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ELIMINATING CONTEXT-DEPENDENT FORGETTING: CHANGING CONTEXTS CAN BE AS EFFECTIVE AS REINSTATING THEM

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Standard context-dependent memory studies have shown that when information is encoded in a certain environmental context (EC), recall performance is weakened when retrieval occurs in a different, rather than the same, EC. Here, we show that this context-dependent forgetting can be eliminated using mental imagery at encoding. In two studies, participants used mental visualization of the retrieval EC during the encoding process. The results of the first study highlighted the importance of context familiarity. When familiarity was controlled in the second study, users of the mental visualization technique who encoded and retrieved in different ECs showed no context-dependent forgetting as compared with participants who encoded and retrieved in the same EC. These findings suggest that information can become linked with mental images of ECs such that the physical instantiation of an imagined EC can function as effectively as physical EC reinstatement and eliminate context-dependent forgetting.

Empirical work on memory and environmental context (EC) spanning the past three decades has shown that recall performance can be strongly affected by the relationship between the EC in which information was encountered (encoded) and the EC in which the retrieval of that information takes place. It is a common finding that, if the EC at the encoding phase differs from that at retrieval, memory performance is poorer than that when the EC at encoding and retrieval are the same; an effect known as context-dependent forgetting (e.g., Allen & Jacoby, 1990; Godden & Baddeley, 1975; Grant et al., 1998; Parker, Gellatly & Waterman, 1999; Smith, Glenberg, & Bjork, 1978; for reviews, see Smith, 1988, 1994). The underlying principle here is that information is encoded along with the context in which it appears, and reexperiencing the originally encoded context can act as a cue for the retrieval of information. However, the effects have been known to be capricious and

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unpredictable, with some experiments failing to find any influences of EC on memory performance (e.g., Eich, 1985; Fernandez & Glenberg, 1985). The literature on EC-dependent memory also documents varying degrees of contextual influence on different forms of memory and on different techniques for testing memory. For example, although context effects on free recall have been widely reported, influences of contextual manipulation on recognition memory have rarely been shown (e.g., Godden & Baddeley, 1980; however, see Smith, 1986). Similarly, investigations of context-dependent implicit memory have shown contrasting results (cf. Gooding, Mayes, & Meudell, 1997; Parker, Waterman, & Gellatly, 2000) with strong suggestions that context-reinstatement effects are more likely to be evident on conceptual, rather than perceptual, implicit memory tests (Parker et al., 1999). Nevertheless, while debate continues as to the precise circumstances under which EC-dependent effects emerge, a majority of theorists agree that EC can exert powerful effects on human memory.

A question of interest, then, is whether there are any viable memory techniques which might be employed to reduce the detrimental effects of context-dependent forgetting? That is, notwithstanding the sometimes erratic nature of EC effects, can any methods be used such that encoding and retrieving information in different environments does not result in weakened recall performance? The present study identifies a technique aimed at reducing the deleterious effects of encoding and retrieving information in different ECs. The technique involves the use of mental imagery, a common strategy in improving human memory retrieval. For example, mental imagery mnemonics are popular memory-improvement techniques used particularly in list-learning paradigms and, typically, these techniques involve the formation of vivid and unusual associations between to-be-remembered items and certain numerically ordered 'pegwords,' for example, one is a bun, two is a shoe, and so forth. The creation of unusual (and therefore, more memorable) mental associations between target items and pegwords enables users to retrieve target items more easily by thinking of the relevant pegword (e.g., Marshark, Richman, Yuille, & Hunt, 1987). Mental imagery techniques have also been used to organize vast amounts of information in memory, an approach typified by the use of the 'method of loci' technique which uses associations between information and rooms in an imaginary house (Bower, 1970; Roediger, 1980). Although associations can be arbitrary, it is perhaps this very random nature of an association which enables it to be so powerful in effecting comprehensive retrieval of information.

The present technique builds on the similarity between these active-imagery mnemonic techniques and the popular concept of context-dependent memory. If the premise behind context effects is built on the implicit association between information and the EC in which that information was encountered, then a more active (rather than a passive) association between the two should enhance and strengthen these effects. The technique draws heavily on the work of Smith (1979) who

demonstrated the power of mental imagery and context reinstatement. In line with standard findings, Smith found that free recall in a 'same-context' condition was significantly higher than that in a 'different-context' condition. However, when members of another 'different-context' group were asked to vividly imagine the encoding-EC before beginning their retrieval attempt, recall performance increased to a level similar to that of the 'same-context' group, thus demonstrating the efficacy of mental (rather than physical) context reinstatement in free recall.

The present study utilizes a similar technique with one crucial difference. Rather than using mental imagery retroactively, as in Smith's study, this investigation examines the efficacy of using a more proactive form of imagery at encoding. Here, participants are asked to vividly imagine a particular physical environment while being exposed to a series of words and, later, they find themselves in this precise environment when they are asked to retrieve the word list. In using mental imagery at encoding, participants may be able to link mentally the to-be-remembered information with the retrieval environment such that, when participants finally go to the retrieval environment, they are effectively reinstating the original learning context. The question of interest here is: Does imagining the retrieval-EC at the encoding phase negate context-dependent forgetting?

Experiment 1

Method

Participants. Eighty-two Year 1 psychology undergraduate students (24 male, 58 female, mean age: 18.6) acted as participants in this study in return for partial course credit. Participants were assigned to conditions on an opportunity basis.

Design. This study utilized a 2 x 2 between-group design with context (same, different) and encoding imagery (imagery, no imagery) as between group factors. Approximately half of the participants encoded and retrieved in the same context (Room A) while the other half encoded and retrieved in different contexts (encode in A, retrieve in B). Within each of these conditions, half of the participants were asked to visualize Room B at encoding and the other half were not. This resulted in 4 groups: A-A (*encode in A, retrieve in A*), A-B (*study in A, retrieve in B*), Ab-A (*study in A while imagining B, retrieve in A*), and Ab-B (*study in A while imagining B, retrieve in B*).

Materials. Fifty words, each of 5 letters and with a frequency of occurrence between 10 and 20 per million (Francis & Kucera, 1967), were chosen as stimuli for this study. The list consisted of a mixture of concrete and abstract words and, for presentation, each word was printed in landscape format in the center of a page in a 140-point font. Presentation order was kept constant for each presentation.

Room contexts. Room A, measuring approximately 5 m x 11 m, was a small, bright seminar room with exterior windows from floor to ceiling taking up one side. Colorful artwork covered the remaining three walls. A

set of tables was arranged in the center of the room forming a rectangular desk area, surrounded by 10 to 12 chairs.

Room B, measuring approximately 14 m x 19 m, was a large, dim, windowless lecture room with a raised dais at one end, supporting a large desk and a projector. On the wall behind this desk was a large whiteboard and a projector screen. The remaining walls were bare. The main floorspace of the room was filled with approximately 60 individual study chairs with attached writing tables, arranged in rows facing the dais.

Procedure. The study was run with groups of 6 to 8 participants in each session, with different conditions being run in separate sessions. In each session, participants sat around the central table in Room A where it was explained that they would shortly be shown a list of 50 words, one at a time, and that they should rate the pleasantness of each word on a 7-point scale which had been provided. Subsequently, the 50 target words were shown serially, with each word being presented for 4 seconds. This was followed by a 3-minute delay, followed by an unexpected recall test where participants were given 3 minutes to remember and write down as many words from the list as they could. When finished, participants were debriefed and thanked for their participation.

The precise instructions given to the participants in each session differed according to condition. Before being presented with the word list, participants in the A-A condition were told that the study concerned influences on the subjective ratings of word pleasantness. After being shown the words, they remained seated while 3 minutes were spent collecting the first set of materials. The retrieval phase took place in the same room. Instructions for the A-B condition were identical with the exception that this group moved to Room B to complete the retrieval phase. The Ab-A condition was identical to the A-A condition with the exception that participants were told that the study concerned the influence of mental imagery on subjective ratings of word pleasantness and they were asked to mentally picture Room B as vividly as possible while completing the word pleasantness rating task. As all participants had attended lectures in Room B for several months, all were familiar with the room. Finally, participants in the Ab-B condition were given the same instructions as the Ab-A condition, but were moved to Room B to compete the retrieval phase. The 3-minute study-test interval was maintained for all groups.

Results and Discussion

Recall scores for all participants were collated by condition and mean recall is shown in Figure 1 where it can be seen that the same context group (A-A) appears to show higher recall scores than the other groups, including the imagery-reinstated group (Ab-B). Two-way analysis of variance (ANOVA) showed a main effect of encoding imagery, $F(1, 78) = 11.57$, $p < 0.01$, with the no-imagery group achieving higher overall recall scores that the imagery group suggesting that visualizing Room B at encoding exerted a detrimental effect on recall. ANOVA also revealed a significant interaction between context and encoding imagery, $F(1, 78) =$

9.78, $p < 0.01$, with post-hoc Tukey tests indicating that the A-A group achieved higher recall scores than the other three groups ($p < 0.01$) which themselves did not differ.

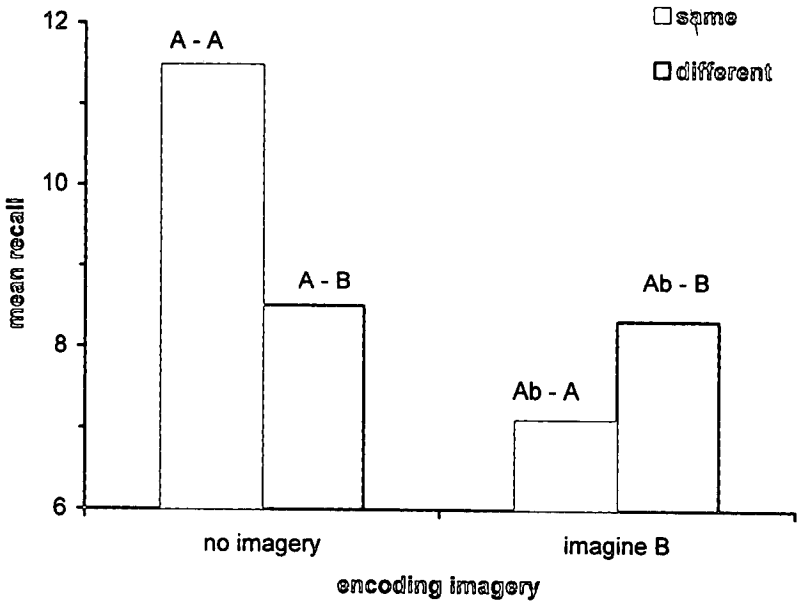

Figure 1. Experiment 1: Mean recall for each condition.

At first glance, these results seem disappointing from the imagined-context point of view as the Ab-B group fared no better than the A-B group; imagining the retrieval context at encoding may have exerted no effect on recall performance at all. However, we believe that, in fact, the results are quite encouraging and for the following reasons. In comparing the A-A and the Ab-A groups, it is clear that concurrently encoding words and carrying out a mental imagery task exerts a detrimental effect on subsequent recall. The Ab-A group encoded and retrieved under the same physical conditions as the A-A group but with the added process of mental imagery, and on average recalled over four fewer items. In addition, comparisons between the A-A and A-B groups also make it clear that changing EC between encoding and retrieval exerts a detrimental effect on subsequent recall: On average, the A-B group recalled three fewer items. Given that these two factors have been shown to reduce considerably the recall performance, it might be expected that a group which were influenced by *both* of these factors should suffer lower recall performance than any other group. In fact, the Ab-B group, who encoded under concurrent imagery instructions and then changed EC at retrieval, fared no worse than either of the groups who suffered only one of these factors.

One parsimonious interpretation of this result could assume the

operation of a floor effect and it may simply have been the case that normal participants could perform no worse than the Ab-B group on this task. However, from the imagined-context point of view, it is possible that the match between the imagined-context at encoding and the physical context at retrieval served to boost recall performance. Using mental imagery of the retrieval context at encoding, it is possible that participants in the Ab-B group were able to link the to-be-remembered information with the imagined context of Room B, thus being able to utilize the physical context of Room B as a retrieval cue when they subsequently found themselves in this location.

The central premise behind this investigation is that the use of mental imagery might be used to negate context-dependent forgetting. The results from the present study have shown that the recall scores of a group who encoded in one environment and retrieved in another (Ab-B) performed no worse than a second group who encoded and retrieved in the same environment (Ab-A). Nevertheless, closer examination of the data reveals that the basis of the effect appears to be in the weakening of recall in the same-context group (Ab-A) as well as a boost in recall of the different-context group (Ab-B). Clearly the mental imagery instructions have detrimental effects on the encoding process. The efficacy of such imagery techniques to improve recall can only be seen as worthwhile if the benefits of such a technique outweigh the costs of their implementation. If mental imagery serves only to negate the decrements in performance which it itself caused, the technique can hold little or no value.

The next experiment reported here attempts to strengthen the effect of contextual mental imagery on retrieval. The strength of this effect may be influenced by a number of factors. Clearly, participants can only link the to-be-remembered material to the target context if they could visualize the target context effectively. However, in the previous study, the degree to which the participants were familiar with the target context is likely to have varied quite considerably. It had been assumed previously that participants were familiar with the target context because all had attended lectures in the room as part of their undergraduate degree course. Nevertheless, it became clear that some participants had spent more time in the target context than others, depending on the number of modules taught in that particular room and the individual student's attendance record. If the participants' familiarity with the target context varied substantially, this is likely to have exerted an influence on the ease with which this context could be visualized at encoding, thus affecting the effect of the subsequent physical reinstatement of that context during the retrieval phase. The following experiment aimed to reduce the effect of this factor.

In addition, participants in the previous study were asked at the start of the encoding phase to visualize the target context throughout the word rating task. Imagery instructions were not given again. Therefore, it may be that, without instructions reminding participants that they should maintain this visualization, the degree to which participants visualized the target context may have declined as the word rating task proceeded,

thereby weakening the link between the encoded information and the target context. If participants were consistently reminded throughout the rating task that they should visualize the target context, this should effect a higher and more consistent degree of visualization, and foster stronger associative links between context and information.

Experiment 2

Experiment 2 represents a second attempt to show effective negation of context-dependent forgetting. This study differed from the previous experiment in two critical ways. Firstly, before taking part in the study, all participants were completely unfamiliar with the room contexts used. The experiment procedure introduced them to these new room contexts so that participants had equivalent degrees of familiarity with them. Second, during the encoding phase, participants in the relevant conditions were reminded consistently that they should visualize the target room, thus increasing the likelihood that the stimuli and the target context would become linked.

In the following study, we again utilize an A-A group and an Ab-A group as well as the target Ab-B group. The instructions and procedures used with these groups are the same as before. However, we also include an additional control group to assess the effect of reinstating *neither* the study EC nor the target EC. At encoding, this Ac-B group are asked to imagine their living room at home and are then moved to Room B to retrieve.

In making these adjustments to the study protocol, we expect that, the A-A group should show no superiority over the Ab-B group, but that both of these groups should demonstrate greater memory performance over the Ab-A and Ac-B groups.

Method

Participants. One hundred and thirteen participants (25 male, 88 female, mean age: 20.49, range 13-54years) took part in this study. All were visitors to the Psychology Department at the University of Liverpool, attending one of four department open days, and the sample comprised a mixture of prospective students of the department and accompanying guests. All participants volunteered to take part in the study and none had ever been inside the Psychology building before their visit.

Materials. The to-be-remembered stimuli were identical to those used in the previous experiment. Owing to building development in the Department of Psychology, room locations were different from those used in the previous studies. Room A remained the same as before. A small theatre on the ground floor of the Psychology building was used as Room B. This measured approximately 18 m x 27 m and was a dimly lit 250-seat theatre with a large raised stage area and orchestra pit at one end. The ceiling of the room was very high to accommodate the steeply tiered theatre-seating which extended from the front of the orchestra pit to the back of the room. Steps on either side of the room formed aisles for access to the seating.

Procedure. Testing took place on four individual afternoons during Psychology Department open days. Two experiment sessions were run on each afternoon with groups of 12 to 15 participants in each session. Participants in Conditions Ab-B and Ab-A were brought initially to Room B and asked to walk around the room for a few minutes to fully familiarize themselves with the environment. They were encouraged to take in the 'feel' of the room as well as note the details of how the room looked. After 5 minutes, participants were brought to Room A where they sat around a large central table and the study task was explained to them. It was explained that the study concerned the influence of mental imagery on subjective perceptions of word pleasantness. Participants were then asked to imagine the previous room as vividly as they could while rating words on a pleasantness scale. Word ratings were given on ratings booklets with space for 7 to 8 ratings on each page. At the bottom of each page was printed the instruction, 'Please keep picturing the other room.' Twice during the ratings task, the experimenter orally reminded the participants to keep imagining the other room as vividly as they could. After the ratings task was complete, participants in the Ab-B condition were led back to Room B where they were given writing materials. Participants in the Ab-A group remained in Room A while the materials from the ratings task were collected. Then participants were given 3 minutes to remember and write down as many words as they could from the previous list.

Participants in the Ac-B group underwent a similar procedure with the exception that they did not undergo the familiarization process in Room B. Rather, before the ratings task, they were asked to visualize their living room at home as vividly as possible while completing the ratings task. This group then moved to Room B before being asked to recall as many words as possible. The A-A group neither underwent the familiarization procedure nor did they receive any imagery instructions before the ratings task. This group was simply told that the study concerned the influences on the subjective ratings of word pleasantness. After the ratings task was completed, materials were collected before participants were asked to remember as many words as they could from the previous list. A 3-minute study-test interval was maintained for all groups.

Results and Discussion

Mean recall scores for each group are shown in Table 1 where it is clear that the recall scores of the Ab-B and A-A groups appear to be higher than those of the Ab-A and Ac-B groups. These differences were confirmed statistically by one-way analysis of variance, $F(3, 109) = 37.4$, $p < 0.001$. Post-hoc Tukey tests showed that both the Ab-B and A-A groups differed from the other two conditions ($p < 0.001$) but were not significantly different from each other.

The central question which prompted this study was whether changing EC always exerted a detrimental effect on human memory performance, and specifically, whether there was any technique which

Table 1

Experiment 2. Mean Recall and Standard Deviations for Each Condition

Condition	Mean Recall (*SD*)
A-A ($n = 28$)	13.25 (3.36)
Ac-B ($n = 29$)	5.97 (3.54)
Ab-A ($n = 27$)	7.26 (4.36)
Ab-B ($n = 29$)	14.10 (3.07)

might be applied to reduce context-dependent forgetting. The answer to the latter question is undeniably, "yes." When a change-EC group used the target visualization technique, context-dependent forgetting reduced dramatically, bringing recall performance to the same level as an equivalent group who reinstated the physical EC.

One interpretation of the results of Experiment 1 is that visualization at encoding imparts a strongly detrimental effect on subsequent recall. Given this effect, it is remarkable that the Ab-B group demonstrated recall scores equivalent to the A-A group (whose encoding efforts were not hampered by visualization). Evidently, to say that visualization is always detrimental to recall is an oversimplification. Rather, the important factor seems to be the degree of overlap between encoding and retrieval conditions. Following the encoding phase, the Ab-A and Ab-B groups are nominally equivalent; both have encoded in Room A while imagining Room B. However, the degree to which they can retrieve information depends not on the fact that they have engaged in visualization at encoding but the degree of overlap between encoding and retrieval. Differing retrieval conditions result in significantly differing recall performances. Similarly, both the Ab-B and A-A groups find a strong degree of overlap between encoding and retrieval environments. In the case of the former, the encoding environment is imagined but, with consistent reminders to picture this environment at encoding, the imagined environment appears to be as effective (in terms of incorporation into a memory trace) as the physical presence of the environment. This finding provides strong convergent evidence in support of Smith's (1979) results involving retrospective imagined-context reinstatement, emphasizing the notion that changing EC between encoding and retrieval need not result in context-dependent forgetting.

When the imagined EC is present at retrieval, its effect can be powerful. The impacts of active processing of context by the Ab-B group and the subsequent physical reinstatement of that context at retrieval, combine to yield potent effects on recall performance. Doubtlessly, the important factor behind this performance is the active processing of context. The Ab-B group were consistently encouraged to mentally picture an alternate location while completing the rating task whereas it is unlikely that the A-A group applied any active processing to their EC at encoding. In employing active processing, it is likely that the Ab-B group created stronger associative links between the target information and the

EC, thus making the EC more effective as a retrieval cue when it was subsequently reexperienced in the retrieval phase.

The effects of visualizing a context at encoding which subsequently affords no benefit at retrieval can be seen in the performance of the Ab-A and Ac-B conditions. Both of these groups completed the encoding task while visualizing another EC; however, they accrued no benefit from this visualization as neither group completed the retrieval task in that EC. The Ab-A group visualized Room B at encoding and remained in Room A to complete the retrieval phase but, even though there was no discernible benefit from visualizing Room B, there may still have been some residual benefit from encoding and retrieving in the same physical EC. In contrast, the Ac-B group accrued benefit neither from their retrieval EC nor from their visualization at encoding. Thus one might predict that recall in the Ac-B group would be poorer than in the Ab-A and, while the data do show a numerical difference in the correct direction, it is not strong enough to reach significance. Nevertheless, the pattern of results here suggests a degree of influence of the context.

In conclusion, these studies have demonstrated the influence of context imagery on memory performance and, in suitable circumstances, mental imagery techniques can be used to improve memory performance and negate context-dependent forgetting. Contrary to prevailing knowledge concerning EC and memory, changing contexts between encoding and retrieval does not always result in poorer memory performance.

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