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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.

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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 performed 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 as possible.

Participant background

Background information was collected on all participants to ensure groups were similar in age, sleep and caffeine consumption, which can all impact performance (Killgore, 2010; Park et al., 2002). We also asked the participants to assess their own test taking ability, to ensure that the 3 groups contained people who had similar aptitudes. The three groups were similar, with no significant differences observed.

	No-gum control	Bubble gum	Herbal-caffeinated gum
Number of participants	22	20	20
Mean age (years)	23.65	24.32	24.86
Male/female	13M/9F	10M/10F	8M/12F
Mean previous night sleep (h)	6.62	7.48	7.21
Caffeine intake during last 24? (Yes/No)	6Y/14N	7Y/13N	5Y/15N
Test taking ability, self assessment (average) (1 = very poor, 10 = excellent)	5.95	6.67	6.87

Results

Concentration

The question of whether chewing bubble gum or herbal-caffeinated gum can improve concentration was investigated by comparing the various groups that took each of the tests via an ANOVA (Fig. 1). The data show that neither herbal-caffeinated gum nor bubble gum was able to improve concentration in the reading comprehension ($p = 0.554$), digit substitution ($p = 0.924$), or number matrices ($p = 0.837$) tests, which were used to quantify concentration. Taken as a whole, the normalized and combined data show no significant difference in any of the groups with regard to ability to concentrate ($p = 0.954$).

Shorter-term memory

The question of whether chewing bubble gum or herbal-caffeinated gum can improve shorter-term memory was investigated by comparing the 2-min word recall and the immediate name recall tests using an ANOVA (Fig. 2).

Chewing herbal-caffeinated gum improved the number of correct answers in the 2-min word recall test by 6.5% (+0.76 correct responses) compared to bubble gum and by 7.6% (+0.88 correct responses) in the no-gum group. The bubble gum group was only marginally better 1.0% (+0.12) than the no-gum group. Chewing herbal-caffeinated gum improved the number of correct answers in the immediate name recall test by 32.87% (+2.38 correct responses) compared to bubble gum and by 30.71% (+2.26 correct responses) in the no-gum group. The bubble gum group was marginally worse 1.7% (−0.12) than the no-gum group. These differences are meaningful as herbal-caffeinated gum improved immediate name recall ($p = 0.053$) but not with 2-min word recall ($p = 0.459$). By normalizing just the shorter-acting data and comparing with an ANOVA, it can be seen that herbal-caffeinated gum improved performance on these tests ($p = 0.027$).

Long-term memory

The question of whether chewing bubble gum or herbal-caffeinated gum can improve long-term information recall was investigated by having the participants chew the same type of gum they chewed during the initial testing. Twenty-four hours after the initial testing, participants were instructed to consume the same

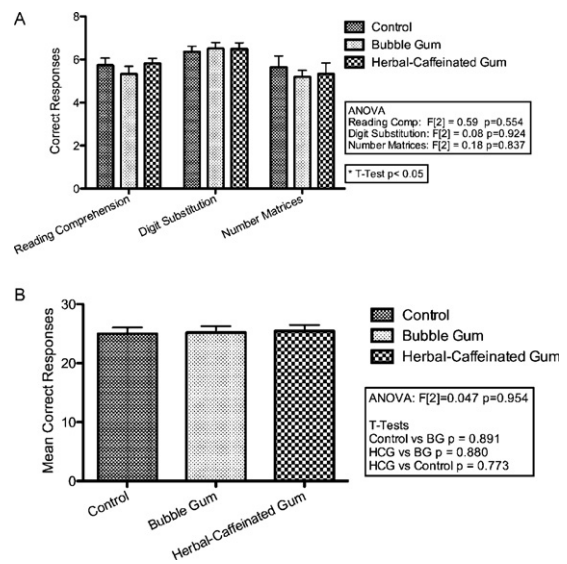


Fig. 1. Chewing gum has no affect on concentration. Participants were given a battery of tests to measure their ability to concentrate. The maximum possible score on the reading comprehension was 8. The maximum possible score on the digit substitution test was 95 (scores shown are $\times 0.10$). The maximum possible score on the number matrices was 9. (A) Shown is the mean and SEM for each concentration test. (B) The concentration data were averaged across all three concentration tests. Error bars reflect SEM.

type of gum while they engaged in the same word recall and name recall test that they took in the first session via the Internet (Fig. 2).

The results show that chewing herbal-caffeinated gum improved the number of correct answers in the long-term word recall test by 25.4% (+2.32 correct responses) compared to bubble gum and by 31.9% (+2.77 correct responses) in the no-gum group. The bubble gum group was 5.2% (+0.45) better than the no-gum group. Chewing herbal-caffeinated gum improved the number of correct answers in the long-term name recall test by 53.2% (+2.16 correct responses) compared to bubble gum and by 31.8% (+1.50 correct responses) in the no-gum group. The bubble gum group was slightly worse 14.0% (−0.66) than the control group. An ANOVA that compared performance in the three groups indicated that herbal-caffeinated gum marginally improved long-term name recall ($p = 0.073$) and significantly improved long-term word recall ($p = 0.048$). When looking at the long-term data overall, participants in the herbal-caffeinated group had significantly improved long-term memory ($p = 0.004$).

As expected, all groups in all long-term tests scored lower than their corresponding shorter-term groups. However, those participants chewing herbal-caffeinated gum retained more information, forgetting just 7.9% (−0.99 words) over 24 h while the bubble gum group forgot 21.85% (−2.55 words), and the control group forgot 24.94% (−2.88 words). A similar trend was seen in the name recall data.

By normalizing shorter-term and long-term memory data, and collapsing across tasks, it is clear that those participants in the herbal-caffeinated group were able to recall significantly more information than the control group or bubble gum group ($p < 0.0001$) (Fig. 2B).

Self-assessment

After finishing the first day of testing, participants were asked to assess their alertness, ability to concentrate and self-perception of performance on the exam (Fig. 3). Three ANOVAs confirmed the differences among the groups across alertness ($p = 0.022$), concentration ($p = 0.009$) and performance ($p = 0.016$). Planned

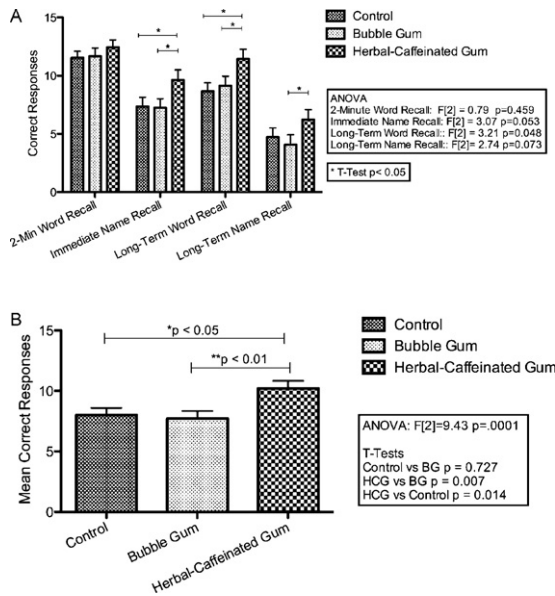


Fig. 2. Chewing herbal-caffeinated chewing gum improves memory. Participants memorized a list of 15 random nouns in the word recall test or 15 first names and their corresponding last names in the name recall test. They were asked to recall the information either just after learning it (2 min later in the 2-min word recall, and immediately after learning it in the immediate name recall) or 24 h later in the long-term recall tests. (A) Shown is the mean and SEM for each memory test. (B) The memory data were averaged across all four memory tests. Error bars reflect SEM.

comparisons between groups indicate that in each case, these differences held between the herbal-caffeinated gum group and each of the two control groups, but not between the two control groups. Taken as a whole, those in the herbal-caffeinated gum group had an extremely significant improvement in their mood when compared to the other groups ($p < 0.00001$).

Discussion

In this study, it was shown that chewing herbal-caffeinated gum improved performance in both shorter-term and long-term memory tests but had no effect on ability to concentrate. Additionally, participants in the herbal-caffeinated gum group had a significantly better self-assessment; they had a heightened level of alertness, an increased ability to concentrate and a belief that their performance was enhanced.

It is interesting that those participants in the caffeinated herbal gum group felt improved concentration when filling out the post exam survey, but scored the same as the other groups on the battery of concentration tests. This observation may be explained by a recent publication by Tucha and Simpson (2010) who investigated the affect of chewing gum on sustained attention over time. They found that chewing gum had detrimental effects initially, but significantly improved attention at later time points. Because the concentration tests in this study were done before the self-assessment, this might explain this non-intuitive observation. One might argue that perceived concentration is relatively unimportant compared to an actual improvement in concentration. However, studies have shown that both are important as positive moods have been shown to improve cognitive flexibility and should lead to better overall performance (Nadler, Rabi, & Minda, 2010).

The fact that neither herbal-caffeinated chewing gum nor bubble gum was able to significantly improve concentration was not surprising given that other studies have reported similar findings (Tucha, Mecklinger, Maier, Hammerl, & Lange, 2004). One might hypothesize that the caffeine in the herbal chewing gum

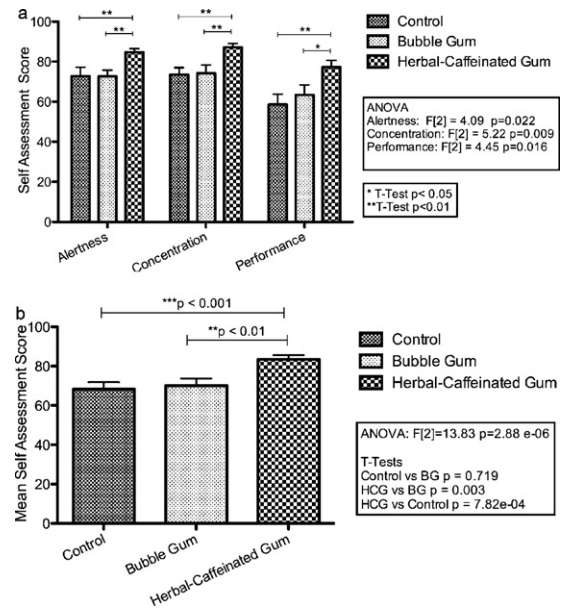


Fig. 3. Herbal-caffeinated gum enhanced perceived alertness, concentration and performance. After the initial testing, participants filled out a questionnaire asking them to assess their alertness, concentration and performance on a 1–100 scale with 100 being the most focused. (A) Shown is the mean and SEM for each memory test. (B) The memory data were averaged across all 3 measures. Error bars reflect SEM.

would be enough to enhance concentration on its own, as past studies with gum containing 40 mg of caffeine showed a significant increase in concentration in sleep-deprived individuals (Smith, 2009). However, the participants in this study only consumed 20 mg of caffeine and were relatively well rested, averaging over 7 h of sleep the previous night. As such, this relatively small amount of caffeine might not have been enough to impact the performance of the group, even though it did impact their perception of alertness and concentration (Fig. 3).

Although regular bubble gum did not improve concentration, bubble-gum chewers did see a small but non-significant bump in shorter-term and long-term word recall (Fig. 2). These data are in line with, but call into question, the robustness of the original Wilkinson et al. (2002) finding that chewing gum improves word recall. The key difference between this current study and the Wilkinson et al. study was that the gum used here was sugar-free bubble-gum-flavored gum rather than sugar-free spearmint-flavored gum. It has been documented that mint aroma can increase alertness (Moss et al., 2008). Because aroma and flavor were not controlled for in most other studies, it is not possible to determine if the observed memory improvement was due to the chewing gum or the mint aroma.

The magnitude of memory improvement in the herbal-caffeinated gum group compared to the no-gum control or bubble gum groups was substantial. Those participants chewing herbal-caffeinated gum improved their word recall by over 25% in the long-term word recall study and by over 30% in the long-term name recall study. Taken as a whole, their retention was greatly enhanced compared to both the bubble gum and control groups.

The question of why such a dramatic difference was seen between the herbal-caffeinated gum group and the bubble gum group can be explained by any number of factors including the gum's aroma, herbal ingredients, caffeine or enhanced context-dependent memory. These factors need to be further studied to elucidate how chewing gum can best be used as a memory aid. Because the herbal-caffeinated gum used in this study was new to the participants, they had no preconceived associations. In

contrast, the bubble gum group was given a well-known brand of chewing gum and it is likely that participants had chewed this particular flavor multiple times. Thus, it is probable that the participants had previous memories and associations tied in with the bubble gum flavor which might inhibit context-dependent encoding and recall. This idea is supported by research showing that novel odors are better in eliciting context-dependent memory effects (Herz, 1997). It is therefore likely that the context-dependent encoding and recall was better with this novel herbal-caffeinated gum than with standard bubble gum.

Regardless of the reasons why, it is clear that herbal-caffeinated gum enhanced information recall and improved the retention rate of learned material in these paper-based memory tests. One would predict that chewing herbal-caffeinated gum would also improve information recall in real-world situations, such as during standardized testing, and would therefore be a beneficial study aid.

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