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Remembering In and Out of Context

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Three experiments examined the incidental associations between list-learning material and the environmental context of that list's presentation. The environmental reinstatement effect is that subjects remember more when tested in their original learning environment relative to those tested in a new environmental context. Experiment 1 demonstrated that this effect is due to a memory process, rather than a general performance decrement caused by the unfamiliarity of the new test room. The reinstatement effect was eliminated in Experiment 2 when subjects tested in a new room were instructed to recall the original learning environment just prior to free recall of list words. This release from contextual dependence was diminished in Experiment 3 when the original learning room was made more difficult to remember. The results show that context effects can be brought under cognitive control; subjects can supply their own contextual retrieval cues when the context can be easily recalled.

Contextual dependence of memory refers to phenomena which show that memory is best when the situational or contextual conditions present at learning are reinstated at the time of the test. Such phenomena have been documented for various memory paradigms and for a variety of types of context. (For reviews, see McGeoch, 1942; Smith, Glenberg, & Bjork, 1978.) For example, words are recalled more poorly when the environmental context is changed (different context [DC] condition) rather than held constant (same context [SC] condition) between input and test (e.g., Godden & Baddeley, 1975; Smith et al., 1978). Similar decrements in verbal memory have been

noted with changes in semantic context (e.g., Light & Carter-Sobell, 1970) and with changes in pharmacological state (e.g., Eich, Weingartner, Stillman, & Gillin, 1975).

Context dependence, however, has failed to occur in certain investigations (e.g., Farnsworth, 1934; Santa & Lamwers, 1974; Smith et al., 1978, Experiments 4 and 5), and such failures cannot necessarily be attributed to experimental insensitivity or to a lack of statistical power. It is apparently not enough to state simply that SC conditions produce better memory than DC conditions, if one wishes to predict memory performance. What is needed is a more complete framework or set of principles to describe the interrelation and functioning of context in memory processes. Such a framework should be capable of predicting, for example, how to enhance or to decrease contextual dependence through manipulation of the type of material learned, type of context, type of test, or instructional variables. It is the aim of the present investigation to point out one such principle of contextual functioning that relates memory for context to the phenomenon of contextual dependence.

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The present studies are specifically concerned with the effects of the general environmental context on memory of verbal material acquired in that situation. The general environmental context refers to the physical surroundings in which an event occurs, including location, size of room, objects and persons present, odors, sounds, temperature, lighting, and so on. The type of contextual dependence dealt with in the present investigation, to be referred to as the environmental reinstatement effect, is the finding that subjects recall more when returned to their original learning environment, as compared with those tested in a new environment (e.g., Smith et al., 1978).

The environmental reinstatement effect, an empirical phenomenon, should be distinguished from the theoretical principle (e.g., Carr, 1925), which states that contextual associations are responsible for the effect. Contextual associations refer to connections in memory between what is learned and the environmental context in which learning takes place. For example, contextual information might be associated with each list word (e.g., Anderson & Bower, 1974; Kintsch, 1974), with the list of words, as a whole (i.e., the search set model, Smith et al., 1978), or with the set of cognitive operations employed for processing and cataloging learned information (e.g., Stillman, Weingartner, Wyatt, Gillin, & Eich, 1974). The meaning of the term *contextual associations* here is not further specified because the hypotheses relevant to the present set of studies do not discriminate among the various possible meanings.

It is not obvious that subjects store contextual associations in memory because there has been no systematic relationship between the environment and list words in any context studies. Experiment 1, therefore, examined the possibility that the environmental reinstatement effect is caused by an experimental artifact, rather than the result of contextual associations. If the effect is due to contextual associations, it is not clear why subjects in the DC condition do not access environmental information in memory to facilitate recall of words. Experiments 2 and

3 tested whether DC subjects could overcome environmental context dependence by remembering the room in which learning took place.

Experiment 1

There is at least one explanation of the environmental reinstatement effect that does not assume that the mental representations of context and of verbal material become integrated when the material is learned. This explanation is based on the fact that in the typical environmental reinstatement paradigm, SC subjects are tested in a familiar room and DC subjects are tested in novel surroundings. It may be assumed that subjects in a psychology experiment attend to their environmental surroundings with anxiety, interest, or suspicion, any of which would produce a performance decrement. Such anxiety or interest in the environment would be greater in novel surroundings. Therefore, the environmental reinstatement effect, or a portion of it, could be explained as a general performance decrement (the performance hypothesis), rather than a result of contextual associations (the memory hypothesis).

There is some evidence of contextual associations that cannot be explained by the performance hypothesis. Bilodeau and Schlosberg (1951) found that retroactive interference (RI) was reduced if original learning (OL) and interpolated learning (IL) occurred in separate rooms, as compared with the standard condition where OL and IL occurred in the same room. This result has been replicated by Greenspoon and Ranyard (1957) and Strand (1970) with human subjects, and by Zentall (1970) with rats. The memory hypothesis states that RI was reduced in the varied context condition because the test context did not match the interpolated list context. Hence, IL list words were remembered more poorly, and there was less interference caused by those words. The performance hypothesis does not predict the reduction of RI because both groups were tested in a familiar experimental setting.

Strand (1970), however, attributed this

text

open list-learning situation. The environment when tested in a new environment is due to a change caused by the environment was eliminated. The subject is instructed to recall of list words learned in Experiment 1. It is difficult to remember under cognitive cues when the

in semantic context (Sobell, 1970) and a psychological state (e.g., Stillman, & Gillin,

however, has failed in investigations (e.g., Santa & Lamwers, 1974; Experiments 4 and 5), cannot necessarily be environmental insensitivity or to power. It is apparently simply that SC condition memory than DC condition needed is a more complete set of principles to relation and functioning memory processes. Such a subject is capable of predicting, enhance or to decrease through manipulation of learned, type of contextual instructional variables. The present investigation to principle of contextual associations memory for context dependence.

result not to contextual associations but instead maintained that the physical disruption involved in changing contexts between OL and IL was responsible for the reduced interference effects. She found that mere physical disruption between lists reduced RI as much as an actual change of context. This finding, she explained, was a result of increased list discrimination caused by a disruption between lists, whether or not the disruption also involved a room change.

With Strand's (1970) disruption hypothesis to explain reduced interference effects and the performance hypothesis as an explanation of the typical environmental reinstatement effect, there remains only one experiment whose results require the memory hypothesis. In Experiment 2 of the study by Smith et al. (1978), subjects studied two lists of words in two different contexts and were tested in one of these two contexts. Smith et al. found that words were remembered best when tested in the room in which that list was studied. Neither the disruption hypothesis (all subjects were equally disrupted) nor the performance hypothesis (all subjects were in the test room prior to testing) can explain this result.

Even though Smith et al.'s results support the memory hypothesis, it is still not certain whether the typical environmental reinstatement effect is caused solely by contextual associations. It is possible that a substantial proportion of the effect is caused by the unfamiliarity of the test context (the performance hypothesis), even if there is some contextual cuing involved in that situation. Experiment 1 was designed to evaluate the performance hypothesis as a possible explanation of the environmental reinstatement effect.

Two variables, context matching and context familiarity, have been confounded in the typical context reinstatement paradigm. The memory hypothesis states that context matching is solely responsible for the environmental reinstatement effect; that is, when the learning and test contexts match (SC condition), a subject can use associations in memory that link that context and the material learned, whereas a mismatch

(DC condition) does not make such associations available. The performance hypothesis states that context familiarity produces the reinstatement effect; the unfamiliar surroundings of the DC condition disrupt those subjects' performance relative to the SC subjects, who are tested in a familiar environment.

The test of these two hypotheses requires a design that separates the variables of context matching and familiarity. Subjects studied a list of words in one room (Room A) and then moved to a second room (Room B or C). They were familiarized with the second room by drawing sketches of the room and its contents. Subjects were subsequently given a test for free recall of list words in the room in which they studied the words (Group ABA), the room that was familiar but in which no words were presented (Group ABB), or in a new environment (Group ACB). If the memory hypothesis is true, then Group ABA should recall more words than Groups ABB and ACB because the input and test rooms matched only for Group ABA. If the performance hypothesis is true, then Groups ABA and ABB should recall equal amounts, since they were both tested in familiar environments, and both should recall more than Group ACB, which was tested in an unfamiliar room. If both matching and familiarity affect recall, then Group ABA should recall the most words (benefiting from both matching and familiarity), Group ABB the next most (tested in familiar, but mismatched room), and Group ACB the fewest words (tested in the unfamiliar, mismatched room).

Method

Subjects. Thirty introductory psychology students served in the experiment. Each was given course credit points following participation.

Procedure. Subjects participated either singly or in pairs for one 30-min. session. The session was divided into three 10-min. sections, and each section was followed by a brief return to the subject waiting room.

The first 10-min. section consisted of list learning, followed by a partial recognition test. Subjects were instructed to memorize list words in any way possible without worrying about the word order.

Individual words were presented at (on slides in Room B or on a tap in Room A). Subjects were then given a test over 10 (old) list words and 10 (new) tractors. Subjects responded on a confidence rating scale; 1-3 indicated complete confidence, with 1 indicating complete confidence and 4-6 indicated a "new" response, indicating complete confidence. Test words were shown for 6 sec apiece. The partial test was used for closure so that subjects were not informed about a later free recall test and not actively rehearse list words during the learning task.

The second 10-min. session was a drawing task. Subjects were told that the purpose of the experiment concerned drawing. They were instructed to draw two sketches of the room they were in without labels on their sketches. Five minutes were given for each sketch. Subjects were instructed to draw the other person(s) in the room (i.e., the experimenter and the other subject, with one exception) from their sketches. It seemed unlikely that subjects would make the ABB subjects at least one sketch with the free recall test room as ABA.

Following the context familiarization task, subjects returned to a waiting room where they were to ensure equal disruption for all groups. Subjects were then taken to the test room corresponding to their experimental group and were told that they had 1 min., all of the list words and to guess if they could remember, and to guess if not.

Design. Three rooms, A, B, and C, were used. Ten subjects were randomly assigned to the three groups, which differed on the order of rooms used for the various conditions. In counterbalancing, subjects in Group ABA learned in Room A, context familiarity in Room B, and free recall testing in Room C. In Group ABB had A first, then B, and then C. In Group ACB had A first, then C, and then B. In the second counterbalancing, Rooms A, B, and C were reversed, giving the corresponding groups BAA, and BCA. The combined subjects in Groups ABA and BAB are referred to as Group ABB, and the combined subjects in Groups ACB and BAA as Group ABB, and ACB as Group ACB.

List learning always occurred in the first room to avoid the possibility of an unequal amount of context familiarity on the learning task (remembering) of the three groups. The free recall task occurred second so that the subject was familiar (but did not match the test room) would be more recent at the time of the test and would, therefore, be at least as familiar to the subject as the list-learning room.

Materials and apparatus. List words were one syllable, four- to five-letter, unrelated, high-frequency English words from the Kucera and Francis (1967) list. The words of frequency 50 or more per

does not make such associations. The performance hypothesis predicts that context familiarity produces the effect; the unfamiliar surround (DC) condition disrupts those associations relative to the SC condition. Subjects are tested in a familiar

environment. These two hypotheses require that the variables of context and familiarity be separated. Subjects were tested in one room (Room A) and then moved to a second room (Room B). They were familiarized with the environment by drawing sketches of the contents. Subjects were subjected to a test for free recall of list words in which they studied the list in Room A (ABA), the room that was familiar in which no words were presented in Room B (ABB), or in a new environment (ACB). If the memory hypothesis is correct, Group ABA should recall more words than Groups ABB and ACB. If context and test rooms matched (ABA), then Groups ABA and ACB should recall equal amounts, since they were tested in familiar environments. If Group ABA should recall more than Group ACB, which was tested in an unfamiliar environment, then Group ABA should recall more words (benefiting from both context familiarity), Group ABB the least in familiar, but mismatched, and Group ACB the fewest in the unfamiliar, mismatched

introductory psychology student experiment. Each was given a test following participation.

Subjects participated either singly or in pairs in a 10-min. session. The session was divided into 4-min. sections, and each section was followed by a brief return to the subject waiting room.

Each section consisted of list learning, followed by a recognition test. Subjects were instructed to memorize list words in any way they wished, carrying about the word order.

Individual words were presented at 3-sec intervals (on slides in Room B or on a tape recording in Room A). Subjects were then given a recognition test over 10 (old) list words and 10 (new) distractors. Subjects responded on a 6-point confidence rating scale; 1-3 indicated an "old" response, with 1 indicating complete confidence, and 4-6 indicated a "new" response, with 6 indicating complete confidence. Test words were shown for 6 sec apiece. The partial recognition test was used for closure so that subjects, who were not informed about a later free recall test, would not actively rehearse list words after the list-learning task.

The second 10-min. session was a context familiarization task. Subjects were told that this part of the experiment concerned depth perception. They were instructed to draw two different views of the room they were in without labeling any part of their sketches. Five minutes were allowed for each sketch. Subjects were instructed to omit the other person(s) in the room (i.e., the experimenter and the other subject, when there was one) from their sketches. It seemed that this task would make the ABB subjects at least as familiar with the free recall test room as ABA subjects.

Following the context familiarization task, subjects returned to a waiting room for 3 min. (to ensure equal disruption for all groups). They were then taken to the test room corresponding to their experimental group and were told to write, for 10 min., all of the list words and test words they could remember, and to guess if necessary.

Design. Three rooms, A, B, and C, were used. Ten subjects were randomly assigned to each of the three groups, which differed only in the pattern of rooms used for the various tasks. For one counterbalancing, subjects in Group ABA had list learning in Room A, context familiarization in Room B, and free recall testing in Room A. Group ABB had A first, then B, and then B, and Group ACB had A first, then C, and then B. For the second counterbalancing, Rooms A and B were reversed, giving the corresponding Groups BAB, BAA, and BCA. The combined subgroups of ABA and BAB are referred to as Group ABA, ABB and BAA as Group ABB, and ACB and BCA as Group ACB.

List learning always occurred in the first context to avoid the possibility of an unequal influence of context familiarity on the learning (as opposed to remembering) of the three groups. The familiarization task occurred second so that the room that was familiar (but did not match the list input room) would be more recent at the time of the test and would, therefore, be at least as familiar to the subject as the list-learning room.

Materials and apparatus. List words and test words were one syllable, four- and five-letter, unrelated, high-frequency English nouns drawn from the Kucera and Francis (1967) norms. Only words of frequency 50 or more per million were

chosen. There were 80 words presented on the list and 10 new distractors on the recognition test (which also contained 10 old list words), making a total of 90 possible words to be recalled.

For context B, words were typed in capital letters on slides, projected onto a wall via a Carousel projector, and changed by an electronic timer. For Context A, words were read aloud over a cassette tape recorder.

Environmental contexts. Room A was on the fifth floor of the psychology building near the animal laboratories. Subjects sat in a crowded sound-proof booth inside a room filled with computer equipment, and words were presented via a tape recorder. Room B was a larger room in the basement of the building. There was a huge orange drapery hanging from the ceiling, posters and pictures on the walls, plastic plants, carpeting, a sink, books, a table, and chairs. Room C was a fairly empty room on the second floor of the building, containing desk chairs, a slide projector (not used), a viewing screen, a wastebasket, and a cabinet. The three rooms were in different locations, and they looked very different from one another.

Results and Discussion¹

Averaged across counterbalancings, the mean recall scores were 24.0 words for Group ABA, 18.5 words for Group ABB, and 17.7 words for Group ACB. An analysis of variance (ANOVA) comparing the three groups did not show significant differences among the means, $F(2, 27) = 3.17$, $MS_e = 37.13$.

Orthogonal contrasts show superiority of recall of Group ABA over the other two groups, $F(1, 27) = 5.78$, accounting for 98.6% of the treatment sum of squares. The remaining orthogonal comparison of Group ABB vs. ACB was not significant, $F(1, 27) = .08$.

The results support the memory hypothesis, since the same-context group (ABA) recalled more words than either of the different-context groups (ABB and ACB). There was no effect of the context familiarity variable. It is concluded, therefore, that the memory hypothesis remains the most parsimonious explanation of known environmental reinstatement effects.

¹ The level of alpha was set at .05 for the analyses in all experiments.

Experiment 2

To reiterate, contextual associations refer not to the actual physical stimuli, but rather to the mental representations of the environmental context and of the list words. The environmental reinstatement principle implies that the SC environment elicits retrieval of the representation of that context that was stored at input, and this process provides access to contextual associations. Subjects in the DC condition do not retrieve a representation of the environment, and therefore cannot access and use contextual associations to help recall of words. Experiments 2 and 3 examined the reason(s) that DC subjects do not retrieve and use the stored representation of the learning environment as a means of facilitating word recall.

Remembering the context as a means of facilitating memory of events that occurred in that context is a mnemonic technique whose usefulness has been pointed out by well-known mnemonists. Simonides (cited in Bower, 1970) remembered the occupants of a room by first recalling the various loci that existed in the room, and Luria's (1968) mnemonist, S., memorized and recalled lists of objects with the use of imagined places along a street in Leningrad. In these examples, it was not necessary for the subject to be placed in the physical surroundings whose mental representation was linked with the sought-for information. The context was reinstated not perceptually but mnemonically; its representation was retrieved from memory without the physical presence of that context to serve as a stimulus.

It is clear that there are situations in which a subject makes use of retrieved information in memory when the physical counterpart of that retrieved information is not present. For example, a subject who recalls a categorized list of words does not always need to have the category name printed out to make use of category-list word associations; the subject need only recall the category name from memory to access those associations. A study by Petersen and Jacob (1978) has pointed out the importance of memory for context when the

subject is recalling noun tetrads, when the context was a word that thematically connected the four words of the tetrad. They found that the primary factor determining recall of the tetrads was the recall of contexts.

The purpose of this discussion is to point out the possibility that DC subjects in the environmental reinstatement paradigm might be able to access contextual associations by recalling aspects of the environmental context from memory. If such a technique is possible, why do DC subjects apparently not use it? Two hypotheses, the cuing hypothesis and the strategy hypothesis, are proposed as answers to this question.

The cuing hypothesis relates recall performance to one's ability to recall the input environmental context. It states simply that a representation of the subject's input environment is cued by the physical reinstatement of that context, thus making contextual associations easily available. When that environment is not physically present (i.e., DC subjects), it is more difficult for the subject to remember the list-learning context, and contextual associations are not as accessible.

The strategy hypothesis states that the mechanism that underlies the environmental reinstatement effect involves not the subject's ability to remember the input environment, but rather the likelihood that a subject will use the strategy of remembering the input room to facilitate recall of list words. According to this hypothesis, both SC and DC subjects are equally able to remember the environment in which list learning took place, but SC subjects are more likely than DC subjects to adopt this strategy. The strategy hypothesis predicts, then, that merely instructing the DC subjects to use this strategy should eliminate the recall difference between SC and DC groups.

A combination of the strategy and cuing hypotheses is also possible. This combination states that DC subjects are less likely than SC subjects to use context recall as a strategy for facilitating word recall, and further, when such a strategy is used, SC subjects are better able to recall their input environment than DC subjects.

To test these hypotheses, three groups were added to the traditional different-context conditions (SC and DC). In these three treatments, subjects in the different context were given specific instructions just prior to a free recall of list words. The different-context-reinstatement (DC-R) group was simply instructed to remember their input room to use that memory to help recall of list words. The different-context-cued (DC-C) group was given the same context-recall instructions as the DC-R group, except that the DC-C subjects were also allowed to view photographs of their input room to facilitate memory of that environment. The different-context-placebo (DC-P) group was given a placebo instruction to view an irrelevant environment to determine the effect of a context-recall instruction. Such an instruction was unlikely to give the subject access to appropriate contextual associations.

The strategy hypothesis predicts that Groups DC-R and DC-C (both of which were told to use the context-recall strategy) will recall more words than the SC group, and that performance of Group DC-C will be equal to that of the SC group. The cuing hypothesis predicts that Group DC-C will recall more than Group DC-R, and DC-P, since DC-C subjects have retrieval cues (photographs) to facilitate memory for the input environment. A combination of the two hypotheses predicts that Group DC-C will recall more words than Group DC-R, which will recall more words than Group DC.

All hypotheses predict that Group DC-C will recall more than Group DC. The strategy hypothesis predicts that Groups DC and DC-C will differ in recall.

Method

Subjects. Fifty introductory psychology students at the University of Wisconsin served as subjects. Each was paid \$10.00 at the end of the two 30-min. sessions.

Materials, apparatus, and context. The materials and apparatus were identical to those described for the list-learning session in Experiment 1. The environmental contexts used

To test these hypotheses, three conditions were added to the traditional same- and different-context conditions (see Table 1). In these three treatments, subjects in a different context were given special instructions just prior to a free recall task for list words. The different-context-remember (DC-R) group was simply instructed to try to remember their input room and to try to use that memory to help recall list words. The different-context-cued (DC-C) group was given the same context-recall instruction given the DC-R group, except that the DC-C subjects were also allowed to view photographs of their input room to facilitate their memory of that environment. Finally, the different-context-placebo (DC-P) group was given a placebo instruction to recall an irrelevant environment to determine the effect of a context-recall instruction when such an instruction was unlikely to give the subject access to appropriate contextual associations.

The strategy hypothesis predicts that Groups DC-R and DC-C (both of which were told to use the context-recall strategy) will recall more words than the DC group, and that performance of Groups DC-R and DC-C will be equal to that of the SC group. The cuing hypothesis predicts that Group DC-C will recall more than Groups DC, DC-R, and DC-P, since DC-C is given retrieval cues (photographs) to facilitate memory for the input environment and Groups DC, DC-R, and DC-P are not. A combination of the two hypotheses predicts that Group DC-C will recall more words than Group DC-R, which will recall more than Group DC.

All hypotheses predict that Group SC will recall more than Group DC, and none predict that Groups DC and DC-P will differ in recall.

Method

Subjects. Fifty introductory psychology students at the University of Wisconsin—Madison served as subjects. Each was paid course credit points at the end of the two 30-min. sessions.

Materials, apparatus, and contexts. The materials and apparatus were identical to those described for the list-learning session of Experiment 1. The environmental contexts used were described

as Room A and Room B in the Method section of Experiment 1. List words were presented on a tape recording at 3-sec intervals in all conditions.

The 15 slides shown to Group DC-C prior to word recall were projected onto the screen in Room A via a Carousel projector. The slides were pictures of the subject waiting room, the corridors and stairway on the way to the experimental room (Room B), and numerous photographs of the inside of the room.

Design and procedure. On the first day, all subjects were brought to Room B and were taken through the list-learning and partial recognition testing procedures described in the Method section of Experiment 1. The 10 subjects randomly assigned to each group differed from the other groups according to their experimental treatment immediately prior to the surprise free recall test on the second day. Subjects in Group SC returned on the second day to the room in which list learning took place (Room B) and were given 10 min. to write, in any order, all of the list words and test words that they could remember from the previous day.

All other groups were tested in Room A on the second day. Group DC differed from Group SC only in that Group DC was tested in Room A, and Group SC was tested in Room B, the list-learning room. Subjects in Group DC-R were first asked to write down the location of their list-learning room, and to list any 10 things they could remember seeing in that room (if they could remember that many). Three minutes were given for this task. Subjects were then asked to take 2 min. to think about Room B, what it looked like, what sounds and smells were there, where it was, and the way it made them feel. They were then told that the context-recall task they had been doing might help them recall words that were presented in that room, and they were asked to try to use their memory for Room B to help them to recall the list and test words from the previous day. Ten minutes were given for the free recall test.

Group DC-C was tested exactly like Group DC-R, except that during the 2 min. context-recall task, subjects were shown slides of the experimental room to help them remember as much about Room B as possible.

Group DC-P was treated the same as Group DC-R except that instead of remembering information about Room B, they recalled information about a room at home (e.g., living room or dormitory room). These subjects were told that the exercise was a good "mental warm-up" for remembering other sorts of information, and that it might help them to recall the words from the experiment.

Results and Discussion

The group means are shown in Table 1. Groups SC, DC-C, and DC-R all recalled

Table 1
Day 2 Instructions and Mean Word Recall for
Five Experimental Groups: Experiment 2

Group	Instructions prior to free recall	M recall
SC	None	18.0
DC-C	Recall Room B, view photos of Room B	18.8
DC-R	Recall Room B, think about Room B	17.2
DC	None	12.0
DC-P	Recall room at home, think about room at home	9.6

Note. SC = same context, DC-C = different context-cued, DC-R = different context-remember, DC = different context, DC-P = different context-placebo instruction.

more than Groups DC and DC-P. An ANOVA comparing the mean free recall scores for the five groups showed a significant difference among the means, $F(4, 45) = 5.13$, $MS_e = 32.35$. Pairwise comparisons, using the least significant difference method (LSD = 5.13) indicated that the means of SC, DC-C, and DC-R did not differ from each other, and that all three recalled more words than DC and DC-P, which did not differ from each other.

The results offer strong support for the strategy hypothesis. The robust environmental reinstatement effect (Group SC recalled one and a half times the number of words recalled by Group DC) was eliminated merely by giving DC-R subjects an instruction to use their memory for their input environment to facilitate word recall. Word recall was not facilitated merely by an instruction to recall information about any environment; DC-P subjects performed, if anything, worse than DC subjects on the free recall test. Facilitation occurred only when the recalled environmental information was specific to the list-learning episode.

One possible criticism of Experiment 2 is that the DC-C and DC-R groups may have implicitly retrieved list words during the context recall that preceded the word recall task. This could have increased the word recall of those subjects, since longer recall intervals and multiple recall sessions have

been known to yield better word recall scores (Erdelyi & Kleinbard, 1978).

This criticism, however, is mitigated by the following: First, the subjects had little reason to believe that they would be tested for memory of list words on the second day. They had already been tested on the list words on the first day, and the context recall instruction specified only that they recall objects in the room. Second, the 10-min. free recall interval was more than enough for subjects to exhaust their memory for list words; there were no subjects still writing responses at the end of the 10 min. Finally, at the very worst, such a criticism would necessarily support the idea of contextual associations, since the DC-P group obviously did not benefit from this potentially longer test interval.

The conclusion drawn from the present set of results was that contextual associations in memory can be accessed whether elicited perceptually or mnemonically; the physical presence of the context is not necessarily needed for its reinstatement to occur. This implies that DC subjects recall less than SC subjects in the typical environmental reinstatement paradigm because DC subjects do not employ the mnemonic strategy of using memory for environmental context to help recall list words. When instructed to use this mnemonic strategy, DC subjects are able to successfully employ it.

The cuing hypothesis was not supported by the results. Group DC-C viewed photographs of their list-learning room, and SC subjects were returned to their input room. These two groups, therefore, were provided with more environmental information than DC-R. According to the cuing hypothesis, DC-R should have recalled fewer words than SC or DC-C because those subjects were given less contextual information. The results, however, did not support this prediction, as the recall scores of SC, DC-C, and DC-R did not differ from one another.

Experiment 3

The fact that no recall differences were found between SC, DC-C, and DC-R in

Experiment 2 suggests that the hypothesis should be rejected; however, that the design of Experiment 2 did not produce a situation in which DC subjects were differentially affected by their input environmental context. It is clear how well a DC subject can be instructed to recall the input environment: the release from contextual information evidenced in Experiment 2. It is only a small amount of environmental information must be recalled for the subject to gain access to contextual associations. The situation in Experiment 2 made contextual information available for recall, such that SC, DC-C, and DC-R were all able to derive the material from the use of their memory for the learning room as a retrieval aid.

It seems reasonable that memory for contextual information should be accessed by the same or similar rules as memory for other types of information. For example, memory for contextual information may prove with increased exposure to the text, and context should be forgotten during the retention interval or the presence of competing responses (i.e., related information) increases.

Experiment 3 was designed to test the subject's ability to remember list words in context by varying the number of competing contextual responses. Subjects were presented with either many (10) or few (one) distractor rooms on the list-learning. (See Table 2 for details of room assignments.) It was expected that memory of these rooms would be forgotten by competing responses for the list-learning, therefore, that subjects would be able to remember one of two environments out of five.

In this experiment those tested in the two conditions were asked to remember list words about their list-learning room. The instruction was used to avoid strategic differences between the groups, so that any differences in free recall performance would be due to differences in the subjects' ability to access environmental information.

yield better word recall scores (Ingham, 1978).

First, however, is mitigated by the fact that the subjects had little recall of words on the second day. They had been tested on the list on the first day, and the context recall was only that they recall the room. Second, the 10-min. interval was more than enough to exhaust their memory for the words. There were no subjects still able to recall the words at the end of the 10 min. In the worst, such a criticism only supports the idea of conditions, since the DC-P group did not benefit from this potential interval.

It is drawn from the present study that contextual associations can be accessed whether verbally or mnemonically; the nature of the context is not relevant for its reinstatement. It is also clear that DC subjects recall words in the typical environment paradigm because DC subjects employ the mnemonic strategy of memory for environmental cues to recall list words. When using this mnemonic strategy, subjects are able to successfully employ

The hypothesis was not supported. The group DC-C viewed photographs of the list-learning room, and SC subjects returned to their input room. Subjects, therefore, were provided with environmental information that was different from the cuing hypothesis, and they recalled fewer words than DC-C because those subjects had no contextual information. The results did not support this prediction. Recall scores of SC, DC-C, and DC-R did not differ from one another.

Experiment 3

No recall differences were found between SC, DC-C, and DC-R in

Experiment 2 suggests that the cuing hypothesis should be rejected. It may be, however, that the design of Experiment 2 did not produce a situation in which SC and DC subjects were differentially able to recall their input environmental context. It is not clear how well a DC subject must be able to recall the input environment to produce the release from contextual dependence evidenced in Experiment 2. It may be that only a small amount of environmental information must be recalled for the subject to gain access to contextual associations. Or, the situation in Experiment 2 may have made contextual information very easy to recall, such that SC, DC-C, and DC-R were all able to derive the maximal benefit from the use of their memory of the list-learning room as a retrieval aid.

It seems reasonable that memory for contextual information should be constrained by the same or similar rules that govern memory for other types of information. For example, memory for context should improve with increased exposure to that context, and context should be forgotten when the retention interval or the number of competing responses (i.e., related contexts) increases.

Experiment 3 was designed to manipulate the subject's ability to remember the learning context by varying the number of competing contextual responses. Subjects were presented with either many (four) or few (one) distractor rooms on the same day as list learning. (See Table 2 for design and room assignments.) It was expected that memory of these rooms would serve as competing responses for the subject's memory of the list-learning room and, therefore, that subjects would be better able to remember one of two environments than one of five.

In this experiment those tested in the DC conditions were asked to remember information about their list-learning room to help them remember list words. This instruction was used to avoid strategic differences between the groups, so that any differences in free recall performance would reflect differences in the subjects' abilities to access environmental information.

Table 2
Room Assignments of Experimental Groups for the Experimental Tasks: Experiment 3

Task	Group			
	SC-2	SC-5	DC-2	DC-5
First day				
Multiplication problems	A	A	A	A
List learning	B	B	B	B
Signal detection	A	C	A	C
Letter rotation	A	D	A	D
Visual search	A	E	A	E
Second day				
Free recall	B	B	F	F

Note. SC-2 = same context-two rooms, SC-5 = same context-five rooms, DC-2 = different context-two rooms, DC-5 = different context-five rooms.

The predictions made by the cuing hypothesis are illustrated in the hypothetical representations and search schemes shown in Figure 1. The hierarchical structure shows the representations of environmental context from the first day subsumed by a more general node labeled *experiment*. List words are subsumed by, or associated only with, Room B. Same-context subjects, whether having had two or five rooms on the first day (SC-2 and SC-5), should be cued to access appropriate environmental information (i.e., Room B) by the physical reinstatement of that context. These two groups, then, should not differ in the amount of environmental information that is accessible and, therefore, should not differ in free recall performance. The two DC groups, however, must recall the appropriate environmental information from memory. Assuming a top-down search beginning with the *experiment* node, DC subjects with two rooms (DC-2) are better able to retrieve Room B information than those with five rooms (DC-5) because DC-5 should be less able to differentiate memory of Room B from memory of the distractor rooms. Therefore, the cuing hypothesis predicts poorer word recall for DC-5 than for DC-2, which

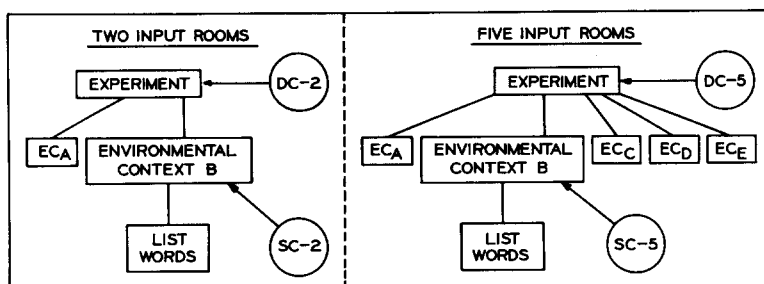


Figure 1. Hypothetical memory search schemes for four groups in Experiment 3. (Groups SC-2 and SC-5 can easily access context-list word associations. Group DC-2 needs only to remember one of two Day 1 rooms to access contextual associations. Group DC-5, however, must discriminate among five Day 1 rooms to recover and use context-list word associations.)

should recall nearly as much as SC-2 and SC-5.

The strategy hypothesis, which is not relevant to the subject's ability to recall information about an environment, predicts equal free recall performance for all groups, since all supposedly are using memory for Room B to help recall of words.

Method

Subjects. Forty introductory psychology students received course credit points following their participation in the 2-day experiment. Subjects participated either singly or in pairs.

Design, procedure, and materials. The general design of Experiment 3 is outlined in Table 2. On the first day, subjects were given a series of five tasks, each of which lasted approximately 10 min. One of the tasks (the second of the five) was the list-learning procedure described in Experiment 1. The other four were dummy tasks designed to be noninterfering with verbal memory, and these took place in either one room or four rooms. For all groups, list learning was the only task to occur in Room B.

On the second day, subjects were given a free recall test for the words learned in Room B on the first day. Half of the subjects were tested in Room B, and half were tested in a new room. The four groups, then, represent same and different context with either two or five rooms presented on Day 1: SC-2 (same context, two rooms on the first day), SC-5 (same context, five rooms), DC-2 (different context, two rooms), and DC-5 (different context, five rooms).

Task 1: Multiplication problems. The multiplication task occurred in Room A (described as "Room C" in Experiment 1). Subjects wrote the answers to simple multiplication problems, which were shown individually on the screen at 2-sec intervals. Three sets of 60 problems were projected via a Carousel slide projector and were changed

by an electric timer. The problems were of the form, $P \times Q = ?$, where P and Q were one-digit numbers.

Task 2: List learning and recognition test. List learning and a partial recognition test for some of the list words occurred in Room B as the second task of the first day. The room and procedure are described in Experiment 1, with the exception that words were presented via cassette tape instead of being shown on slides.

Task 3: Auditory vigilance. The auditory vigilance task occurred in Room A for SC-2 and DC-2, and in Room C for SC-5 and DC-5. (Room C is described as "Room A" in Experiment 1.) Faint tones were played over a background of white noise on a cassette recorder. During three 2-min. intervals, subjects kept a tally of the number of tones heard.

Task 4: Letter rotation. The letter rotation task occurred in Room A for SC-2 and DC-2, and in Room D for SC-5 and DC-5. Room D was a cramped and cluttered room on the fourth floor of the psychology building. Subjects were seated at two small tables in a room otherwise crammed with books, papers, and tape-recording equipment.

For this task, pairs of letters were arranged in columns on a page. The left-hand member of each pair was printed in its normal reading orientation. The right-hand member was printed at one of four angles from vertical (45° , 135° , 225° , and 315°) and was half of the time forward and half of the time reversed in mirror image of the forward letter. The letters F, G, J, P, R, and S were printed in capital block form. The subject's task was to mentally rotate the right-hand letter of each pair to see if it matched the letter on the left.

Subjects were given eight columns with 12 letter pairs per column and were allowed 10 sec to evaluate the letters of each pair as "same" or "different" with 30-sec breaks given between columns.

Task 5: Visual search. The visual search task occurred in Room A for SC-2 and DC-2, and in Room E for SC-5 and DC-5. Room E was a small, uncluttered room on the fourth floor of the psychology building. Beside the table at which

subjects sat, the room contained booth, cabinets, and miscellaneous equipment.

Subjects scanned columns of searching for and circling exemplars of letter N. Twelve seconds was given per column, with 30-sec breaks between target letter N was randomly embedded strings, made up from the letters B and R. Each letter string contained one N. There were 36 letter strings per column. There were 10 columns of letter strings per

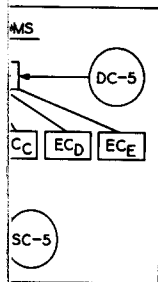
Day 2: Free recall. On the second day, subjects were taken either to Room B (SC-2 and SC-5), or to a new room, Room F (DC-2 and DC-5). Room F was a very large room on the second floor of the psychology building. It contained four long tables with chairs, a back wall were boxes of equipment, and storage cabinets.

Subjects were asked to write, from memory, the list words and test words that were presented on Day 1. They were asked to guess if necessary.

Prior to the free recall test, subjects in Room B and DC-5 were asked to remember about Room B and to try to use that information to help recall list words. They were initially given 3-min. to memorize the location of the list-learning room, and then asked to list any two things that they could remember seeing in that room. All subjects were given at least two of these three items of information (location plus two objects) correct for the context recall exercise. Subjects were given 2-min. of silence to try to recall the sights, sounds, and general atmosphere of the list-learning room. Following the free recall test, subjects were given free recall instructions. They were asked to try to use their memory of the list-learning room to help their memory of the list words. These context recall instructions included to ensure that all subjects would use environmental information available to aid word recall. Differences in word recall should not reflect strategies that they should reflect differences in available environmental information.

After the free recall test, DC-2 and DC-5 were given a context recall test and a recognition test. For context recall, they were given 5-min. to list any of the things they could remember seeing in the list-learning room. The context recall was scored as the number of items correctly recalled from a comprehensive checklist of items in Room B. The three items of information from the initial 3-min context recall were included in this recall score.

For the context recognition test, subjects were asked whether photographic slides were pictures of objects in the list-learning room. Fourteen of the slides were "old," that is, pictures of objects in



Experiment 3. (Groups SC-2 and DC-5, however, must remember word associations.)

The problems were of the type where *P* and *Q* were one-digit

learning and recognition test. The partial recognition test for words occurred in Room B as the first day. The room and test were presented via cassette shown on slides.

vigilance. The auditory vigilance in Room A for SC-2 and DC-5. (Room "Room A" in Experiment 1.) played over a background of cassette recorder. During three tests kept a tally of the num-

rotation. The letter rotation in Room A for SC-2 and DC-2, and DC-5. Room D was a room on the fourth floor building. Subjects were seated in a room otherwise crammed with tape-recording equipment. Letters were arranged in the left-hand member of each in normal reading orientation. Number was printed at one of the angles (45°, 135°, 225°, and 315°) of the time forward and half in mirror image of the forms F, G, J, P, R, and S were in check form. The subject's task was to match the right-hand letter of the letter on the left. In eight columns with 12 letters and were allowed 10 sec to judge each pair as "same" or "different" given between columns.

search. The visual search task for SC-2 and DC-2, and DC-5. Room E was a room on the fourth floor of the building. Beside the table at which

subjects sat, the room contained a soundproof booth, cabinets, and miscellaneous electronic lab equipment.

Subjects scanned columns of letter strings, searching for and circling exemplars of the target letter N. Twelve seconds was given for each column, with 30-sec breaks between columns. The target letter N was randomly embedded in letter strings, made up from the letters B, D, G, S, C, and R. Each letter string contained six letters. There were 36 letter strings per column, and there were 10 columns of letter strings per subject.

Day 2: Free recall. On the second day, subjects were taken either to Room B (SC-2 and SC-5), or to a new room, Room F (DC-2 and DC-5). Room F was a very large room on the second floor of the psychology building. It contained four long tables with chairs, and along a back wall were boxes of equipment, file drawers, and storage cabinets.

Subjects were asked to write, for 10-min., all of the list words and test words they could remember that were presented on Day 1 in Room B, guessing if necessary.

Prior to the free recall test, subjects in DC-2 and DC-5 were asked to remember information about Room B and to try to use that remembered information to help recall list and test words. They were initially given 3-min. to write the location of the list-learning room, and they were asked to list any two things that they could remember seeing in that room. All subjects got at least two of these three items of information (location plus two objects) correct in this initial context recall exercise. Subjects were then asked to take 2-min. of silence to try to mentally recreate the sights, sounds, and general impressions of the list-learning room. Following this, subjects were given free recall instructions, and they were asked to try to use their memory of the list-learning room to help their memory of the list and test words. These context recall instructions were included to ensure that all subjects would be likely to use environmental information as a strategy to aid word recall. Differences in word recall that remained should not reflect strategic differences, they should reflect differences in ability to recall environmental information.

After the free recall test, DC subjects were given a context recall test and a context recognition test. For context recall, they were given 5-min. to list all of the things they could remember seeing in the list-learning room. Context recall was scored as the number of items recalled from a comprehensive checklist of items contained in Room B. The three items of information listed on the initial 3-min context recall were included in this recall score.

For the context recognition test, subjects judged whether photographic slides were pictures of the list-learning room. Fourteen of the photos were "old," that is, pictures of objects in Room B that

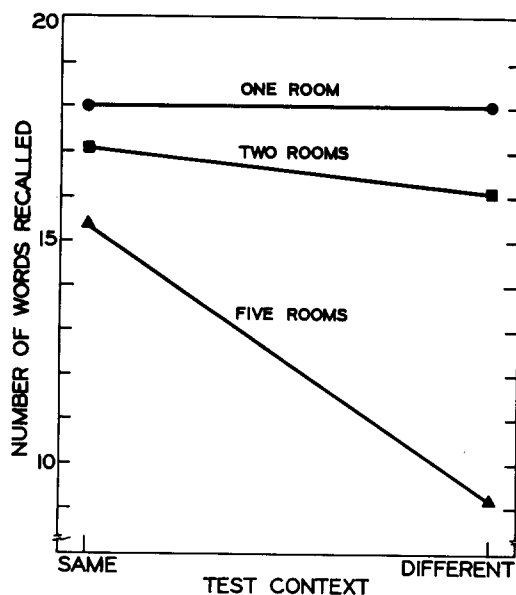


Figure 2. Mean free recall scores for Experiments 2 and 3 comparing SC- vs. DC-instructed groups with varying numbers of Day 1 rooms. (Triangles indicate results for Groups SC-5 vs. DC-5 in Experiment 3, squares show Groups SC-2 vs. DC-2 in Experiment 3, and circles compare Group SC with the combined mean of Groups DC-R and DC-C in Experiment 2.)

had been clearly visible. These were photos, for example, of posters, plastic plants, a sink, a bookcase, or the table at which the subject set. The other 14 photos were taken in psychology department rooms in which the subjects had not been, showing objects such as a fire extinguisher, a clock, a bulletin board, or pieces of laboratory equipment. The 28 test slides were paced at a rate of 10 sec apiece.

Results and Discussion

The mean free recall scores for words are shown in Figure 2. As predicted by the cueing hypothesis, the reinstatement effect occurred only for the five-room condition, where memory for environmental information supposedly suffered from more interference than in the two-room condition. Also included in Figure 2 are the results of Groups DC-R and DC-C versus Group SC from Experiment 2. Although these data were not included in the analysis of Experiment 3, their inclusion in Figure 2 helps illustrate the increase in the size of the environmental reinstatement effect that occurs

when more interfering distractor rooms are added to the Day 1 session.

A 2×2 (Context \times Number of Rooms) ANOVA computed from the word recall scores showed a significant effect only for number of rooms, $F(1, 36) = 4.25$, $MS_e = 50.93$. Planned orthogonal comparisons, however, bear out the primary predictions more clearly.

Memory for Context B, the list-learning room, should have been most severely impaired for DC-5, which had to recall one of five possible rooms from the first day to access appropriate contextual information. Group DC-5 recalled significantly fewer words than the other three groups, $F(1, 36) = 6.35$, accounting for 91% of the total treatment sum of squares.

As noted in Figure 1, both SC groups should have had equal access to appropriate environmental information at the time of the test; hence, recall performance of SC-2 should not differ from that of SC-5. The SC groups did not differ, $F(1, 36) = .66$.

Group DC-2 should have had access to nearly as much environmental information as the two SC groups, since that group had only one distractor room on the first day to interfere with memory for Environmental Context B. There was no difference in recall performance between Group DC-2 and the SC groups, $F(1, 36) = .01$.

The strategy hypothesis predicted that word recall for all groups would be equal; because they were instructed, all groups were likely to use the context recall strategy to help word recall. Although the strategy hypothesis explains the findings of Experiment 2, it cannot account for the poorer free recall performance of DC-5 in Experiment 3. Given the combined results of Experiments 2 and 3, it appears that the typical environmental reinstatement effect can occur because the SC subject is more likely than the DC subject to use remembered environmental information to help word recall, and/or because such environmental information may be easier for the SC subject to access from memory.

The context recall and context recognition tasks were not particularly sensitive to the

assumed difference of context accessibility between DC-2 and DC-5, although the small difference that was found was in the predicted direction. Group DC-2 recalled an average of 8.2 objects, as compared with 7.0 for Group DC-5. This difference was not significant, $t(18) = 1.50$. For the context recognition test, d' scores were calculated as a measure of the subject's ability to discriminate photographs of objects in the list-learning room from photos of objects not seen by the subject during the experiment. The mean d' for DC-2 was 1.13, as compared with .97 for DC-5. This difference was not significant, $t(18) = .69$.

These results suggest that some aspect of environmental context other than the objects in the room becomes associated with list words in a list-learning experiment. It is also possible, however, that the context memory tests were contaminated by the prior free recall test; perhaps list information acted as a retrieval context that facilitated later memory for environmental information.

General Discussion

The present experiments provide evidence that the environmental reinstatement effect is not caused by an experimental artifact. They also show that activation of contextual associations can be achieved by physically reinstating the appropriate environmental context or mnemonically by instructing subjects to remember their list-learning environment. Mnemonic activation of contextual associations was shown to be an effective retrieval aid only when the environmental context was not difficult to remember.

The results have strong implications for both theory and application. First, they demonstrate that environmental context information is, as formerly believed, a source of retrieval cues useful for recalling information learned in that context. The results further imply that memory depends on physical contextual cues because subjects are not aware that information already in memory can be used as a retrieval aid. When instructed, subjects can bring context effects at least partially under cognitive control by

generating their own retrieval cues from memory. Finally, the results show that memory for context is constrained by cues similar to those that affect memory for material. The addition of several rooms interfered with memory for a particular room, reducing the effectiveness of generated contextual cues.

The results are empirically important because they show a means for enhancing the environmental context effect. The effect can be wiped out by instructing DC subjects to remember the learning environment if that environment is easy to remember, or it can be enhanced if the learning environment is difficult to remember. These results have important considerations for applications, as well as for further investigations of environmental context effects.

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presence of context accessibility in DC-2 and DC-5, although the small difference was found in the pre-experiment. Group DC-2 recalled an average of 7.0 objects, as compared with 7.0 for DC-5. This difference was not significant ($t(18) = 1.50$). For the context condition, d' scores were calculated as a measure of the subject's ability to distinguish objects in the list from photos of objects not in the list during the experiment. For DC-2 this was 1.13, as compared with 1.13 for DC-5. This difference was not significant ($t(18) = .69$).

These results suggest that some aspect of the context other than the object itself becomes associated with the list-learning experiment. It is possible, however, that the context was contaminated by the prior list; perhaps list information in the retrieval context that facilitated recall of environmental information.

General Discussion

These experiments provide evidence for the role of environmental reinstatement in memory. It is shown that activation of contextual information can be achieved by presenting the appropriate environment or mnemonically by presenting retrieval cues. Mnemonic activation was shown to be effective only when the environment was not difficult to

recall. These results have strong implications for the application of environmental context information. Formerly believed, a source of information useful for recalling information about that context. The results further suggest that memory depends on physical cues because subjects are not aware of information already in memory and a retrieval aid. When instructions can bring context effects into memory under cognitive control by

generating their own retrieval cues from memory. Finally, the results show that memory for context is constrained by factors similar to those that affect memory of verbal material. The addition of several distractor rooms interfered with memory for a particular room, reducing the effectiveness of self-generated contextual cues.

The results are empirically important because they show a means for eliminating or enhancing the environmental reinstatement effect. The effect can be wiped out by simply instructing DC subjects to remember their learning environment if that environment is easy to remember, or it can be enhanced if the learning environment is made more difficult to remember. These methods are important considerations for practical applications, as well as for further laboratory investigations of environmental context effects.

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