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Research report

Herbal-caffeinated chewing gum, but not bubble gum, improves aspects of memory☆

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ABSTRACT

Research has shown that standard chewing gum can affect aspects of both attention and memory. The present study examined the effects of Think Gum®, a caffeinated-herbal chewing gum, on both concentration and memory using a series of paper-based and online testing. Compared to standard chewing gum and a no-gum control, chewing caffeinated-herbal gum during testing improved aspects of memory, but did not affect concentration. The findings suggest that caffeinated-herbal chewing gum is an effective memory aid.

Introduction

Anecdotal evidence suggests that chewing gum may improve cognitive function. In fact, the first study published on the topic by Wilkinson, Scholey, and Wesnes (2002) showed that chewing gum could improve both short-term and long-term word recall. However, this discovery was met with skepticism, and subsequent studies have since cast doubt on the robustness of the original findings (Miles & Johnson, 2007; Overman, Sun, Golding, & Prevost, 2009). While most researchers in the field would agree that chewing gum has some impact on cognition, it is still unclear exactly how and why this effect happens and which aspects of cognition are affected.

Chewing gum's use as a cognitive enhancer has been studied extensively. However, several different mechanisms have been cited as reasons for enhanced cognitive function. Researchers have shown that the act of chewing gum increases heart rate, blood flow to the brain and prefrontal cortex activation, all of which are associated with improved cognitive function (Hasegawa, Ono, Hori, & Nokubi, 2007; Onozuka et al., 2002; Wilkinson et al., 2002). Following this view, chewing gum enhances cognition via enhanced glucose and oxygen transport to regions of the brain like the fronto-temporal regions that are known to play a role in memory (Sesay, Tanaka, Ueno, Lecaroz, & De Beaufort, 2000). Other researchers have shown that the improved memory seen with chewing gum is in part due to context-dependent memory, i.e. the idea that information can more readily be recalled if the environment is similar to the environment experienced while learning (Baker, Bezance, Zelaby, & Aggleton, 2004). And others have suggested that the smell of the chewing gum itself might be playing a role, since it is known that aroma can modulate cognitive performance and serve as a context-dependent cue (Moss, Hewitt, Moss, & Wesnes, 2008; Schab, 1990). Following these views, chewing gum serves as a cognitive reminder when chewed during encoding and recall, thus enhancing memory. While much has been elucidated about how chewing gum affects cognition, the general public simply wants to know whether chewing gum can be used as a cognitive enhancer, and if so, for what types of tasks.

The desire to improve cognitive performance might be best exemplified by the presence of a coffee shop on every block and a coffee pot in every office. Caffeine, the active ingredient in coffee and tea, has been shown in multiple studies to improve performance and reaction time in fatigued subjects (Nehlig, 2010). As such, considerable interest has been shown in caffeinated

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gum, which might be able to combine some of the beneficial effects seen in some of the aforementioned studies on chewing gum and the well-appreciated boost that caffeine provides. It has been shown that caffeine enters the blood stream faster via buccal absorption (chewing gum) than via other routes of ingestion (caffeine pills) and that chewers of caffeinated gum report better performance and mood compared to chewers of regular chewing gum (Kamimoi et al., 2002; Smith, 2009). The US army has even gone so far as to recommend the use of caffeinated gum in army rations (Committee on Military Nutrition Research, 2002).

But the army is not the only group looking for an advantage. Students, and even professors, have begun using dietary supplements and prescription drugs such as methylphenidate (Ritalin®) and modafinil (Provigil®) to maximize the cognitive aptitudes. In fact, an informal study performed by Maher (2008) of 1400 people showed that "one in five respondents said they had used drugs for non-medical reasons to stimulate their focus, concentration or memory." While these prescription drugs have been clearly shown to improve cognition, they have not been rigorously tested for safety or approved by the FDA for off-label use (Repantis, Schlattmann, Laisney, & Heuser, 2010; Turner et al., 2003). On the other hand, naturally occurring dietary supplements meant to improve cognitive performance, such as Hyperzine A, phosphatidylserine and ginseng, are "generally recognized as safe" by the FDA, but have only limited data to support their efficacy.

Decades of research have shown that stimulating aroma, compounds such as caffeine, enhanced blood-flow to the brain, and context-dependent learning and recall can all contribute to improved concentration and memory. Think Gum®, a chewing gum infused with caffeine and herbal supplements chosen because they have been associated with improved cognitive function, was developed with these previous studies in mind. The strongly scented peppermint and rosemary flavored gum contains 20 mg of caffeine per serving. It also contains vinpocetine, a phosphodiesterase type-1 inhibitor, and ginkgo biloba, which have been shown to improve cerebral blood flow along with Bacopa monniera, a supplement that has been shown to improve learning rate in healthy human subjects as well as memory in a double-blind placebo-controlled study (Hagiwara, Endo, & Hidaka, 1984; Mashayekh et al., 2010; Morgan & Stevens, 2010; Stough et al., 2001; Vas & Gulyás, 2005). This study aimed to investigate whether Think Gum® could out-perform bubble gum or no gum in a series of paper-based and online tests measuring memory and concentration.

Methods

Sixty-two members of the Stanford University community participated in the study. Each participant was compensated $15 for his or her time and a $75 motivational bonus was awarded to the participant who received the highest cumulative score.

Prior to beginning the study, all participants signed an experimental consent form that stated they could opt out of the experiment at any time for any reason without penalty. They also filled out background questionnaires.

Participants were randomly divided into one of three groups: control group ($n = 22$), bubble gum group ($n = 20$) or herbal-caffeinated gum group ($n = 20$). The study was not blinded, meaning the participants were aware of the group to which they were assigned as well as the ingredients in the gum they were about to consume. However, no explicit claims were made about the ability or lack of ability of any gum to affect aspects of concentration or memory. The control group did not chew any gum during testing. The bubble gum group members chewed 1 serving of bubble gum (Trident®, Bubblegum flavored sugar-free, Cadbury-Adams USA LLC) for the duration of the first and second part of the study. The herbal-caffeinated gum group members chewed 1 serving of Think Gum® for the duration of the first and second part of the study (Think Gum® herbal-caffeinated sugar-free gum, Think Gum LLC). A serving of Think Gum contains 20 mg caffeine from guarana, along with ginkgo biloba, Bacopa monniera, vinpocetine, peppermint and rosemary.

Participants were instructed to begin chewing their chewing gum immediately prior to testing and to keep chewing it throughout the duration of testing. Each participant took three concentration tests, two shorter-term memory tests and two long-term memory tests along with post-testing questionnaires. The tests were given in the following order: reading comprehension, digit substitution, memorizing random words, number matrices and finally memorizing first names. The long-term memory testing took place 24 h after the initial test via the Internet. Participants chewed the same type of chewing gum as they initially received for 15 min prior to taking the 24-h follow up tests, and continued to chew it while they completed testing.

Data was compared using an ANOVA with p-values <0.05 deemed statistically significant. Data was fit to a mixed-effects repeated-measures ANOVA model with a random intercept for *task* (Baayen, Davidson, & Bates, 2008). The advantage of this model is that it can compare the effect of group (bubble gum, herbal-caffeinated gum or no gum) across multiple tests (i.e. tasks with different means and standard deviations). All *T*-tests preformed on the data were planned when determining the experimental design.

Concentration tests

Reading comprehension: Participants were given 10 min to answer 8 reading comprehension questions. The questions were in the format and difficulty of the Standardized Aptitude Test (SAT®).

Digit substitution: Participants were given 90 s to substitute as many symbols as possible using a key. The key showed each symbol and its equivalent 1–9 numerical digit. This test is a good measure of concentration as it requires little intellectual ability, but does require sustained attention (Wechsler, 1981).

Number matrices: Participants were given 9 matrices. Each matrix contained 12 numbers. Two and only two of the numbers summed exactly to 10 (example: 3.22 and 6.78). They were given 3 min to determine which two numbers summed to 10 in as many matrices as possible.

Shorter-term memory tests

Memorizing random words: Participants were provided with a list of 15 random 6-letter nouns that were tested for concreteness and imagery and had been used previously in a similar study (Baker et al., 2004; Paivio, Yuille, & Madigan, 1968). They studied the words for 2 min. Afterwards, the list was taken away and they did the Digit Substitution test. Approximately 2 min after the list was taken away they were given 2 min to write down as many of the original words as possible.

Memorizing first names: Participants were given a list of 15 full names, first and last. They had 2 min to study the names before the list was taken away. Immediately afterward, they were provided a list of just the last names, in a different order and were asked to recall as many corresponding first names as possible in 2 min.

Long-term memory tests

Memorizing random words: 24 h after learning the random words, participants were asked to recall as many of the random words as possible.

Memorizing first names: 24 h after learning the first names, participants were provided with the last names as initially studied and asked to recall as many first names a possible.