

## **BRIEF REPORT**

# Chewing Gum as Context: Effects in Long-Term Memory

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The possibility that chewing gum serves as a contextual cue for retrieval from long-term (episodic) memory representations was examined. Participants learned a word list either whilst chewing gum or not chewing gum. During a 30 s consolidation period participants were required to count backwards from 10 to 1 repeatedly in order to prevent maintenance of recently presented list items within short-term memory. Participants were then required to retrieve the words in the same or alternate context. The total number of words recalled correctly was significantly higher for those participants in the consistent learn-retrieve combinations. Consistent with earlier studies there was no independent benefit of chewing gum to either learning or retrieval. We conclude that chewing gum acts to provide contextual cues that aid retrieval of list items primarily from episodic memorial representations.

#### Key Terms: Chewing Gum, Context, Memory, Context-Dependent Memory

If a participant both learns and retrieves information in the same context or internal state, then retrieval is generally superior compared to a condition where the learning and retrieval contexts or states are different (Capaldi & Neath, 1995; Tulving, 1983). Perhaps the most widely known experiment examining the effect on recall of a context switch between study and test is that reported by Godden and Baddeley (1975). Experienced scuba divers studied a list of 36 common and unrelated words in one of two environments: either on land or underwater. Participants later retrieved the list items either in the original learning environment or in the alternate context. Even though the location of the dives and time of day were not controlled for, there was a pronounced context-dependent retrieval deficit: mean free recall averaged 35% in the consistent learning and retrieval conditions but was markedly reduced to24% in the changed conditions. A second experiment required one-half of the participants to both learn a list of words and recall them on land.

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C. Miles, Ph.D. School of Psychology Cardiff University Tower Building Park Place Cardiff University CF10 3YG UK Telephone: (44) 029 20 875372 Email: Miles@Cardiff.ac.uk The other half also learned and recalled on land but they were required to enter the pool, swim a short distance, dive to a depth of 20 ft, and then return to land prior to recall. Recall performance of both groups was equivalent, thus ruling out the possibility that disruption between learning and test was the cause of poorer recall in the first experiment. A similar context manipulation study with greater ecological validity (Martin & Aggleton, 1993) used novice divers who were required to learn and recall decompression tables and demonstrated an equally powerful context-dependent retrieval effect.

The cardiovascular state of participants was manipulated by Miles and Hardman (1998) who required participants to pedal a bicycle ergometer at an average heart rate of either 150 bpm or 75 bpm. Once again, those participants who both learned and recalled in the same cardiovascular state recalled most words. Additionally, Miles and Hardman showed a significant and negative association between the degree of change in heart rate and the retrieval deficit. That is, the greater the change in cardiovascular state between the rest and exercise conditions the greater the retrieval deficit. Together, these findings are generally taken to reflect the reactivation at retrieval of cues incidentally associated with the to-be-remembered material at learning.

More recently, a number of studies (e.g. Baker, Bezance, Zellaby, & Aggleton, 2004; Johnson & Miles, 2007; Johnson & Miles, 2008; Miles & Johnson, 2007) have been concerned to determine the extent to which any memorial benefits accruing from chewing gum may be attributable to contextdependent memory. Initial interest in the possibility of an association between chewing gum and memory performance was prompted by the work of Wilkinson, Scholey and Wesnes (2002) showing that chewing gum led to improved performance on both immediate and delayed word recall. They proposed that such memorial facilitation is governed by increased blood flow to the fronto-temporal brain regions via the process of mastication. Such a proposal is consistent with fMRI studies demonstrating activation of the prefrontal cortex (Fang, Li, Lu, Gong, & Yew, 2005) and increases in neural blood oxygenated level-dependent (BOLD) signals following gum chewing (Onozuka et al., 2002). Because the Wilkinson et al. (2002) study required participants to chew gum throughout both the learning and retrieval phases of their study, Baker et al. (2004) reasoned that the observed memorial benefit might reflect a chewing gum induced context dependent effect rather then an effect of chewing gum per se. Baker et al. (2004) therefore, in a between-subjects design, parametrically manipulated the requirement to chew gum at either learning and/or retrieval and showed superior recall for a 15 word list in a condition where participants chewed gum at both learning and retrieval. Close inspection of their data, however, reveals that the retrieval benefit was apparent only for a delayed recall (24 hours postlearning) condition.

To date, however, a number of studies have since failed to corroborate the finding of a chewing gum induced context dependent memorial benefit. For instance, Miles and Johnson (2007) report two studies incorporating within-subject designs and immediate recall tasks and each singularly failed to demonstrate either a learning benefit or a context dependent memory effect attributable to chewing gum. In a close replication of the original Baker at al. study, Johnson and Miles (2007) employed a between-subjects design and failed to replicate the Baker et al. result. Further, the possibility that flavour might exert independent learning and context dependent effects has been examined by both Anderson, Berry, Morse and Diotte (2005)and more recently, Johnson and Miles (2008), neither of whom who found support for this possibility. In addition, Johnson and Miles (2008) found no evidence that chewing flavourless gum acted as a sufficient context to aid retrieval.

The weight of evidence might suggest, therefore, that the original positive finding reported by Baker et al. was due to chance or between-group differences. However, the studies reported by

Johnson and Miles (2007; 2008) and Miles and Johnson (2007) all required immediate recall of previously presented material. In contrast, the context-dependent effect shown by Baker et al (2004) was apparent only after a 24 hr delay. This invites the possibility that chewing gum exerts contextual cues upon items represented in long-term, episodic memory rather than those items represented in shortterm memory. In the following study we examine this possibility directly whilst employing an immediate recall paradigm in order to avoid strategically determined recall processes facilitated by a delayed recall paradigm. Specifically, after initial learning, participants were required to repeatedly count backwards from the number 10 to the number 1 for 30 s prior to recall. This technique, known as articulatory suppression, disrupts rehearsal of the most recently presented items within the phonological loop component of short-term memory and thus the recalled items are largely attributable to long-term memory representations (see, Glanzer & Cunitz, 1966; Postman & Phillips, 1965). This technique, therefore, allows us to examine directly context-dependent chewing-gum effects for material retrieved predominantly from long-term memory. Additionally, the period elapsing between learning and retrieval is short and approximates to that employed by Miles and Johnson (2007).

#### Methods

## Participants

Twenty-four volunteer Cardiff University undergraduates (15 females. 9 males: mean age = 19 years 10 months) were recruited from a range of disciplines via an online participant booking system. Each was paid a small honorarium for their participation. Ethical approval for the study was obtained from the School Of Psychology Ethics Committee prior to the commencement of the study.

## Materials

Four word lists each comprising 15 disyllabic nouns were constructed. The lists were matched for word frequency, age-of-acquisition, imagery and familiarity (Morrison, Chappell and Ellis, 1997). Each word was presented in the centre of a computer screen for 1 s with an inter-stimulusinterval (ISI) of 1 s. In all gum chewing conditions participants were provided with a piece of Wrigley's Extra Spearmint sugar-free chewing gum.

### Design

A 2 x 2 repeated measures design was adopted where the first factor refers to the 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 at learning in each of the experimental combinations and order of the word lists was counter balanced across the experimental combinations. Participants completed each experimental combination on one visit to the laboratory and had a 2 min rest between each.

#### Procedure

Participants were tested individually in a dark, sound-proof laboratory where the computer screen was the single extraneous experimental cue. The luminance of the computer screen was sufficient for participants to both read the instructions and write their responses. Upon entering the laboratory each condition was described verbally to the participants and each was issued with accompanying written instructions. Participants were informed that they were required to complete four separate memory tasks and that each involved the presentation of a different list of words to be recalled after a short Participants were informed that some delay. conditions required them to chew gum during the learning and/or retrieval phases of the task. The requirement to count backwards from 10 to 0 rapidly and repeatedly during the retention interval was emphasized. It was also emphasised that participants could recall the words in any order they wished as was the instruction to guess if unsure as to the veridicality of a particular word. For all participants each of the four experimental combinations comprised a learning phase, a 30 s articulatory suppression phase and a 2 min retrieval phase. Following Miles and Johnson (2007) participants viewed the same 15 word list twice with a 5 s interval between presentations. Participants were given 2 minutes to complete a written free-recall task for the presented word list.

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

1. No gum-no gum (NgNg): The participant completed each phase 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 end of the 30 s. articulatory suppression phase the participant received a single piece of chewing gum which was chewed for 15 s. both prior to, and throughout, the retrieval phase.
- 3. Gum-no gum (GNg): the participant received a single piece of chewing gum 15 s. prior to the learning phase. This was chewed through to completion of the learning phase and removed at the commencement of the articulatory suppression phase. Both the 15 s. following the articulatory suppression phase and the retrieval phase were completed in the absence of both gum and chewing activity.
- 4. Gum-gum (GG): The participant received a single piece of chewing gum 15 s. prior to the learning phase. This was chewed through to completion of the learning phase and removed at the start of the articulatory suppression phase. At the end of the articulatory suppression phase the participant received another single piece of chewing gum which was chewed for 15 s both prior to, and throughout, the retrieval phase.

Participants were encouraged to sip water during the 2 min interval between consecutive experimental combinations.

### **Results and Discussion**

Prior to the formal analysis individual participant's data sets were screened for both proactive interference and intrusion errors over the successive memory trials. There was no evidence for the former and the total number of intrusion errors was 9 for the entire data set. The mean correct recall scores for each experimental combination are shown in Figure 1. The correct recall data were subjected to a 2-factor (2x2) 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 (both Fs <1). However, their interaction was highly significant, F(1,23)=13.3, MSe=1.51, p<.001, and further analysis (Newman-Keuls, p < .05) confirmed that both the Gum/Gum and No Gum/No Gum conditions elicited significantly higher recall scores then either of the altered-context experimental combinations. Thus, the data demonstrate a complete context-dependent memory effect. Although the average recall deficit between



Figure 1. The mean number of words correctly recalled as a function of the four experimental combinations (Gum-Gum; Gum-No gum; No gum-No gum; No gum-Gum)

the consistent and inconsistent context groups is only one word, this equates to a substantial 17% degradation in memory performance.

It is noteworthy that correct recall averaged approximately 5.5 items (37%) compared to the Johnson and Miles' (2007) average of 11 items (73%). This difference in correct recall is taken to reflect the action of articulatory suppression preventing rehearsal of items within short-term memory and thereby, biasing retrieval towards those items available within long term memory. Across the four experimental combinations, the average percentage of words correctly recalled from the first 5 serial positions was 37% compared to 24% for the last five serial positions: a significant difference, t(1,23)=23.7, p<.05. Thus, correct recall from longterm memory was significantly more probable than correct recall from short-term memory. This finding supports our contention that the chewing gum induced contextual cues acted via their association with predominantly long-term (episodic) memory representations of the earlier list items.

Our results are, therefore, consistent with Baker et al's. (2004) original finding of a long-term gum-dependent context effect. In addition, they are consistent with the earlier work in our laboratory e.g., Miles and Johnson (2007), Johnson and Miles (2007; 2008) in their failure to demonstrate beneficial effects of chewing gum at either learning or retrieval. The failure of our earlier studies, especially that of Miles and Johnson (2007) upon which the current study is predicated, to demonstrate a context-dependent chewing gum effect points to the memorial processes involved. In particular, Miles and Johnson employed a quiet consolidation period facilitating not only retrieval from both short- and long-term memory, but also the development of a range of recall strategies (see, Campoy & Baddeley, 2008; Logie, Della Sala, Laiacona, Chalmers & Wynn, 1996).

In conclusion, we suggest that future work examining the effects of chewing gum on memorial processes would benefit from a focus on long-term memory processes and, in particular, those processes underpinning episodic memory.

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