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On the Puzzling Relationship Between Environmental Context and Human Memory

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It would be hard to overstate the importance of understanding the profound influence of environmental context on human memory. Such influences appear in nearly all aspects of our everyday lives, and a full understanding of storage and retrieval processes in human memory awaits our ability to describe how such processes are influenced by environmental context (EC).

Anecdotal Evidence for EC-Dependent Memory

In an excellent recent chapter, Smith (1988) summarizes the kinds of anecdotal evidence that our episodic memories become attached to and can later be cued by environmental stimuli. Many of us have experienced, on returning to the town in which we grew up or to a school we attended, the flood of memories for events, pranks, names, colloquial expressions, and emotions that are resurrected by reinstating such environmental cues. In the case of immigrants returning to their country of origin, or soldiers returning to battlefields or prison camps, the effects can be especially profound, even after absences of 40 or 50 years. Language abilities come back, events are reconstructed, and powerful emotions return, often to an extent that is overwhelming.

As Smith (1988) points out, such long-term effects of reinstatement do not exhaust the kinds of effects of environmental context on memory. There are short-term effects as well. Failing to recognize a known person (e.g., the neighborhood butcher) when that person is encountered in an atypical context (e.g., the opera) is a situation familiar to most of us. Forgetting what one left one's office to do until one returns to one's office is another familiar case. Smith's compelling examples could easily be augmented by many more.

Those of us who have competed in some sport know well the perils of attempting to "improve" one's execution of some well-learned cognitive-motor skill. The environmental cues during a sports competition, including body-state variables such as stress, anxiety, and level of adrenalin, differ markedly from those present during practice. Unless one has highly overlearned the new technique—and managed to associate that technique with competition-type cues—actual competition will trigger the old form, or worse yet, something in between the old and the new form. Teachers who decide to reorganize a "canned" lecture on some topic often find themselves, in the actual lecture context, confused and tongue-tied in some netherland midway between the new organization and the old organization. In actual combat, military personnel trained in the operation of new equipment will often regress to motor behavior appropriate to the old equipment.

The preceding examples represent cases in which a change of context produces undesirable forgetting, but changing context can produce desirable forgetting as well. A sabbatical or vacation in a new setting can aid creativity. As Smith (1988) notes, an author who becomes "stale" on the job may become—by virtue of a move to a new environment—"freed from the hackneyed ideas one cannot escape in the old work setting" (p. 18). He also points out that environmental cues help compartmentalize our lives because "different personal roles are called upon . . . when one is at one's work place, one's home, a restaurant, a theater, a workout gym, a bank, a party, a doctor's office, a campground, or a place of worship" (p. 18). Contextual associations ensure that appropriate, and not inappropriate, material is retrieved from memory, and used to control behavior. The general dependency of proactive and retroactive interference on context overlap is a topic to which we return later.

Finally, if one considers mood state part of one's environmental context, another array of instances could be cited. The present cognitive therapy for depression, for example, views the patient as caught in a pathological deteriorating spiral. The patient's depressed state leads her/him to retrieve those memories consistent with that state, worsening the depression, which further restricts retrieval access, and so forth. The goal of the therapy is to break that cycle by reschematizing the patient's interpretation of his/her roles and relationships at home and at work.

Practical Importance of the Context–Memory Relationship

If human memory and performance is as dependent on environment context as the foregoing examples suggest, the practical importance of understanding that dependency is clear for areas such as political and social psychology, environmental psychology, education, artistic performance, sports, witness testimony, therapy, and manipulating one's own moods or creativity. As will become increasingly clear in this chapter, however, understanding the interplay of context and memory requires us to enumerate the different effective forms of context, internal and external, and to discover how those forms interact with different aspects of performance.

Theoretical Importance of the Context–Memory Relationship

One need look no further than the chapters in this volume, particularly those by Murdock, Nelson, and Shiffrin, to appreciate the importance of contextual factors in current models of memory. That context influences what is activated or available in memory, that generating or studying items somehow "connects" them to the current episodic context, and that recall probabilities are a function of strength of association to the current context are primitive assumptions in many theories.

Thirty or forty years ago the emphasis in explaining forgetting was on interference between different sets of learned materials; presently such interference mechanisms are deemphasized and the concept of context occupies the central explanatory role. For example, E. Bjork and R. Bjork (1988) contend that the retrieval failures that seem to be a fundamental weakness of human memory are in fact an adaptive feature of the system. Given that human long-term memory has such an astounding storage capacity, in terms of both amount and duration of storage (e.g., see the estimates in Landauer, 1986), it is adaptive that information becomes inaccessible with disuse and/or a change in context. Even highly overlearned material such as one's phone number or street address eventually becomes inaccessible when that information is no longer current. Such loss of retrieval access is adaptive because information that is nonretrievable, by virtue of its being out of date or irrelevant to the current context, is also noninterfering, which improves retrieval speed and accuracy for information that is current and relevant.

Integrated, Influential, and Incidental Context

A number of researchers have distinguished between those aspects of context that are related in a meaningful way to the to-be-remembered event or information of interest, and those aspects of context that are incidental to or independent of the target event or information. For example, Baddeley (1982) distinguishes *interactive* and *independent* forms of context, Eich (1985) distinguishes *integrated* and *isolated* aspects of context, and Hewitt (cited in Godden & Baddeley, 1980) distinguishes between *intrinsic* and *extrinsic* context. All of these distinctions capture the idea that contextual stimuli can either become explicitly associated with target stimuli at encoding or that they can be encoded in some sense independently of the target information. Here we wish to accommodate the additional possibility that contextual stimuli can influence the encoding of target material without necessarily becoming explicitly associated with that material at the time of encoding. For example, a context can influence a subject's interpretation of an ambiguous stimulus without the subject becoming aware of that influence. At the risk of adding to the proliferation of terms, we therefore make a threefold distinction between *integrated, influential*, and *incidental* aspects of context. Incidental context, in the sense in which we use it, is not only independent or isolated from the target information, but also does not influence the subject's interpretation of, or interaction with, the target material at encoding.

The reason the integrated/influential/incidental distinction is important is that the existence of sizeable effects on memory of integrated–influential aspects of context are not surprising, nor of much interest for present purposes. We know that cuing recall of a target event by reinstating a cue that was originally explicitly associated with that target at encoding will exceed uncued recall (e.g., Thomson & Tulving, 1970). Similarly, changing semantic context so as to activate different senses of a word at study and test is known to impair recall and recognition, in contrast to the case in which the same sense is activated on both occasions (e.g., Barclay, Bransford, Franks, McCarrell, & Nitsch, 1974; Light & Carter-Sobell, 1970). On the other hand, it is still an open question whether there are effects of incidental context on memory—a question that is currently subject to considerable debate (e.g., Fernandez & Glenberg, 1985).

There are two issues concerning incidental EC that must be distinguished. First, is incidental EC information encoded into the episodic memory trace corresponding to target information? Second, assuming EC information is encoded into the memory trace, what role, if any, does it play in the retrieval of target information?

Before proceeding further, it is worth noting that the prevalent view of EC as an incidental form of context may not always be easy to defend in practice. For example, Smith (1988) restricts his consideration of environmental context (EC) to those "external stimuli which are not implicitly or explicitly related to the learning material in any meaningful way" (p. 14), and he defines "EC-dependent memory" as "a class of phenomena in which cognitive processing is affected in subtle, profound, and sometimes important ways by the coincidental background EC in which the experiences are set" (p. 14). However, in a number of naturalistic examples, including some of those previously discussed, the relationship between the environmental cues and the target material could be interpreted as "meaningful" (i.e., integrated–influential). Consider the interesting story Smith recounts about his father returning to Austin, Texas "after 42 long years of forgetting." Among other things, his father recalled "in vivid detail . . . how an armadillo had climbed up the drainpipe one night and become his pet" (p. 13). Is the drainpipe in this case related in a meaningful way to the event being recalled? (In fact, Smith's father was looking at a parking lot, his former residence having been torn down. The example nonetheless illustrates that "meaningfulness" may be difficult to judge in practice.)

TABLE 9.1
Types of EC-Dependent Memory Phenomena

Manipulation of interest	*Sequence of events*	*Phenomenon of interest*
1. Physical reinstatement of study context at test	Learn List 1 (in Context A) Recall List 1 (in Context A or B)	AA > AB
2. Imaginal reinstatement of study context at test	Learn List 1 (in Context A) Recall List 1 (in Context B, with or without imagining A)	AB(A) > AB
3. Varied contexts across study sessions	Learn List 1 (in Context A) Learn List 2 (in Context A or B) Recall List 1 (in neutral context, N)	ABN > AAN
4. Varied contexts across study sessions	Learn List 1 (in Context A) Learn List 2 (in Context A or B) Recall Lists 1 and 2 (in neutral context, N)	ABN > AAN

THE LABORATORY PHENOMENA OF INTEREST

Controlled experimentation dating back at least as far as the 1930s has revealed several important types of EC-dependent memory. Reinstatement (actual or imaginal) at test of the study context has been shown to enhance recall, and variation of study contexts across study sessions has been found to reduce interference between sets of learned materials and to enhance total recall. Those phenomena are outlined in Table 9.1 and are described briefly later. It is important to emphasize that we are focussing here on recall as the measure of memory performance; recognition performance does not show the same pattern of EC-dependency as that shown by recall (e.g., Godden & Baddeley, 1980; Smith, 1985, 1986; Smith, Glenberg, & Bjork, 1978).

Contextual Reinstatement at Test

Physical Reinstatement. In numerous published reports, material presented to subjects in some environment, A, has been better recalled when subjects were later tested in A than when they are tested in some different environment, B; that is AA > AB. The typical experiment in the literature, of which there are many (see Smith, 1988, Table 2.1), has examined the effect of reinstating room context on recall, but other types of EC manipulations have been employed (e.g., on land vs. underwater). The conditions under which physical reinstatement enhances performance are a matter of current debate, and are considered further later in this chapter.

Imaginal Reinstatement. In 1979 Smith showed that when study and test contexts differ subjects can enhance performance at test by mentally reinstating the study context. Since Smith's original report, there have been several other demonstrations of such imaginal reinstatement effects (Fisher, Geiselman, Holland, & MacKinnon, 1984; Frerk, Holcomb, Johnson, & Nelson, 1985; Smith, 1984).

Contextual Variation at Study

Reduction of Retroactive Interference. When a first list is learned in some context, A, the retroactive interference owing to the learning of a second list can be reduced if the second list is learned in a new context, B, compared to the case in which the new list is learned in A. In the general case, recall or relearning of the first list in some neutral context, N, will be better in the ABN case than in the AAN case. Such results first appeared in the 1950s (Bilodeau & Schlosberg, 1951; Greenspoon & Ranyard, 1957) and have since been replicated with several types of lists and several types of recall tests, together with additional experimental controls to rule out the possibility of certain artifacts (Coggins & Kanak, 1985; Eckert, Kanak, & Stevens, 1984; Kanak & Stevens, 1985). Some evidence for reduction of proactive interference due to context variation has also been provided (Dallett & Wilcox, 1968).

Enhanced Total Recall. Smith, Glenberg, and Bjork (1978) demonstrated that recall of a twice-studied list in a neutral context, N, was enhanced if the two study sessions took place in different environments A and B; that is, ABN > AAN. Glenberg (1979) obtained similar results, and Smith (1982) showed that the same effect held for unique lists as well as repeated lists. Subsequent studies using course materials (Chen, 1984; Smith & Rothkopf, 1984) as well as word lists (e.g., Smith, 1984) have obtained mixed results.

THE PUZZLE: PART I

Reinstatement Phenomena in the Laboratory and in the Real World

Although we tend to believe—based on our experiences and the kind of anecdotes alluded to earlier—that being back in the context in which certain experiences took place helps the recall of those events in a big way, the laboratory evidence for physical reinstatement effects is inconsistent. The positive reports of physical reinstatement effects in the literature are offset by other reports (some published, but many only "word-of-mouth") of insignificant differences between same-room and different-room recall levels. The recent papers by Fernandez and Glenberg (1985) and Saufley, Otaka, and Bavaresco (1985) are particularly impressive in the number of comparisons that show nonsignificant differences. Additionally, Fernandez and Glenberg's Experiment 8 was a direct replication of Smith (1979, Experiment 1), using precisely the same materials and environmental contexts that were used in the original study, but more than twice the number of subjects. Fernandez and Glenberg failed to obtain a context effect despite statistical power of .94 to detect an effect of the size reported by Smith (1979). In view of the pervasive tendency to suppress publication of nonsignificant effects, these data suggest the possibility that a number of the significant effects of physical reinstatement in the literature represent Type I errors.

Possible Solutions to Part I of the Puzzle

Incidental EC-Dependent Memory Does Not Exist. As mentioned earlier, the question is not whether some environmental stimuli can cue memories, but whether environmental stimuli that are truly incidental—unrelated to the episode or learned material to be recalled—can aid later recall when they are reinstated. In the typical laboratory experiment the experimental task is unrelated to the environment (typically a room) in which the task is administered. In naturalistic examples, however, the contexts are not so clearly incidental. We are often recalling connected episodes, for example, in which some feature of the environment (e.g., a school flagpole) may have played a central role (e.g., in a high school prank).

Consider the following example from Smith (1988): "While working at my desk, I interrupted my work to go to the office for some file folders. Still thinking about my work, I trudged absent-mindedly to the office. Upon arriving at the office, I realized I had forgotten what I needed there. The file folders could not be remembered until I returned to my office" (p. 15). It could well be that on returning to his office Smith's file-folder memory was triggered by the materials that he wanted to file, which were possibly sitting in a prominent place. In that case, the to-be-filed materials seem like a meaningful rather than an incidental aspect of context. Eich (1985) showed that when subjects are asked to use interactive imagery to relate the to-be-remembered materials to objects in or features of the room environment at study there is a clear advantage of physically reinstating the study context at test.

Another potentially important difference between controlled experiments and naturalistic incidents is that in experiments we tell *all* subjects, whether they are tested in the study context or in a different context, to try to recall the study material. By contrast, in naturalistic cases a return to some original context can cue us to attempt to recall information associated with that context that we would not otherwise have attempted to recall. When we return to a school or town and interact with people we knew during the time that we spent there, the nature of those experiences induces us to attempt to recollect events, names, and facts from the past era. We are put in an appropriate retrieval mode, so to speak. It may well be that we *could* recollect that information as well outside the original context as we could in it, but we are not induced to try.

At the Flowerree Symposium in New Orleans in February 1987, for example, one of us (RAB), together with Richard Shiffrin and Judy Mahy-Shiffrin, attempted to recall a dinner we had eaten together some years earlier at L'Orangerie, an expensive restaurant in Beverly Hills. We were able to recall a number of details, including some of the dishes that we ate, where we sat, how the restaurant was decorated, that the restaurant was somewhat hot and cramped for such a luxurious place, and that Goldie Hawn was sitting at a table about 10 ft away. Could we have recalled more had we been back at L'Orangerie? Maybe we could have, but the point is that the appropriate comparison is not typically made in the case of naturalistic incidents that we label "EC-dependent" memory; there is no attempt to recall the target material in a context different from the context in which that material was initially encountered.

The possibility that physical reinstatement of environmental context aids recall only because it induces the rememberer to try to recall suggests that we come to believe that incidental context aids recall in a manner analogous to the way many people come to believe that they have psychic abilities. When we attend a school reunion, or return to an arena where we played some sport, to a country club where we worked as a teenager, or to a town in Europe where we spent a year in an education-abroad program, the process of recollecting triggered by our return is itself memorable and worthy of comment in a way that similar recollections out of context—as we are falling asleep, for example—are not. So we become believers.

That the typical layperson—and probably every novelist—believes in the power of environmental cues to aid recall there can be no doubt. Consider the following passage from Isaac Asimov's (1986) *Robots and Empire*, for example, in which Gladia—a central character in the book—returns to her home planet (Solaria) after an absence of 20 decades:

> Gladia stood on the soil of Solaria. She smelled the vegetation—not quite the odors of Aurora—and at once she crossed the gap of twenty decades.
>
> Nothing, she knew, could bring back associations in the way that odors could. Not sights, not sounds.
>
> Just that faint, unique smell brought back childhood—the freedom of running about, with a dozen robots watching her carefully—the excitement of seeing other children sometimes, coming to a halt, staring shyly, approaching one another a half-step at a time, reaching out to touch, and then a robot saying, "Enough, Miss Gladia," and being led away—looking over the shoulder at the other child, with whom there was another set of attendant robots in charge. (p. 127)

The assertion that smells are powerful cues in reinstating memories is one with which most people would agree. However, in two unpublished experiments carried out at UCLA by Stephen White and the first author, there has been no evidence whatsoever that reinstating incidental environmental odors aids recall of material studied in the presence of those odors.

Our Experiments Are Poor Simulations of the Real World. The typical controlled experiment on the effects of reinstating environmental context differs from the typical real-world anecdote in the nature of the material recalled, in the length of the interval between initial exposure to some type of material and retrieval of that material, and in the extent of the similarity between the context of initial exposure and the retrieval context in the case in which those contexts are different. In experiments, the typical recall target is some kind of relatively sterile verbal-learning list, the retention interval from study to test ranges from a few minutes to a few days, and the characteristics of the test context in the "different context" condition overlap in many respects with those of the study context (e.g., same campus, same building, same experiment, same experimenter, same fellow subjects). By contrast, in real-world anecdotes the recall target is often a social/behavioral event in one's life, the retention interval is years or decades, and the difference between the same and different contexts is enormous in terms of geographic location, physical features of the environment, nature of the social context, and so forth. Given these differences, experiments are usually weak simulations, at best, of real world cases. One could argue that context reinstatement effects are more likely to be observed when the target material is inaccessible under normal circumstances, as would occur at very long retention intervals, and when physical reinstatement of the original context re-presents environmental cues that differ greatly from those typically available.

It should be added that certain experimenters have gone to considerable lengths to make the same/different manipulation of EC a potent manipulation. One example is research by the second author that we report later. In the first of the recent papers reviving interest in EC effects, Smith et al. (1978) changed every dimension of room context that they could think of, including altering the appearance of the experimenter to such an extent that some subjects did not realize that the experimenter was the same person. In the work of Godden and Baddeley (1975, 1980) the subjects were student divers and the two contexts were on land versus underwater, which should be a potent difference. In terms of what can be done within the confines of a standard experimental room, however, Dallett and Wilcox (1968) may deserve the prize. To make their "box environment" different from their "drum environment" —as in *memory drum*—they concocted the following arrangement.

> In the box environment, *S* stood with his head inside a large box, his neck in a foam-rubber-padded U-shaped cutout in the floor of the box, with a curtain to eliminate peripheral stimuli behind him. The room was darkened, and the interior of the box lighted with flashing red and green lights. The inner dimensions of the box were about 3 ft. × 3 ft. at the end where *S*'s head was, and tapered to about 1 ft. × 2 ft. approximately 3½ ft. in front of *S*'s head. None of the walls were parallel. The inside of the box was painted white, with green and black lines added, converging to a false vanishing point which did not coincide with the perspective of the walls. Some of these painted lines were "connected" to black strings hung across the interior of the box. Half of one wall was covered by furry red patches made of a nylon bathmat. After constructing the box and using it, it seemed to the *E*s that a great deal of its effect came from the changing illumination; a red 40-w. bulb flashed at a rate of approximately 80/min, while a green bulb flashed at approximately 18/min. These were the only lights in the box. The *S*s generally agreed that the box was highly unusual, and on two occasions *S*s had to be excused because of nausea. (pp. 475–476)

The extremity of the contextual manipulations in the Godden and Baddeley and Dallett and Wilcox studies point up the possibility that some manipulations of EC may achieve their effects via changes in the physiological state of the subjects. Physiological and drug state-dependent effects must clearly be distinguished from the effects of interest here, namely those produced simply by a change in the location in which material is studied and tested.

THE PUZZLE: PART II

First-Order versus Second-Order Effects of Environmental Context

The second piece of the puzzle is that the other three categories of laboratory phenomena summarized in Table 9.1 (imaginal reinstatement at test and the two effects of context variation at study) are apparently more reliable than the basic physical-reinstatement effect. These three categories of effect seem to require the assumption that learned material is associated to its incidental environmental context. Curiously, then, effects that might be regarded as second-order consequences of associative processes tying material to incidental context seem more reliable than does an effect that would be expected to be

TABLE 9.2
Two Measures of Original-List Retention as a Function of Whether Original and Interpolated Lists were Learned in the Same or Different Contexts

Original and interpolated contexts	*Measure of retention*	
	CVCs recalled on Trial 1[a]	*Trials to relearn*
Same (Groups AAA, AAB, BBA, BBB)	2.63	8.46
Different (Groups ABA, ABB, BAA, BAB)	5.52	6.26

Note: After data presented in "Stimulus Conditions and Retroactive Inhibition" by J. Greenspoon and R. Ranyard, 1957, *Journal of Experimental Psychology, 53*, 55–59.
[a]Out of 10 possible.

a first-order consequence of such contextual–associative processes. The six tests of imaginal reinstatement and the eight tests of interference reduction owing to varied input contexts in the literature (see Smith, 1988, Tables 2.2 & 2.4) all yielded positive results, and 8 out of 13 tests of enhanced total recall owing to multiple input contexts (see Smith, 1988, Table 2.5) yielded positive results.

The data presented in Table 9.2 demonstrate how large such "second-order" effects can be. Greenspoon and Ranyard (1957) had subjects learn each of two successive lists of 10 nonsense syllables to a criterion of two successive errorless trials through the list (serial anticipation method). After the second list was learned, subjects relearned the first list—again to a criterion of two errorless trials. Two distinctive rooms (A & B) served as the learning contexts. Across subjects the List-1 and List-2 contexts were either the same or different and List 1 was relearned either in its original study context or in the other context. Combining these two manipulations resulted in eight conditions: AAA, AAB, ABA, ABB, BAA, BAB, BBA, and BBB.

The results in Table 9.2 are shown as a function of whether List 1 and List 2 were learned in the same or in different rooms. Two measures of List 1 retention are shown: The mean number of nonsense syllables recalled correctly on the first relearning trial, and the mean number of trials necessary to relearn List 1 to criterion. The data are averaged over cases in which original and relearning contexts for List 1 matched and mismatched. Looking at either measure in Table 9.2, the retroactive interference owing to List-2 learning was greatly reduced when List 1 and List 2 were learned in different rooms. We could cite equally impressive examples of enhanced total recall of material learned in different contexts (compared to material learned in a single context) and of imaginal reinstatement effects.

A Possible Solution to Both Pieces of the Puzzle

Both of the preceding solutions to the first part of the puzzle fail on the second part of the puzzle. They present reasons why we should not expect first-order physical reinstatement effects in the typical laboratory experiment, but neither explanation accounts for the fact that other types of EC effects are apparently reliable in controlled experiments. If learned material does not become associated to incidental environmental context, then those second-order effects (of imaginary reinstatement and of contextual variation during input) should not obtain. And if our laboratory manipulations of EC are too ineffective to reveal first-order (physical reinstatement) effects they should not reveal second-order effects either. We propose a hypothesis in this section that provides a potential solution to both parts of the puzzle.

The key assumption is that physical reinstatement will only be advantageous in situations in which subjects in the different-context condition either cannot or do not mentally reinstate the original context. We assume further that mental reinstatement is as good as physical reinstatement in facilitating recall (and might be even better for reasons we touch on later), and that in the typical laboratory experiment subjects can and do mentally reinstate the study context when they are in the different-context condition. It follows that EC effects in the typical physical reinstatement experiment (i.e., first-order EC effects) should be weak or nonexistent.

The advantage of context variation across study sessions in terms of retroactive interference reduction may then be explicable for the following reason. When subjects attempt to reinstate the List-1 study context mentally at test, any advantage of mental reinstatement that accrues to List 1 will be offset in the AAN case by increased interference from List 2, because both lists are associated with the context that is mentally reinstated. In the ABN case, by contrast, mental reinstatement of the List-1 context will not lead to reinstatement of the List-2 context, so that mental reinstatement does not carry the cost of increased List-2 interference. It might also be the case, however, that subjects *could* mentally reinstate the List-1 episode without reinstating List-2 learning if they tried, but that the three-session procedure in such experiments renders them (for some reason) unlikely to do so.

The advantage of context variation for total recall is explicable along similar lines. The to-be-remembered material is associated with more EC cues in the ABN case than in the AAN case. More retrieval cues are therefore available for mental reinstatement in the former case than in the latter case. The advantages of providing multiple retrieval routes to target material are well known (the *encoding variability* principle).

One can also account for the positive effects of imaginal reinstatement instructions. In the typical physical reinstatement experiment, any mental reinstatement strategy employed by subjects in the different-context condition will be largely of their own devising (although, as we note below, their likelihood of adopting such a strategy and the precise strategy employed might be influenced by demand characteristics). By contrast, in an imaginal reinstatement experiment the group of subjects instructed to reinstate are likely to receive precise instructions as to strategy. In Smith (1979, Experiment 2), for example, one reinstatement group was told to "write down the location of their list-learning room, and to list any 10 things they could remember seeing in that room . . . [and] . . . to take 2 min. to think about [the study room], what it looked like, what sounds and smells there were, where it was, and the way it made them feel" (p. 465). Those subjects were then told to "use their memory for [the study room] to help them recall the list and test words from the previous day" (p. 465). Subjects receiving mental reinstatement instructions may therefore adopt more varied and effective retrieval strategies than do subjects who mentally reinstate without receiving explicit instructions.

We argued earlier that subjects in the different-context condition in the typical first-order physical reinstatement experiment can and do mentally reinstate the study context, weakening or eliminating the context effect. This argument is plausible for two reasons. First, the relatively short retention intervals typically employed permit successful mental reinstatement. Second, whether subjects attempt to reinstate the study context at test might be influenced in subtle but profound ways by the recall instructions. Given that the experimenter in such experiments is not typically blind to experimental condition, some of the positive effects of physical and imaginal context reinstatement in the literature might be attributable to differing demand characteristics placed on subjects in the same- and different-context conditions.

Whether we actually obtain an effect of physically reinstating the study context at test should, therefore, depend on how difficult it is to mentally reinstate the study context, on the extent to which our instructions induce subjects to attempt such mental reinstatement, and on the distribution of mental-reinstatement ability in the population from which our sample is drawn. Consistent with this view, Smith (1979) showed that the advantage of physical reinstatement over mental reinstatement increases as mental reinstatement is rendered more difficult (by increasing the number of rooms previously encountered in the experiment, and in which the target list might have been studied).

WITHIN-SUBJECT MANIPULATIONS OF EC MATCH/MISMATCH

Smith, Glenberg, and Bjork's (1978) Experiment 2

With respect to the issues raised in the preceding section, a design used by Smith, Glenberg, and Bjork (1978, Experiment 2) is of particular interest. In contrast to most other experiments in the literature, the effect of physically reinstating study context was tested within subjects. The experiment was carried out across 3 consecutive days. On Day 1 subjects studied a list of 45 word pairs in which the response word was a weak associate of the stimulus word. At the end of Day-1 training Smith and his colleagues tested cued recall of 15 of the 45 pairs in order to give a sense of closure to the subjects. On Day 2 all subjects were brought to a context that differed from their Day-1 context (if tested in context A on Day 1, they moved to context B on Day 2, and vice versa). In the Day-2 context they studied a second list of 45 word-word pairs. Fifteen of the pairs in List 2 shared a stimulus member with 15 of the pairs in List 1, but had a different response term (Common-Cue pairs). The remaining 30 pairs were unique to List 2 (Unique-Cue pairs). As for List 1, 15 of the List-2 pairs were tested at the end of training; for both List 1 and List 2 the stimulus terms (and response terms) of the tested pairs were unique to that list.

For the final Day-3 test subjects returned either to the context in which they had served on Day 1 or to the context in which they had served on Day 2 (there was also a condition in which they returned to a novel, neutral, context but that condition is not relevant here). They received a 45-item MMFR cued recall test, containing the stimulus terms of the 15 Common-Cue pairs, and the 30 stimulus terms from the Unique-Cue pairs that had not been tested on Day 1 or Day 2 (15 stimulus terms from List 1 and 15 from List 2).

The results of the Day-3 final test are shown in Fig. 9.1, with performance for Unique-Cue pairs plotted in the top panel and performance on the Common-Cue pairs plotted in the bottom panel. The context effect is clear, and similar for both types of pair: Physically reinstating either the Day-1 or the Day-2 context enhanced recall of the response terms studied in that context in comparison to recall of the response terms studied in the other context. In the Common-Cue case the context effect is superimposed on a recency effect, with Day-2 responses recalled better overall than Day-1 responses.

The particular within-subject design employed by Smith et al. (1978) has several major advantages. First of all, in contrast to a number of recent experiments in which there has been little or no effect of physical EC reinstatement, the effects in Fig. 9.1 are clear and sizeable. It is possible that the 3-day design employed by Smith et al., coupled with the cued-recall procedure, deterred subjects from mentally reinstating the "other" study context, that is, the context that differed from the context in which the Day-3 test took place. Second, the design removes certain concerns about differences in demand characteristics across same- and different-context conditions because each subject acts as her/his own control. Third, the design does not confound the manipulation of match between study and test contexts with a manipulation of old/novel context. With the standard between-subject context manipulation different-context subjects are tested in a context that they have not encountered before in the experiment, whereas same-context subjects are tested in a context that they have encountered before (for an exception, see Smith,

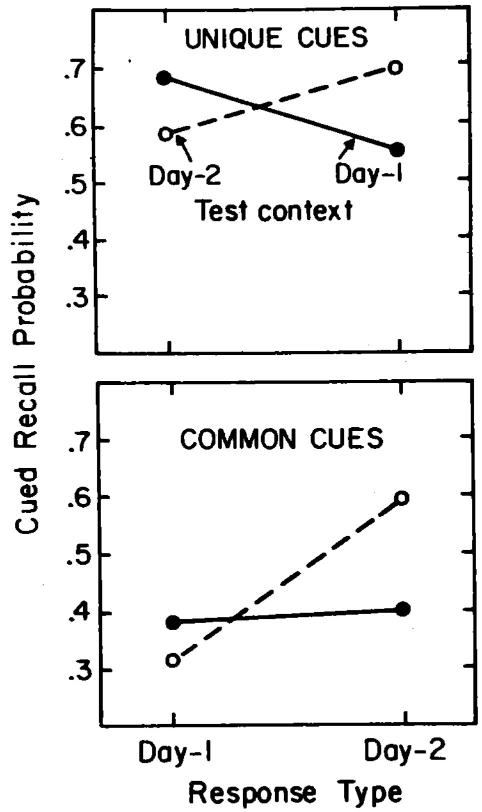

FIG. 9.1. Cued-recall proportions on Day 3 for cues that were unique to (top panel, or common to (bottom panel) Day-1 and Day-2 lists, as a function of whether the Day-3 test context matched the Day-1 or the Day-2 study context (after Smith et al., 1978, Experiment 2).

1979, Experiment 1). Finally, the within-subject design opens the possibility of correlating (across individual subjects) the size of the memory advantage of same- over different-context items with certain individual-difference variables.

Richardson-Klavehn's (1988) Experiment 1

In his doctoral dissertation, Richardson-Klavehn (1988) set out to perform an "improved" version of the Smith et al. experiment. The same Day-1, Day-2, and Day-3 conditions were employed, but there was an attempt to increase the strength of the contextual manipulation. The two contexts used on Day 1 and Day 2 were quite dramatically different (inside a cramped office without natural light on the seventh floor of an eight-story building vs. outdoors on a sunny foliage-surrounded patio). In addition, the interpersonal context was systematically varied across contexts. The experimenter was either a caucasian male or an Asian-Indian female, and, for a given subject, the other three subjects in the four-member group changed. The method of presentation of the to-be-remembered pairs also differed across contexts. Pairs were either presented to the subjects as a group in large green uppercase letters on large white cards, or they appeared in small individual booklets in lowercase black letters on a blue background.

An attempt was also made to increase the statistical power of the experiment over that of the Smith et al. (1978) experiment. The total number of subjects (across the four groups ABA, ABB, BAA, and BAB) was increased from 16 to 53. Additionally, the Day-3 test was changed from cued recall to free recall in view of the argument that free recall provides fewer explicit retrieval cues to the subject than does cued recall, increasing the probability that EC cues will be used (e.g., Eich, 1980; Smith, 1988). To permit a free recall test to be used, eight word-word pairs were studied on each day and no Day-1 and Day-2 pairs shared stimulus terms (that is, there were no Common-Cue pairs). In contrast to the intentional learning task used by Smith et al., an incidental learning task was used in which subjects generated sentences linking the two members of each word-word pair.

A further difference between Richardson-Klavehn (Experiment 1) and

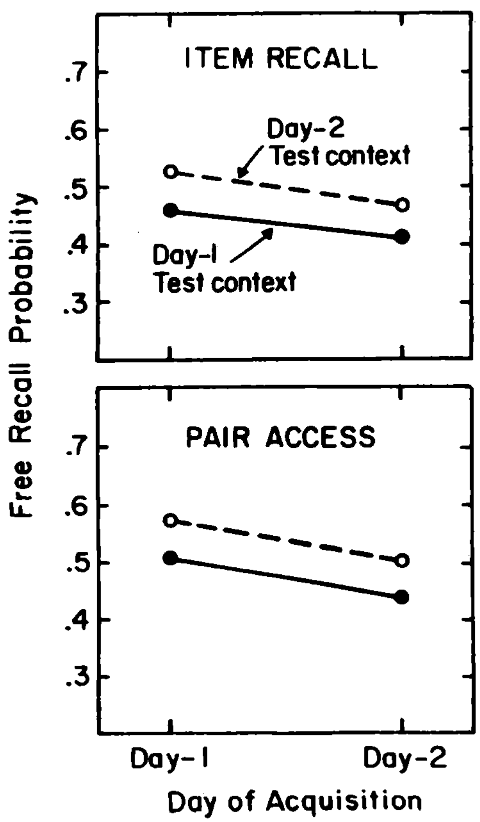

FIG. 9.2. Two measures of Day-3 free recall performance (proportion of individual items recalled, and proportion of pairs accessed) for Day-1 and Day-2 lists, as a function of whether the Day-3 test context matched the Day-1 or the Day-2 study context (after Richardson-Klavehn, 1988, Experiment 1).

Smith et al. (Experiment 2) was that a battery of 11 individual-difference tests was administered across the 3 hour-long experimental sessions. The battery included objective tests of spatial ability and field dependence, together with questionnaire measures of imagery vividness and control, use of imagery in spontaneous thought, tendency to become absorbed in current experiences, and tendency to "screen out" irrelevant environmental stimulation. The design of the experiment permitted the individual-difference measures to be correlated with a derived within-subject measure of context-dependency, namely the number of words recalled from the study context that matched the Day-3 test context minus the number of words recalled from the other (nonmatching) context.

The results of Richardson-Klavehn's Experiment 1 are shown in Fig. 9.2. Whether one looks at the proportion of individual words recalled (top panel), or the proportion of pairs for which one or both members of the pair was recalled (bottom panel), there is no indication whatsoever that recall was influenced by the match/mismatch of study and test contexts. Recall was somewhat better overall when the Day-3 test was administered in the Day-2 context, but that trend was equally evident for Day-1 and for Day-2 words, and apparently reflects nothing more than chance differences between subjects tested in their Day-1 context and subjects tested in their Day-2 context.

As subjects had been permitted to recall Day-1 and Day-2 words in any order they chose, it was possible that an output order measure might prove sensitive to EC match/mismatch (as in Smith, 1982, Experiment 3, for example). The output position of each word correctly recalled by a subject was expressed as a percentage of the total number of items (including intrusions) output by that subject. The mean of these percentile scores was computed separately for Day-1 and Day-2 words. Analyses using these mean output percentile scores showed that Day-1 words appeared, on average, earlier in output than did Day-2 words; however, there was no indication that the relative positions of Day-1 and Day-2 words in output changed as a function of Day-3 test context (Day-1 vs. Day-2).

The absence of any indication, however weak, of an overall context effect in Experiment 1 rendered the individual-difference measures of limited usefulness with respect to the original goals of the experiment: If some subjects were more sensitive to match between ECs at study and test than others were, the differences between means should still be in the direction expected under the hypothesis of a context effect. Any argument for the value of the individual difference measures would have to assume that context-sensitive subjects in the experiment were balanced by subjects who were negatively context-sensitive (i.e., subjects who consistently perform better under different-context than under same-context conditions).

Richardson-Klavehn's (1988) Experiment 2

The contrast between the clear effects obtained in Smith et al.'s Experiment 2 and the absence of effects in Richardson-Klavehn's Experiment 1 is perplexing. This difference in results could have resulted from a number of procedural differences between the studies, including number of to-be-remembered items (45 pairs/day vs. 8 pairs/day), orienting task (intentional learning vs. incidental learning), and test type (cued recall vs. free recall). In particular, it was considered possible that a cued recall test (as used by Smith et al.) was less likely than was a free recall test to induce the subjects to mentally reinstate the study context that was not physically reinstated at test. A cued recall test might induce subjects to search memory using the current cue-word as a probe, which might inhibit mental reinstatement and might, therefore, permit incidental context to influence that search. Richardson-Klavehn therefore repeated his experiment using the same study procedures and cued recall tests used by Smith et al. Appropriate numbers of Common-Cue and Unique-Cue pairs were generated from word-association norms according to the guidelines given by Smith et al., and study and test lists constructed exactly as in the original experiment.

The procedure in Richardson-Klavehn's Experiment 2 was exactly the same as the Smith et al. procedure—including a change in input modality (visual

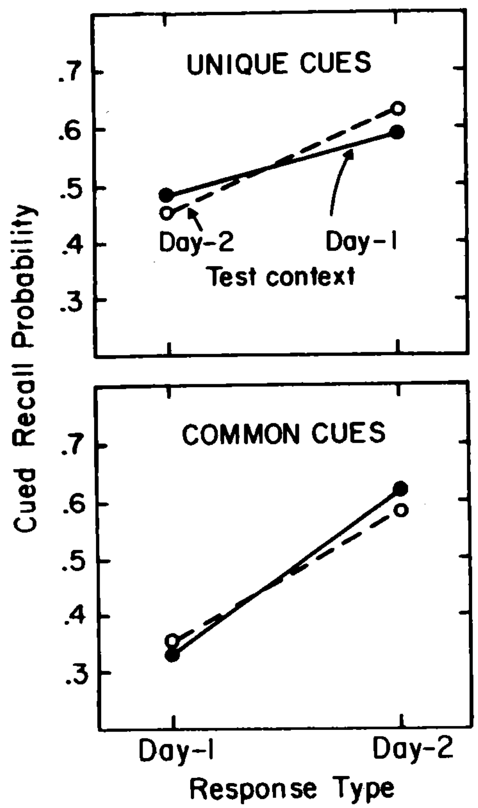

FIG. 9.3. Cued-recall proportions on Day 3 for cues that were unique to (top panel) or common to (bottom panel) Day-1 and Day-2 lists, as a function of whether the Day-3 test context matched the Day-1 or the Day-2 study context (after Richardson-Klavehn, 1988, Experiment 2).

to auditory, auditory to visual) from Day 1 to Day 2—except for the following differences: (a) The difference between Day-1 and Day-2 environments was larger in Richardson-Klavehn's experiment than in Smith et al.'s, both in terms of physical differences (the indoor and outdoor contexts were again used) and because experimenter and subject cohort changed systematically across contexts; (b) there were more subjects in Richardson-Klavehn's experiment than in the corresponding conditions of Smith et al.'s (a total of 57 vs. a total of 16); and (c) seven individual difference measures (a subset of those described earlier) were administered—three on Day 1, two on Day 2 and two on Day 3.

The results of Richardson-Klavehn's Experiment 2 are shown in Fig. 9.3, with performance for Unique-Cue pairs plotted in the top panel and performance on Common-Cue pairs plotted in the bottom panel. Overall performance was in the range obtained by Smith et al., but same-context words were not recalled more frequently than were different-context words. The small (statistically insignificant) trend in the direction of a context effect in the Unique-Cue data is perfectly offset by a small (insignificant) trend in the opposite direction in the Common-Cue data. One other difference in the results of the two experiments is that there was a recency effect for both Unique-Cue and Common-Cue pairs in the Richardson-Klavehn data (Day-2 responses being recalled better than Day-1 responses); by contrast, recency was present only for Common-Cue pairs in Smith et al.'s experiment.

WHEN IS RETRIEVAL AIDED BY THE PHYSICAL REINSTATEMENT OF INCIDENTAL ENVIRONMENTAL CONTEXT?

Given the inconsistency between the results shown in Fig. 9.1 and those shown in Figs. 9.2 and 9.3, and given the other failures to obtain advantages of physical context reinstatement in the literature, what is one to believe? Does physical reinstatement of incidental environmental context aid recall of material originally learned in that context or not? If physical reinstatement does aid recall, under what conditions does it do so?

One could attempt to argue that the reinstatement of *truly* incidental context *never* aids recall. The central assumption of such a position is that EC does not influence the form of a given episodic memory trace except when features of the EC were actively associated with the material learned (or the event that took place) in that environment, or when the EC influences the subject's interpretation of the learned material or event. By definition, then, the EC in these cases would be integrated or influential, not incidental. In that view, as mentioned earlier, reinstating incidental EC might trigger a recall effort that might not otherwise be attempted. Presumably, however, the same attempt to recall the target information in a different context would be as productive.

For a number of reasons, however, we question the tenability of the position that incidental EC never influences the form of the episodic memory trace. For example, this view cannot account for what we have termed the "second-order" effects of EC, and it seems at odds with the growing evidence that stimulus-driven processing, which is mostly or entirely automatic and independent of awareness, influences heavily the form of long-term memory representations.

Given that we assume that incidental aspects of environmental context *are* encoded as part of the episodic memory trace corresponding to the target material, how do we account for the repeated failures to find positive effects of physical reinstatement in controlled experiments? In the following, we summarize two interpretations of when physical reinstatement of EC should and should not aid recall.

The Outshining Hypothesis

Smith (1988; Smith & Vela, 1986) formulated an *Outshining Hypothesis*, the central tenet of which is that the effectiveness of EC cues depends on what other cues are available. The *outshining* label comes from a visual analogy: ". . . the idea that a heavenly body which is visible on a moonless night is more difficult to see when there is a full moon, and is completely outshone in the daytime by the sun" (p. 19). According to the analogy, EC cues are relatively weak retrieval cues in comparison to other types of retrieval cues (e.g., a copy cue or the stimulus member of a paired associate). EC cues will therefore influence retrieval processes only when more powerful cues are not available to guide retrieval.

The basic idea that EC cues become more important the fewer the other retrieval cues available has been stated by a number of other authors (e.g., Eich, 1980; Geiselman & Bjork, 1980; Smith et al., 1978; Spear, 1978). Smith elaborated the idea and applied it in a systematic fashion to a number of contextual phenomena. The strongest evidence in support of the hypothesis thus far is that recognition memory tests show little sensitivity to EC under conditions in which recall shows reliable effects of EC match/mismatch (e.g., Godden & Baddeley, 1980; Smith et al., 1978). The hypothesis accounts for these findings in a natural way: The copy cue provided on a typical recognition test overrides (outshines) EC cues. If the value of the copy cue is decreased by inducing shallow (poor) encoding at input, or by altering physical form of the copy cue between study and test, recognition should show positive effects of EC reinstatement. Smith (1985, 1986) reported finding EC-dependent recognition under such conditions.

It is our view that there is considerable merit to the outshining hypothesis, but that it is not a sufficient explanation of the pattern of effects and non-effects of EC match/mismatch. Among the findings not explained by the hypothesis are the following:

1. As reviewed earlier, there have been a number of failures to find EC effects in free recall (e.g., Richardson-Klavehn's Experiment 1—see Fig. 9.2), including a failure to replicate a published report (Fernandez & Glenberg, 1985, Experiment 8). According to the outshining principle, however, free recall tests should be maximally sensitive to EC reinstatement because those tests provide little to the subject in the way of external retrieval cues.

2. The outshining hypothesis cannot explain why Richardson-Klavehn's Experiment 2 failed to replicate the substantial effects in Smith et al.'s Experiment 2. Although, according to the hypothesis, the cued recall test used in these experiments is not the most EC-sensitive test that could have been used, the encoding procedures and test cues were precisely the same in the two experiments.

3. The positive effects of EC variation during study (in terms of reduced interference and enhanced total recall) seem reliable—apparently more reliable than is the effect of physical EC reinstatement. The outshining principle does not address this difference between the first- and second-order effects of EC.

A Mental Reinstatement Hypothesis

According to the outshining principle, the physical reinstatement of EC cues will aid performance only if such cues are not "outshone" by other cues at the time of test. In order to account for the failures to find effects of EC reinstatement on recall measures, we believe it is necessary to make the additional assumption that physical reinstatement of EC cues will benefit performance only when those EC cues cannot (or typically would not) be reinstated mentally at the time of test.

In laboratory experiments, of course, subjects who are tested in a context different from that used for original learning are normally given exactly the same recall instructions and recall time as the subjects who are tested in the original learning context (assuming that the possible subtle differences in demand characteristics across conditions, alluded to earlier, are avoided). The recall instructions given to different-context subjects in an episodic memory task—to recall material encountered earlier at a particular time and place—essentially constitute instructions to mentally reinstate the study context. Given that all subjects receive the same instructions, the ability of different-context subjects to mentally reinstate the study context weakens or eliminates the context effect.

Thus, only in those situations in which imaginal reinstatement is difficult or impossible should we expect reliable effects of physical reinstatement. Such situations can be brought about experimentally (e.g., as in Smith's 1979 Experiment 3, referred to earlier), but may also occur naturally, particularly in those real-world situations that involve long retention intervals.

Judgment concerning the truth of the mental reinstatement hypothesis must necessarily await explicit experimental testing. The current virtue of the hypothesis, however, is that it provides an integrated framework within which the unreliability of first-order (physical reinstatement) EC effects and the reliability of second-order (imaginal reinstatement, interference reduction, and enhanced total recall) EC effects can be naturally accommodated.

Memory and Metamemory Effects of EC Reinstatement

In our view, given that both outshining and mental reinstatement do not occur, physically reinstating EC cues can affect cognitive processing in two ways. To distinguish these effects, we describe one as a memory effect, and the other as a metamemory effect.

Memory. The memory effect is straightforward. We *do* think that EC cues are encoded as part of episodic memory traces, so physically reinstating those cues should aid access to the target episode of interest (subject to the caveats given earlier). The effectiveness of such cues will vary greatly depending on the extent to which those cues were available to, and processed by, the subject's sensory organs at encoding (the *functional* contextual cues as opposed to the *nominal* physical contextual cues—see Geiselman & Bjork, 1980), and on the extent to which those cues are unique to the episode in question. If many episodes take place in the presence of the same EC cues, the effectiveness of those cues will be diminished *(cue-overload*—see Watkins & Watkins, 1975). The reduction of interference between sets of learned materials that occurs when those materials are learned in different contexts (compared to when they are learned in the same context) can be viewed as an enhancement of the ability of the EC cues to specify target material uniquely, increasing the signal-to-noise ratio of the retrieval operation.

Metamemory. The metamemory effect is an effect on the subject's control processes. Physically reinstating EC cues may trigger a person to attempt to recall a prior event, or material learned earlier, whereas without such reinstatement no attempt would have been made to recall the target event or material. In certain situations, being in the context of original learning for an extended time period may result in more active, extensive, and temporally extended attempts at recollection than would be attempted in a different context, were such attempts made at all. The "triggering effect" of environmental cues that we note here bears some similarities to the notion of *retrieval mode* put forward by Tulving (1983, Chap. 9). In Tulving's view a necessary precondition for the effectiveness of stimuli as cues for the recall of personal experiences is that the memory system be in retrieval mode (because the majority of potential retrieval cues do not elicit episodic memories unless the subject is instructed to retrieve memories connected with those stimuli). Our concept of the metamemory effects of environmental cues differs from Tulving's retrieval mode notion in that we postulate that reinstatement of environmental cues (and not just recall instructions) can have the effect of inducing a subject to attempt to remember events that occurred in the presence of those cues.

Interpreting the Effects and Non-Effects, Anecdotal and Experimental, of Reinstating Incidental EC Cues

One implication of the explanations we offer here is that the conditions under which physical reinstatement of incidental EC cues will aid memory is quite restricted. What are we to make, then, of the numerous anecdotes that seem so convincing, and of the numerous positive effects reported in the literature?

Naturalistic Examples. We believe that the naturalistic examples reflect both genuine and nongenuine effects of reinstating incidental context. There are straightforward reasons to treat some anecdotes as genuine examples: Some of the examples satisfy the preconditions for the effectiveness of reinstatement that we set forth earlier. The long retention intervals (years, decades) common to many cases would make mental reinstatement difficult or impossible. In many cases the EC cues were unique to the episode in question, and there would usually not be any explicit "test" procedure that might provide cues that would outshine the EC cues.

As mentioned earlier, however, we also believe that there are two reasons why many such examples are fallacious—as far as being demonstrations that recall is aided by the physical reinstatement of *incidental* cues: (a) In real-world cases the reinstated context typically contains environmental stimuli that were integrated with target material at encoding, or which influenced the interpretation of that material when it was encoded; and (b) the anecdotes do not typically include the appropriate different-context comparison, in which the subject is to try to recall target information when in an EC different to that in which original learning took place. The memories "reinstated" by a return to some context might be just as accessible in a different context were something to cue the person to attempt to access those memories as actively and extensively as they are likely to do when in the original context.

Published Results. With respect to the positive effects of physical reinstatement in controlled laboratory experiments, we make three points:

1. Given the editorial policies of major journals, many failures to find effects of context reinstatement may never have appeared in print. It is therefore possible that some published examples of positive effects of incidental context represent Type I errors.

2. In certain cases manipulations that were nominally of incidental context may actually have constituted manipulations of influential context. Subjects may, for example, have used environmental stimuli as "pegs" to anchor

learned items at encoding, a technique similar to that of the method of loci. It is plausible that this type of encoding strategy is sometimes adopted spontaneously because subjects learn of such techniques in psychology classes. Alternatively, subtle cues given by the experimenter might induce the subjects to focus attention on environmental stimuli during encoding of target material.

3. Certain of the positive results reported may have been a consequence of the recall instructions given by the experimenter. As these experiments do not typically use single-blind testing (in which the experimenter is unaware of the subject's experimental condition), the experimenter may sometimes be more enthusiastic and motivating in the same-context condition than in the different-context condition. Even in the case of the within-subjects designs discussed earlier, which would seem to be free of differential biasing, our experience indicates that the instructions to subjects at test must be very carefully worded. If they are not, subjects tested in a particular context can assume that they are only to recall material learned in that context, and not material learned in the other context. Recall of different-context words would then reflect intrusion errors on the part of the subject. In free-recall experiments of the within-subject type, subjects could assume that they are to begin recall with words learned in the test context, causing output interference for different-context items. Output order analyses of Richardson-Klavehn's (1988) Experiment 1 data revealed no indication that such interference was occurring, but it must be noted that this experiment did not obtain a positive context effect.

Implications for Models of Memory

As we noted at the outset, context-dependent forgetting is a primitive assumption in many current memory models. This assumption is not often submitted to critical analysis, even though the value of such memory models as explanations of remembering and forgetting is largely predicated on its truth. The literature reviewed here suggests that our reliance on context change as the major factor explaining forgetting needs to be seriously questioned. We have argued that the range of situations under which changing incidental EC will negatively affect performance (i.e., produce forgetting) is limited, owing to the roles of outshining and mental reinstatement. Tying general explanations of forgetting to changes in incidental EC would therefore not appear to be advisable, even if EC cues are encoded and later influence retrieval under some conditions. It might be argued that changes in integral and influential context are primarily responsible for forgetting; however, this argument lacks plausibility. It is clear that large amounts of forgetting occur in situations in which no obvious changes in integral or influential context have occurred. For example, an item on a recognition test, unless highly ambiguous in meaning, is likely to be interpreted semantically in the same way as it was interpreted at study. Yet a subject might still fail to recognize that item. Change in physiological context is another often-invoked candidate in explanations of forgetting. Again, the idea that this type of context is subject to changes within an experimental session that are extreme enough to produce forgetting is simply implausible.

Based on the evidence reviewed above concerning the role of contextual variation in reducing interference, it seems that theoretical explanations of forgetting need to focus not on contextual change, but on the interference that occurs between items that are encoded in similar contexts. In other words, we need to develop theories that deal in a systematic manner with the problems of interference that preoccupied researchers in an earlier era. As proposed by those earlier researchers (e.g., Bilodeau & Schlosberg, 1951; McGovern, 1964), contextual factors probably play an important role in modulating interference processes. However, as noted by Bjork (1989), in the brain-metaphor-influenced theoretical environment of the late 1980s, it is perhaps finally appropriate to reintroduce the additional notion of active retrieval inhibition into our explanations of forgetting and remembering.

INCIDENTAL EC CUES IN PERSPECTIVE: TOWARD A TAXONOMY

We have restricted our focus here to contexts of a particular type (incidental environmental context) and to effects on memory measured in a particular way (recall). In terms of the possible types of contextual features that might be reinstated, however, and in terms of the possible measures of memory that might show an influence of such reinstatement, that restriction is severe. In this final section, in an attempt to lend some organization to the entire space defined by the various types of contexts and types of measures, we propose a three-dimensional taxonomy.

In describing our taxonomy, we use the word "target" to refer to information presented in some original context, the memory representation of which is then assessed with or without some aspect or aspects of that context being reinstated at test. The three dimensions in our taxonomy are *Type of Context, Context-Target Relationship*, and *Type of Processing* demanded by the test used to assess memory.

Type of Context

The first dimension refers to the distinction between *intraitem and extraitem* aspects of context (Geiselman & Bjork, 1980). Intraitem context refers to the various features of the stimulus bundle when the target is presented in the original context. Examples are modality of presentation, language, voicing, typeface, and so forth. Extraitem context denotes those aspects of the environment that are "outside" the stimulus bundle. Room cues, body-state cues (including physiological state and drug state), mood, background noises, other list items, the cue-member of a cue-target pair, and so forth are all examples of extraitem aspects of context.

Context-Target Relationship

The second dimension refers to the relationship between the aspect of context that is of interest and the target item as encoded. As we argued above, that relationship can be *integral*, *influential*, or *incidental*. Given typical encoding processes, examples of intraitem contextual features that are integral to the encoded representation of the target might be the language in which a to-be-remembered sentence is spoken, the melody accompanying to-be-remembered lyrics, and several different features of a to-be-remembered face. Examples of integral extra item context might be the stimulus member of a highly integrable S-R pair (e.g., *sour grapes*), or a feature of an environment with which the subject specifically associated a to-be-remembered word at encoding (as in the method of loci).

Influential context refers to intraitem or extraitem aspects of context that are not integral to the target as encoded, but nonetheless influence the form of the encoding. Intraitem aspects of context such as voicing or script may not end up as integral to the memory trace of the target but they may influence the encoding of the target. For example, consider the possible differential impact of male versus female speaker on the encoding of the homophone *bow* (weapon vs. piece of clothing). Experimental evidence suggests that sex of speaker also affects the connotative meaning of nonhomophonic words (e.g., Geiselman & Bellezza, 1977; Geiselman & Crawley, 1983). Extraitem aspects of context can exert similar influences on encoding. Smith et al. (1978) point out that the homographs *knot* and *bow* would both be interpreted very differently in the context of a ship and in the context of a gift shop. Certain drug states, such as that induced by marijuana, are thought to influence the form of encoded target material. Similar influences could clearly occur in the case of mood changes. Even time of day has been found to influence semantic memory retrieval processes (e.g., Tilley & Warren, 1983), suggesting that time of day could influence episodic encoding. These types of influences can occur at least sometimes without the awareness of the subject; for example, in Tulving's famous experiments (e.g., Tulving & Thomson, 1973), a subject would sometimes fail to recognize the response-word (e.g., *COLD*) of a previously studied pair (*ground-COLD*) on a recognition test even though he/she had generated that response alternative him/herself in response to an associated word (*hot*). In other experiments targets and biasing contexts were not attentionally encoded (e.g., they were presented on the unattended channel in a dichotic listening task—see Eich, 1984), but the context nonetheless influenced subjects' subsequent interpretation of the target.

Finally, incidental context is defined by exclusion to refer to those aspects of context that are not integral or influential. We have given a number of examples in this chapter of extra item cues that would typically be incidental, such as room cues, ambient temperature (over a reasonable range), and so forth. Intraitem contextual cues that would frequently be incidental are print color, print case (upper and lower), intensity of a visual or auditory target over the normal range, and so forth.

Type of Processing at Test

The third dimension in our taxonomy refers to the nature of the processing demanded by the test that is used to assess memory. We presume, following Jacoby (1983) and Roediger and Blaxton (1987), that two types of test processing can be distinguished: *Data-driven processing* and *conceptually driven processing*. In data-driven tests the subject is required to operate on perceptual information provided by the experimenter. For example, the subject might be required to identify a rapidly flashed word (perceptual identification), supply deleted letters to complete a word (fragment completion), or spell an auditorily presented homophone. In conceptually driven tests the subject must engage in constructive, semantically based processing in order to perform the task. A typical example of such a test is free recall. Recognition memory tests involve a blend of data-driven and conceptually driven processing: The subject operates on perceptual data provided by the experimenter, but must usually reconstruct the study episode in order to perform successfully.

The differential sensitivity of different memory tests to manipulations of elaboration at study and of match between perceptual and linguistic contexts at study and test can also be used to classify memory tests as data-driven or conceptually driven (e.g., Jacoby, 1983; Roediger & Blaxton, 1987; see following discussion). By contrast, we classify memory tests as data-driven or conceptually driven based on criteria of type of test cues and task requirements. We prefer the latter method of classification for the purpose of constructing a taxonomy of forms of context because it avoids certain problems of circularity when it comes to determining the forms of context to which each type of memory measure is sensitive.

Blaxton (1985) and Roediger and Blaxton (1987) point out that data-driven tests typically differ from conceptually driven tests with respect to whether the subject is required to display explicit knowledge concerning some prior episode. In the terms used by Johnson and Hasher (1987) and Richardson-Klavehn and Bjork (1988), data-driven tests are generally *indirect* tests of memory whereas conceptually driven tests are generally *direct* tests of memory. In indirect tests, the subject is simply required to engage in some cognitive activity, the instructions refer only to the task at hand, and the effect of a prior episode is assessed by comparing performance with relevant prior experience to performance without such experience (a control condition). In tests of perceptual identification or fragment completion, for example, some test items have been studied prior to their appearance on the test, whereas other items have not been studied. The measures of interest reflect a change in performance (typically a facilitation) caused by prior exposure to the test stimuli. It is particularly appropriate, therefore, to refer to such measures as *indirect* because the measure of the effect of an episode that is obtained is usually derived from a comparison of at least two data points.

As indirect memory tests involve no reference to a prior episode on the part of the experimenter, they are particularly well-suited to reveal effects of a prior episode that are expressed in performance without the subject consciously remembering the episode that caused the behavioral change. An outstanding example of such *memory without awareness* (Jacoby & Witherspoon, 1982) is the human global anterograde amnesic syndrome. Amnesics are, by definition, people who experience profound difficulty remembering information encountered subsequent to the onset of the amnesia—notably information concerning personal experiences. Despite this deficit, amnesics will often behave exactly like normal control subjects if their memory is assessed using an indirect test, such as fragment completion (for summaries, see Richardson-Klavehn & Bjork, 1988 and Shimamura, 1986). Of course, the fact that indirect tests *can* reveal the effect of an episode when a subject is not making conscious reference to that episode does not imply that normal subjects never make such conscious reference in performing indirect tests.

In contrast to indirect tests, the instructions in direct memory tests refer explicitly or directly to some prior episode in the personal history of the subject, and the subject must give evidence of knowledge concerning the episode in order to achieve success at the task. A normal subject is therefore typically in some sense made consciously "aware of the episode" in question by the task instructions; there is, however, considerable latitude with respect to the mental processes that can be involved in direct tests. Subjects might experience mental states similar to those that they experienced during the episode in question (reexperiencing the episode); on the other hand, they might achieve success by using semantic-conceptual knowledge to reconstruct what most likely occurred, or could simply guess correctly (e.g., as in forced-choice recognition). Performance on direct tests typically reflects a blend of these different mental processes.

Although direct tests are typically conceptually driven and indirect tests are typically data-driven, Blaxton (1985) and Roediger and Blaxton (1987) correctly point out that the conceptually driven/data-driven and direct/indirect dichotomies are not logically coextensive. Direct tests can be data-driven, such as when a subject is given a word (such as *CHOPPER*) as a cue to recall a graphemically similar word (such as *COPPER*) that was presented during some prior episode (*graphemically cued recall*). On the other hand, indirect tests can be conceptually driven: Retrieving the answer to a general knowledge question (e.g., "What metal makes up 10% of yellow gold?"), which does not require knowledge of a prior episode, clearly involves semantically based constructive processing.

One might expect that the direct/indirect distinction would be important with respect to a taxonomy of forms of context. Direct measures, after all, require retrieval of information about prior episodes, whereas indirect measures do not. One could therefore entertain the hypothesis that reinstatement of prior episodic context would matter only for direct measures, and not for indirect measures. That hypothesis, however, is false. As documented by Richardson-Klavehn and Bjork (1988) and Roediger and Blaxton (1987), the data-driven/conceptually driven distinction performs better than does the direct/indirect distinction in helping to clarify the pattern of contextual effects on memory. Regardless of direct/indirect status, data-driven tests are not sensitive to manipulations of elaboration of processing at study, but are sensitive to the match between study and test language, modality, typeface, and so forth. Conceptually driven tests, on the other hand, uniformly benefit from increasing the amount of elaborative processing accorded to study items, but are relatively not sensitive to factors such as language and modality—in fact, performance can actually be better when the perceptual data at study and test do not match than when they do match. For example, recognition memory for an item presented in verbal form at test (e.g., *CART*) is better when that item was studied as a picture or generated in response to a cue (*horse-???*) than when that item was presented in verbal form at study. The reverse pattern holds for data-driven tests: Performance in perceptual identification and fragment completion is enhanced more by prior study of an item in verbal form than by prior generation of that item, or study of that item in pictorial form (e.g., Blaxton, 1985; Jacoby, 1983; Roediger & Blaxton, 1987; Roediger & Weldon, 1987; Weldon & Roediger, 1987; Winnick & Daniel, 1970).

Concluding Comments

Combining the three dimensions of the taxonomy ($2 \times 3 \times 2$) yields 12 cases in which physical reinstatement might or might not enhance performance. For some of those cases, as we pointed out earlier, the research literature provides a fairly clear answer. When the context-target relationship is *integral*, for example, physical reinstatement aids performance whatever the type of context (intra- or extraitem) or the type of processing (data-driven or conceptually driven). By contrast, the status (with respect to effects/noneffects) of a number of the cells in the taxonomy is currently unclear. It is not the purpose of this chapter to address all of these cases; here we have been concerned largely with one problematic cell—the effects of incidental extra item context on performance on a conceptually driven memory test (recall). We have tried to emphasize the importance of the distinction between integral, influential, and incidental context in the analysis of this issue. The data-driven/conceptually driven distinction, although not introduced in our analysis, is also important with respect to the effects of incidental EC: Thus far there is little evidence that data-driven tests such as perceptual identification are sensitive to manipulations of incidental EC. Speaking more generally, our taxonomy demonstrates that "context" cannot be treated as a unitary construct (as it often is, particularly in theoretical models of memory): Whether reinstating context affects memory will depend on an interaction of the form of context in question and the way that memory is measured.

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