 81, 743–746.
- Princeton Review and Wrigley. (2005). *Study habits survey*. Princeton Review. New York.
- Scholey, A., Haskell, C., Robertson, B., Kennedy, D., Milne, A., & Wetherell, M. (2009). Chewing gum alleviates negative affect and reduces cortisol during acute laboratory psychological stress. *Physiology & Behavior*, 97, 304–312.
- Shiba, Y., Nitta, E., Hirono, C., Sugita, M., & Iwasa, Y. (2002). Evaluation of mastication-induced change in sympatho-vagal balance through spectral analysis of heart rate variability. *Journal of Oral Rehabilitation*, 29, 956–960.
- Smith, A. (in press). Effects of chewing gum on cognitive function, mood and physiology in stressed and non-stressed volunteers. *Nutritional Neuroscience*.
- Smith, A.P. (2000). The scale of perceived occupational stress. *Occupational Medicine*, 50, 294–298.
- Smith, A.P. (2001). Perceptions of stress at work. *Human Resource Management Journal*, 11, 74–86.
- Smith, A.P. (2009a). Effects of caffeine in chewing gum on mood and attention. *Human Psychopharmacology: Clinical and Experimental*, 24, 239–247.
- Smith, A.P. (2009b). Effects of chewing gum on mood, learning, memory and performance of an intelligence task. *Nutritional Neuroscience*, 12, 81–88.
- Takada, T., & Miyamoto, T. (2004). A fronto-parietal network for chewing of gum: A study on human subjects with functional magnetic resonance imaging. *Neuroscience Letters*, 360, 137–140.
- Tucha, O., Mecklinger, L., Maier, K., Hammerl, M., & Lange, K.W. (2004). Chewing gum differentially affects aspects of attention in healthy subjects. *Appetite*, 42(3), 327–329.
- Wilkinson, L., Scholey, A., & Wesnes, K. (2002). Chewing gum selectively improves aspects of memory in healthy volunteers. *Appetite*, 38(3), 235–236.
- Yagyu, T., Kondakor, I., Kochi, K., Koenig, T., Lehmann, D., Kinoshita, T., Hirota, T., & Yagyu, T. (1998). Smell and taste of chewing gum affect frequency domain EEG source localizations. *International Journal of Neuroscience*, 93, 205–216.
- Yagyu, T., Wackermann, J., Kinoshita, T., Hirota, T., Kochi, K., Kondakor, I., Koenig, T., & Lehmann, D. (1997). Chewing-gum flavor affects measures of global complexity of multi-channel EEG. *Neuropsychobiology*, 35, 46–50.
- Zigmond, A.S., & Snaith, R.P. (1983). The Hospital Anxiety and Depression Scale. *Acta Psychiatrica Scandinavica*, 67, 361–370.