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Context Specificity of Automatic Influences of Memory

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It has often been shown that intentional recollection is influenced by context manipulations, such as context reinstatement (e.g., Smith, 2013; Smith & Vela, 2001), but whether or not automatic retrieval (e.g., Jacoby, 1991) is likewise context dependent remains an open question. Here, we present two experiments that examined effects of context manipulations on indirect measures of memory. The first experiment tested anagram completion, and the second experiment used word fragment completion to test effects of context reinstatement; both experiments found reinstatement effects. To address potential problems of explicit contamination, we also asked participants if they were aware of the priming manipulations. Separating participants according to their test awareness showed effects of context manipulations for both aware and unaware participants. A greater effect size was found for aware participants only in Experiment 1, in which participants had enough time on each test trial for recollection to be used. We conclude that context reinstatement does affect automatic retrieval.

Keywords: context reinstatement, automatic retrieval, memory

Is automatic retrieval context dependent? For example, when you tell a clever joke or explain a great idea to the very colleague who (you forgot) had told it to you in the first place, does context play a role? That is, does the context provided by the colleague you originally associated with the joke or idea make this embarrassing situation even *more* likely to happen? Such errors reflect automatic influences of memory, retrieving memories for earlier hearing of the idea or joke without awareness of those automatic influences. Errors and cognitive illusions such as these are explained by the opposition of automatic and controlled influences of memory, but context-specific automatic memories need not be oppositional; unbidden memories of seemingly forgotten experiences, songs, stories, or conversations commonly pop into mind, for example, at reunions, triggered by reencountering the contexts in which those experiences occurred. Such anecdotal experiences suggest that even a single, arbitrary episodic pairing of an event with a context may be automatically retrieved when that context is reinstated. In the present study, we ask whether automatic influences of memory are context specific.

Before describing our experiments aimed at this question, we consider the contrast between automatic and cognitively controlled processing. As described by Neumann (1984), this contrast has been widely applied, in areas including bilingualism and second-language learning (Segalowitz & Hulstijn, 2005), control of posture and gait (Woollacott & Shumway-Cook, 2002), and models of drug urges and drug use (Tiffany, 1990). Cognitively controlled processing is generally described as accompanied by awareness, being intentional, and relatively slow. In contrast, responses originating from automatic influences are described as being reflex-like in their being fast, unaccompanied by either intention or awareness of their cause, and not requiring attention. Being reflex-like, automatic processes are generally considered to be peripheral and, so, context free. In contrast, Neumann described reflexes as context dependent. For example, he noted that even the knee-jerk reflex depends on the general context in which an attempt to elicit the reflex occurs. Against this backdrop, one might expect automatic influences of memory to be context specific, not context free.

The contrast between cognitively controlled and automatic influences has been used to describe findings of dissociations between direct and indirect tests of memory. For direct tests of memory, such as cued recall or recognition memory, people are asked directly to report on the occurrence of a particular past event. In contrast, for an indirect test, participants are not asked to report on the past, but rather to engage in a task that can reflect the occurrence of a particular prior event without the participant being aware that it does so. As an example of an indirect test, a fragment of a word (e.g., "_OT_L") might be presented, with the participant being asked to complete the fragment to form a word. Prior presentation of a word that completes the fragment (e.g., "MOTEL") makes it likely that the earlier-presented word will be produced as a completion even when participants are unable to report or recognize the word as previously presented. More generally, memory performance revealed by a variety of indirect tests can be dissociated from performance on direct tests of memory (e.g., Jacoby, 1991; Tulving, Schacter, & Stark, 1982; Warrington & Weiskrantz, 1978). Tulving et al. (1982) identified performance on indirect tests of memory as reflecting implicit memory, whereas performance on direct tests was said to reflect explicit memory.

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Rather than identifying processes with tasks in that way, Jacoby (1991) argued that tasks are seldom process pure. It was argued that indirect tests of memory generally weight toward reflecting automatic influences of memory but can also reflect cognitively controlled influences of memory. In contrast, direct tests of memory weight toward cognitively controlled influences of memory but can also reflect automatic influences of memory.

There is now a great deal of evidence to show context specificity of effects on *direct* tests of memory. For example, Godden and Baddeley (1975) used two radically different environmental contexts, on dry land versus underwater, to test context-dependent memory, and they found that reinstating the study context at test, rather than testing in a different environmental context, produced better recall. Other studies have used room manipulations (McDaniel, Anderson, Einstein, & O'Halloran, 1989; Smith, 1979; Smith, Glenberg, & Bjork, 1978), ambient odors (Cann & Ross, 1989), or background music (Balch, Bowman, & Mohler, 1992; Smith, 1985) as environmental contexts to demonstrate effects of context reinstatement on recall. Despite notable failures to find context reinstatement effects (e.g., Fernandez & Glenberg, 1985; Saufley, Otaka, & Bavaresco, 1985), a meta-analysis of incidental environmental context effects by Smith and Vela (2001) showed that, across all studies, a significant, but modest, effect of environmental context was found (Cohen's $d = .28$).

Most environmental context-dependent memory studies have used tests that are likely to rely on recollection, such as recall tests (e.g., Godden & Baddeley, 1975; McDaniel et al., 1989; Smith, 1979, 1984, 1985). A good example is the study by Smith (1979), which reported significant room reinstatement effects on a free recall test. That study also reported effects of mental reinstatement of the study context; participants tested in a nonreinstated room who were instructed to think about the study context before the recall test recalled as much as participants who were physically returned to the study room. It is difficult to explain these mental reinstatement effects, and other context effects that use recall tests, without relying on the notion that context reinstatement can enhance recollection.

Studies of context reinstatement effects with recognition memory tests suggest the possibility that environmental context reinstatement benefits *only* recollection and does not affect automatic memory processes. Whether or not studies of recognition memory show reliable context-dependent memory effects has long been in question, based on early failures to find such effects (Godden & Baddeley, 1980; Jacoby, 1983; Smith et al., 1978). Nonetheless, there have been several reports of context-dependent recognition memory (e.g., Dalton, 1993; Hayes, Nadel, & Ryan, 2007; Hockley, 2008; Krafka & Penrod, 1985; Macken, 2002; Murnane, Phelps, & Malmberg, 1999; Rutherford, 2004; Shahabuddin & Smith, 2016; Smith, 1985, 1986; Smith & Vela, 1992), and in their meta-analysis of such effects, Smith and Vela (2001) noted that despite notable failures to find context-dependent recognition effects, overall, such effects are no less robust than the effects of context reinstatement measured with recall tests. Although there are several factors that are likely responsible for failures and successes of context-dependent recognition effects, one factor is the involvement of recollection, as opposed to familiarity or automatic retrieval, on the recognition test. For example, Macken (2002), using a *remember–know* paradigm (e.g., Gardiner, 1988), found a context-dependent recognition effect only for *remember* judgments, a measure of recollection, and not for *know* responses, considered more of a measure of familiarity or automatic retrieval. Similarly, Hockley (2008) found a context-dependent recognition effect only when target words had been intentionally encoded in association with their study contexts, thereby enabling contextually cued recollection; Hockley's finding occurred only for *remember* responses and not for *know* responses. These studies, combined with the effects of environmental context-dependent memory effects for recall tests, indicate that context reinstatement clearly affects recollection, as measured by direct tests of memory.

In contrast to context effects found for direct tests, the results for indirect tests have been much more mixed. Effects of verbal *associative contexts* (i.e., unrelated words paired with target words) have been clearly demonstrated for indirect memory measures, whereas the effects of *environmental contexts* (i.e., places and situations in which events occur) on indirect tests are inconclusive. The effects of verbal associative contexts on word-stem completion, an indirect memory test, have been demonstrated repeatedly (e.g., P. Graf & Schacter, 1985, 1989; Schacter & Graf, 1986, 1989). Although these associative context priming results are suggestive, performance on stem completion tests could be contaminated by recollection, an intentional, consciously controlled use of memory. Addressing this problem, Jacoby (1996) used the process dissociation method (e.g., Jacoby, 1991), showing that the associative context specificity of automatic influences of memory could be understood by considering study/test compatibility. Jacoby noted that reinstating associative contexts allows both prior conceptually and data-driven processing to serve as sources of automatic influences of memory, whereas nonreinstatement of associative contexts allows only prior data-driven processing to automatically influence memory. Thus, a body of research shows that automatic retrieval, an unconscious influence of memory, is affected by verbal associative context reinstatement.

Does environmental context reinstatement, like verbal associative context reinstatement, influence performance on indirect measures of memory, and, more to the point, does it affect automatic retrieval? The evidence relevant to this question has been inconsistent. We hypothesize that the inconsistency of published results is because of: (a) The environmental context-dependent recollection effect size is greater than the context-dependent automatic retrieval effect, and (b) the environmental context methods (room or odor manipulations) in all of the published studies with indirect tests produce small effects. Thus, the weak context manipulations in all of the previously published studies have been robust enough only to detect the stronger effects of context-specific recollection, not the weaker effects of context-specific automatic retrieval. Viewed through this lens, it can be seen that indirect tests in studies that permitted test-aware participants to use recollection have tended to show effects, whereas studies with tests that restricted recollection have not shown context-specific effects.

For example, one of the first studies of context-dependent automatic retrieval was reported by Jacoby (1983, Experiment 3), who examined perceptual identification as a function of the environmental context. This test involved trials in which a word was presented on a computer screen for 35 ms, followed by a mask (a row of ampersands where the word had been); participants tried to name the words, some of which had been read earlier in the experiment (participants were not informed that some of the test words had been seen earlier in the experiment). Although no memory task may be completely process pure, recollection appears to have little effect on the level of priming in a perceptual identification task (e.g., Jacoby & Dallas, 1981). The environmental context manipulation that Jacoby used involved two different global contexts; one was in a particular room with a particular experimenter, computer, list format, study order, and test order, whereas the other context consisted of a different room with a different experimenter, computer, list format, study order, and test order. Jacoby found no significant effects of environmental context reinstatement on perceptual identification, a task that permits very little recollection. Consistent with this reported noneffect were the results of Mori and Graf (1996), who also failed to find environmental context-dependent perceptual identification. Thus, an indirect test that involves primarily automatic retrieval, and that greatly restricts recollection, repeatedly failed to show context-specific effects as a function of weak context manipulations.

In contrast to these negative findings, several studies in which explicit contamination was quite possible have reported positive effects of environmental context manipulations on indirect memory measures. Room manipulations have been reported to affect word fragment completion (Vela, 1989), homophone spelling (Smith, Heath, & Vela, 1990), category production (W. Graf, 1988; Parker, Gellatly, & Waterman, 1999), naming words from their definitions (Vela, 1989), answering general knowledge questions (Parker et al., 1999), and anagram solution (Garberg & Radtke, 1986). In addition, manipulations of ambient odors have been used to show context reinstatement effects on word-stem completion (Schab, 1990) and word-fragment completion (Ball, Shoker, & Miles, 2010). In every one of these studies, however, the pacing of the indirect tests was slow enough to allow time for test-aware participants to use recollection to influence their responses. Thus, effects of "weak" manipulations of context, such as room changes and odor manipulations, are observable only when explicit contamination allows context-dependent recollection.

Consistent with this idea, Mulligan (2011), using rooms as environmental contexts, found context-dependent memory effects using an indirect memory measure: category production. After the category production test, participants in Mulligan's study were given a test awareness questionnaire to determine which participants were aware of the relation between the initially studied pairs of words and the category production test. The posttest questionnaire was based on similar ones used by Mulligan, Guyer, and Beland (1999) and Barnhardt and Geraci (2008), and has been used to assess explicit contamination in implicit memory tests, asking questions such as "What do you think was the purpose of the task you just completed?" Participants taking an implicit memory test who are aware of the relationship between the studied words and items on the subsequent test may engage in intentional recollection, contaminating the test results, making it less a test of automatic or implicit retrieval. Based on test awareness classifications, Mulligan (2011) found a context reinstatement effect for participants identified as test aware, but there was no effect for unaware participants. This result and conclusion suggest that prior positive findings of environmental context reinstatement effects with indirect memory measures (e.g., Ball et al., 2010; W. Graf, 1988; Parker et al., 1999; Schab, 1990; Smith et al., 1990; Vela, 1989), in which weak context manipulations were used, were observed only because of explicit contamination (i.e., recollection), rather than implicit or automatic retrieval.

Published research studies of context-dependent memory effects on automatic retrieval have used weak context manipulations, such as room manipulations, that are powerful enough to evoke modest reinstatement effects due to recollection but too weak to reveal even weaker effects of context on automatic retrieval. Stronger context manipulations might reveal such weaker effects. A stronger manipulation of context would include a nonoverloaded context cue; making the cue strength greater; a rich (rather than simple) context, which might provide more opportunities for contextual associations; and an intentional encoding of contextual associations (even though context cues are incidental at test).

The Present Experiments

In the present experiments, we hypothesized that our video context manipulations would affect measures of automatic retrieval, despite previous failures to find effects on indirect memory measures (e.g., Jacoby, 1983; McKone & French, 2001; Mori & Graf, 1996; Parker et al., 1999; Parker, Waterman, & Gellatly, 2000), because our methods are known to produce far stronger environmental context-dependent memory effects (e.g., Smith & Handy, 2014; Smith, Handy, Angello, & Manzano, 2014; Smith & Manzano, 2010) than more traditional global manipulations of incidental contexts (see Smith & Vela, 2001). We also predicted that the effect size of our context manipulations would be stronger when recollection was a possible or likely contaminant of performance, and weaker, but still detectable, when effects of recollective contamination are minimized. This prediction was based on previous findings that reinstatement of "weak" context manipulations (e.g., incidental room contexts) benefitted performance on indirect memory measures only in studies whose procedures may have permitted explicit contamination on the test.

Of his failure to find environmental context-dependent perceptual identification, Jacoby (1983) speculated, "Perhaps more extreme manipulations of environmental context would be sufficient to produce effects on both perceptual identification and recognition memory" (p. 29). We now have a highly robust method for examining the effects of incidental environmental context on memory, based on studies that have used videotaped clips of environments as discrete environmental contexts (e.g., Jonker, Seli, & MacLeod, 2013; Smith et al., 2014; Smith & Handy, 2014; Smith & Manzano, 2010; Staudigl & Hanslmayr, 2013). Whereas the average effect size for context-dependent memory studies that manipulated rooms or other physical environments is small (Cohen's $d = .28$), the effect sizes of studies that used video clips of environments are quite large; Smith et al. (2014) reported effect sizes greater than $d = 1.0$, and Smith and Manzano (2010) reported effect sizes greater than $d = 2.0$.

To obtain the most robust context reinstatement effects possible, we were guided in the present study by three principles: (1) use visually rich environmental contexts, (2) use the smallest possible context-to-item fan size, and (3) ensure that target items and contextual stimuli are intentionally associated at study. The first of these principles was taken from studies of context-dependent recognition by Murnane and colleagues (Murnane & Phelps, 1993, 1994, 1995; Murnane et al., 1999). Across these four sets of experiments, Murnane et al. manipulated visually simple screen contexts (typically, unique combinations of screen location, foreground color, and background color) in 10 of the experiments, and found that context reinstatement caused no enhancement of memory in terms of discriminating studied items from unstudied ones in any of those experiments. One experiment, however, used what Murnane et al. (1999) called "rich visual contexts," operationally defined as unique line drawings of places, such as a living room or the side of a road; that experiment found that reinstatement improved recognition memory performance. Thus, these studies indicate that effective contextual stimuli are meaningful and visually rich places. The video contexts used in the present study were quite rich in the sense that each was an identifiable type of environment (such as a restaurant, a soccer field, traffic on a bridge, or a living room), and each involved sounds and movement in addition to many visual details. The second guiding principle in the design of our experiments was to use a small context-to-item fan. Smith and Manzano (2010) showed clearly that the more memory targets that are associated with a given context (i.e., the greater the fan size), the weaker the effect of reinstating a context cue at test. The strongest reinstatement effect in that study used a 1:1 ratio of video contexts to target items, a typical procedure in recent studies (e.g., Burgess, Hockley, & Hourihan, 2017; Hayes et al., 2007; Hockley, 2008; Jonker et al., 2013; Shahabuddin & Smith, 2016; Smith et al., 2014; Smith & Handy, 2014; Smith & Manzano, 2010; Staudigl, & Hanslmayr, 2013), and a procedure that we have used in the present study. Our third guiding principle was to instruct participants to associate target items with their accompanying contexts at study; such an instruction has been shown to yield robust context reinstatement effects (e.g., Burgess et al., 2017; Eich, 1985; Hockley, 2008). Although attention is directed toward the context stimuli at encoding with this method, participants are never told to remember the contexts either as cues or as targets, nor are the video context stimuli necessary for performing on the test trials (i.e., anagram solving and word fragment completion); these are criteria involved in defining contexts and in distinguishing contexts from test stimuli (Silberg & Vakil, 2017).

In addition to our attention to methods for observing robust context reinstatement effects, we incorporated procedures into our experiments to reduce explicit contamination on our anagram solving and word fragment completion tests. First, to reduce test awareness, we took several precautions to "camouflage" the relation between the encoded target words, and their accompanying video contexts, with the final test. These camouflaging precautions included the use of three "filler" tasks, in addition to the word encoding task, prior to the final anagram or fragment completion test. Each of the filler tasks, like the encoding task, involved stimuli superimposed over noncritical video contexts. In addition to filler tasks, we also used a number of filler stimuli on various tasks, again, to disguise the nature of our indirect memory measures. Never, during the experiment, were participants told to memorize the target words or contexts, nor were they ever told that there would be a subsequent memory test. The critical target items at test were mixed in with a large number of "filler" items, that is, items that did not correspond to any previously viewed target words. In addition to our camouflaging precautions, we used a posttest awareness procedure, which allowed us to examine effects separately for aware and unaware participants (Barnhardt & Geraci, 2008; Bowers & Schacter, 1990; Mulligan, 2011). This procedure was used in both of our reported experiments. Finally, in Experiment 2, we used a very-fast-paced word fragment completion test, 1.5 s per test fragment, to prevent or curtail the use of conscious recollection of target words (see Weldon, 1993).

To summarize, we predicted that context reinstatement, relative to nonreinstatement, at test would enhance performance on anagram solving (Experiment 1) and word fragment completion (Experiment 2) tests, and that the effect would be observed for participants in the test-aware and test-unaware conditions.

Experiment 1

In Experiment 1, an anagram test served as an indirect measure of memory for words incidentally encoded in association with context videos. It was predicted that context reinstatement at test, relative to testing in a new context, would yield greater rates of anagram completion, and that the effect would occur for both test-aware and test-unaware participants.

Method

Participants. Based on an a priori power analysis, to detect a medium sized effect (Cohen's $d = .5$) with an error probability of .05 and statistical power of .8, our planned comparisons required approximately 34 participants for each condition of each experiment. The only between-subjects variable we used in Experiment 1 was test awareness, a subject-determined factor. Based on prior research that showed approximately equal numbers of participants in the aware and unaware conditions (Mulligan, 2011), we therefore engaged a total of 60 Texas A&M University undergraduate students, who self-enrolled for participation in Experiment 1 in exchange for course credit. Enrollment was voluntary, using an online signup system to enroll as many as 15 participants per session, and all participants were briefed on other options for earning equal credit. Each experimental session consisted of a maximum of 15 self-enrolled participants, and counterbalancing assignment was determined randomly for each session. All participants in a given session were in the same counterbalancing condition. For participants in Counterbalancing 1, 10 were classified as test aware and nine were unaware; for Counterbalancing 2, 13 were aware and eight were unaware; and for Counterbalancing 3, 12 were aware and eight were unaware.

Design. Test condition was manipulated within subjects; at test, one third of the anagrams were unprimed, one third were primed and tested with reinstated contexts, and one third were primed and tested with nonreinstated contexts. Nonreinstated contexts were filler video clips seen on the encoding task but that were not previously shown with solutions of critical anagrams.

The items used in each of these three test conditions were counterbalanced between-subjects. One third ($n = 5$) of the 15 critical words in each counterbalancing condition were in the unprimed condition, one third were in the primed-reinstated condition, and one third were in the primed-non-reinstated condition. For the counterbalancings, each of the 15 critical items (i.e., each critical word paired with an encoding video context) was randomly assigned to Set A, Set B, or Set C. In one counterbalancing condition, Set A items were in the unprimed condition, Set B items were in the primed-reinstated condition, and Set C items were in the primed-non-reinstated condition. In the second counterbalancing, Set A items were primed-non-reinstated, Set B items were unprimed, and Set C items were primed-reinstated. In the third counterbalancing, Set A items were primed-reinstated, Set B items were primed-non-reinstated, and Set C items were unprimed. Thus, items were counterbalanced such that each critical item was in each of the three test conditions.[1] One of the three counterbalancing conditions was randomly assigned to each scheduled experimental session before the scheduled sessions were posted on the online enrollment system; because different sessions had different numbers of participants, counterbalancing was not completely even in terms the numbers of participants in each group.

Assignment to the two test awareness conditions (aware, unaware; a between-subjects variable) was based on participants' answers on a posttest questionnaire. Participants who gave responses that in any way linked the presented words with the subsequent anagram test were coded as "aware," and those that did not were coded as "unaware." The percentage of correctly solved anagrams for each of the context groups was the dependent variable.

Materials. Fifteen critical items (i.e., solution words for anagrams) were selected from the MRC Psycholinguistic Database. All words were five to six letters in length, all were common nouns, and none were proper names. Letters of critical solution words were scrambled to form the 15 critical anagrams. An additional 51 words were selected with the same criteria and were used as fillers, in addition to the 15 critical items, on the final anagram test.

Altogether, 65 different 5-s video clips of various environments were used in Experiment 1. Video contexts consisted of 5-s movie clips showing familiar activities in familiar types of places (e.g., a crowd on a campus, a kitchen, cars driving on a highway, diners eating at a restaurant, an outdoor softball game, or people walking in a park). Each video was in color and included movement and sound. Of the 65 video clips, 15 were used for critical items on the anagram test; in pairing critical words with video contexts, we avoided any obvious relationships between the words and the corresponding videos. The rest were used for filler tasks and as filler items on the critical encoding and anagram solving tasks.

The 16 word–video pairs in the encoding task were shown in a single randomized order for all participants. Five of the critical items were unprimed and did not appear on this encoding task. The video clips associated with five of the filler words on the encoding task were used on the final anagram test as contexts for primed-non-reinstated context items, and five more (new) filler videos were used as test contexts for anagram solutions that had been unprimed. Thus, primed-reinstated and primed-non-reinstated video contexts were all familiar when they were seen subsequently on the anagram test.

The same set of 25 filler video clips (in randomized orders) was used as backgrounds in all three filler tasks. These filler videos were used with filler anagrams on the anagram solving task.

Procedure. The experiment included six tasks (see Figure 1) for which participants wrote their answers on paper. These included an initial filler task (pleasantness ratings of filler video clips), then the incidental encoding task, followed by two more filler tasks, followed by the anagram solving task and, finally, posttest awareness questions. The general procedure is outlined in Figure 1. For each session of the experiment, participants were seated together at a large table with the others in the self-enrolled session. Paper response forms were passed out before each task and collected before the subsequent task. Stimuli and instructions were projected on a screen at the front of the room. An experimenter read the instructions aloud to the participants and answered questions before each task.

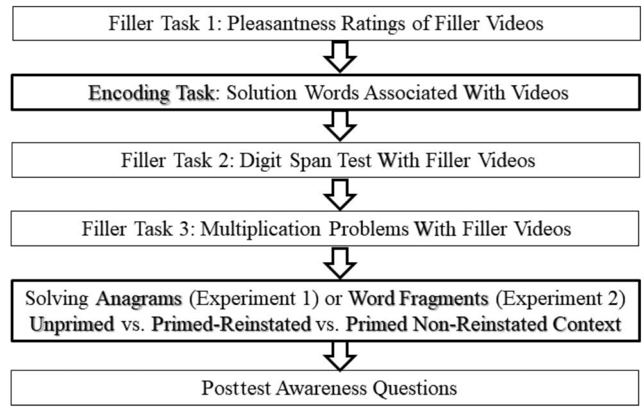

Figure 1. General procedure for Experiments 1 and 2, in which participants completed an encoding task, a critical test, and posttest questions.

Pleasantness ratings of videos (first filler task). The first filler task was a pleasantness rating task for which participants rated, on a scale of 1 to 10, how pleasant each of 25 filler video clips made them feel. This filler task consisted of 25 5-s trials.

Encoding task. The incidental encoding task, in which anagram solution words were shown with background video contexts, was the next task. Participants rated, on paper, how related they thought each 5-s context video clip was to the word superimposed over the center of the video. The following instructions were read to participants for the encoding task:

> In this task you will see a series of words on the screen; the words will appear one at a time. Each word will be superimposed over a different background video clip. For each word that appears, you should read the word and rate how well the word relates to the background video. Your ratings will be based on a 1–10 scale. Give a rating of ***1*** if the word and background video are *not related*. Give a rating of ***10*** if the word and background video are *extremely related*. Give intermediate ratings to words in between the 2 extremes. Each word will appear on the screen for 5-seconds while you think of your association rating. You will then get a few more seconds to write down your rating, before the next word appears. Use any strategy you like for your ratings. Try to work quickly to keep pace with the words on the screen, which will change every 5-seconds.[2]

A total of 16 5-s trials were given for this task. Each video context was 5 s in duration; 0.5 s after the onset of each video, a word appeared, superimposed and centered on-screen for the remainder of the video's duration. After each word–video pair, a 5-s blank screen signaled the onset of the next word–video pair.

Digit span task (second filler task). The digit span task consisted of 25 5-s trials. Each trial consisted of a string of 10 digits superimposed over a filler background video. Participants recalled

[1] Performance in a preliminary experiment, with a procedure and results very similar to those reported for Experiment 1, provided solution rates for items. These rates showed that the counterbalancing sets of items for Experiment 1 were, on the average, about equally difficult.

[2] The mean ratings of the critical word–context pairs ranged from 2.1 to 7.6 (on a 10-point scale), with a mean of 4.7, indicating that the words and their contexts were not seen as strongly related.

as many of the digits as they could during a 2-s break in between trials.

Multiplication task (third filler task). The multiplication filler task consisted of 25 5-s trials. On each trial, participants solved a math problem (a 3-digit number $\times$ 1-digit number) that was superimposed over a filler video clip.

Anagram solving task. A total of 60 anagrams were presented with videos in the same format as the encoding task. Each anagram was shown 0.5 s after the beginning of a 5-s video, centered on-screen, and with a 1-s blank screen in between anagram–video pairs. Of the 60 trials in the anagram task, 15 were critical anagrams and 45 were filler anagrams (i.e., anagrams corresponding to words that were never primed or scored in the analyses). The first 10 items on the anagram task were filler anagrams, and the remaining 50 were organized into five randomized blocks of 10 anagrams each. Each of the five blocks contained a critical item from each of the test conditions (primed-reinstated context, primed-non-reinstated context, unprimed) and seven items of the block were filler anagrams. The solutions to 10 of the 15 critical items had been primed during the encoding task. Five critical anagrams were paired with the same background video as their primed answer in the encoding task (primed-reinstated context condition). Another five critical anagrams were paired at test with different videos: filler videos from noncritical trials of the encoding task (primed-non-reinstated context condition). Five critical anagrams that had never been primed were paired with new videos, clips not used during the encoding task (unprimed condition).

Posttest awareness questions. After all anagrams had been shown, participants were asked, "What did you think was the purpose of the anagram task?" to measure their awareness of the link between words on the encoding task and solutions of some items on the anagram task. Those indicating any connection between the encoded words and the anagrams were coded as "aware," and those who did not were coded as "unaware." To assess whether aware participants intentionally tried to recollect words from the encoding task, participants were also asked, "If you noticed that some of the anagram solutions corresponded to the words presented earlier, did you intentionally try to use words from the earlier part of the experiment as anagram solutions?"

Results

A 3 $\times$ 2 mixed analysis of variance (ANOVA) was computed (because initial analyses indicated that there was no main effect of counterbalancing or interactions with that variable, the results reported for Experiment 1 were collapsed across the three counterbalancing conditions), test condition (unprimed, primed-reinstated context, primed-non-reinstated context) was a within-subjects variable, and test awareness (aware, unaware, based on the test awareness question) was a between-subjects variable. Of the 60 participants in Experiment 1, 35 were coded as test aware and 25 were coded as unaware (71% of the aware participants claimed that they intentionally tried to recall encoded words). The proportion of anagrams solved was the dependent measure.

There was a significant main effect of test condition, $F(2, 116) = 42.08$, $p < .001$, $MSE = 2.39$, $\eta_p^2 = .45$; participants in the primed-reinstated context condition solved the most anagrams, the primed-non-reinstated context condition solved the next most anagrams, and the unprimed condition solved the fewest anagrams (see Figure 2). Pairwise comparisons, using a Bonferroni correction, compared anagram solution rates among all three conditions—unprimed, primed-non-reinstated, and primed-reinstated. The difference between the primed-reinstated context and unprimed conditions was significant ($p < .001$), as was the difference between the primed-reinstated and primed-non-reinstated context conditions ($p < .001$). The difference between the unprimed and primed-non-reinstated context conditions, however, was only marginally significant ($p = .063$).

The main effect of test awareness was not significant, $F(1, 58) < 1.0$, but the Test Awareness $\times$ Test Condition interaction was significant,[3] $F(2, 116) = 3.18$, $p = .045$, $MSE = .18$, $\eta_p^2 = .06$; greater effects of test condition appeared to occur for the aware participants compared with the unaware ones (see Figure 3).

Planned comparisons were calculated to compare the primed-reinstated context condition with the primed-non-reinstated context condition (i.e., the context reinstatement effect) for aware participants, and again for unaware participants (see Figure 2), using the proportion of anagrams solved as the dependent variable. For the aware participants, there was a significant effect of reinstatement, $t(34) = 7.01$, $p < .001$, Cohen's $d = 1.60$. For unaware participants, the effect of reinstatement was also significant, $t(24) = 2.92$, $p = .008$, Cohen's $d = 0.66$; for both test-aware and test-unaware participants, more anagrams were solved for items in the primed-reinstated context conditions than for those in the primed-non-reinstated context condition.

Discussion

Context reinstatement effects were significant for both test-aware and test-unaware participants in Experiment 1. Experiment 1 provided evidence that automatic retrieval is context dependent. It is noteworthy that the context reinstatement effect for aware participants in Experiment 1 was far greater than the reinstatement effect for unaware participants. This pattern could indicate that context reinstatement has a smaller effect on automatic retrieval than it has for conscious recollection.

Experiment 2

There were three goals of Experiment 2. One goal was to see if the significant effect of context reinstatement for unaware participants, observed in Experiment 1, would be replicated. The second goal was to see if the context reinstatement effect for unaware participants would generalize to a different indirect test of memory: word fragment completion (e.g., P. Graf & Schacter, 1985; Weldon, 1993). The third goal of Experiment 2 was to use a procedure that would limit participants' ability to use recollection on the final test. In Experiment 1, many measures were taken to conceal the link between words on the encoding task and solutions on the final anagram test, including the use of many filler (i.e.,

[3] To better compare effects for participants relying on automatic retrieval with those relying on recollection, this interaction was computed again, comparing the unaware participants with aware participants who intentionally attempted to recollect the primed words, dropping the 10 participants who were classified as aware but not intentional. Despite the reduced power due to the smaller n in this analysis, the interaction was nonetheless significant, $F(2, 96) = 3.83$, $p = .025$, $MSE = .21$, $\eta_p^2 = .07$; greater effects of test condition occurred for the aware/intentional participants than for unaware participants.

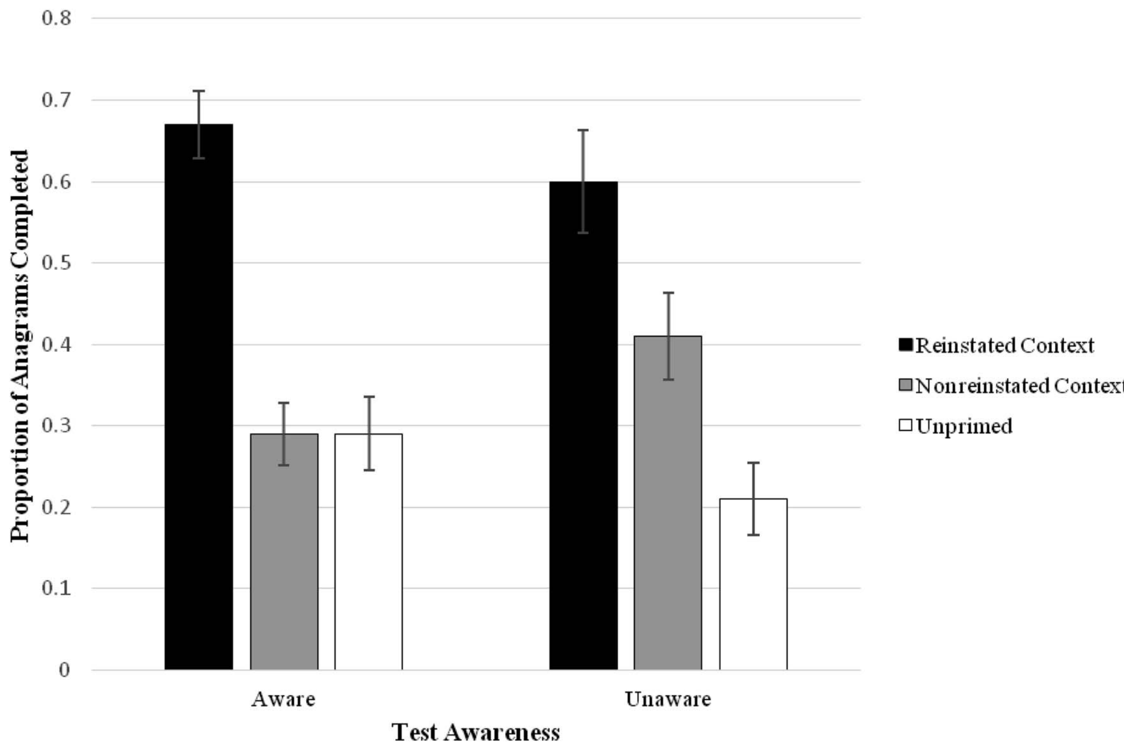

Figure 2. Proportion of anagrams solved as a function of test condition and test awareness in Experiment 1. Error bars show standard errors of means.

noncritical) tasks, the inclusion of filler items on the encoding list, the use of many filler anagrams with a small number of critical items mixed in on the anagram test, and the use of many familiarized context videos on the primed-non-reinstated context conditions. In Experiment 2, in addition to all of these "camouflaging" measures, we also used rapid presentation and responding on the critical test. This speeded test should have been rapid enough to curtail recollection, even for test-aware participants. Weldon (1993), for example, primed the solutions of visually tested word fragments either with visually presented words, aurally presented words, or line drawings of word referents. When test fragments were presented slowly (i.e., 5 s or 12 s each, giving participants the opportunity to initiate conscious recollection), priming effects were observed for all three types of primes. When word fragments were shown rapidly (i.e., 0.5 s or 1 s each, speeds that may be too fast for recollection); however, only visually primed words led to a priming effect. The fast, automatic, perceptually driven retrieval process was primed by transfer-appropriate encoding and could be seen on a fast-paced word fragment completion test. Contamination of the fragment completion measure with slower, conscious recollection was possible at slower testing rates. In Experiment 2, therefore, a rapid rate of testing was used on the word fragment completion test in order to curtail the use of conscious recollection on the test. Whereas participants were given 5 s per trial to solve and write the answers to anagrams in Experiment 1, they were given only 1.5 s per trial, with responses to word fragments spoken aloud, in Experiment 2.

Method

Participants. As we noted in Experiment 1, our a priori power analysis indicated that we would need about 34 participants for each condition. A total of 72 Texas A&M University undergraduate students signed up for participation in Experiment 2 in exchange for course credit. Enrollment was voluntary and all participants were given other options for earning credit. Each experimental session consisted of one self-enrolled participant. Counterbalancing assignments were determined randomly. There were 24 participants in each of the three counterbalancing conditions. For participants in Counterbalancing 1, 13 were classified as test aware and 11 were unaware; for Counterbalancing 2, 12 were aware and 12 were unaware; and for Counterbalancing 3, 11 were aware and 13 were unaware. None of the participants in Experiment 2 had participated in Experiment 1.

Design. As in Experiment 1, test condition was a within-subjects variable (primed-reinstated context, primed-non-reinstated context, and unprimed), and test awareness (aware and unaware) and counterbalancing were between-subjects variables. Test awareness was determined as described in Experiment 1, and the critical items were counterbalanced across the test conditions by using three counterbalancing groups, as described in Experiment 1. The proportion of correctly solved word fragments for each of the context conditions was the dependent variable.

Materials. The background video clips were the same as those described in Experiment 1. None of the words used in Experiment 1 were used in Experiment 2. The word fragment solutions shown with

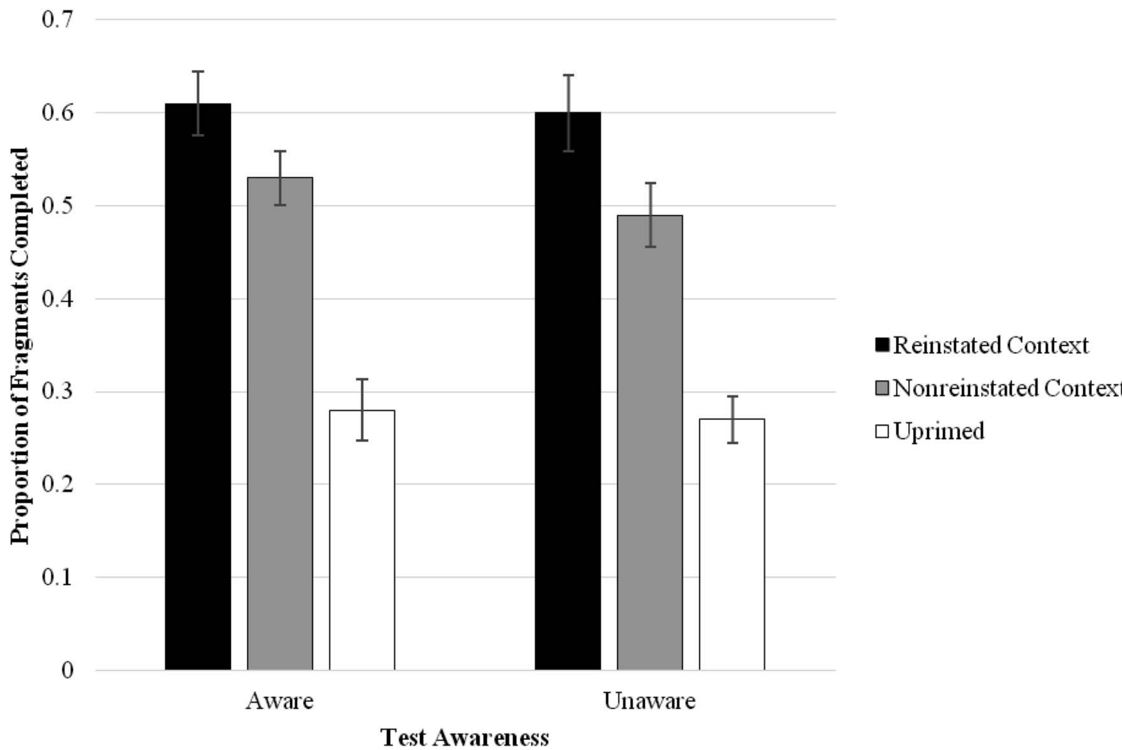

Figure 3. Proportion of word fragments completed as a function of test condition and test awareness in Experiment 2. Error bars show standard errors of means.

video contexts on the encoding task in Experiment 2 were drawn from the MRC Psycholinguistic Database from a set of words that were seven to eight letters in length, selecting 18 words with that word length, with six word fragments per condition. On the fragment completion test, word fragments were presented with two to three underscores (e.g., "L _ U G _ E _") to indicate missing letters (the solution is "LAUGHED").

The same filler task materials for the digit span test, described for Experiment 1, were also used in Experiment 2. The same questions used for the posttest awareness task in Experiment 1 were again used in Experiment 2.

Procedure. Experiment 2 involved four tasks, rather than the six tasks used in Experiment 1; two of the filler tasks from Experiment 1 were dropped from the procedure. Participants in Experiment 2 were given an encoding task, then a digit span task, then the critical word fragment completion task, and, finally, the posttest awareness questions. The encoding and digit span tasks were done in the same way as described for Experiment 1, except that participants had to speak their answers aloud to the experimenter instead of writing them. Participants were seated in front of a computer monitor, on which all stimuli were presented.

Encoding task. Forty-eight word–video pairs were presented during the encoding task, including 12 critical words serving as primes for the word fragment completion task. The remaining 36 words and their accompanying video contexts on the encoding task were fillers.

Digit span task. The digit span task consisted of 25 trials, as described for Experiment 1.

Word fragment completion task. The word fragment completion task was comprised of 70 word fragments, each superimposed and centered over a background video context. On the word fragment completion task, videos were displayed for 2 s, with their corresponding word fragments appearing 0.5 s after the onset of the accompanying video. There were no buffers or blank screens between word-fragment/video test stimuli, so participants gave their speeded responses aloud, which were recorded by the experimenter.[4] Eighteen of the word fragments were critical test items and the rest were fillers. The solutions to 12 of the 18 critical fragments had been primed in the first task and six were unprimed. Six word fragments of the 12 primed items were shown at test with their corresponding encoding video contexts (the primed-reinstated context items). Another six word fragments were tested with video contexts originally seen with filler words; these contexts were familiar, but they were not the encoding contexts of the critical word fragment solutions (primed nonreinstated context). Six critical word fragments whose solutions had never been presented (unprimed) were paired with filler video contexts at test. Item order on the word fragment completion test was blocked randomized, as described for Experiment 1.

Posttest awareness questions. After the word fragment completion test, participants answered the same questions described for Experiment 1 to assess awareness of the study's purpose.

[4] We did not observe any responses that exceeded the deadline.

Results

A 3 × 2 mixed ANOVA was computed (the results reported for Experiment 2 were collapsed across the three counterbalancing conditions), with test condition (unprimed, primed-reinstated context, primed-non-reinstated context) as a within-subjects variable, and test awareness (aware, unaware) as a between-subjects variable.[5] The proportion of word fragments solved was the dependent variable. The coding of test awareness was the same as in Experiment 1. There was a significant main effect of test condition, $F(2, 140) = 44.99$, $p = <.001$, $MSE = .05$, $\eta_p^2 = .39$; the primed-reinstated condition had the highest proportion of completed anagrams, the primed-non-reinstated context condition had the next highest mean completion rate, and the unprimed condition had the lowest fragment completion rate (see Figure 3). Pairwise comparisons, using a Bonferroni correction, compared anagram solution rates among all three conditions—unprimed, primed-non-reinstated, and primed-reinstated. Both the primed-reinstated and primed-non-reinstated context conditions had significantly greater rates of fragment completion than the unprimed condition ($p < .01$). The difference between the primed-reinstated and primed-non-reinstated context conditions was also significant ($p = .01$).

Of the 72 participants in Experiment 2, 36 were coded as test aware and 36 were coded as unaware (89% of the aware participants claimed that they intentionally tried to recall encoded words). The effect of test awareness was not significant ($F < 1$), nor was the interaction of test condition with test awareness ($F < 1$).

Planned comparisons were calculated to compare the primed-reinstated context condition with the primed-non-reinstated context condition (i.e., the context reinstatement effect) for aware participants, and again for unaware participants, using the proportion of word fragments completed as the dependent variable. For the aware participants, the proportion of completed word fragments in the primed-reinstated context condition was numerically higher than in the primed-non-reinstated context condition, $t(35) = 1.99$, $p = .054$, Cohen's $d = .41$. For unaware participants, the effect of reinstatement was significant, $t(35) = 2.06$, $p = .047$, Cohen's $d = .49$; for test-unaware participants, more word fragments were completed for items in the primed-reinstated context conditions than for those in the primed-non-reinstated context condition (see Figure 3).

Discussion

The results of Experiment 2 replicate and extend the results of the first experiment, strengthening the case in support of the conclusion that automatic retrieval is context dependent. In Experiment 2, there were significant priming and context reinstatement effects across all subjects. More importantly, the reinstatement effect was significant for unaware participants, an indication that automatic retrieval is context dependent.

Interestingly, the context reinstatement effect was only marginally significant for participants coded as aware, a result at odds with the results of Experiment 1. Test awareness may be taken as an indication of explicit contamination or the use of conscious recollection at test. The reinstatement effect size of the aware participants in Experiment 1 was larger than the effect of unaware participants in that experiment, suggesting the use of contextually cued recollection by aware participants in that experiment. The reinstatement effect for aware participants in Experiment 2, however, was no greater than the reinstatement effect seen in unaware participants, consistent with the idea that the rapid paced test in Experiment 2 reduced the use of recollection on the word fragment completion test. Even though most of the test-aware participants claimed that they intentionally tried to use recollection, our results indicate that such attempts to recollect primed items were unsuccessful due to time constraints. It is also possible that the self-report method we used for determining test awareness was a less-than-perfect means of assessing the use of recollection in Experiment 2, possibly as a result of experiment demand characteristics, or the suggestive nature of the self-report questions, as we discuss in the General Discussion.

General Discussion

Whether or not the automatic influences of memory are context specific is an issue that is important not only for theoretical reasons but also for wide-ranging practical concerns. The experience of vivid memories popping involuntarily into mind at reunions is quite common. Contextually triggered episodic memories may also explain why jargon terms come easily to mind when one is in the appropriate setting for work, recreation, or religious worship. The "home-court advantage," that is, better performance by the sports team when they compete where they practice, may also be explained by the notion of context-specific automatic influences of memory. Memories that may burst automatically into mind at the scene of a crime or of a traumatic experience are likewise explained by context specificity of automatic retrieval.

Our two experiments provide evidence that automatic retrieval *is* reliably influenced by test context conditions. Both of the present experiments found that reinstating at the time of an indirect memory test the encoding context of a word, relative to testing with a nonreinstated context, significantly increased performance. Both priming conditions (i.e., primed-reinstated context and primed-non-reinstated context conditions) showed better performance than a baseline (unprimed) condition. Most importantly, even when additional measures were taken to limit the influence of explicit contamination on the critical test, environmental context reinstatement effects were still observed. One of our additional measures was a test awareness question used to classify participants as test aware or test unaware. The effect of context reinstatement was significant for test-unaware participants in Experiment 1. A context reinstatement effect was again observed, for both aware and unaware participants, in Experiment 2, in which word fragments were tested at a very fast pace, 1.5 s per test fragment; the fast pace was implemented to further curtail the use of explicit recollection during the fragment completion test. Taken together, our results support Jacoby's (1983) conjecture that automatic retrieval is influenced by reinstatement of episodic contexts. As such, our experiments can be seen as demonstrations of the rapid automatic retrieval process that can precede recollection in the course of involuntary recollection of episodic and autobiographical

[5] A preliminary analysis that included counterbalancing as a between-subjects variable found no effect of counterbalancing, but an interaction of counterbalancing with test condition, indicating that the three counterbalancing conditions differed in terms of the magnitude of the context-dependent priming effects. It is not possible for us to sensibly interpret this interaction, which could be due to particular words, contexts, or test positions of items in the different counterbalancing conditions.

memories (e.g., Berntsen, 1996; Berntsen & Hall, 2004; Schlagman & Kvavilashvili, 2008), suggesting that some involuntary memories may be triggered by contextual cuing. Automatic triggering of involuntary recollection, in fact, fits the profile of our participants who, on the test awareness report, indicated that, on the final test, they were aware of memories of primed words but that they did not intentionally try to remember the contextually associated primed words. Another theoretical conjecture that is consistent with our findings is the assumption of the "retrieving effectively from memory–implicit" theory (Schooler, Shiffrin, & Raaijmakers, 2001), which states that implicit memory facilitation is due to the match between the original encoding context and the test context. Other models, such as the counter model of implicit memory (Ratcliff & McKoon, 1997), would have to be amended to be consistent with the implicit memory facilitation found in the present study.

As in many studies that wish to distinguish automatic from controlled memory processes, there is the concern in our experiments that explicit recollection could contaminate our measures of automatic retrieval (i.e., anagram solving and word fragment completion). One way that we addressed this concern was with the use of a test awareness questionnaire. Our posttest awareness data confirmed that, despite our careful measures to conceal the purpose of the indirect memory test, a large proportion of participants were test aware, including 58% of the participants in Experiment 1 and 50% of the participants in Experiment 2. These proportions are similar to those reported by Mulligan (2011); 50% of the participants in his category production task were classified as test aware, based on his posttest awareness questionnaire. A high proportion of the test-aware participants in the present experiments, over 80%, on average, claimed that they had intentionally tried to remember encoded words on the final test.

In Experiment 1 of the present study, anagrams were tested at a rate of 4.5 s per anagram, a duration long enough for conscious recollection to explicitly contaminate anagram completion rates. If test-aware participants used recollection to solve anagrams in those two experiments, and if recollection, relative to automatic retrieval, is more strongly affected by context dependence, then test-aware participants should show a greater context reinstatement effect than test-unaware participants. That is exactly what we observed in Experiment 1, that is, a greater context reinstatement effect size (more than twice as large, as measured by Cohen's *d*) for aware participants than for unaware participants (see Table 1). If reinstatement has a weaker effect on automatic retrieval of a single event than its effect on recollection of that event, that could explain why less robust manipulations of environmental context, including those that used large context-to-target fans, simple contexts, and/or incidental context-to-target encoding, have failed to clearly demonstrate the effect in the past (e.g., Jacoby, 1983; McKone & French, 2001; Mori & Graf, 1996; Parker et al., 1999, 2000).

Table 1
Cohen's d Scores for Context Reinstatement Effects for Test-Aware and Test-Unaware Participants in Experiments 1 and 2

Experiment	Test-aware	Test-unaware
1	1.60	.66
2	.41	.49

In Experiment 2, unlike Experiment 1, test trials were presented at a rapid pace, 1.5 s per word fragment. Prior research (e.g., Weldon, 1993) indicates that such a fast pace allows the occurrence of automatic retrieval of previously encoded items, but that it is too fast for the effects of recollection to have as great an impact on performance as is seen with slower (e.g., 5 s or 12 s per item) presentation rates. Although test awareness was observed in half of the participants, and most of those participants claimed to have used intentional retrieval of encoded words, there was no interaction of test awareness with context reinstatement, as had been observed in Experiment 1. In Experiment 2, context reinstatement of primed items increased word fragment completion rates as much for test-unaware participants as for test-aware ones (see Table 1). These results indicate that our fast-paced test helped curtail the use of recollection on the fragment completion test to the point that reinstatement-enhanced recollection was not observed in Experiment 2. This finding, that the reinstatement effect with the fast-paced fragment completion test was the same for aware and unaware participants, suggests that all participants showed context-dependent automatic retrieval, and that neither aware nor unaware participants were affected by context-dependent recollection, given the time constraints of the task. These results further support our conclusion that that automatic retrieval is context dependent.

We attribute our findings of context-dependent automatic retrieval, in large part, to our use of robust methods for observing episodic-based context-dependent memory. These methods include the use rich environmental contexts—in our case, video clips of familiar types of places, complete with movement and sound (Smith et al., 2014; Smith & Manzano, 2010), rather than simpler contexts, such as colors or positions on a computer screen. Our methods also used a small context fan, with one video context per item; this arrangement has been shown to yield larger context reinstatement effect sizes (Smith & Manzano, 2010). In the present experiments, although our encoding task used incidental, rather than intentional, learning instructions, we arranged for participants to directly associate target words with context cues at encoding (video contexts at test were incidental, not mentioned in the instructions, and not necessary for performing the task). Such direct encoding of items to contexts has been found to increase both associative context reinstatement effects (e.g., P. Graf & Schacter, 1989) and environmental context reinstatement effects (e.g., Hockley, 2008). Finally, on each test trial, the background video context was first shown alone on the screen for 0.5 s before the test stimulus (an anagram or a word fragment) was shown superimposed over the video. This procedure allowed time for each test context to become actively instantiated, a process that requires some time (e.g., Burgess et al., 2017; Malmberg & Shiffrin, 2005) and that has been implemented in other studies of context-dependent memory (e.g., Jonker et al., 2013; Smith et al., 2014; Smith & Handy, 2014).

Although we have focused on the context dependence of automatic retrieval, another automatic memory process is familiarity (e.g., Jacoby, 1991). Recognition decisions can be based on a combination of conscious recollection and judgments of familiarity, judgments described as "relatively automatic in that they are generally said to be faster, less effortful, and less reliant on intention" (Jacoby, 1991, p. 516). There have been several published findings of context-dependent familiarity (e.g., Hockley, 2008; Murnane & Phelps, 1993, 1994, 1995; Murnane et al., 1999; Rutherford, 2004). These studies do not show better, or more accurate, recognition memory as a function of context reinstatement (referred to as "context-dependent discrimination"), but rather increased familiarity in the form of greater hits and greater false alarms when familiar contexts are presented, whether or not those familiar contexts were originally associated with recognition memory targets. Automatic retrieval, in contrast, is a process that brings content to mind, rather than simply conferring a sense of familiarity.

There are some limitations to the present study that need to be noted. One limitation may be that our tightly controlled experimental methods are somewhat removed from expressions of automatic influences of memory in the real world. Although environmental contexts typically do not change rapidly in most real-world situations, they often change rapidly in movies and TV, media that are quite familiar to our participants. Another limitation may be our use of self-reports of test awareness to operationally distinguish between recollection and automatic retrieval. On the one hand, self-reports are often in error, and participants might under- or overestimate their use of conscious recollection on a previous test. A variety of subject demand characteristics, for example, could influence self-reports of intentional retrieval. Forgetting one's prior state of mind could contribute another source of inaccuracy of introspective reports. In addition, test awareness can occur not only because of intentional efforts to retrieve material but also because of involuntary explicit memory or an awareness of the contents of automatic memory retrieval after the fact (e.g., Kinoshita, 2001; Richardson-Klavehn, Lee, Joubran, & Bjork, 1994; Schacter, 1987; Schacter, Bowers, & Booker, 1989). Furthermore, although posttest self-reports are intended to reduce explicit contamination, such reports may underestimate the role of implicit contamination, that is, the involvement of automatic retrieval in intentional recall. Future research on the contextual dependence of automatic retrieval might seek to use other methods for observing automatic retrieval, such as reaction timing, or process dissociation procedures (e.g., Jacoby, 1991, 1998).

Contextually triggered automatic retrieval may be generally adaptive in the sense that it tends to bring appropriate memories effortlessly to mind, but it is also worth noting the possible maladaptive effects that such automatic reminding may have. For example, the location of a traumatic experience might automatically trigger unwanted memories with painful content. In another example, experts whose knowledge may be associated with their work contexts might become fixated when their expert knowledge, inappropriate or even counterproductive for a particular creative task, is constantly brought to mind by their work environment. Retiring to new surroundings may erode the environmental contextual support that is needed by the elderly, but it may also liberate people from the automatic habits that constrain their lives.

References

Balch, W. R., Bowman, K., & Mohler, L. (1992). Music-dependent memory in immediate and delayed word recall. *Memory & Cognition, 20,* 21–28. http://dx.doi.org/10.3758/BF03208250

Ball, L. J., Shoker, J., & Miles, J. N. (2010). Odour-based context reinstatement effects with indirect measures of memory: The curious case of rosemary. *British Journal of Psychology, 101,* 655–678. http://dx.doi.org/10.1348/000712609X479663

Barnhardt, T. M., & Geraci, L. (2008). Are awareness questionnaires valid? Investigating the use of posttest questionnaires for assessing awareness in implicit memory tests. *Memory & Cognition, 36,* 53–64. http://dx.doi.org/10.3758/MC.36.1.53

Berntsen, D. (1996). Involuntary autobiographical memories. *Applied Cognitive Psychology, 10,* 435–454. http://dx.doi.org/10.1002/(SICI)1099-0720(199610)10:5<435::AID-ACP408>3.0.CO;2-L

Berntsen, D., & Hall, N. M. (2004). The episodic nature of involuntary autobiographical memories. *Memory & Cognition, 32,* 789–803. http://dx.doi.org/10.3758/BF03195869

Bowers, J. S., & Schacter, D. L. (1990). Implicit memory and test awareness. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 404–416. http://dx.doi.org/10.1037/0278-7393.16.3.404

Burgess, N., Hockley, W. E., & Hourihan, K. L. (2017). The effects of context in item-based directed forgetting: Evidence for "one-shot" context storage. *Memory & Cognition, 45,* 745–754. http://dx.doi.org/10.3758/s13421-017-0692-5

Cann, A., & Ross, D. A. (1989). Olfactory stimuli as context cues in human memory. *The American Journal of Psychology, 102,* 91–102. http://dx.doi.org/10.2307/1423118

Dalton, P. (1993). The role of stimulus familiarity in context-dependent recognition. *Memory & Cognition, 21,* 223–234. http://dx.doi.org/10.3758/BF03202735

Eich, E. (1985). Context, memory, and integrated item/context imagery. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11,* 764–770. http://dx.doi.org/10.1037/0278-7393.11.1-4.764

Fernandez, A., & Glenberg, A. M. (1985). Changing environmental context does not reliably affect memory. *Memory & Cognition, 13,* 333–345. http://dx.doi.org/10.3758/BF03202501

Garberg, R. B., & Radtke, R. C. (1986, May). *Contextual specificity of repetition priming*. Paper presented at the meeting of the Midwestern Psychological Association, Chicago, IL.

Gardiner, J. M. (1988). Functional aspects of recollective experience. *Memory & Cognition, 16,* 309–313. http://dx.doi.org/10.3758/BF03197041

Godden, D. R., & Baddeley, A. D. (1975). Context dependent memory in two natural environments: On land and underwater. *British Journal of Psychology, 66,* 325–331. http://dx.doi.org/10.1111/j.2044-8295.1975.tb01468.x

Godden, D. R., & Baddeley, A. D. (1980). When does context influence recognition memory? *British Journal of Psychology, 71,* 99–104. http://dx.doi.org/10.1111/j.2044-8295.1980.tb02735.x

Graf, P., & Schacter, D. L. (1985). Implicit and explicit memory for new associations in normal and amnesic subjects. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11,* 501–518. http://dx.doi.org/10.1037/0278-7393.11.3.501

Graf, P., & Schacter, D. L. (1989). Unitization and grouping mediate dissociations in memory for new associations. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15,* 930–940. http://dx.doi.org/10.1037/0278-7393.15.5.930

Graf, W. (1988). Motion detection in physical space and its peripheral and central representation. *Annals of the New York Academy of Sciences, 545,* 154–169. http://dx.doi.org/10.1111/j.1749-6632.1988.tb19561.x

Hayes, S. M., Nadel, L., & Ryan, L. (2007). The effect of scene context on episodic object recognition: Parahippocampal cortex mediates memory encoding and retrieval success. *Hippocampus, 17,* 873–889. http://dx.doi.org/10.1002/hipo.20319

Hockley, W. E. (2008). The effects of environmental context on recognition memory and claims of remembering. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34,* 1412–1429. http://dx.doi.org/10.1037/a0013016

Jacoby, L. L. (1983). Perceptual enhancement: Persistent effects of an experience. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 9,* 21–38. http://dx.doi.org/10.1037/0278-7393.9.1.21

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language, 30,* 513–541. http://dx.doi.org/10.1016/0749-596X(91)90025-F

Jacoby, L. L. (1996). Dissociating automatic and consciously controlled effects of study/test compatibility. *Journal of Memory and Language, 35,* 32–52. http://dx.doi.org/10.1006/jmla.1996.0002

Jacoby, L. L. (1998). Invariance in automatic influences of memory: Toward a user's guide for the process-dissociation procedure. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24,* 3–26. http://dx.doi.org/10.1037/0278-7393.24.1.3

Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General, 110,* 306–340. http://dx.doi.org/10.1037/0096-3445.110.3.306

Jonker, T. R., Seli, P., & MacLeod, C. M. (2013). Putting retrieval-induced forgetting in context: An inhibition-free, context-based account. *Psychological Review, 120,* 852–872. http://dx.doi.org/10.1037/a0034246

Kinoshita, S. (2001). The role of involuntary aware memory in the implicit stem and fragment completion tasks: A selective review. *Psychonomic Bulletin & Review, 8,* 58–69. http://dx.doi.org/10.3758/BF03196139

Krafka, C., & Penrod, S. (1985). Reinstatement of context in a field experiment on eyewitness identification. *Journal of Personality and Social Psychology, 49,* 58–69. http://dx.doi.org/10.1037/0022-3514.49.1.58

Macken, W. J. (2002). Environmental context and recognition: The role of recollection and familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28,* 153–161. http://dx.doi.org/10.1037/0278-7393.28.1.153

Malmberg, K. J., & Shiffrin, R. M. (2005). The "one-shot" hypothesis for context storage. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31,* 322–336. http://dx.doi.org/10.1037/0278-7393.31.2.322

McDaniel, M. A., Anderson, D. C., Einstein, G. O., & O'Halloran, C. M. (1989). Modulation of environmental reinstatement effects through encoding strategies. *The American Journal of Psychology, 102,* 523–548. http://dx.doi.org/10.2307/1423306

McKone, E., & French, B. (2001). In what sense is implicit memory "episodic"? The effect of reinstating environmental context. *Psychonomic Bulletin & Review, 8,* 806–811. http://dx.doi.org/10.3758/BF03196221

Mori, M., & Graf, P. (1996). Nonverbal local context cues explicit but not implicit memory. *Consciousness and Cognition: An International Journal, 5,* 91–116. http://dx.doi.org/10.1006/ccog.1996.0006

Mulligan, N. W. (2011). Conceptual implicit memory and environmental context. *Consciousness and Cognition: An International Journal, 20,* 737–744. http://dx.doi.org/10.1016/j.concog.2010.11.008

Mulligan, N. W., Guyer, P. S., & Beland, A. (1999). The effects of levels-of-processing and organization on conceptual implicit memory in the category exemplar production test. *Memory & Cognition, 27,* 633–647. http://dx.doi.org/10.3758/BF03211557

Murnane, K., & Phelps, M. P. (1993). A global activation approach to the effect of changes in environmental context on recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 882–894. http://dx.doi.org/10.1037/0278-7393.19.4.882

Murnane, K., & Phelps, M. P. (1994). When does a different environmental context make a difference in recognition? A global activation model. *Memory & Cognition, 22,* 584–590. http://dx.doi.org/10.3758/BF03198397

Murnane, K., & Phelps, M. P. (1995). Effects of changes in relative cue strength on context-dependent recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 158–172. http://dx.doi.org/10.1037/0278-7393.21.1.158

Murnane, K., Phelps, M. P., & Malmberg, K. (1999). Context-dependent recognition memory: The ICE theory. *Journal of Experimental Psychology: General, 128,* 403–415. http://dx.doi.org/10.1037/0096-3445.128.4.403

Neumann, O. (1984). Automatic processing: A review of recent findings and a plea for an old theory. In W. Prinz & A. F. Sanders (Eds.), *Cognition and motor processes* (pp. 255–293). Berlin, Germany: Springer-Verlag. http://dx.doi.org/10.1007/978-3-642-69382-3_17

Parker, A., Gellatly, A., & Waterman, M. (1999). The effect of environmental context manipulation on memory: Dissociation between perceptual and conceptual implicit tests. *European Journal of Cognitive Psychology, 11,* 555–570. http://dx.doi.org/10.1080/095414499382291

Parker, A., Waterman, M., & Gellatly, A. (2000). Effect of environmental context manipulations on explicit and implicit memory for categorized and random words. *Current Psychology of Cognition, 19,* 111–132.

Ratcliff, R., & McKoon, G. (1997). A counter model for implicit priming in perceptual word identification. *Psychological Review, 104,* 319–343. http://dx.doi.org/10.1037/0033-295X.104.2.319

Richardson-Klavehn, A., Lee, M. G., Joubran, R., & Bjork, R. A. (1994). Intention and awareness in perceptual identification priming. *Memory & Cognition, 22,* 293–312. http://dx.doi.org/10.3758/BF03200858

Rutherford, A. (2004). Environmental context-dependent recognition memory effects: An examination of ICE model and cue-overload hypotheses. *The Quarterly Journal of Experimental Psychology A: Human Experimental Psychology, 57,* 107–127. http://dx.doi.org/10.1080/02724980343000152

Saufley, W. H., Jr., Otaka, S. R., & Bavaresco, J. L. (1985). Context effects: Classroom tests and context independence. *Memory & Cognition, 13,* 522–528. http://dx.doi.org/10.3758/BF03198323

Schab, F. R. (1990). Odours and the remembrance of things past. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 648–655. http://dx.doi.org/10.1037/0278-7393.16.4.648

Schacter, D. L. (1987). Implicit memory: History and current status. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 501–518. http://dx.doi.org/10.1037/0278-7393.13.3.501

Schacter, D. L., Bowers, J., & Booker, J. (1989). Intention, awareness, and implicit memory: The retrieval intentionality criterion. In S. Lewandowsky, J. C. Dunn, & K. Kirsner (Eds.), *Implicit memory: Theoretical issues* (pp. 47–65). Hillsdale, NJ: Erlbaum.

Schacter, D. L., & Graf, P. (1986). Preserved learning in amnesic patients: Perspectives from research on direct priming. *Journal of Clinical and Experimental Neuropsychology, 8,* 727–743. http://dx.doi.org/10.1080/01688638608405192

Schacter, D. L., & Graf, P. (1989). Modality specificity of implicit memory for new associations. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15,* 3–12. http://dx.doi.org/10.1037/0278-7393.15.1.3

Schlagman, S., & Kvavilashvili, L. (2008). Involuntary autobiographical memories in and outside the laboratory: How different are they from voluntary autobiographical memories? *Memory & Cognition, 36,* 920–932. http://dx.doi.org/10.3758/MC.36.5.920

Schooler, L. J., Shiffrin, R. M., & Raaijmakers, J. G. (2001). A Bayesian model for implicit effects in perceptual identification. *Psychological Review, 108,* 257–272. http://dx.doi.org/10.1037/0033-295X.108.1.257

Segalowitz, N., & Hulstijn, J. (2005). Automaticity in bilingualism and second language learning. In J. F. Kroll, & A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 371–388). New York, NY: Oxford University Press, Inc.

Shahabuddin, S. S., & Smith, S. M. (2016). Asymmetric reinstatement effects in recognition. *Journal of General Psychology, 143,* 267–280. http://dx.doi.org/10.1080/00221309.2016.1214100

Silberg, T., & Vakil, E. (2017). Context-dependent recognition is related to specific processes taking place at encoding and at retrieval. *Psychology, 8,* 335–349. http://dx.doi.org/10.4236/psych.2017.83020

Smith, S. M. (1979). Remembering in and out of context. *Journal of Experimental Psychology: Human Learning and Memory, 5,* 460–471. http://dx.doi.org/10.1037/0278-7393.5.5.460

Smith, S. M. (1984). A comparison of two techniques for reducing context-dependent forgetting. *Memory & Cognition, 12,* 477–482. http://dx.doi.org/10.3758/BF03198309

Smith, S. M. (1985). Background music and context dependent memory. *The American Journal of Psychology, 98,* 591–603. http://dx.doi.org/10.2307/1422512

Smith, S. M. (1986). Environmental context-dependent recognition memory using a short-term memory task for input. *Memory & Cognition, 14,* 347–354. http://dx.doi.org/10.3758/BF03202513

Smith, S. M. (2013). Effects of environmental context on human memory. In T. J. Perfect & D. S. Lindsay (Eds.), *The SAGE handbook of applied memory* (pp. 162–182). London, UK: Sage.

Smith, S. M., Glenberg, A., & Bjork, R. A. (1978). Environmental context and human memory. *Memory & Cognition, 6,* 342–353. http://dx.doi.org/10.3758/BF03197465

Smith, S. M., & Handy, J. D. (2014). Effects of varied and constant environmental contexts on acquisition and retention. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40,* 1582–1593. http://dx.doi.org/10.1037/xlm0000019

Smith, S. M., Handy, J. D., Angello, G., & Manzano, I. (2014). Effects of similarity on environmental context cueing. *Memory, 22,* 493–508. http://dx.doi.org/10.1080/09658211.2013.800553

Smith, S. M., Heath, F. R., & Vela, E. (1990). Environmental context-dependent homophone spelling. *The American Journal of Psychology, 103,* 229–242. http://dx.doi.org/10.2307/1423144

Smith, S. M., & Manzano, I. (2010). Video context-dependent recall. *Behavior Research Methods, 42,* 292–301. http://dx.doi.org/10.3758/BRM.42.1.292

Smith, S. M., & Vela, E. (1992). Environmental context-dependent eyewitness recognition. *Applied Cognitive Psychology, 6,* 125–139. http://dx.doi.org/10.1002/acp.2350060204

Smith, S. M., & Vela, E. (2001). Environmental context-dependent memory: A review and meta-analysis. *Psychonomic Bulletin & Review, 8,* 203–220. http://dx.doi.org/10.3758/BF03196157

Staudigl, T., & Hanslmayr, S. (2013). Theta oscillations at encoding mediate the context-dependent nature of human episodic memory. *Current Biology, 23,* 1101–1106. http://dx.doi.org/10.1016/j.cub.2013.04.074

Tiffany, S. T. (1990). A cognitive model of drug urges and drug-use behavior: Role of automatic and nonautomatic processes. *Psychological Review, 97,* 147–168. http://dx.doi.org/10.1037/0033-295X.97.2.147

Tulving, E., Schacter, D. L., & Stark, H. A. (1982). Priming effects in word-fragment completion are independent of recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 8,* 336–342. http://dx.doi.org/10.1037/0278-7393.8.4.336

Vela, E. (1989). *The effects of input processing and test demands on environmental context-dependent memory: A cue competition interpretation* (Unpublished doctoral dissertation). Texas A&M University, College Station, TX.

Warrington, E. K., & Weiskrantz, L. (1978). Further analysis of the prior learning effect in amnesic patients. *Neuropsychologia, 16,* 169–177. http://dx.doi.org/10.1016/0028-3932(78)90104-5

Weldon, M. S. (1993). The time course of perceptual and conceptual contributions to word fragment completion priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 1010–1023. http://dx.doi.org/10.1037/0278-7393.19.5.1010

Woollacott, M., & Shumway-Cook, A. (2002). Attention and the control of posture and gait: A review of an emerging area of research. *Gait & Posture, 16,* 1–14. http://dx.doi.org/10.1016/S0966-6362(01)00156-4

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