In what sense is implicit memory “episodic”? The effect of reinstating environmental context

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We consider three aspects of the term *episodic*. Previous literature shows implicit memory does not make *conscious autobiographical reference* but does code an item's *intrinsic context* (e.g., perceptual detail). Here, we consider *extrinsic context*—namely, that not directly processed as part of item identification and not overtly relevant to the task. Study–test mismatch in environmental context (outdoors vs. indoors) reduced memory in an explicit stem-cued recall task but had no effect on repetition priming in an implicit stem completion task. This was true even for very low frequency words. We support the view that implicit memory reflects traces within perceptual (or semantic) knowledge-based systems that are instance specific but do not code the full spatiotemporal context information necessary to support conscious recollection. We also interpret our results as consistent with differences in environmental context specificity between free recall and recognition.

Explicit memory requires deliberate reference back to a previous learning episode and is associated with conscious recollection. Explicit retrieval, at least as instantiated in free recall tasks, necessarily relies on placing a remembered item as part of a specific personalized event in a spatiotemporal context (i.e., recollecting that I saw a target word in the study list and not, say, in yesterday's newspaper). It is this type of remembering that Tulving (1972) originally labeled *episodic memory*.

Implicit memory, in contrast, is reflected in the influence of prior exposure on behavioral measures (Graf & Schacter, 1985). For example, in the stem completion task, the stem *acc _____* might be completed more often with the target *accept* if that target appeared at study than if it was unstudied, a phenomenon referred to as *repetition priming*. The definition of implicit memory makes no reference back to any particular encounter with the stimulus; the instructions for the stem completion task, for example, are to “complete each stem with the first word that comes to mind.” On the face of it, then, there is no requirement that implicit memory be episode specific in the way that explicit memory must be.

This apparently key difference has often been used to explain the range of experimental dissociations (see Roediger & McDermott, 1993) observed between explicit and implicit memory. Schacter and Tulving (1994), for example, assign implicit memory phenomena to memory systems whose primary purpose is to store *knowledge* (perceptual or semantic), and not to the *episodic memory system*, which supports explicit retrieval. Within a perceptual representa-

tion system, priming has often been modeled as reflecting temporary changes in the state of stable abstract representations (e.g., leftover activation of word units; Morton, 1979). Indeed, in the terminology of some researchers, *episodic* and *explicit* are completely synonymous, and it is a contradiction in terms for implicit memory to be episodic.

However, empirical evidence clearly indicates that implicit memory can be specific to the reinstatement of details of a particular encounter with a stimulus. On perceptual implicit memory tests, priming is reduced by study–test mismatch of the target's perceptual form, such as auditory–visual modality, and sometimes even typefont and letter case (at least with right hemisphere presentation; Marsolek, 1995; see Tenpenny, 1995, for a review). These results show that implicit memory phenomena can rely on a trace that codes the specifics of an individual episode. Several researchers have therefore proposed *episodic* theories of implicit memory (e.g., Logan, 1990; Tenpenny, 1995).

How can we resolve this conflict regarding the role of episodic information in implicit memory? We argue that at least three theoretically independent aspects of the term *episodic* can be distinguished. The first is that of *autobiographical reference*—that is, the feeling of conscious recollection from a personal past (Tulving, 1972). Although this is clearly involved in explicit memory performance, there seems little doubt that implicit memory is *not* episodic in this sense; for example, amnesics can show intact priming in the absence of any recollection that a study list was presented at all (Warrington & Weiskrantz, 1968). A second aspect of episodic is *coding of the intrinsic context* of the target item. By *intrinsic context* (Godden & Baddeley, 1980), we mean the properties of the item that are unavoidably processed in order to perform the task (e.g., reading a written word involves early visual processing, orthographic identification, conversion to phonology, determination of meaning, etc.). The reduction in priming

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observed with study–test mismatch in perceptual form indicates that implicit memory *is* episodic in this second sense. (Interestingly, explicit memory is generally sensitive to mismatch in meaning, but not in perceptual form, presumably because the standard explicit tasks rely on semantic processing. Thus, explicit memory is usually sensitive to the *semantic* aspects of the intrinsic context.)

The third aspect is *coding of the extrinsic context* of the item. *Extrinsic context* refers to those aspects of the study–phase event that are not processed as part of item identification and are not of direct relevance to the task. This includes elements of the spatiotemporal context (physical setting, ambient temperature, odor and noise, time of day) and, potentially, also the internal mood state of the subject. The coding of extrinsic context is included in Tulving's (1972) definition of episodic memory. Empirical evidence shows that explicit memory (free recall) is sensitive to study–test mismatch in both spatiotemporal context and mood state (see Smith, 1988, for a review). For example, Godden and Baddeley (1975) tested deep sea divers in two environmental contexts, on land and underwater, and found a substantial benefit to free recall performance when the study and the test environments matched, as compared with when they mismatched.

The aim of the present research was to assess whether implicit memory is episodic in the third sense of coding extrinsic context. Only three studies have addressed this question, with contradictory results. Jacoby (1983, Experiment 3) found no effect on priming of mismatching study–test location, using a perceptual identification task (naming briefly presented masked words). The locations used, however, were two experimental testing rooms described as very similar in appearance. Schab (1990) held location constant and varied the odor in the room. Priming on a stem completion task was greater when the study and the test odors matched than when they mismatched. However, the subjects were instructed to think about and imagine the odor, making it uncertain that it formed part of the extrinsic, as opposed to intrinsic, context; furthermore, no controls were reported for the use of explicit retrieval strategies on the stem completion task. Smith, Heath, and Vela (1990) used two rooms described as very different in appearance and did obtain context dependency, using a homophone spelling task (priming the low-frequency meaning of the homophone: *beet* rather than *beat*).

Thus, of the three previously reported studies, two have found an effect of environmental context match, whereas one has not. In addition, one of the studies that found an effect is open to the possibility of explicit contamination, whereas the study that did not may not have had a strong enough manipulation. Furthermore, none of the three studies contrasted implicit memory with a directly comparable explicit memory task.

In the present experiment, we examined the effects of environmental context reinstatement on an implicit memory task (stem completion). A comparable explicit memory task (stem-cued recall) was tested to ensure that the environmental context manipulation was effective. A word

frequency manipulation was also included. Tulving (1972) proposed that it is frequent presentations of an item that allow that item to become abstracted from its spatiotemporal context; similarly, Dalton (1993) suggested that environmental context effects (on explicit memory) may be more apparent with novel items (specifically, unfamiliar faces) than with familiar items. Thus, a possible interaction between word frequency and context was of interest; specifically, environmental context effects on implicit memory might show up for very low frequency words, even if not for higher frequency words.

METHOD

Subjects and Design

The 68 subjects were students of the Australian National University, participating for course credit. All had English as a first language. Type of memory test and context condition were between-subjects variables. For *explicit memory*, 14 subjects were assigned to the *context match* condition (7 studied inside [I] and were tested inside, and 7 studied outside [O] and were tested outside), and 14 were assigned to the *context mismatch* condition (7 I–O, 7 O–I). For *implicit memory*, 20 subjects were assigned to *context match* (10 I–I, 10 O–O), and 20 were assigned to *context mismatch* (10 I–O, 10 O–I). Word frequency (low vs. medium) was manipulated within subjects.

Stimuli

There were 48 target words that were 5–8 letters in length; half were low frequency (1–2 occurrences per million; Kučera & Francis, 1967), and half were medium frequency (40–116 per million, $M = 75$). Words strongly associated with either environmental context (e.g., *grass*) were excluded. The three-letter stem of each target was unique within the set, and each stem had at least five other possible completions. Medium-frequency words were used, rather than high-frequency, to ensure that baseline stem completion rates would not be too high to allow priming. For the same reason, pilot testing excluded any stems that strongly suggested one particular completion.

The 48 items were split into two 24-item study lists, each containing 12 low-frequency and 12 medium-frequency words. The lists were equated for word length, frequency, number of syllables, grammatical status, and abstract/concrete status. Studied versus unstudied (baseline) status of the lists was counterbalanced across subjects. At test, the three-letter stems of all 48 target words (i.e., 24 old, 24 new) were presented. Study and test presentations used the same font and case. Items were presented in a new random order for each subject.

Environmental Contexts

The two environmental contexts were selected to be as different from each other as possible, while within the range of environments ordinarily encountered by students. The I context was a 2.5×4 m room in the ANU Chifley library, plainly furnished with two laminated tables. Walls were of brown brick, brown wood paneling, and white plaster. Two windows were curtained to obstruct the view to the outside. The O context was an open grassed area between the psychology and the physics buildings, containing a pond with running water and frequented by ducks. The subjects were seated around wooden picnic tables; they often commented that they found this environment pleasant and relaxing. Testing was conducted in August–September (i.e., late winter; outside temperature, 10°–14° C; inside temperature, 21° C).

Given the requirement that processing of environmental context should remain *extrinsic* to item processing, the subjects were told that the aim of the experiment was to examine the effects of nonstrenuous exercise on memory. This cover story provided a reason for a change of location between study and test.

Procedure

The subjects were tested for a 1-h session in groups of 1 to 6. At study, 4 sec were given to learn each word in turn, with all other words obscured, followed by a further 30 sec to look over the entire list.

The subjects were then escorted on a 10-min walk around campus. The subjects in the context match conditions (I-I and O-O) walked halfway along a set route between the two locations, before retracing their steps back to the original study environment. The subjects in the context mismatch conditions (I-O and O-I) walked from their study environment to the other location. To reinforce the cover story, the subjects recorded their pulse rates at the end of the walk.

In the test phase, stems were attempted sequentially, with no return to earlier blank responses. For explicit memory, retrieval instructions were to complete stems only with words seen in the study phase of the experiment and to leave a stem blank if no study-list completion could be recalled. No time limit was imposed. For implicit memory, the instructions were to complete each stem with the first word that came to mind. To encourage genuinely implicit retrieval, it was stressed that the word could come from anywhere (e.g., a lecture, a conversation earlier in the session, something a friend said, etc.) but that it was *very* important that the subjects write down the *first* word that popped into their head. For the same reason, the subjects were told to complete every stem as rapidly as they could, and a stopwatch was provided to record completion time on the test paper.

Finally, the subjects completed a posttest questionnaire. This was used to determine (1) whether the subjects guessed the relevance of environmental context (*What do you think was the purpose of this experiment? What variables do you think were being considered?*) and (2) whether an explicit or implicit retrieval strategy was used (*What was your general strategy in completing the stems? Did you deliberately try to complete the stems with words you remembered from the study list? Did you complete the stems with whatever word first popped into your head?*). The subjects were replaced if they realized the relevance of the environmental context manipulation ($n = 1$) or reported retrieval strategies inconsistent with those required (e.g., reported completing stems with any word that came to mind in the explicit memory conditions [$n = 2$] or admitted deliberate recall from the study list in the implicit conditions [$n = 3$]). The posttest questionnaire also assessed whether the subjects attempted to mentally reinstate details of the study environmental context during the test phase (*Did you try to reimagine the situation in which you stud-*

ied the list of words—e.g., room, surroundings, position of the item on the page?).

RESULTS

For both explicit and implicit retrieval, percentages of word stems completed with the target word were calculated. Memory scores were then computed as the difference between studied and baseline (unstudied) completion rate, for each subject. Figure 1 shows mean explicit (stem-cued recall; Figure 1A) and implicit (stem completion; Figure 1B) memory scores as a function of environmental context condition (match vs. mismatch) and word frequency (low vs. medium). A three-way (test type $\times$ context match $\times$ word frequency) analysis of variance (ANOVA) revealed two interactions. Most important, the effect of context match was found to differ significantly for explicit and implicit memory [$F(1,64) = 7.52$, $MS_e = 248.24$, $p < .01$]. The effect of word frequency also depended on test type [$F(1,64) = 7.66$, $MS_e = 140.74$, $p < .01$]. Word frequency and context match condition did not interact ($F < 1$, $MS_e = 140.74$), and there was no three-way interaction ($F < 1$, $MS_e = 140.74$). Given the two-way interactions involving test type, we then examined the effects of context match (and frequency) separately for explicit memory and implicit memory.

Explicit Memory

Collapsing over word frequency, explicit memory was better when study and test environmental contexts matched ($M = 38.7\%$, $SEM = 3.3\%$) than when they mismatched ($M = 26.5\%$, $SEM = 3.4\%$). This difference is on a par with that produced by the most extreme manipulation of environmental context in the literature: 34.0% versus 23.5% (average $SEM = 2.9\%$) with on-land and underwater contexts (Godden & Baddeley, 1975). A 2×2 ANOVA

Figure 1. (A) Explicit stem-cued recall scores (studied minus baseline), as a function of study-test match in environmental context (match combining I-I and O-O; mismatch combining I-O and O-I) and word frequency (LF = low frequency; MF = medium frequency). Error bars show SEMs for the between-subjects comparison of match versus mismatch. Average baseline completion rate (i.e., false recall) = 1.4%. (B) Implicit stem completion scores (studied minus baseline). Average baseline completion rate = 5.4%.

for Figure 1A confirmed that the main effect of match versus mismatch in context was significant [$F(1,26) = 7.26$, $MS_e = 301.00$, $p < .02$].¹ The lack of any interaction with word frequency ($F < 1$, $MS_e = 188.11$) indicated that both low- and medium-frequency words demonstrated the context effect. A main effect of word frequency emerged [$F(1,26) = 10.55$, $MS_e = 188.11$, $p < .02$], in which explicit memory was better overall for low-frequency than for medium-frequency words. Stem-cued recall has components of both free recall and recognition, and the effect of word frequency is opposite for these two tasks (e.g., see Mandler, 1980); here, the stem-cued recall data acted more like recognition than like recall.

Implicit Memory

The analyses above demonstrated strong environmental context dependency in the explicit stem-cued recall task. For the implicit stem completion task, however, a very different pattern emerged. Figure 1B shows that there was no benefit whatsoever of reinstating the study context at test. Collapsing across word frequency, stem completion priming was, if anything, slightly *less* in the context match condition ($M = 13.3\%$, $SEM = 2.3\%$) than in the context mismatch condition ($M = 15.0\%$, $SEM = 2.3\%$). A 2×2 ANOVA found no main effect of context match versus mismatch ($F < 1$, $MS_e = 120.43$). There was also no interaction between context and word frequency ($F < 1$, $MS_e = 120.43$); specifically, there was no advantage of reinstating context even for very low frequency words (13.3% match vs. 14.6% mismatch). There was also no overall effect of word frequency ($F < 1$, $MS_e = 120.43$), consistent with previous findings in the stem completion task (see Roediger & McDermott, 1993). The lack of an effect of environmental context on implicit memory cannot be attributed to any obvious design problems, such as floor effects on priming or unequal baselines between the match and the mismatch conditions. The overall level of priming (approximately 14%) was in the range normally obtained in the stem completion task (and was certainly well above zero; $p < .001$), and the baseline rate was the same in both the context match ($M = 5.4\%$, $SEM = 1.0\%$) and the mismatch ($M = 5.4\%$, $SEM = 1.0\%$) conditions.

Mental Reinstatement in Explicit Memory

The posttest question regarding mental reinstatement strategies assessed a proposed explanation of why some studies have found no effect of environmental context even on explicit memory (see the Discussion section). Bjork and Richardson-Klavehn (1989) suggested that subjects in the *mismatch* condition routinely use mental reinstatement of a physically absent environment when completing explicit memory tasks. However, only 1 of the 28 explicit memory subjects (and 0 of the implicit) reported reimagining details of the study presentation; furthermore, this subject was in the *match* condition, where the previous environment was physically present and did not need to be mentally reinstated.

DISCUSSION

Our results show no evidence of environmental context dependency on an implicit memory task (stem completion), under conditions shown to be adequate to produce environmental context dependence on an equivalent explicit memory task (stem-cued recall). Moreover, there was no effect on implicit memory even for very low frequency words, where context dependency might have been considered most likely to emerge (Tulving, 1972).

Our results regarding implicit memory are consistent with those of Jacoby (1983) but contrast with those of Smith et al. (1990). With so few extant studies, it is difficult to make informed speculations regarding the origin of these conflicting results, although we note that Smith et al. used a conceptual task (priming one meaning of a homophone), rather than the perceptual tasks used here (stem completion) and by Jacoby (perceptual identification). With respect to perceptual priming tasks, at least, we emphasize the strength of our own results. Our study used a very strong manipulation of environmental context and good controls for explicit contamination in the implicit memory test and is the only study to test directly comparable explicit and implicit memory tasks. Also, note that our null effect of context reinstatement on implicit memory is unlikely to be attributable to low statistical power: The effect on implicit memory was in the *wrong* direction; we tested more subjects (and thus obtained smaller *SEMs*) in the implicit condition than in the explicit; and the pattern for implicit memory was shown to be significantly different from that for explicit memory.

The conclusion that implicit memory is insensitive to extrinsic context is consistent with a theoretical interpretation of differences in context dependency between different *explicit* memory tests in the literature—specifically, between the recall tests we have considered so far and recognition memory tests. Recall tests usually show robust effects of mismatching environmental context (see Smith, 1988). Recognition tests, however, show more variable results (Dalton, 1993; Jacoby, 1983; Parkinson & Aggleton, 1994; Smith, Glenberg, & Bjork, 1978); for example, Godden and Baddeley (1980) used the same on-land versus underwater environmental context manipulation as in their original (1975) free recall experiment but found no effect of context mismatch on recognition.² Various explanations of failures to find context dependency in recognition have been proposed, ranging from the methodological (using two experimental testing rooms of similar appearance provides too weak a manipulation of environmental context; Godden & Baddeley, 1980) to the more theoretically interesting (a change in location may be insufficient to change subjects' mood state [Eich, 1985]; subjects may routinely use mental reinstatement of the study environment when physical reinstatement is not possible [Bjork & Richardson-Klavehn, 1989]; context dependency occurs only for unfamiliar items [Dalton, 1993]; or other retrieval cues are often stronger than environmental

context and “outshine” the effect of context reinstatement [Smith, 1988]). With the possible exception of the “outshining” hypothesis, however, none of these proposals explains why context effects should be any easier to obtain in recall than in recognition.

We suggest that a useful way of thinking about why context effects are strong in recall, intermittent in recognition, and absent in implicit memory is provided by Jacoby's (1983) distinction between *perceptual fluency* and *elaboration*. Jacoby argued that, in recognition, an old judgment can be made on the basis of increased perceptual fluency (the item seems easier to process or more familiar than it should) or on the basis of an elaboration process that involves retrieving the unique context in which an item was presented. Only the second of these two processes should be sensitive to reinstatement of environmental context. In free recall, there is no perceptual fluency cue (since the target item is not presented at test), and only the elaboration process can be used to support memory; thus, context effects will be strong. In recognition, performance can rely largely on perceptual fluency, with only secondary reference to elaboration; thus, context effects will emerge only under limited circumstances (e.g., for novel items, where perceptual fluency is poor). In implicit memory, performance is thought to rely purely on perceptual fluency (Jacoby & Hollingshead, 1990) and so should be unaffected by mismatch in environmental context; this is exactly the result we have obtained. Thus, our results for implicit memory can be integrated with a theoretical framework explaining differences in context dependency between recall and recognition.

We can now return to our original question—namely, *In exactly what sense is implicit memory “episodic”?* The previous literature has made it clear that implicit memory, unlike explicit memory, is *not* episodic in the sense of making *autobiographical reference*. Previous literature has also clearly demonstrated that implicit memory is episodic in the sense of being specific to the *intrinsic context* of a particular encounter with the item—that is, to those details of the stimulus that must necessarily be processed as part of the study task requirements. The contribution of the present research has been to examine a third aspect of an episodic trace—namely, coding of *extrinsic context* (i.e., details of the wider spatiotemporal context in which the item was encountered that are not directly relevant to the task at hand but are nevertheless known to influence performance on explicit memory tests, such as free recall). Our results argue that implicit memory, at least as indexed by stem completion, is *not* episodic in this third sense.

The conclusion that implicit memory is independent of *extrinsic* context (as well as of autobiographical reference) is consistent with Schacter and Tulving's (1994) assignment of implicit memory phenomena to knowledge-based memory systems, rather than to an episodic memory system supporting explicit retrieval. The sensitivity of implicit memory to intrinsic context requires, however, that these knowledge-based systems themselves store details of individual encounters with an item (i.e., instance-based

traces), although not the full temporal relationships between events necessary to specify spatiotemporal context.

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NOTES

1. The context match effect was evident both for inside test contexts (42.3% I-I vs. 31.0% O-I) and for outside test contexts (35.1% O-O vs. 22.0% I-O), although with only $n = 7$ in each of these conditions, the difference was significant ($p < .05$) only in the latter case.

2. Murnane and Phelps (e.g., 1995) have shown strong effects of what they called the *environmental context* on recognition. However, their ma-

nipulation involved presenting words on a computer screen, with simultaneous alterations of item color, item font/case, item position, and background color between study and test. The first three of these variables are clearly *intrinsic* to the stimulus. Even background color was not clearly extrinsic, given that it was varied from trial to trial, encouraging subjects to notice its importance.

(Manuscript received March 1, 2000;
revision accepted for publication March 16, 2001.)