

Brief Communication

Chewing gum can produce context-dependent effects upon memory

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Received 17 May 2004; accepted 11 June 2004

Abstract

Two experiments examined whether chewing spearmint gum can affect the initial learning or subsequent recall of a word list. Comparing those participants in Experiment 1 who chewed gum at the learning or the recall phases showed that chewing gum at initial learning was associated with superior recall. In addition, chewing gum led to context-dependent effects as a switch between gum and no gum (or no gum and gum) between learning and recall led to poorer performance. Experiment 2 provided evidence that sucking gum was sufficient to induce some of the same effects as chewing.

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Keywords: Chewing gum; Context-dependent effects; Memory

Introduction

There is a general belief that chewing gum can aid concentration and, thereby, influence cognition. This belief remained essentially untested until [Wilkinson, Scholey, and Wesnes \(2002\)](#) recently showed that chewing gum could lead to improved performance on tests of immediate and delayed recall of words. In addition, chewing gum appeared to improve both spatial and numeric working memory ([Wilkinson et al.](#)). This information may be of considerable practical relevance given that chewing gum is used worldwide, with the US having the highest consumption. An indication of the prevalence of gum chewing in the US comes from a survey of 584 university students, of which 87% reported that they chewed gum at least occasionally ([Britt, Collins, & Cohen, 1999](#)).

It is not yet known why chewing gum might enhance performance on some memory tasks. As [Wilkinson et al. \(2002\)](#) found no direct support for the view that chewing gum aids concentration they suggested other possible mechanisms, including an indirect effect of insulin release

or changes in brain blood flow brought about by mastication. Another means by which chewing gum could affect memory is if it is sufficient to induce context-dependent effects. These effects were not examined by [Wilkinson et al.](#) as all participants chewed gum throughout the battery of memory tasks, i.e. at encoding and retrieval. It has long been known that an item can be more readily recalled if the environment at recall is similar to the environment while learning ([Godden & Baddeley, 1975](#); [Tulving & Thompson, 1973](#)). While the term environment can refer to physiological states ('state dependent learning'), it can also refer to other forms of context. Given that smells are sufficient to induce context-dependent effects ([Aggleton & Waskett, 1999](#); [Chu & Downes, 2000](#); [Schab, 1990](#)) it is quite plausible that tastes are able to do the same. If chewing gum can invoke context-dependent effects it is predicted that chewing gum at both learning and recall will produce superior performance to chewing gum only at learning or only at recall (Experiment 1). This experiment also provided the opportunity to test the reliability of the reported enhancement in word recall ([Wilkinson et al.](#)). A second experiment investigated whether the taste of the gum, without the associated chewing, is sufficient to produce any effects upon memory (Experiment 2).

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Experiment 1: chewing gum as a context change

Methods

Participants comprised an opportunity sample of 83 undergraduates from Cardiff University (57 females), with an age range from 18 to 46 years (mean 24). Participants were randomly assigned to one of four conditions, which refer to whether they were asked to chew gum (or not) at the time of learning or at the time of recall: gum (learning)–gum (recall) ($n=23$), gum–no gum ($n=20$), no gum–gum ($n=20$), and no gum–no gum ($n=20$). In all gum conditions participants were given Wrigley's Extra spearmint chewing gum, sugar free (Wm. Wrigley Jr. Company, Chicago, IL).

All participants were tested individually on their ability to learn a list of 15 words printed on a single sheet of paper. Participants were told that they had 2 min to learn as many of the words as possible. Recall was tested at the end of the 2 min and again 24 h later. The 15 words were matched for concreteness and imagery (Paivio, Yuille, & Madigan, 1968). Participants in the conditions where gum chewing occurred during learning (gum–gum, gum–no gum) were given the gum to chew prior to receiving the word list. Participants in the no gum–gum condition were given gum to chew immediately after the 2 min learning period, and asked to chew throughout the recall period. Participants were told in advance whether they would have to remove gum (gum–no gum group) or start to chew gum (no gum–gum) immediately after initial learning. Those participants in the gum at recall groups (gum–gum, and no gum–gum) were again given gum to chew 24 h later, immediately prior to recall. All participants were given 2 min to write down as many of the 15 words that they could remember.

Results

Fig. 1 shows the mean scores for the four conditions for the two retention intervals. The first question (can chewing

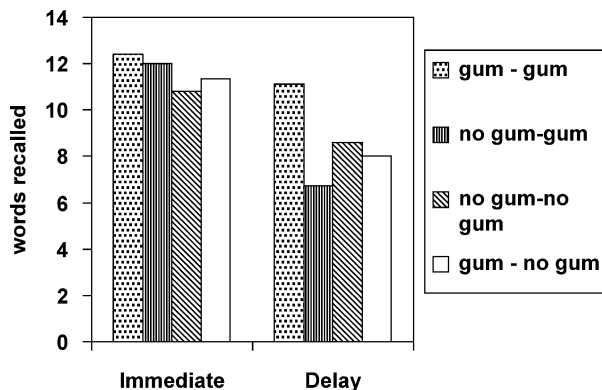


Fig. 1. Experiment 1. Mean number of words recalled (maximum 15) after no retention interval ('Immediate') or after 24 h ('Delay'). Participants in two of the four groups chewed gum at initial learning (gum–gum, gum–no gum), and two of the groups chewed gum during both of the recall tests (gum–gum, no gum–gum).

gum induce context-dependent effects?) was tested by comparing the scores of the two context change groups (gum–no gum, no gum–gum) with the scores of the two consistent groups (gum–gum, no gum–no gum). An ANOVA using data from both recall tests showed that the consistent groups had significantly higher recall scores $F(1,81)=5.96$, $p=0.017$. This comparison also revealed a highly significant group by retention interval interaction, $F(1,81)=29.2$, $p<0.0001$, reflecting the steeper decline in performance in the two inconsistent groups. Analysis of the simple effects (Winer, 1971) showed that there was a group difference at the 24 h delay, $F(1,114)=20.04$, $p<0.001$, but not at immediate recall $F<1$.

The second question (can chewing gum enhance initial learning?) can be considered by comparing the two groups that chewed gum at initial learning ($n=43$) with the two groups that did not ($n=40$). An ANOVA using data from both recall sessions found higher scores for those chewing gum at encoding, $F(1,81)=5.72$, $p=0.019$, as well as a significant interaction with recall session, $F(1,81)=7.73$, $p=0.0068$. This interaction reflected the lack of a group difference for immediate recall $F<1$, which contrasted with a clear difference after 24 h, $F(1,121)=11.5$, $p=0.001$.

Evidence that chewing gum can aid learning was still found when the comparisons were restricted to conditions matched for whether there was or was not a context shift. For the constant context groups, the gum–gum group had higher overall scores than the no gum–no gum group $F(1,41)=7.25$, $p=0.010$. There was a clear superiority for the gum–gum group at the 24 h delay, $F(1,54)=9.36$, $p=0.003$, but a less marked difference for the immediate condition $F(1,54)=3.70$, $p=0.06$. While there was no overall difference between the gum–no gum and no gum–gum conditions ($F<1$), there was a group by delay interaction, $F(1,38)=7.96$, $p=0.0076$. This interaction (Fig. 1) reflected the flatter decline in performance of the group that had gum at encoding (gum–no gum).

Experiment 2: chewing gum versus sucking gum

The results from Experiment 1 strongly suggest that chewing gum cannot only promote initial learning but can also lead to context-dependent effects. The goal of Experiment 2 was to determine if the cues promoting these memory effects were from the taste of the gum or the action of chewing.

Methods

Participants comprised an opportunity sample of 48 undergraduates from Cardiff University (31 females), with an age range from 19 to 28 years (mean 22). Participants were randomly assigned to one of four conditions: gum–gum ($n=13$), suck–suck ($n=11$), no gum–gum ($n=12$), no gum–suck ($n=12$). The gum–gum and no gum–gum

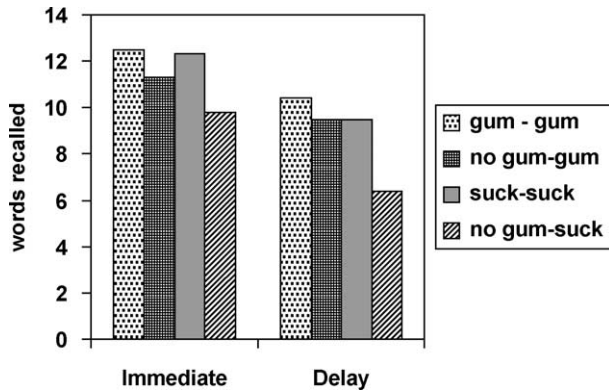


Fig. 2. Experiment 2. Mean number of words recalled (maximum 15) after no retention interval ('Immediate') or after 24 h ('Delay'). Participants in the four groups were tested on both retention conditions. Participants in the gum–gum and suck–suck groups chewed (or sucked) gum at initial learning and during all retention tests. Participants in the no gum–gum and no suck–suck groups were given gum immediately before recall.

conditions were identical to the corresponding conditions in Experiment 1. Participants in the 'suck' conditions were asked to suck, but not chew, the gum (Wrigley's Extra spearmint, sugar free). The rest of the procedure was identical to Experiment 1 as participants were asked to learn the same list of 15 words, and recall was then tested immediately and after a 24 h delay.

Results

The scores of the four groups over the two delays (Fig. 2) were compared in a mixed ANOVA with four groups and two retention delays. There was an overall group difference $F(3,44)=5.26$, $p=0.0035$ but no interaction $F<1$. Newman–Keuls tests showed that the scores of both the gum–gum group ($p<0.01$) and the scores of the suck–suck group ($p<0.05$) were higher than those of the no gum–suck group. There were no other differences.

Discussion

The results of the two experiments support three conclusions. The first is that chewing gum can aid learning. Evidence for better learning came from the superior performance of the gum at encoding groups over their no gum counterparts in Experiment 1. This difference was most evident at the 24 h recall test. These results support the finding of Wilkinson et al. (2002) for word list learning. The second conclusion is that chewing gum can lead to context-dependent effects so that recall is hampered when there is a change in context. The third is that sucking gum can have some of the same effects as chewing gum.

Evidence for a context-dependent effect came from the highly significant difference between the consistent and inconsistent groups. This was clearest after 24 h. One possibility is that the context shift effect was an artefact due

to the additional disruption of removing gum or starting to chew gum immediately before the first recall. Such an explanation would not, however, account for the lack of a group difference in Experiment 1 at immediate recall (when any such disruptive effects might be expected to be greatest) yet there was a large group difference after 24 h (when there was no difference in immediate disruption).

While previous experiments have shown that olfactory cues can induce context-dependent effects on recall (Aggleton & Waskett, 1999; Chu & Downes, 2000; Schab, 1990), there do not appear to be equivalent experiments for taste even though one of the most famous anecdotal examples of context aided recall concerns the recall of childhood experiences associated with a distinctive taste (Proust, 1922). For this reason the second experiment explored the effects of sucking as opposed to chewing gum. The significant difference between the suck–suck group and the no gum–suck group supports the conclusion that sucking gum can alter memory, as does the lack of a difference between the gum–gum and the suck–suck groups. It cannot, however, be determined whether these results reflect a context-dependent effect or enhanced initial learning when sucking gum. Irrespective of this, the results indicate that mastication is not necessary to alter memory. This conclusion is consistent with Wilkinson et al. (2002) who found that word recall was significantly better in the gum group than in a 'sham chewing' control group. In their sham chewing group the subjects were asked to mimic the action of chewing but had no gum, and so aspects such as the texture of the gum could not be incorporated. For these reasons, any future research into the nature of the memory enhancement effect with chewing gum should consider including a group that chews flavourless gum.

Perhaps the most interesting, and practical, question is why chewing gum can affect memory. While context-dependent effects appear to be a part of the answer, they are not a sufficient explanation. The finding that chewing gum can aid some working memory tasks (Wilkinson et al., 2002) does not, for example, fit a context shift account. Likewise in the present study, the superior performance when gum was present at the original learning, irrespective of whether there was a context shift, indicates an effect upon encoding. This interpretation would be consistent with the general belief that chewing gum may aid concentration, even though the lack of an effect of chewing gum on vigilance tasks (Wilkinson et al., 2004) was taken as evidence against such an effect. This leaves the possibility that vigilance tasks are either insensitive measures or do not capture the appropriate dimension of attention that is aided by chewing gum.

Acknowledgements

The authors would like to thank the generous assistance of Dr A. Scholey.

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