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Appetite 48 (2007) 154–158
Appetite
www.elsevier.com/locate/appet

Research report

Chewing gum and context-dependent memory effects: A re-examination

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Received 6 July 2006; accepted 24 July 2006

Abstract

Two experiments re-examined whether chewing spearmint gum affects initial word learning and/or immediate recall for a word list. Both experiments failed to show effects of chewing gum at learning or recall, nor did they suggest that chewing gum produces a context-dependent memory effect. This was true when extraneous contextual cues at learning and recall were minimised (Experiment 2). Together, the data are inconsistent with [Wilkinson, L., Scholey, A. & Wesnes, K. (2002). Chewing gum selectively improves aspects of memory in healthy volunteers. *Appetite*, *38*, 235–236.] claim that chewing gum aids immediate recall of visually presented words. Our results are consistent with [Baker, J. R., Bezance, J. B., Zellaby, E. & Aggleton, J. P. (2004). Chewing gum can produce context-dependent effects upon memory. *Appetite, 43*, 207–210.] finding that chewing gum of itself is not a sufficient condition to provoke context-dependent learning with immediate testing.

Keywords: Chewing gum; Context-dependent memory

Introduction

That chewing gum may positively influence both immediate and delayed recall of visually presented word lists was first demonstrated by Wilkinson, Scholey, and Wesnes (2002). One explanation (Baker, Bezance, Zellaby, & Aggleton, 2004) proposes that the beneficial memory effects attributed to chewing gum may occur via context-dependent effects. If a participant both learns and recalls information in the same environmental context, or state, then recall is generally superior compared to a condition where the learning and recall contexts/states are different (see e.g., Aggleton & Waskett, 1999; Godden & Baddeley, 1975; Miles & Hardman, 1998; Tulving & Thompson, 1973). Because the Wilkinson et al. (2002) study tested participants whilst chewing gum at both learning and recall, the possibility of a context-dependent result cannot be ruled out. To examine this possibility directly, Baker et al. (2004, Experiment 1) in a between-subjects design required participants to learn and recall a 15 word list both immediately and after a 24 h delay. Their data demonstrated superior recall whilst chewing gum both at learning and in a same-context learn-recall condition for delayed (but not immediate) recall.

In contrast to Baker et al.'s (2004) finding of beneficial learning of word lists whilst chewing gum, Tucha, Mecklinger, Maier, Hammerl, and Lange (2004) failed to find such a benefit for auditorily presented word lists, but rather reported both positive and negative effects of gum chewing on various measures of attention. They argue that these empirical inconsistencies may be due to differences in the design and statistical power of the reported experiments. These issues are of particular importance with reference to the Baker et al. study. That study used a between-subjects design and it is always possible that between-group baseline differences contributed to overall findings. In addition, participants were presented with 15 words printed on a single sheet of paper and given 2 min to learn the words. This method of presentation resulted in very efficient learning: correct recall was approximately 80% at immediate testing. After a 24 h delay correct recall was approximately 50%. It is possible, therefore, that the failure to observe a context-dependent effect at immediate test was due to near ceiling levels of correct recall.

We report two experiments designed to re-examine the emergence of both benefits at learning and

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doi:10.1016/j.appet.2006.07.082

context-dependent memory effects attributable to chewing gum. Both studies differed from that reported by Baker et al. (2004) in two important respects. First, we adopted the more typical within-subjects design in order to rule out base-line differences between groups (see Tucha, Mecklinger, Hammerl, & Lange, 2004). Second, words were presented sequentially at initial learning (Miles & Hardman, 1998) in order to minimise possible artificial inflation of immediate recall scores due the range of strategies that block presentation can encourage.

Experiment 1

Method

Participants: Twenty-four volunteer Cardiff University Psychology undergraduates (21 females, 3 males: mean age = 20 years 11 months) participated. Each received course credit upon completion of the study.

Materials: Four word lists were prepared. Each list comprised 15 disyllabic nouns and lists were matched for frequency, age-of-acquisition, imagery and familiarity (Morrison, Chappell, & Ellis, 1997). Each word was presented on a computer screen for 1 s with an inter-stimulus-interval of 1 s. In all gum chewing conditions participants were provided with Wrigley's Extra Spearmint sugar free chewing gum.

Design: A 2-factor repeated measures design was adopted where the first factor refers to learning condition (chewing gum versus no gum) and the second refers to retrieval condition (chewing gum versus no gum). Order of completion of the four experimental combinations was counterbalanced across participants. Participants received a different word list pair at learning in each of the experimental combinations and presentation of the word list pairs was counterbalanced across experimental combinations. Participants completed the four experimental combinations on one visit to the laboratory and had a 2 min. rest between conditions.

Procedure: Participants were tested individually in a soundproofed laboratory. Upon entering the laboratory the experiment was described to the participants who were each issued with written instructions. For all participants each of the four experimental combinations comprised a learning phase, a 1 min consolidation phase and a 2 min retrieval phase. Following Miles and Hardman (1998) participants viewed the same 15 word list twice with a 5 s interval between presentations during the learning phase. Following the 1 min consolidation phase participants were allowed 2 min to complete a written free-recall task for the presented list.

The four conditions in which each participant was tested are detailed below:

1. No gum-no gum (NgNg): The participant completed all phases of the experiment in the absence of both gum and chewing action.
2. No gum-gum (NgG): The participant completed the learning phase in the absence of both gum and chewing action. At the commencement of the consolidation phase the participant received a piece of gum which was chewed throughout both the consolidation and retrieval phases.
3. Gum-no gum (GNg): The participant received a piece of gum 1 min prior to the learning phase. This was chewed through to completion of the learning phase and removed at the commencement of the consolidation phase. Both the consolidation and retrieval phases were completed in the absence of both gum and chewing action
4. Gum-gum (GG): The participant received a piece of gum 1 min prior to the learning phase. This was chewed through to completion of the learning phase and removed at the start of the consolidation phase. The participant immediately received another piece of gum which was chewed throughout both the consolidation and retrieval phases.

Participants were encouraged to sip water during the 2 min interval between consecutive experimental conditions. We introduced a new piece of gum in the gum-gum condition in order to match the procedures in no gum-gum and gum-no gum conditions. Without the introduction of such (that is, if participants chewed the same piece of gum throughout the gum-gum condition) the contexts effects due to chewing gum would not be reliable across these conditions.

A related methodological point raised during the review process concerns the role of novelty in the experience of chewing gum. Our participants were required to chew gum during the consolidation phase rather than just the acquisition and/or retrieval phases. The introduction of chewing gum prior to recall was not related to consolidation per se but as a methodological control in order to obtain consistency between chewing at learning and chewing at recall. In the gum at learning conditions participants were given a piece of gum and instructed to chew for one minute in silence prior to list commencement (in the no gum at learning conditions participants sat in silence throughout this period). This was introduced so that participants became familiar with chewing and additionally allowed sufficient time for the participant to fully formulate the gum texture/flavour through chewing. If participants were given the list immediately after receiving the gum it is possible that any effect reported may have been governed through the novelty of having the gum, rather than the context of chewing. Since a minute of chewing was introduced prior to list commencement, it was important that a minute of chewing was employed prior to recall in order to control for changes in gum texture/flavour and thereby maintain a consistent context between learning and recall.

The minute of gum chewing introduced prior to both learning and recall is also important in the light of Stephens

and Tunney's (2004b) suggestion that gum chewing familiarity was one of the possible origins of the recall facilitation discrepancies between Tucha, Mecklinger, Hammerl et al. (2004), Tucha, Mecklinger, Maier, Hammerl et al. (2004) and Wilkinson et al. (2002). They argue that the German participants employed by Tucha, Mecklinger, Hammerl, et al. (2004) and Tucha, Mecklinger, Maier, et al. (2004) were less familiar with chewing gum (due to cultural differences) and consequently did not experience cognitive facilitation through chewing gum. The preparatory minute in the current study therefore encouraged familiarity with the act of chewing gum.

Results

The correct recall data were subjected to a 2-factor within-subjects ANOVA with learning (gum versus no gum) and recall (gum versus no gum) as factors. The effects of both learning and recall were non-significant, Fs = 0.33 and 1.7, respectively, as was the interaction, $F = 1.4$ (see Fig. 1).

Discussion

It is unlikely that we failed to show a same-context benefit due to a ceiling effect: overall correct recall was 67%. Furthermore, these data, in line with Baker et al., find no support for a beneficial effect of chewing gum at immediate word learning nor do they suggest that chewing gum can produce context-dependent effects upon memory. There is a caveat to our conclusion. Participants were tested in a laboratory containing a range of visual cues and, in addition, many participants commented on the strong odour cues prevalent in the laboratory (it is typically used for experiments studying learning and memory for odours). It is possible that our null-effect was due to a form of overshadowing (see Smith & Vela, 2001). If a range of environmental cues is present at both learning and recall, then an incidental association can be provoked between the words and the extraneous environmental contextual cues and this may act to overshadow the contextual cues due to chewing gum. In order to rule out this possibility we conducted a further experiment.

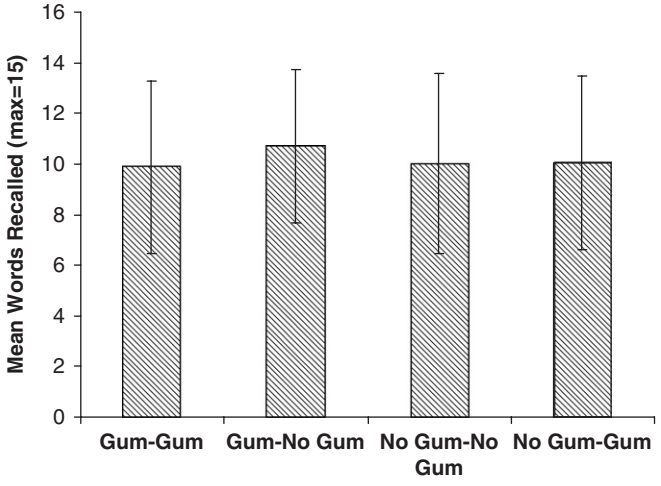

Fig. 1. Mean number of words recalled (maximum 15) after immediate testing for each of the four learning and recall context conditions. The participants chewed gum at both learning and recall (gum-gum), chewed gum at learning but not at recall (gum-no gum), neither chewed gum at learning or recall (no gum-no gum) and did not chew gum at learning but did at recall (no gum-gum). Errors bars denote the standard deviation.

Experiment 2

Method

Participants: Twenty-four volunteer Cardiff University Psychology undergraduates (20 females, 4 males: mean age = 20 years 6 months) participated. Each received course credit upon completion of the study and none had participated in Experiment 1.

Material, Design and Procedure: These were each as described for Experiment 1 with two exceptions: (1) all participants were tested in a dark, odour-free laboratory where the computer screen was the single extraneous environmental cue; (2) all participants returned 24 h later and were asked to recall as many words as possible from the lists learned the previous day. Half the participants recalled whilst chewing gum and the remainder recalled without gum. For both immediate and delayed conditions participants were allowed 2 mins. to complete a written free-recall task for the presented list.

Results

The correct immediate recall data were subjected to a 2-factor within-subjects ANOVA. The effects of both learning and recall were non- significant, Fs = 0.6 and 1.1, respectively, as was the interaction, $F = 0.22$, (see Fig. 2a).

The immediate recall results for Experiment 2 are therefore consistent with the null findings of Experiment 1: minimising extraneous environmental cues exerted no effect on recall. For the delayed recall condition, an exploratory 2-factor (4×2) within-subjects ANOVA was computed, comparing recall for lists in each gum condition and whether participants received gum on day 2. (See Fig. 2b).

Receiving gum on day 2 did not significantly aid recall ($F < 1$). Additionally, no effect of gum condition was found ($F < 1$). Of most relevance to the current study is the absence of any interaction between gum condition and whether participants received gum on day 2 ($F < 1$). If context effects were present one might predict an interaction, with gum-gum words recalled optimally when also given gum to recall on day 2 (and similarly for NG/NG when no gum is given on day 2).

Discussion

For both experiments, one consequence of the within-subjects design was that participants experienced the same

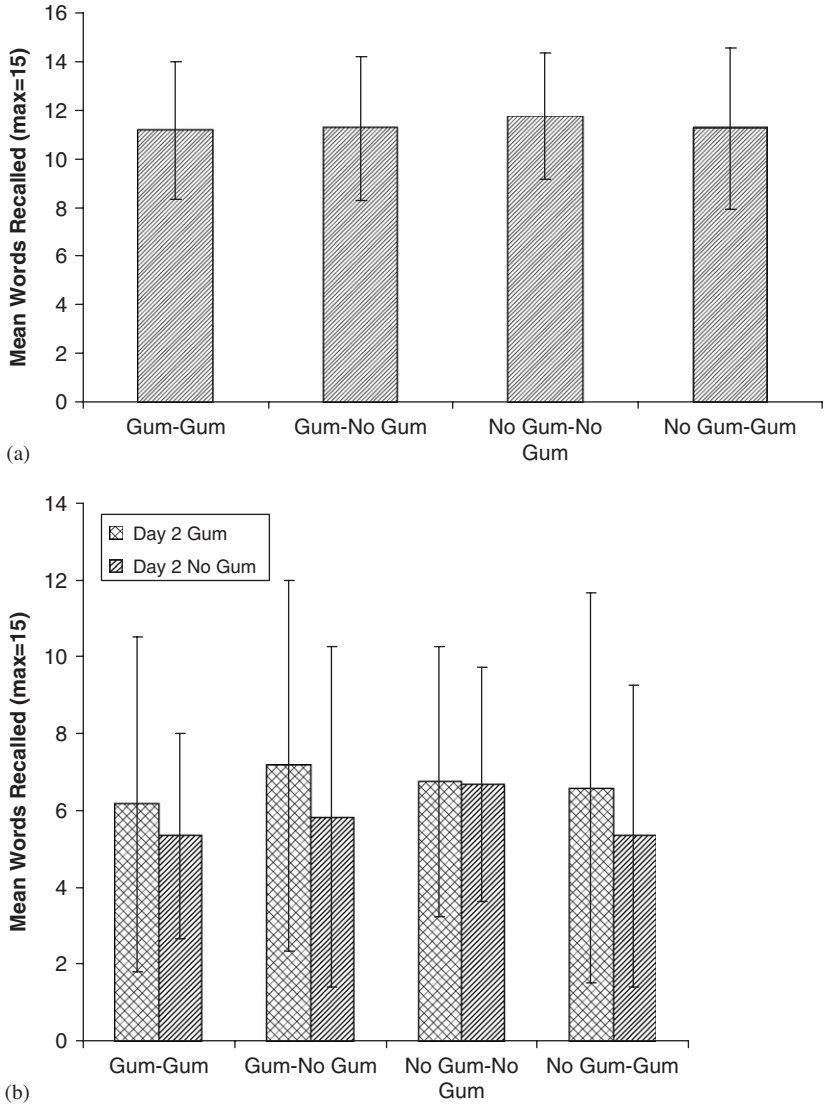

Fig. 2. (a) Mean number of words recalled (maximum 15) after immediate testing for each of the four learning and recall context conditions. The participants chewed gum at both learning and recall (gum-gum), chewed gum at learning but not at recall (gum-no gum), neither chewed gum at learning or recall (no gum-no gum) and did not chew gum at learning but did at recall (no gum-gum). Errors bars denote the standard deviation. (b) Mean number of words recalled (maximum 15) following delayed (24 h) testing for each of the four learning and recall context conditions. The participants had chewed gum at both learning and immediate recall (gum-gum), chewed gum at learning but not at immediate recall (gum-no gum), neither chewed gum at learning or immediate recall (no gum-no gum) and did not chew gum at learning but did at immediate recall (no gum-gum). On day 2 participants either chewed gum at recall or did not. Errors bars denote the standard deviation.

context in consecutive conditions e.g., G/G G/nG but with exposure to different words (recalling one set in gum and then learning another set in gum). During the review process it was suggested that carry over effects might be present in, and thereby distort, the data. However, the within-subjects counterbalanced design adopted here negates such a possibility because each condition and order of conditions was equally distributed across the 24 participants. Thus, any carry over effects or presentation order benefit will be distributed equally across the participants and thereby affect each condition equally.

In addition, and more importantly, the data offer no support for such a contention. Our analysis of the error data suggests limited between-list interference as a consequence of their close temporal proximity. Throughout Experiment 1, only 13 of the learnt items (from a total of $15 \times 24 = 360$ presentations) were recalled in erroneous lists (a mean of 0.54 intrusion errors per participant). For Experiment 2 there was a total of five intrusion errors (a mean of 0.21 intrusion errors per participant). These data indicate that despite the close temporal proximity of list presentation, the lists were represented separately as unique memorial events, minimising between list interference across the different experimental manipulations.

With respect to carry over effects, we suggest that the only potential issue of concern relates to the potential

lingering of flavour. When a no gum condition followed a gum condition it is possible that the flavour of the gum (spearmint) persisted and this might produce a gum context in a control condition. There is some evidence to suggest that the arousing effect of mint flavouring may be sufficient to induce a context-dependent memory effect and/or cognitive facilitation (Baker et al., 2004, Experiment 2; Stephens & Tunney, 2004a, b). However, in the present experiment we sought to limit any persistence of flavour by introducing a 2 min interval between conditions in which the participant was encouraged to sip water in order to remove any lasting flavour.

In conclusion, the results of the two experiments are consistent with those reported by Baker et al. for immediate recall: chewing gum exerts no effect on learning of visually presented word lists nor does it exert a context-dependent effect in an immediate word recall paradigm. Furthermore, the present findings provide a more methodologically complete demonstration of the absence of gum induced context-dependent memory effects at immediate recall. In the present study the contexts employed at learning and recall were equivalent, contrary to Baker et al. where participants chewed the same piece of gum throughout learning and recall, with the stimulus possibly altering in both texture and flavour throughout the two stages. In contrast to Baker et al. we found no evidence that chewing gum provokes a context-dependent effect at delayed recall. What underpins this discrepancy in the data? Although no obvious explanation is forthcoming it is possible that methodological differences are responsible and, in particular, that between-group base-line differences in recall underpinned (the context) differences in the Baker et al. (2004) study. For the present study, the data strongly suggest that the chewing of gum is an insufficiently salient context to produce a context-dependent memory effect (Experiment 1) even when all other extraneous cues are eliminated (Experiment 2).

Acknowledgements

Our thanks to anonymous reviewers for their comments on an earlier version of this paper and to Hannah G. Jewell for technical assistance.

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