Journal of Behavioral and Neuroscience Research
2010, Vol. 8(2), 9-19

FEATURED ARTICLE

Switching between Chewing-Gum and No-Gum at Learning and Retrieval does not Accentuate Error Production in Free Recall

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Three experiments compared chewing gum to a no gum condition to examine further the finding (Anderson, Berry, Morse & Diotte, 2005) that switching flavour between learning and recall encourages error production independently of free recall. In order to encourage error production, participants in Experiment 1 were told to guess responses at recall, participants in Experiment 2 were required to recall categorised word lists and in Experiment 3 participants repeated the same learning-recall combination on four immediately successive occasions and were required to recall different categorised word lists on each. The experiments produced universally null effects. Consistent with previous research, for correct recall, there were no independent effects of chewing gum for learning or recall and nor was their evidence of context dependency. Error production was not biased towards the inconsistent learning-recall contexts even when participants switched successively between the learning-recall contexts. Finally, there was no evidence that extended temporal exposure to chewing gum was an important determinant of context-dependent memory effects.

Key Terms: *Chewing Gum, Context-Dependent Memory, Error Production*

The possibility that chewing gum may benefit immediate free-recall for word lists has been studied extensively in recent years, prompted by the work of Wilkinson, Scholey and Wesnes (2002) who first demonstrated improved memory performance whilst chewing gum. The possibility that the positive finding reported by Wilkinson et al. (2002) was due to chewing gum throughout both the learning and retrieval phases, thereby acting as a contextual cue, was examined by Baker, Benzance, Zellaby and Aggleton (2004). In a between-subjects design they demonstrated that delayed word recall benefitted from gum-chewing congruency between the learning and retrieval phases with no concomitant benefit for immediate recall. Baker et al. (2004) thus concluded that chewing gum can act as a sufficiently salient contextual cue to aid delayed word recall.

Since the work of Baker et al. (2004) the contextual benefit of chewing gum has proved hard to replicate. For instance, Miles and Johnson (2007), in two experiments employing both immediate and delayed (24hr.) free recall conditions, showed null effects of chewing gum at both learning and retrieval, in addition to a null contextual effect. These null effects maintained even when close attention was paid to particular features of the experiment. In particular, re-instatement of context at retrieval was matched with that at learning by providing participants with a fresh piece of chewing gum prior to commencement of the retrieval stage. In addition, extraneous contextual cues, which may act to reduce the salience of the gum as a context (see, Vela & Smith, 1998), were minimized i.e., participants completed the tasks in a darkened, soundproofed laboratory. In a further replication where the design mirrored that employed by Baker et al. (2004) i.e., a between groups design, and tested both immediate

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and delayed retrieval conditions, Johnson and Miles (2007) found again, universally null effects of chewing gum. Similar results were obtained by Johnson and Miles (2008) who examined, independently, the contextual salience of both chewing gum in the absence of flavour and flavour in the absence of chewing gum. More recently, Overman, Sun, Golding and Prevost (2009) extended the Johnson and Miles (2008) methodology by examining the possible interactive effects of chewing gum and flavour in determining the context-dependent memory effect. Participants were assigned to one of four conditions in which cinnamon gum and cinnamon sweets were used to formulate the 4 learning-recall experimental combination. Their results, consistent with the majority of work from our laboratory, showed universally null effects for gum and flavour both independently and interactively.

One of the few studies demonstrating a positive contextual effect of chewing gum was reported by Miles, Charig and Eva (2008) who re-examined the delayed-recall contextual-benefit of chewing gum initially reported by Baker et al. (2004). Using a modified experimental methodology, participants were prevented from sub-vocally rehearsing the previously presented word list by the requirement to count backwards from 10 to 0 rapidly and repeatedly during the 30 s consolidation period. Articulatory suppression has the effect of minimizing rehearsal within the phonological loop component of short-term memory (Baddeley, 2002). Recall is thus biased towards those items presented earlier in the list and is, therefore, presumed to be, largely, a product of long-term memory (e.g., Glanzer & Cunitz, 1966; Postman & Phillips, 1965). The Miles et al. (2008) study showed a strong and symmetrical chewing-gum context-dependent effect, thereby, in one regard, offering support for Baker et al.'s (2004) finding.

Rather than assessing correct recall for earlier explicit learning, the current studies were designed to examine the extent to which incongruent gum-chewing at learning and retrieval impairs memory accuracy. The impetus for this work is predicated on the findings of Anderson, Berry, Morse and Diotte (2005) who examined the possibility that flavour acts as a contextual retrieval cue. In a between-participants design, participants learned a word list whilst exposed to one of two flavours: sugar-free peppermint or butterscotch, presented in the form of candy. Retrieval was required either in the same or opposite context. Correct recall did not vary across the four experimental combinations but the frequency of intrusion errors, that is, producing words that were not in the original list, was significantly greater in the condition where participants shifted from Butterscotch at learning to Peppermint at retrieval. From their data we have calculated that the proportion of errors in this condition was approximately 21% compared to an average of approximately 8% across the other three experimental combinations.

Experiment 1

To date, none of the studies from our laboratory (see, Johnson & Miles, 2007; Johnson & Miles, 2008; Miles & Johnson, 2007; Miles et al. 2008) have been designed with the explicit intention of examining the contextual effects of chewing gum on error production in free recall. The following series of experiments were designed to allow such an examination. The results allow also for a test of the generalisabilty of the Anderson et al. (2005) finding to studies employing a different flavour as context: spearmint flavoured chewing gum in this instance. In the first experiment we contrast chewing spearmint gum with no gum chewing. Consistent with earlier work from our laboratory, we employed a within-participants design (e.g., Miles & Johnson, 2007) such that all participants completed each of the four experimental combinations in a different order. In addition, because error production for this paradigm is generally very low (<5%) in our laboratory, we needed to encourage error production in order to facilitate adequate statistical analyses between the experimental combinations. To this end, for Experiment 1, participants were encouraged to guess during the retrieval phase. In summary, Experiment 1 was designed to assess the extent to which an increase in error production is evident for a free recall task when there is a switch between the learning (gum/no gum) and retrieval (gum/no gum) contexts.

Method

Participants: Twenty-four Cardiff University undergraduates, postgraduates and members of staff (15 females. 9 males: mean age = 19 years 10 months) participated. Ethical approval 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 & Ellis, 1997). Each word was presented in the centre of a computer screen for 1 s with an inter-stimulus-interval (ISI) of 1 s. In all gum chewing conditions participants were provided with a single pellet of Wrigley's Extra Spearmint sugar-free chewing gum.

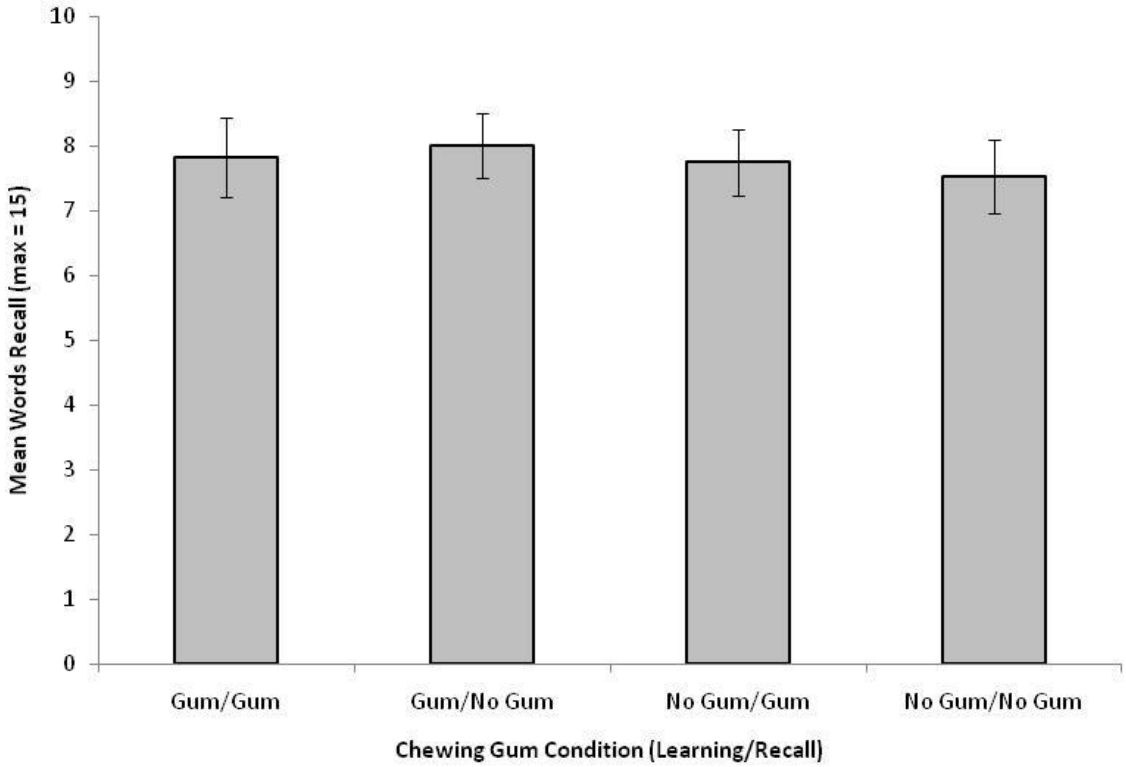

Figure 1. Mean correct word recall as a function of experimental combination for Experiment 1. Error bars denote +/- SEM.

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 the 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: In order to minimize the possibility that environmental cues may influence the external context, all participants were tested individually in a darkened, sound-proof laboratory where the computer screen was the single extraneous experimental cue. Upon entering the laboratory the experiment was described to the participants and each was issued with written instructions. Participants pressed the space bar on the computer to start the task. A star appeared in the centre of the screen for 10 s prior to the start of the task. The word list was then presented. Each word appeared in the centre of the screen for 1 s with a 1 s ISI. The word list was presented twice in succession. At the end of the presentation phase a star appeared in the centre of the screen for 30 s during which participants sat quietly. Participants then completed a 2 min written free recall of the word list. Because we were interested in the frequency with which participants recalled words that were not in the to-be-remembered list, participants were encouraged to guess during the word recall phase of the experiment.

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

1. No gum-no gum (ng-ng): The participant completed each phase of the experiment in the absence of both gum and chewing action.
2. No gum-gum (ng-g): The participant completed the learning phase in the absence of both gum and chewing action. At the end of the learning phase participants received a single piece of chewing gum which was chewed throughout both the 30 s consolidation phase and the 2 min retrieval phase.

3. Gum-no gum (g-ng): The participant received a single piece of chewing gum 30 s prior to the learning phase. This was chewed through to completion of the learning phase and removed at the end of the learning phase. Both the 30 s consolidation phase and the 2 min retrieval phase were completed in the absence of both gum and chewing activity.
4. Gum-gum (g-g): The participant received a single piece of chewing gum 30 s prior to the learning phase. This was chewed through to completion of the learning phase and removed at the end of the learning phase. The participant immediately received a single piece of fresh chewing gum which was chewed throughout both the 30 s consolidation phase and the 2 min retrieval phase.

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

Results and Discussion

Correct Recall Scores

Figure 1 shows the mean correct recall scores for each of the four experimental combinations. The correct recall data were subjected to a 2-factor (2x2) repeated measures Analysis of Variance (ANOVA) where the first factor refers to learning (g versus ng) and the second refers to retrieval (g versus ng). Main effects of both learning, $F(1,23)=0.52$, $p=0.48$, partial eta squared=0.02, power=0.11; means: g=7.92 and ng=7.65, and retrieval, $F(1,23)=0.01$, $p=0.97$, partial eta squared=0.01, power=0.05; means: g=7.79 and ng=7.77, were non-significant as was their interaction, $F(1,23)=0.18$, $p=0.67$, partial eta squared=0.01, power=0.07. These negative findings are consistent with our earlier studies (e.g., Johnson & Miles 2007; Johnson & Miles, 2008; Miles & Johnson, 2007).

Error Production

The error scores represent less than 5% of the total recall corpus across all experimental combinations and thus preclude meaningful statistical analysis. It is evident that asking participants to guess their responses during retrieval failed to elicit a sufficient number of error scores for legitimate statistical analysis. Experiment 1, therefore, provides no empirical support for Anderson et al.'s (2005) findings with regard to either overall error productions, or, in particular, an increase in error production for those conditions where there is a mismatch in context between learning and retrieval.

The pattern of correct recall scores for Experiment 1 is consistent with earlier work in our laboratory (e.g., Johnson and Miles, 2007; Johnson & Miles, 2008; Miles & Johnson, 2007) in showing null effects of chewing gum at both learning and retrieval together with a lack of an interaction. Encouraging participants to guess during the retrieval phase failed to increase appreciably the error production with respect to our earlier studies. In fact, the error production of approximately 5% in Experiment 1 is below the level of 8% reported by Anderson et al. (2005) for three of their experimental combinations.

Experiment 2

In Experiment 2 we manipulated the content of the to-be-recalled word lists with the aim of increasing the number of errors produced at recall. Such a manipulation should increase the sensitivity of error production to the bias shown by Anderson et al. (2005). To this end, we created four different word lists within which each comprised category exemplars taken from four different categories. The idea here is that the category exemplars activate their specific categories, via spreading activation (e.g., Anderson, 1973) such that 'guess' words (errors) at recall will also be exemplars of the activated categories. A pilot study (N=10) showed that for such material error production at retrieval represented approximately 10% of the complete recall corpus with immediate testing. We should note that constructing word lists in this fashion may act to reduce the likelihood of demonstrating context-dependent effects for correct recall. The inclusion of non-environmental cues at learning i.e., inter-item associations such as those used here, may act to 'overshadow' or decrease the learning of context (Smith & Vela, 2001) by drawing attention from the learning environment and towards the to-be-learned material. Therefore, we make no prediction for a chewing-gum dependent contextual effect with regard to correct recall. Importantly however, the concept of overshadowing does not necessarily impact upon our current experimental hypothesis which is concerned with differential error production for the changed-context combinations.

Method

Participants: Twenty-four Cardiff University undergraduates and postgraduates (19 females, 5 males: mean age = 19 years 3 months)

participated. None had participated in Experiment 1. Ethical approval was obtained from the School of Psychology Ethics Committee prior to the commencement of the study.

Materials: Four word lists, each comprising 16 nouns varying between one and three syllables, were constructed (see Appendix 2). Each list comprised 4 exemplars taken from each of 4 categories: a type of bird, a girl's name, a country, something that makes a noise. Each exemplar word was selected from the lower half of each category as defined by typicality rating. Each list was constructed such that no more than two exemplars from a particular category were present successively. As far as possible, lists were matched for word frequency, age-of-acquisition, imagery and familiarity (Morrison, Chappell & Ellis, 1997). Each word was presented in the centre of a computer screen for 1 s with an inter-stimulus-interval (ISI) of 1 s. In all gum chewing conditions participants were provided with a single pellet of Wrigley's Extra Spearmint sugar-free chewing gum.

Design: The Design was as described for Experiment 1.

Procedure: The Procedure was as described for Experiment 1.

Results and Discussion

Correct Recall Scores

Figure 2 shows the mean correct recall scores for each of the four experimental combinations. The correct recall data were subjected to a 2-factor (2x2) repeated measures ANOVA where the first factor refers to learning (g versus ng) and the second refers to retrieval (g versus ng). Main effects of both learning, $F(1,23)=0.68$, $p=0.41$, partial eta squared=0.03, power=0.13; means: g=7.27 and ng=7.02, and retrieval, $F(1,23)=0.08$, $p=0.78$, partial eta squared=0.01, power=0.06; means: g=7.21 and ng=7.08, were non-significant, as was their interaction, $F(1,23)=0.01$, $p=0.99$, partial eta squared=0.01, power=0.05. This finding is consistent with both Experiment 1 and our earlier studies (e.g., Johnson & Miles, 2007; Johnson & Miles, 2008; Miles & Johnson, 2007).

Error Production

Figure 3 shows the mean error scores for each of the experimental combinations. The error scores were subjected to a 2-factor (2x2) repeated measures ANOVA where the first factor refers to learning (g versus ng) and the second refers to retrieval (g versus ng). Main effects of both learning, $F(1,23)=0.1$, $p=0.33$, partial eta squared=0.04, power=0.16; g=1.06 and ng=1.23, and retrieval, $F(1,23)=1.57$, $p=0.22$, partial eta squared=0.06, power=0.22; means: g=1.29 and ng=1.00, were non-significant, as was their interaction, $F(1,23)=1.61$, $p=0.22$, partial eta squared=0.07, power=0.23.

The pattern of data for both the correct and error scores mirrors that observed for Experiment 1 and, once again, finds no support for Anderson et al. (2005). Manipulation of the word list material was successful in that the magnitude of error production increased to an average of 13.3% which comfortably exceeds the Anderson et al. (2005) average of 8% for 3 of their combinations. Nevertheless, the experiment produced no evidence that switching between the gum-chewing and no gum-chewing contexts differentially influenced the number of error responses compared to the non-switch combinations.

Experiment 3

The final experiment examines the possibility that our inability to demonstrate either a chewing-gum induced context-dependent effect for correct recall (e.g., Johnson & Miles, 2007; Johnson & Miles, 2008; Miles & Johnson, 2007) or a significant increase in error production for the context-switch combinations (Anderson et al. 2005), reflects insufficient temporal exposure to the chewing gum context. It has been suggested (Smith & Vela, 2001) that time-in-context during the learning phase increases the probability of observing a context-dependent effect. That is, both the encoding, and representation of, contextual information will increase probabilistically as time-in-context increases. In our earlier work, and Experiments 1 and 2 in the current series, exposure to the chewing-gum context never exceeded 2 minutes. Of course, what constitutes a sufficient temporal exposure is unknown, and therefore remains an empirical question beyond our present concern. Nevertheless, in Experiment 3 we increased temporal exposure to the chewing-gum context by altering our experimental design. Different groups of participants were assigned to each of the four (g/g, g/ng, ng/g and ng/ng) experimental combinations. Within each of these combinations participants were required to learn and recall, successively, each of the four word lists described for Experiment 2. Therefore, the g/g group chewed gum throughout the four list presentation and recall combinations. In contrast, the ng/g and g/ng groups switched between gum-chewing and no-gum-chewing on four occasions (once for each list presentation).

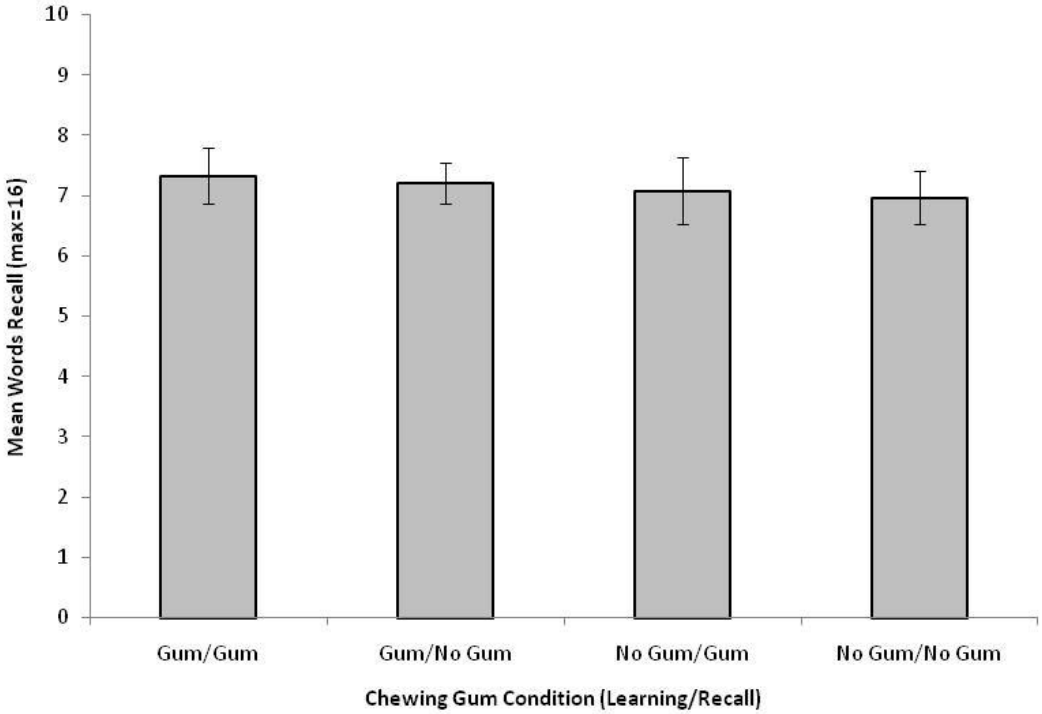

Figure 2. Mean correct word recall as a function of experimental combination for Experiment 2. Error bars denote +/- SEM.

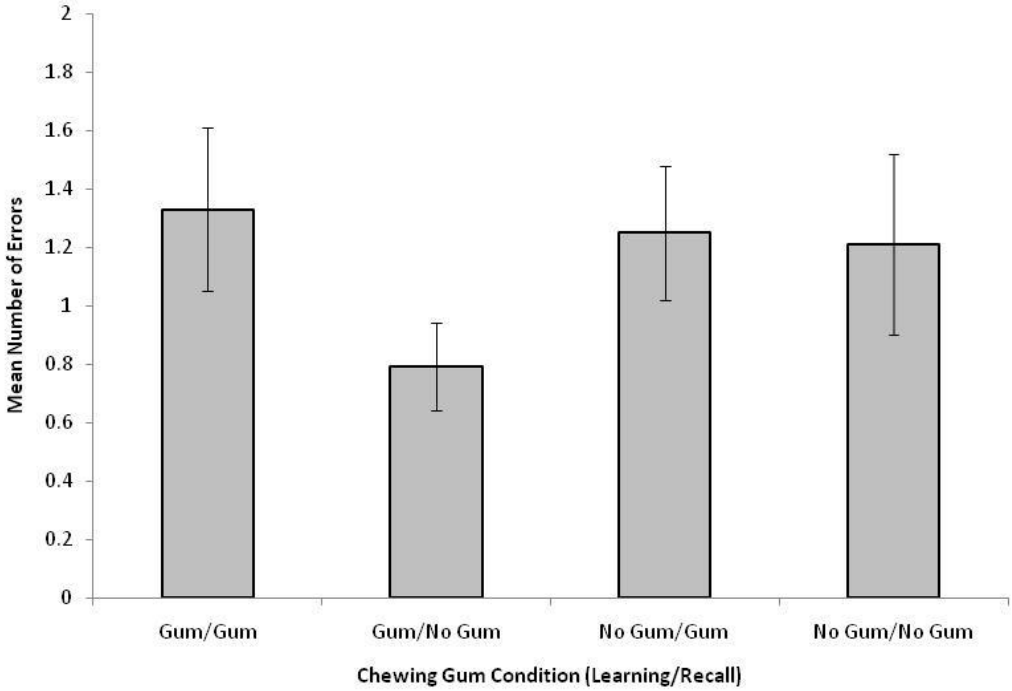

Figure 3. Mean error production as a function of experimental combination for Experiment 2. Error bars denote +/- SEM.

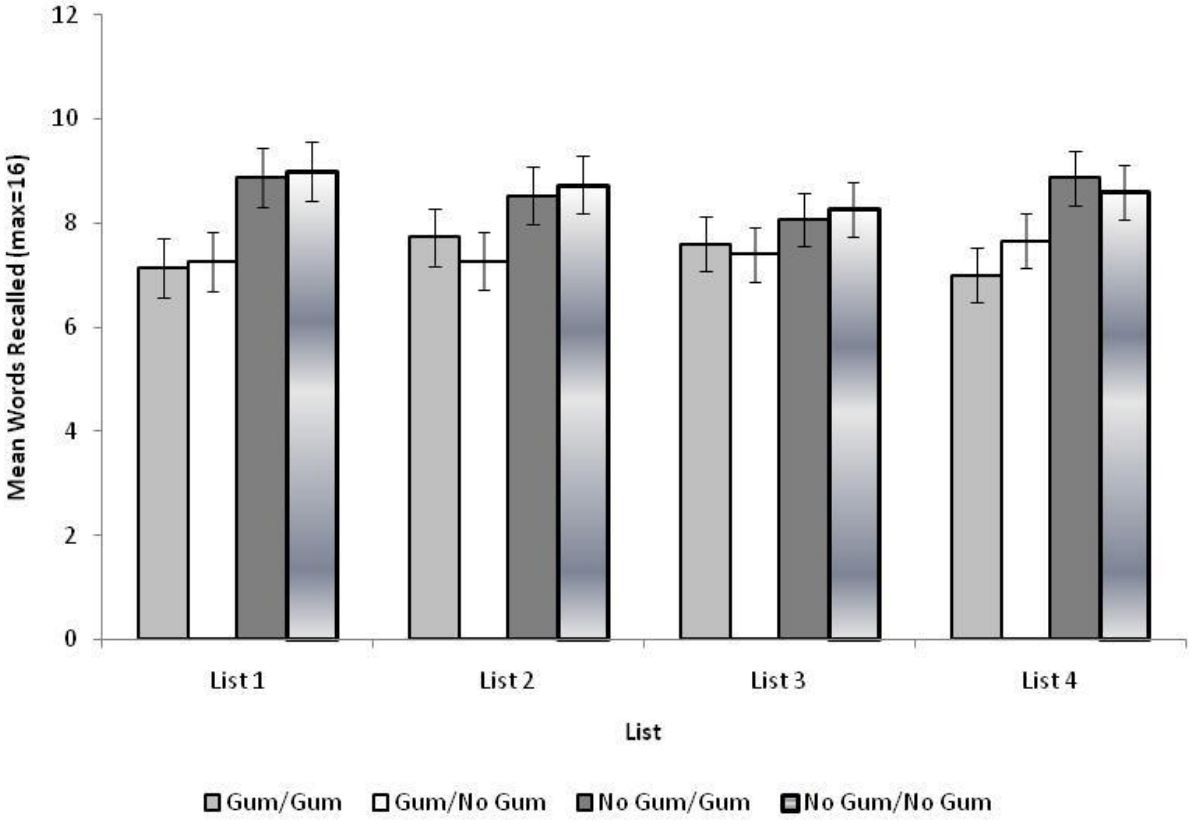

Figure 4. Mean correct word recall as a function of experimental combination for Experiment 3. Error bars denote +/- SEM.

For Experiment 3 we derive two predictions predicated on the Smith and Vela (2001) temporal exposure hypothesis. The first prediction proposes that for those participants in the context-consistent conditions, i.e., g/g and ng/ng, correct recall will improve as temporal exposure to the same context increases. This will be reflected by superior correct recall for that list presented fourth compared to that list presented first. Statistical support for this prediction requires a significant interaction between experimental condition and list number reflecting an increase in correct recall for that list presented last compared to that list presented first for the g/g combination, coupled with relatively stable levels of recall for the remaining experimental combinations. The second prediction proposes that for those participants in the context-change conditions, i.e., g/ng and ng/g, error production will be greater for that list presented fourth compared to that list presented first. Statistical support for this prediction requires a significant interaction between experimental condition and list number reflecting an increase in error production for that list presented last compared to that list presented first for both the g/ng and ng/g combinations, coupled with relatively stable levels of error production for the remaining experimental combinations. Based on the Anderson et al. (2005) findings, the g/ng and ng/g combinations are susceptible, a priori, to production errors. In addition, error production can comprise errors of two types: erroneous production of words not presented previously and intrusion errors resulting from proactive interference i.e., words presented in earlier lists.

Method

Participants: Sixty Cardiff University undergraduates and postgraduates (50 females, 10 males: mean age = 19 years 11 months) participated. Participants were assigned at random to one of four experimental groups (n=15 participants per group). None had participated in Experiments 1 and 2. Ethical approval was obtained from the School of

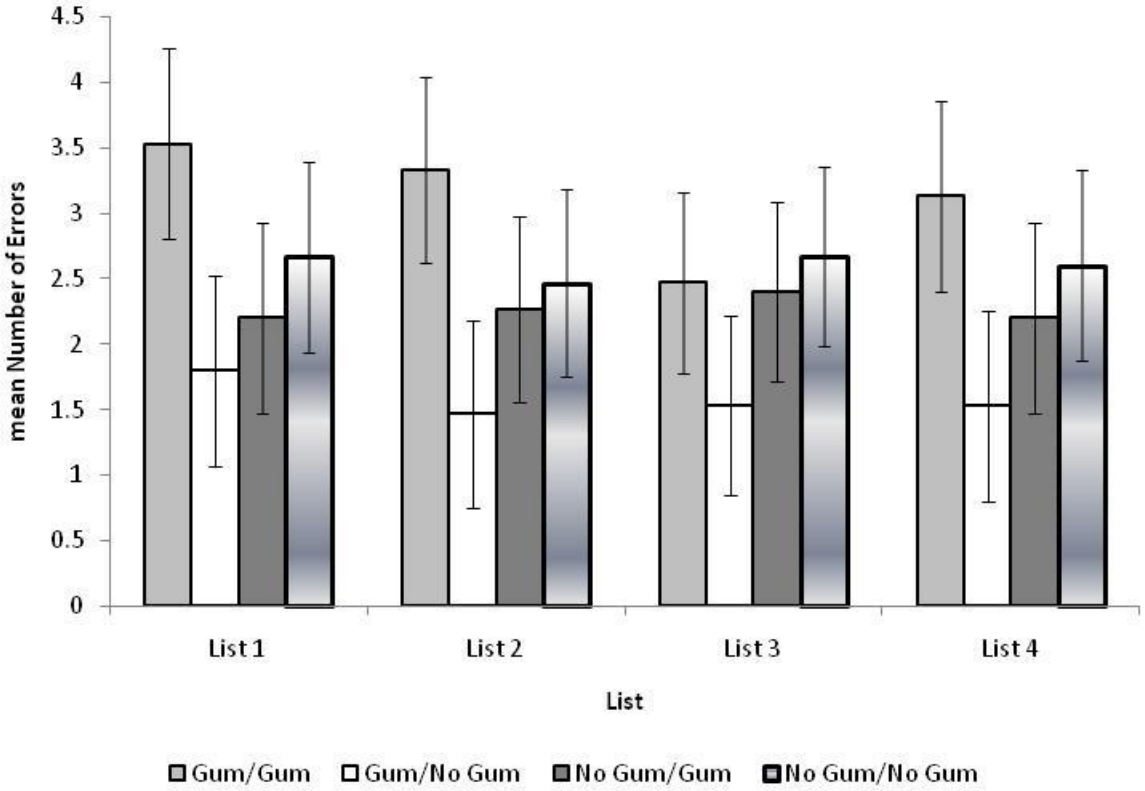

Figure 5. Mean error production as a function of experimental combination for Experiment 3. Error bars denote +/- SEM.

Psychology Ethics Committee prior to the commencement of the study.

Materials: The four word lists were as described for Experiment 2.

Design: A 4x4 mixed design was adopted. The first factor is between-participants and refers to experimental group. The four groups of participants were assigned at random to one of the four experimental combinations (g/g; g/ng; ng/g; ng/ng). The second factor is within-participants and refers to word list (1-4). Each experimental combination was repeated on four occasions. Order of word list presentation was randomised within the repetitions for each experimental group

Procedure: The procedure for each individual condition was as described for Experiment 1 with the exception that each group repeated their particular learning and retrieval combination on four successive occasions. Each learning and retrieval combination followed with a minimum interval. Participants were provided with fresh pieces of chewing gum or a glass of water between experimental combinations when appropriate.

Results and Discussion

Correct Recall Scores

Figure 4 shows the mean correct recall scores for each of the four experimental combinations as a function of list presentation position (1-4). The correct recall scores were subjected to a mixed design 3-factor (2x2x4) ANOVA where the first two factors are between-subjects and refer to learning (g versus ng) and retrieval (g versus ng), respectively, and the third factor is within-subjects and refers to list presentation position (1-4). The main effect of learning was significant, $F(1,56)=9.09$, $p=0.004$, partial eta squared=0.14, power=0.84; means: g=7.38 and ng=8.62, reflecting better learning in the no gum condition. The main effects of both recall and list presentation position were non-significant, $F(1,56)=0.08$, $p=0.9$, partial eta squared=0.01, power=0.05; means: g=7.98 and ng=7.8.03, and, $F(3,168)=0.3$, $p=0.82$, partial eta squared=0.005, power=0.11; means: List Position 1=8.07; List Position 2=8.06; List Position 3=7.83; List Position 4=8.03, respectively. Critically, the predicted

interaction between experimental condition and list position was non-significant, $F(3,168)=0.74$, $p=0.53$, partial eta squared=0.05, power=0.25. This analysis, therefore, provides no support for our first prediction stating that a context-dependent chewing-gum effect will evolve as time-in-context increases.

Error Production

Figure 5 shows the mean error scores for each of the experimental combinations. The error scores were subjected to the same model 3-factor (2x2x4) ANOVA and revealed that main effects at learning, $F(1,56)=0.02$, $p=0.9$, partial eta squared=0.001, power=0.05; means: g=2.35 and ng=2.43, retrieval, $F(1,56)=0.85$, $p=0.36$, partial eta squared=0.02, power=0.15; means: g=2.69 and ng=2.09, and list position, $F(3,168)=0.47$, $p=0.71$, partial eta squared=0.008, power=0.14; means: List Position 1=2.55, List Position 2=2.38, List Position 3=2.27, List Position 4=2.37, were absent. Critically, the predicted interaction between experimental combination and list position failed to reach significance, $F(3,168)=0.14$, $p=0.77$, partial eta squared=0.002, power=0.07. This analysis, therefore, provides no support for our second prediction stating that error scores (comprising both 'new' and 'old' words) will increase over successive list presentations when coupled to successive context switches.

General Discussion

The primary aim of the experiments reported here was to examine the generalisability of the finding reported by Anderson et al. (2005). Specifically, consistent with work from our laboratory employing flavoured chewing gum as a context, they demonstrated a null effect of context dependency (peppermint flavoured candy versus butterscotch flavoured candy) for correct word recall. However, Anderson et al.'s (2005) novel finding relates to the disproportionate increase in error production when participants learned a list of words whilst exposed to butterscotch flavoured candy and retrieved those words whilst exposed to peppermint flavoured candy. This finding was not apparent when participants learned and retrieved in the alternate order. In order to assess further the Anderson et al. (2005) finding, for Experiment 1 we encouraged participants to guess responses when unsure in an attempt to encourage error production. The low error production (less than 5%) precluded statistical analysis. Experiment 2 employed categorised word lists to encourage error responses and, although successful in increasing error production to approximately 13%, the predicted bias was not apparent. Experiment 3 employed the same categorised word lists and explored the additional possibility that temporal exposure to a context (see Smith & Vela, 2001) was important for both correct and error responses. Increased temporal exposure to the chewing-gum context at both learning and recall failed to produce a context-dependent effect for correct recall. Additionally, repeated alternations between the chewing-gum and no chewing-gum contexts failed to elicit an increase in error production compared to the non-alternating contexts. In summary, across 3 experiments employing chewing gum and no chewing-gum as experimental contexts we obtained no data in support of the Anderson et al. (2005) finding.

There are a number of observations with regard to the Anderson et al. (2005) study which may impact on our failure to replicate their finding. First, the Anderson et al. (2005) finding is post-hoc: Their experiment was not designed with the intention of examining differential error productions for mismatch contextual conditions. Second, the magnitude of the error scores, and in particular that for the Butterscotch-Peppermint condition, is higher than that observed in our own laboratory, which is typically 5%. Third, the mean correct recall score for Anderson et al. (2005) is approximately 22%. This is very low compared to studies from our own laboratory where mean correct recall scores typically exceed 70%, (e.g., Miles & Johnson, 2007). Fourth, from a theoretical perspective, a purely context-dependent memory account predicts that if a mismatch in cue availability between learning and retrieval does provoke a memory bias towards error production, then such provocation should be observed equally for both mismatch conditions. Even in the absence of a mechanism to accommodate the increased error production under mismatch conditions, any account premised on the idea of cue availability e.g., Tulving (1983), must predict symmetry. That is, such accounts, ipso facto, predict equivalent error production for both mismatch learning and retrieval conditions. Fifth, one account that adequately handles a lack of equivalence in error production for both mismatch conditions in the Anderson et al. (2005) study is premised on the concept of asymmetric transfer (Poulton, 1982). In any experiment where one participant completes two tasks in the order A-B and another participant completes the same tasks in the order B-A, there exists the potential for performance on the task completed first to affect performance on the task completed second. But, the nature of such a performance affect is dependent upon the order of task completion. For instance, completing task A first

may provoke particular strategic or context effects which then corrupt performance on the following task. Performing task B first might provoke a different type of strategic or context effect which will then act to corrupt performance on task A. For the Anderson et al. (2005) study then, it is possible that learning in Butterscotch and recalling in Peppermint provoked a performance strategy different to that for those participants completing the task in the alternate Peppermint-Butterscotch order. By this account, the Anderson et al. finding is a consequence of their between-subjects experimental design rather than a consequence of an unidentified cognitive process.

A final important methodological difference between the studies reported here and that of Anderson et al. (2005) refers to the contexts employed. Anderson et al. employed Butterscotch and Peppermint candy as their contexts. We employed chewing spearmint flavoured gum and a no gum chewing condition as our contexts. It may be important that Anderson et al.'s (2005) participants switched between flavours whilst our participants switched between a flavour and no flavour. However, the Anderson et al. (2005) finding has theoretical weight only if it generalises to other context–switch conditions and our data suggests it might not. It is worth emphasising also that the Anderson et al. (2005) finding of a 20% error production for their butterscotch-peppermint context switch condition is extraordinarily high. Participants in our laboratory, across a range of studies (Johnson & Miles, 2007; Johnson & Miles, 2008; Miles & Johnson, 2007; Miles & Johnson, 2008) consistently produce an average error production in the range of 5%.

To our knowledge, Experiment 3 is the first study to examine directly the temporal exposure hypothesis as outlined by Smith & Vela (2001). It is possible that our failure to find support for such a hypothesis is because our temporal exposure was insufficient. However, in Experiment 3, for those participants in the repeated g-g condition, exposure to chewing gum certainly exceeded 10 minutes. A second possibility speaks to the strength of the time-in-context hypothesis. Certainly in their meta-analysis of 75 studies taken from 41 articles published between the years of 1935 and 1997, Smith & Vela (2001) failed to support their prediction. Time-in-context was a not a strong predictor of the magnitude of context-dependent effects

In conclusion, the current studies add to the body of evidence (Johnson & Miles, 2007; Johnson & Miles, 2008; Miles & Johnson, 2007) together indicating that the beneficial effects of chewing gum for both learning and retrieval are unreliable as is the finding (Baker et al. 2004)) that chewing gum acts as a salient context for word learning. The primary aim of the current study was to examine Anderson et al.'s (2005) finding that, independently of correct recall, a switch in flavour context between learning and retrieval provokes a significant increase in error production compared to a consistent context condition. In a series of three studies designed to provoke error production at recall, we found no evidence to support the Anderson et al. (2005) finding. Further we found no evidence for a previously untested hypothesis, that extended temporal exposure to the chewing-gum context is associated with either correct word recall or error production.

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Appendix 1: Word lists for Experiment 1.

Word List 1	Word List 2	Word List 3	Word List 4
candy	stagecoach	heaven	tribute
pudding	sunburn	beaver	sheepskin
theory	glutton	event	hamlet
costume	valley	mercy	party
casement	conquest	victim	landscape
lobster	circle	hardwood	mantle
concept	courtship	arrow	damsel
menace	instance	christmas	machine
trellis	angle	henchman	moment
circuit	reptile	glory	outcome
goblet	invoice	amount	malice
safety	footwear	pupil	baron
meeting	bagpipe	slipper	vision
tower	belief	freedom	chaos
preview	satire	excuse	offshoot

Appendix 2: Word lists for Experiments 2 and 3.

Word List 1	Word List 2	Word List 3	Word List 4
blackbird	seagull	woodpecker	crow
bus	siren	toy	guitar
brazil	stacey	chile	portugal
stephanie	europe	oriole	jenny
raven	falcon	truck	dove
gun	whistle	iran	speaker
scotland	karen	courtney	switzerland
rebecca	russia	flamingo	sally
penguin	vulture	bird	duck
train	trumpet	iraq	music
egypt	britain	jamie	african
amanda	kathy	mockingbird	susan
ostrich	chicken	nicole	finch
mouth	alarm	peru	children
israel	japan	kathryn	india
samantha	anna	cat	linda