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Published online: 31 May 2013.

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Effects of similarity on environmental context cueing

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Three experiments examined the prediction that context cues which are similar to study contexts can facilitate episodic recall, even if those cues are never seen before the recall test. Environmental context cueing effects have typically produced such small effect sizes that influences of moderating factors, such as the similarity between encoding and retrieval contexts, would be difficult to observe experimentally. Videos of environmental contexts, however, can be used to produce powerful context-dependent memory effects, particularly when only one memory target is associated with each video context, intentional item-context encoding is encouraged, and free recall tests are used. Experiment 1 showed that a not previously viewed video of the study context provided an effective recall cue, although it was not as effective as the originally viewed video context. Experiments 2 and 3 showed that videos of environments that were conceptually similar to encoding contexts (e.g., both were videos of ball field games) also cued recall, but not as well if the encoding contexts were given specific labels (e.g., ''home run'') incompatible with test contexts (e.g., a soccer scene). A fourth experiment that used incidental item-context encoding showed that video context reinstatement has a robust effect on paired associate memory, indicating that the video context reinstatement effect does not depend on interactive item-context encoding or free recall testing.

Keywords: Context; Similarity; Cueing.

Many theories of memory rely on mechanisms based on context-dependence, the idea that memories of events are better when encoding contexts are reinstated. Consistent with the idea of cue-dependent memory and the principle of encoding specificity (e.g., Tulving, 1972, 1983), context-dependence is often used as a key mechanism in theories that explain phenomena of interest, such as directed forgetting (e.g., Sahakyan, 2004; Sahakyan & Kelley, 2002), cueing effects of inter-item associations (e.g., Howard, Fotedar, Datey, & Hasselmo, 2005; Howard & Kahana, 2002; Sederberg, Howard, & Kahana, 2008), false memories (e.g., Kimball, Smith, & Kahana, 2007), and long-term recency effects (e.g., Glenberg, Bradley, Kraus, & Renzaglia, 1983; Glenberg & Swanson, 1986). Contextual processes are also important in many

formalised theories of memory, such as SAM (e.g., Raaijmakers & Shriffrin, 1980, 1981; Gillund & Shiffrin, 1984), CHARM (Eich, 1985), Minerva 2 (Hintzman, 1988), the Matrix Model (Humphreys, Bain, & Pike, 1989), and TODAM (Murdock, 1993, 2006). Cognitive neuroscientific theories of memory also rely on context-dependence (e.g., Davachi, 2006; Kalisch et al., 2006; Wagner, Desmond, Glover, & Gabrieli, 1998). Thus mechanisms involving contextual encoding, contextual cueing, and contextual associations are essential for many types of theories that concern human memory. The evidence for strong effects of environmental context on human memory, however, is somewhat fragile, with many weak findings, as well as failures to find effects of context reinstatement on memory (e.g., Farnsworth, 1934; Fernandez & Glenberg,

1985; Godden & Baddeley, 1980; Jacoby, 1983; Nagge, 1935; Saufley, Otaka, & Bavaresco, 1985; Smith, Glenberg & Bjork, 1978; see Smith & Vela, 2001, for a review).

A meta-analysis of environmental context-dependent memory effects by Smith and Vela (2001) indicated that such effects are, overall, reliable, but the effect sizes reported were modest, with a mean effect size of $d = .28$.[1] Most of these studies manipulated global environments, such as two different-appearing rooms, examining the effects of those manipulations on memory for lists or large sets of verbal materials. From that meta-analysis, and from other context-dependent memory studies published since Smith and Vela 2001), it is clear that certain conditions are very important for ensuring that manipulations environmental contexts affect memory for events that occur in those environmental contexts. Those conditions include non-associative encoding among to-be-remembered items (Smith & Vela, 2001), interactive encoding of target items with their contexts (e.g., Eich, 1985; Gruppuso, Lindsay, & Masson, 2007), the use of contextual materials that are rich in content (e.g., Murnane, Phelps, & Malmberg, 1999), difficulty in generating one's own context cues from memory (Smith, 1979), the use of few memory targets per context cue (Rutherford, 2004; Smith & Manzano, 2010), and the use of few or poor non-contextual cues at test (Smith & Vela, 2001).

Although some research concerning the role of similarity in memory cueing has been reported, the cueing effects of similar environmental contexts on recall have not been demonstrated. Yum (1931), for example, showed that stimuli that are similar to paired associate stimuli can evoke the learned responses at test. For certain operational definitions of similarity, Yum showed that greater stimulus similarity led to better memory; cue words (e.g., *battle*) that were more meaningfully similar to originally learned stimulus words (e.g., *fight*), were better cues, and cues in the form of abstract visual patterns that were more like the original stimuli were better memory cues. Since Yum's original report there have been numerous demonstrations that stimuli similar to an originally perceived stimulus can likewise cue memory (e.g., Gibson, 1941; Gillund & Shiffrin, 1984; Newman & Taylor, 1963; Postman, 1951;

Snodgrass & Hirschman, 1994; Vakil, Hornik & Levy, 2008). Vakil et al. (2008), for example, tested recognition memory as a function of the similarity of encoding and test contexts, with contexts defined in terms of accompanying words. For example, the target word *table* might be accompanied by the context word *dog* at study, and then at test by the same context word (*dog*), a conceptually similar one (e.g., *cat*), a perceptually similar word (e.g., *fog*), or a dissimilar context word (e.g., *bean*). Relative to dissimilar context words, same context (original) had the best benefit, then conceptually similar context words; perceptually similar context words aided recognition no more than did dissimilar context words.

Given that similar verbal contexts cue memory, is the same true for environmental contexts? A study that examined this question using environmental contexts was one by Abernethy (1940), who gave students exams either in the regular classroom or in a different room, and with the regular proctor vs a new proctor present at the time of the exam. Abernethy considered the regular classroom with the regular proctor to be the most like the learning context, the new classroom with a different proctor to be the most dissimilar to the learning context, and the conditions with same-room-different-proctor and different-room-same-proctor to be somewhere between those two extremes, in terms of similarity to the learning context. The mean exam scores bore out Abernethy's predictions, with the best scores in the same context condition, worse scores when either room or proctor were changed at test, and the worst scores when both room and proctor changed. However, these differences were not statistically significant, leaving the conclusion in doubt. Further complicating interpretation of Abernethy's results are multiple findings that exam scores do not suffer when exams are taken away from the regular classroom (e.g., Farnsworth, 1934; Saufley et al., 1985). The extent to which exam scores reflect the effects of episodic memory for material encountered in a classroom may be a limiting factor in such classroom studies.

Hockley (2008, Expt 4A) reported an experiment that examined the effect of similar context cues on recognition memory for words. In that experiment participants studied a list of words, with each target word shown individually in the centre of a different picture. The picture contexts comprised six different categories of environments, such as buildings, rain forest pictures, and public gardens. Recognition memory of studied

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[1] Cohen (1992) stated that d values in the range of 0.2 are small effects, 0.5 are medium effects, and 0.8 or greater can be considered large effects.

words was tested, using a remember/know paradigm, with each test word on either the original picture, a similar picture (i.e., a new picture from the same category), or a new picture that was not from one of the studied categories. Hockley found that both hit rates and false alarm rates were greater for target words tested in their original contexts and contexts that were similar to the encoding contexts, relative to hit and false alarm rates for words tested in new contexts. However, this context effect was not evidence that memory is better in reinstated and similar contexts, because in that study reinstatement did not affect participants' abilities to discriminate new test words from old (studied) ones, as measured by d'. The present study used methods similar to Hockley's, but rather than testing with a recognition memory test, we used recall tests, which rely more on recollection, and less on familiarity and criterion setting.

The methods used in the present experiments took many important factors into consideration to maximise context reinstatement effects. In the present investigation we asked whether environmental contexts which are similar to encoding contexts, yet different in some ways, cue recall as well as the original contexts. Finding effects and non-effects of variables that might moderate environmental context effects—contextual similarity, in the present case—depends greatly on the power of the experimental paradigm for producing those effects. Measuring the effect of a single environment on memory for a large set of verbal materials (such as a list of words) is not the best approach for examining the potential effects of encoding/retrieval environmental context similarity on memory, because such methods often produce null effects, and investigating moderators of null effects makes little sense. In the present investigation we took the most important conditions for context dependence into consideration, using a powerful method for observing environmental context-dependent memory. Our procedure involved: (1) a 1-to-1 context-to-target ratio, (2) environmental contexts that were rich in content, (3) instructions that encouraged interactive item-context processing, rather than inter-item association, (4) a large number of contexts (making them difficult for participants to recall them as self-generated cues at test), and (5) a free recall test, which presents minimal cues. We wanted to use such a method to begin with a highly reliable environmental context-dependent memory effect so that the potentially moderating

effects of environmental context similarity could be fairly assessed.

We chose to use a method first reported by Smith and Manzano (2010), using video-recorded scenes of various environmental contexts, with target memory materials superimposed over the video contexts. The environmental contexts used in this method are 5-second video clips of places that are generically familiar to participants, although the specific places in the videos are not likely to have been encountered by any participants. These 5-second video clips show environments, such as an indoor basketball game, a bridge over a river, a restaurant, traffic in a big city, a kitchen, walking on a stairway, or a soccer game. Each 5-second video context shows a scene, complete with colour, movement, and sound. No dialogue is heard on these environmental context scenes, but background noise can be heard. Target (to-be-remembered) stimuli, printed words, are shown superimposed over each context scene. Obvious relationships between video context scenes and their accompanying verbal stimuli are avoided, so that any relationship between an environmental context and its accompanying target word is incidental or episodic in nature, rather than semantically related. On a final free recall test participants are asked to recall as many of the words as possible, in any order. Half of the encoding contexts are re-exposed during the test, and half are not, but participants are urged to recall all of the words they saw, whether or not their corresponding video scenes were shown during the test. Smith and Manzano found very large environmental context-dependent memory effects, with effect sizes larger than $d = 3.0$; in Experiment 1 of their study, for example, words corresponding to reinstated environmental contexts were recalled more than five times as often as words with no reinstated video contexts. Because environmental reinstatement effects are so powerful with this experimental paradigm, we expected that the method would provide the best means for observing the moderating effects of factors, such as similarity, which may moderate environmental context reinstatement effects.

Contextual similarity to the encoding video context was manipulated in the following ways. At test, a video context cue could be either the original scene viewed at encoding (*same context / same scene*), a different video scene of the original environment (*same context/different scene*, Experiment 1), a video of an environmental context related to the encoding context (*conceptually*

similar context, Experiments 2 and 3), or an unrelated new scene (*different context*). To create same context /different scene videos, we used two slightly different 5-second scenes of the same physical environment, for example, two different 5-second scenes of the same pickup basketball game, of the same windmills seen from a highway, of the same walk up a stairway, or of a fire engine roaring up the street. A pair of 5-second scenes taken from one environment constituted our same context /different scene videos. To create two conceptually similar contexts (Experiments 2 and 3) we selected two 5-second scenes that could both be described with a brief, but accurate descriptive phrase, such as ''ball field'', ''restaurant'', ''wedding'', or ''grocery aisle''. Each pair of conceptually similar environmental contexts always included two different ball fields (see Figure 1), two different restaurants, two different weddings, two different grocery aisles, etc.

In each experiment there was a study phase, during which each of the 30 target words was shown, one at a time, each superimposed over a different video context. Participants were given a free recall test in which they were urged to recall all of the target words they had seen. During the free recall test some video contexts were shown three times in succession, including 10 of the

encoding contexts (the same context /same scene video cues), 10 video contexts that were similar to encoding contexts in some way, and (in Experiments 1 and 3) 10 new video contexts that were different from the encoding contexts. It was predicted that target words associated with same context/same scene cues would be recalled the best, those associated with similar context cues (i.e., same context/different scenes) would be recalled next best, and targets not associated with any test cues would be recalled the worst.

EXPERIMENT 1

Experiment 1 examined the effects of the similarity of encoding/retrieval environmental contexts, using as cues at test either the original video context corresponding to a memory target (i.e., the same context /same scene video), a same context /different scene video, or an altogether different context. It was predicted that the best recall would occur when the retrieval context was exactly the same as the encoding context, next best for similar context (i.e., same context/different scene) cues, and worst when context cues were different from the encoding contexts.

Figure 1.   Examples of same, similar, and different contexts. Only snapshots of the video contexts are shown here; all videos used in the experiments included colour, motion, and sound.

Method

Participants. A total of 99 Texas A&M University undergraduate students participated in Experiment 1 in return for partial course credit. Participation was voluntary, and other options were available to earn equal credit. Participants self-enrolled in one of three counterbalancing conditions. The number of participants in each experimental session depended on the random enrolment of participants, and varied from 5 to 15 participants per session. There were 33 participants in each of the three counterbalancing conditions.

Design and materials. A total of 30 English nouns were derived from the MRC Psycholinguistic Database with written frequencies ranging from 50–100 (Kučera & Francis, 1967, frequency norms). The words were all one-syllable concrete nouns, and word length varied from four to five letters per word. The background movie scenes associated with the words were randomly paired, although obvious relationships between target words and video contexts were avoided. The video contexts were 5-second clips of simple everyday scenes (e.g., a park, a stairway, a kitchen, or cars driving down the highway). Each of these video contexts included movement and sound without narrative content. Each of the 30 target words was shown one at a time for 5 seconds apiece, in white capital letters superimposed over a movie clip, with a voice-over pronouncing each word aloud. Target words were displayed using the ''movie titles'' application of the CyberLink PowerDirector software package for editing video-recordings; each word appeared in large white letters in varying positions (position was selected for maximal contrast and readability) on the screen, with the video contexts showing in the background. Participants could hear the sounds of the events recorded on the video scenes. For same context /same scene videos, the exact same 5-second video clip (without the target word shown or spoken) was shown. For the same context /different scene condition, a 5-second video of the same encoding context was shown. Same context/different scene videos were created by taking a 15-second video (one continuous shot) of an environment, and using the first 5-second of the 15-second clip for one context, and the last 5-second of the original as a second context; the two were considered to be highly similar, but not identical, both being in the same environment, and separated in real time by only 5 seconds. In the same context/different scene condition, one of these two video contexts would be shown during encoding, and the other would be shown at test.

Procedure. Participants were tested in groups of 5–15 people, depending on participant enrolment, and were seated in front of a large video screen. For the encoding task participants were told to rate their judged relatedness of each word presented with its background video environmental context, and to judge that relatedness on a 5-point scale. Participants had 5 seconds to write down each of these relatedness judgements. They were not informed of the subsequent memory test. After all of the 30 word-context pairs had been rated, and 45 additional seconds for instructions had passed, participants took a free recall test in which they were asked to recall as many of the presented words as possible, and that the order of the words was not important. Participants were also told that they would see some videos during the test that might help them remember some of the words. As participants began listing their free recall responses, they saw a sequence of 5-second video contexts on the screen, one-third (10) of which corresponded to originally viewed video contexts (same context/same scene), one-third (10) of which were similar clips of the original video contexts (same context/different scene), and one-third (10) that were new (different context) video contexts, not similar to any that had yet been seen by participants. These 30 video clips were played during the free recall test in a randomised sequence, and then all 30 were shown (in the same randomised order) a second time. Participants were encouraged to recall all of the words they had seen, not just the ones corresponding to the videos shown during the test. Five minutes were given for this free recall test.

Results

A one-way analysis of variance (ANOVA) was computed, using test context (same as encoding, similar to encoding, different from encoding context, a within-participants manipulation) as the independent variable, and the proportion recalled as the dependent measure. Because the between-participants counterbalancing variable had no significant main effect or interactions in any of our experiments, that factor was omitted in all of the reported analyses of this study. The effect of test context was significant, $F(2, 196) = 367.860$, $p < .0001$, $MSE = .018$, $\eta^2 = .790$ (see Figure 2). The
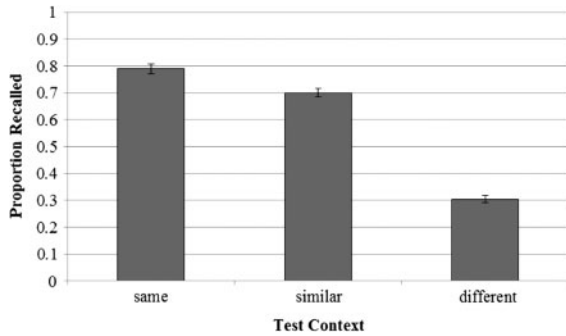
Figure 2. Mean proportion recalled as a function of test context in Experiment 1.

highest proportion recalled was found for the same context/same scene condition, next most for the same context/different scene condition, and worst for the different context condition. All of these differences are significant, according to pairwise comparisons: same context cued higher recall levels than did similar test contexts, $t(98) = 5.272$, $p < .001$, $SEM = .018$, and more than different test contexts, $t(98) = 21.428$, $p < .001$, $SEM = .016$. Similar test contexts cued recall better than did different contexts, $t(98) = 23.232$, $p < .001$, $SEM = .015$.

Discussion

As predicted, the presentation of video clips of different scenes of environmental contexts seen at encoding led to significantly greater recall than did new video contexts that had not been seen during encoding. These similar video environmental contexts were video-recordings of the same places shown during encoding, but displaced by 5 seconds in time when the video contexts were recorded. The exact same original video contexts seen during encoding, however, yielded even greater recall than did the similar contexts or the different contexts, replicating and extending previous reinstatement effects with video-recorded environmental contexts (e.g., Smith & Manzano, 2010).

EXPERIMENT 2

The same context/different scene video environmental context cues used in Experiment 1 were highly similar to the original contexts, consisting of slightly different shots of the original contexts, only a few seconds earlier or later. If the environmental contexts that we used had been physical, rather than videotaped, then a return to the same physical environment would not be an exact match for the original experience of that environment. In this manner, the similar contexts used in Experiment 1 resembled test contexts that are physically reinstated, that is, similar views of the same place.

In Experiments 2 and 3 we asked whether environmental context cues that are conceptually similar to encoding contexts would likewise produce high levels of recall. By conceptually similar, we meant whether or not each of a pair of videos of two different environmental contexts could be adequately described with the same label or brief phrase. For example, one video of a softball game and another one of a soccer game could both be labelled ''ball field'', a Korean grill restaurant and a kosher delicatessen could both be called ''restaurants'', and a downtown street scene and cars on a desert highway can both be labelled ''traffic''. Would these conceptually similar contexts, none of which had been seen during encoding, also cue recall, as same context/different scene videos had done in Experiment 1?

One other difference between Experiments 1 and 2 was that the ''different context'' cues were eliminated from the test procedure, because it is not clear what effect such cues might have. That is, the test scenes that did not correspond to any encoding contexts, used at test in Experiment 1, were not used in Experiment 2. In Experiment 2 only same-context and conceptually similar-context video cues were shown at test.

Method

Participants. A total of 120 Texas A&M University undergraduate students participated in this experiment in return for partial course credit. Participation was voluntary, and other options were available to earn equal credit. Participants self-enrolled in one of the three counterbalancing conditions. The number of participants in each experimental session depended upon the random enrolment of participants, and varied from 10 to 15 participants per session.

Design and materials. The experiment used a 3×3 mixed design. Context reinstatement at test served as the within-participants variable; at test, participants viewed either the same video contexts they observed at study, or video contexts

conceptually similar to those observed during study. No video cues were presented for items corresponding to the no-context condition. The videos assigned to the same, similar, and no test context conditions at test were counterbalanced between-participants. Video order at study was constant for all test conditions.

The same types of video environmental contexts described for Experiment 1 were used in Experiment 2. Each 5-second clip contained the original ambient sound associated with each scene, though with no discernible dialogue or plot. Superimposed over the centre of each scene was one of 30 four-letter words derived from the MRC Psycholinguistic Database. Written frequencies of these words ranged from 50 to 100, according to the Kučera and Francis (1967) word frequency norms. To aid in contrasting the text with the associated clip's background environment, each of the target words appeared, without transition, capitalised in red font. Same-context recall cues were the exact same 5-second scenes viewed at encoding. Conceptually similar environmental contexts were established using the criteria that the two scenes were videos of different physical places, and each pair of places must be capable of being described by the same single word or brief phrase. None of these labels was used in Experiment 2, but their use will be described for Experiment 3. The no-context condition in Experiment 2 consisted of presenting no videos at test corresponding to target words.

Procedure. The procedure for Experiment 2 was identical to the procedure described for Experiment 1, with one exception. At test, participants were shown a series of 20 short video scenes intended to serve as recall cues. Of these scenes, 10 were reproduced from the study phase of the experiment—the word/scene rating task; 10 others were categorised as conceptually similar to scenes from the earlier word/scene rating task. No test cues corresponded to target words in the no-context condition. The 20 test video cues were shown three times apiece, so the free recall test took a total of 5 minutes.

Results

A one-way ANOVA was computed, using test context (same as the encoding context, conceptually similar to encoding context, or no test context, a within-participants manipulation) as
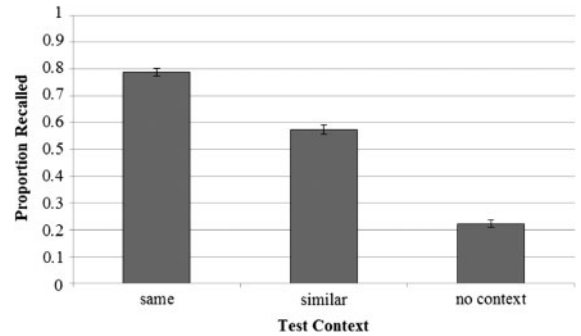

Figure 3. Mean proportion recalled as a function of test context in Experiment 2.

the independent variable, and the proportion recalled as the dependent measure. The effect of test context was again significant, $F(2, 238) = 400.382$, $p < .0001$, $MSE = 9.729$, $\eta^2 = .771$. The highest proportion recalled was found for the same context condition, next most for conceptually similar contexts, and worst for the no context condition (see Figure 3). The differences among the three conditions were significant: the same context condition had greater recall than did the conceptually similar test context condition, $t(119) = 12.488$, $p < .0001$, $SEM = .017$, and more than the no test context condition, $t(119) = 26.658$, $p < .0001$, $SEM = .021$. The similar test context condition produced better recall than did the no test context condition, $t(119) = 16.096$, $p < .0001$, $SEM = .022$.

Discussion

The results of Experiment 2 replicate and extend the results of Experiment 1. As in Experiment 1, target words associated with same context cues at test were recalled best, targets associated with similar test contexts were recalled next best, and target words not corresponding to test cues were recalled the worst. The results of Experiment 2 extend this finding to conceptually similar contexts. Although the video cues in the similar context condition of Experiment 1 were both videos of the same place, the encoding video contexts and the similar test cues in Experiment 2 were videos of *different* places. The fact that different places, never seen before the test, reminded participants of encoded items indicates that conceptually similar scenes might be coded at test the same way that the original context had been encoded. That suggests, for example, that if a scene of a softball game were encoded as

"a game on a ballfield", then a scene of a soccer game at test might be encoded exactly the same way. If instead, the encoding scene was "home run", then the test cue from a soccer game might not correspond to what was encoded. This notion, a prediction of the encoding specificity hypothesis, was tested in Experiment 3.

One difference between the procedures of Experiments 1 and 2 was that no context videos were shown at test corresponding to targets in the no-context condition in Experiment 2. In Experiment 1, 10 new videos that were different from the encoding videos were shown at test. The fact the findings of Experiment 2 were the same as those of Experiment 1 shows that this control is probably not important for the procedure.

EXPERIMENT 3

An encoding specificity perspective indicates that physical cues have limited power for evoking specific cognitive states; two different cues (that are somehow similar) might evoke the same state, and the same cue perceived at two different times might evoke two different states. Experiment 3 of the present investigation deals with this distinction between physical cues and cognitive states, in terms of the cueing effects of environmental contexts.

In Experiment 3 we tested predictions derived from the principle of encoding specificity, which indicates that the effect of the similarity of encoding and test contexts should be moderated by the consistency of *mental representations* of the encoding and test contexts. In Experiment 3 we tried to manipulate mental representations of video contexts by biasing their encoding with verbal labels. It was predicted that labels could moderate the effect of context similarity if the labels biased similar vs different mental representations of the video contexts. In the general label condition each video context was accompanied with a word or phrase that described both the encoding video and the corresponding conceptually similar video. For example, a video of a softball game might be given the general label "Ball Field" at encoding, a label that also fits the conceptually similar test video of a soccer game (see Figure 4). In the specific label condition each video context was accompanied by a label that could fit only the original context, and not the conceptually similar test context. For example, the softball video was labelled "Home Run" at encoding in the specific label condition, which did not fit the conceptually similar soccer game, given as a test cue.

It was predicted that in Experiment 3, as in Experiments 1 and 2, target words corresponding to same context test cues would be recalled best, those corresponding to similar test cues would be next best recalled, and those associated with no test context cues would be recalled worst. Furthermore it was predicted that target words
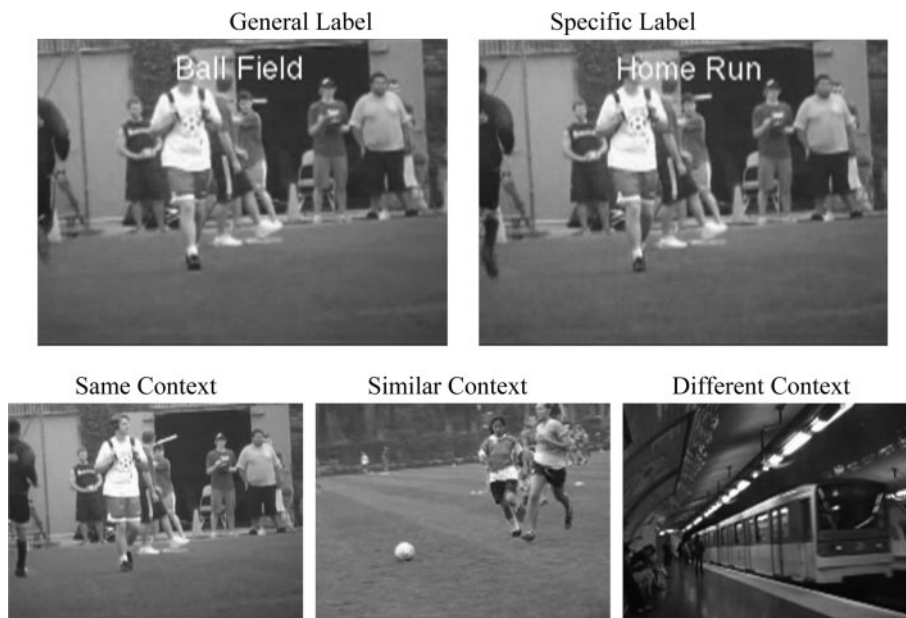

Figure 4.   Examples of contexts and labels used in Experiment 3.

associated with similar context cues would be recalled better if general labels of video contexts were given at encoding, as compared to specific encoding labels. This latter prediction was derived from the encoding specificity principle, which states that test cues that evoke the same mental representations that were encoded will be better cues than ones that evoke different mental representations at encoding and test. Experiment 3 contrasted the context reinstatement principle, which states event memory will be better the more an encoding context is reinstated, with the principle of encoding specificity, which states that memory depends on the match between the mental representations of environmental contexts present at encoding and retrieval. A key prediction, with respect to these two principles, is the between-participants comparison of paired associate recall for similar contexts in the general condition (where test contexts were conceptually compatible with encoding context labels), relative to the specific condition (in which test contexts were logically incompatible with encoding context labels). Recall was predicted to be better in the similar-general label condition relative to the similar-specific label condition.

Method

Participants. A total of 120 Texas A&M University undergraduate students participated in this experiment in return for partial course credit. Participation was voluntary, and other options were available to earn equal credit. Participants self-enrolled in one of the two conditions. The number of participants in each experimental session depended on the random enrolment of participants, and varied from 5 to 15 participants per session. There were 60 participants in the general labels condition, and 60 in the specific labels condition.

Design and materials. The same 30 context–target word pairs, as well as the conceptually similar context cues used in Experiment 2 were again used in Experiment 3. Reinstatement condition, a within-participants variable, was either same context cues, similar context cues, or different context cues, with 10 context–target pairs in each condition. Each of three sets of 10 context–target pairs was assigned to each of the three context cue conditions (same, similar, and different), using three between-participants counter-balancing conditions. Context labels at encoding, a between-participants variable, was either general or specific labels.

The same-context and conceptually similar-context cues described for Experiment 2 were also used in Experiment 3. In addition, 10 different-context cues were shown at test, as was done in Experiment 1. Thus, during the free recall test, a set of 30 5-second videos was shown twice, including 10 same-context videos, 10 similar-context videos, and 10 different-context videos.

The encoding context–target pairs in Experiment 3 were slightly different from those used in Experiment 2 because of the context labels that were added to each context–target word pair. The context labels were printed at the top of each encoding context video in small white letters. The target words were printed in large red letters in the centre of each encoding video. The context label appeared for the entire 5-second duration of an encoding video, but the red target word did not appear until the label and video had been on the screen for 1 second. This arrangement helped ensure that participants would see a labelled context video at encoding before seeing the accompanying red target word. No labels or target words appeared at test.

Procedure. The procedure for Experiment 3 was identical to that of Experiment 1 with one exception, the use of context labels at encoding. Participants were instructed that white-lettered labels would appear for each video, and that they were to rate the relatedness of each red-lettered word to its background video. At test, participants were instructed to recall only the red-lettered words, not the white-lettered context labels. As in Experiment 1, the 30 5-second video context cues were shown twice during the recall test, and the free recall test lasted for 5 minutes.

Results

The effect of reinstatement on recall was significant, $F(2, 236) = 245.702$, $p < .0001$, $MSE = 6.356$, $\eta^2 = .676$; recall was greatest when test contexts were the same as the encoding contexts, next best for similar test contexts, and worst for different test contexts (see Figure 5). Differences among these three conditions were all significant, according to pairwise comparisons; same contexts cued higher recall than did similar test contexts, $p < .001$, $SEM = .022$, and more than different test
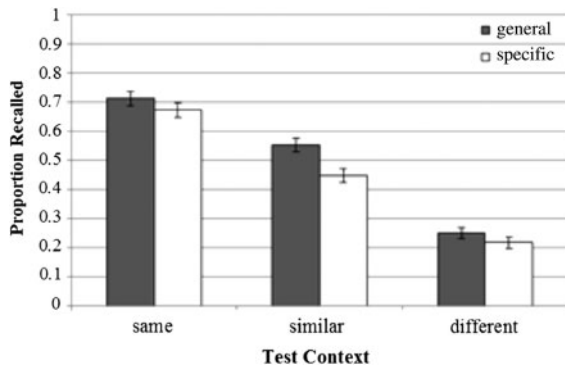
Figure 5. Mean proportion recalled as a function of text context and context labels in Experiment 3.

contexts, $p < .001$, $SEM = .019$, and similar test contexts cued higher recall than did different contexts, $p < .001$, $SEM = .021$.

The effect of context labelling was significant, $F(1, 118) = 7.347$, $p = .008$, $MSE = .312$, $\eta^2 = .059$; general context labels produced better recall than did specific labels (Figure 5). Although the interaction of test context and context labels was not significant, $F(2, 236) = 1.998$, $p = .138$, $MSE = .026$, $\eta^2 = .017$, the mean recall for similar contexts in the general labelling condition was higher than recall for similar contexts in the specific labelling condition, as had been predicted. Planned comparisons showed that the simple main effect of context labels in the similar test context condition was significant, $t(118) = 3.166$, $p = .002$. The effect of context labels was not significant for the same test context condition, $t(118) = 1.064$, $p = .290$, nor for the different test context condition, $t(118) = 1.192$, $p = .236$.

Discussion

The results of Experiment 3 both replicate and extend the results of the previous experiments. Once again, test contexts that were similar to encoding contexts cued recall far more than different test contexts, but not as well as the original contexts. As in Experiment 2, this effect was found in Experiment 3 even though the similar context cues were conceptually similar to the original encoding contexts. The results of Experiment 3 go beyond those of Experiment 2, however, because they show that the way that environmental context stimuli are encoded determines the relative effectiveness of similar test context cues. In accordance with the encoding specificity theory, the matchup of the mental

representations of encoding and test contexts was more important than the matchup of the physical stimuli themselves. When a test context could be seen as the same as an encoding context, such as when the encoding context (e.g., a softball game) was given a general label (e.g., ''ball field'') that could also fit the similar test context (a soccer game), it was a better cue than if the test context (a soccer game) was incompatible with the label of the encoding context (e.g., ''home run''). Of course, reinstating the exact original was the best way to align the mental representations of contexts at encoding and retrieval, so the same-context condition yielded the best recall.

EXPERIMENT 4

In Experiments 1, 2, and 3 methods were used that would maximise the effect of environmental context cues on memory so that we could observe the effects (or lack of effects) of a moderating variable, contextual similarity. Strong methods include the use of few (rather than many) memory targets per context (e.g., Hockley, 2008; Rutherford, 2004; Smith & Manzano, 2010), instructions at study that direct some attention to the context (Eich, 1985; Gruppuso et al., 2007; Hockley, 2008), retention tests that provide minimal retrieval cues (e.g., Smith et al., 1978; Smith & Vela, 2001), and memory tests that maximise recollection (e.g., Hockley, 2008; Macken, 2002). In Experiments 1–3 we maximised reinstatement effects by using one target per context, instructions that encouraged item-to-context association encoding, and free recall testing, which provided few memory cues.

A reductionist interpretation of the methods used in first three experiments might see these methods as nothing more than paired associate learning, with video scenes as stimuli and target words as responses. We would argue, however, that this interpretation is overly reductionist for several reasons. The paired associates method, first reported by Calkins (1894), has been an important tool in the explication of human memory processes, using pairs of discrete stimuli (or cues) and responses (or targets) that are studied by participants. Any context-dependent memory study could be characterised as one in which responses are cued by contexts, or perhaps by features of contexts paired with target items. As such, all studies of context effects could be characterised as ''merely studies of paired associates'', a notion at

odds, for example, with theories of embodied cognition that assume that cognition is situated and that the environment is an essential part of the cognitive system (e.g., Wilson, 2002), or neuroscientific theories that give special status to contextual processing (e.g., Davachi, 2006). Such theories see processes involving environmental contexts as different from the verbal processes involved in typical paired associated learning. In addition, the paired associates procedure has participants learning the correct response for each stimulus, and the method tests each stimulus for the one correct answer—any other responses are considered incorrect. In Experiments 1–3 participants were not instructed to learn the correct response for each stimulus, and at test they were not asked to link correct responses with the corresponding video cues. The instructions used in Experiments 1, 2, and 3 stated that participants should try to recall *all* of the words they had seen initially, not just the ones that corresponded to the video cues provided at the test; this instruction is clearly different from directions given to participants in the method of paired associate recall, in which a word recalled in response to the wrong stimulus is considered an incorrect response.

As further evidence that our method goes beyond the paired associates method, and to demonstrate that the reinstatement effects do not depend on interactive or intentional encoding of response words with video contexts, we conducted Experiment 4, in which paired associates were learned and tested, each accompanied at test by either a reinstated video context, or a new context, different from videos seen at encoding. That is, we wished to demonstrate the effect of video environmental context reinstatement on memory for pairs of verbal units, showing that an accompanying video context can act independently of the effects of the stimulus members of paired associates. In Experiment 4 a list of Swahili–English word pairs was studied once, and the English responses were recalled, using the Swahili words as cues for their English translations. As in Experiments 1–3, unrelated video contexts were shown in the background of the learned pairs and the test stimuli; at test, stimulus words were accompanied either by the encoding context for that pair, of by a new video context.

Providing paired associate cues, as compared with free recall, was expected to diminish the video context reinstatement effect due to out-shining (e.g., Smith, 1994; Smith & Vela, 2001). That is, a weakened context effect was anticipated due to the provision of other (verbal) memory cues. Furthermore, in Experiment 4, attention was *not* directed to the video contexts accompanying the paired associates, as it was in Experiments 1–3. Thus, the video scenes in Experiment 4 were *incidental* contexts; attention was directed only to the paired associate words, which participants were instructed to study. Because item-context associations were less likely to be encoded intentionally, it was expected that reinstatement effects would be further decreased.

Method

Participants. A total of 40 Texas A&M University undergraduate students participated in this experiment in return for partial course credit. As in previous experiments participation was voluntary, and other options were available to earn equal credit. Participants self-enrolled in one of the two counterbalancing conditions. The number of participants in each experimental session depended upon the random enrolment of participants, and varied from 5 to 15 participants per session. There were 20 participants in each of the two counterbalancing conditions.

Design and materials. A total of 20 Swahili–English pairs of words were drawn from Nelson and Dunlosky's (1994) norms; English responses were translations of the corresponding Swahili stimulus terms. Each word pair was randomly matched with a video context, with the stipulation that a context was not obviously related to the matched paired associate. A subset of 30 of the video contexts described for Experiments 1–3 were used in Experiment 4. Of those video contexts, 10 were used only for the different context test condition. Each of the video contexts used during encoding and at test was 5 seconds in duration. Half of the 20 paired associates were tested with the Swahili stimulus word superimposed over the same video scene seen at encoding (same context condition), and half were tested with new videos of environments participants had not previously seen (different context condition). The two subsets of paired associates were counterbalanced between-participants, with respect to the test context variable, and 20 participants were randomly assigned to each of the two counterbalancing conditions.

Procedure. The procedure for Experiment 4 was similar to that of Experiment 1–3, including a single 5-second presentation of the to-be-learned items, followed by a single retention test. Prior to the study phase participants were instructed to learn the English response word for each Swahili (stimulus) word. At test, participants were shown each Swahili stimulus word for 5 seconds superimposed on its accompanying video context, during which time participants wrote down the associated English response term.

Results

A 2×2 mixed ANOVA was computed, with test context (same vs different) as a within-participants variable, and counterbalancing as a between-participants factor, using the mean proportion recalled as the dependent measure. The effect of reinstatement on paired associate recall was significant, $F(1, 38) = 38.648$, $p < .0001$, $MSE = .033$, $\eta^2 = .504$; significantly more paired associate responses were recalled (more than double, a 25% difference in the means) when video contexts were reinstated (same context) at test, rather than changed (different context) at test (see Table 1), although it was somewhat smaller than the mean differences observed in Experiments 1–3, which ranged from about 40% to over 50%. The effect size, $d = 1.220$, indicated that the reinstatement effect observed in Experiment 4 was a large one.

Discussion

Swahili–English paired associates, tested with reinstated vs new video environmental contexts at test, showed a very large effect of context manipulations on memory. In Experiment 4, unlike Experiments 1, 2, and 3, there were no instructions to interactively encode contexts with words; rather participants were instructed to learn the English word that went with each Swahili

TABLE 1
Mean proportion recalled in Experiment 2 as a function of test context

Same context	*Different context*
.463 (.039)	.210 (.025)

Standard errors of the mean are shown in parentheses.

word. Thus, contexts in Experiment 4 were incidental, as in many other studies of context-dependent memory (see Smith & Vela, 2001). As such, the results help validate the methods used in the present study as showing more than simple paired associates learning (context cues affected paired associate memory independently of the paired associate cues), and linking the video context method better with the existing literature on context-dependent memory. These results also help validate the use of the even more powerful method we used in Experiments 1–3 because the context effects in those experiments were even larger than those seen in Experiment 4, thereby better enabling our investigation of a potentially moderating factor, contextual similarity.

GENERAL DISCUSSION

Three experiments show that environmental context stimuli that are similar to encoding contexts can provide strong retrieval cues at test. The cueing effects of similar contexts were found both for video-recorded scenes that were different video scenes of the original encoding contexts, and for videos that were conceptually similar to the video contexts seen at encoding. Although the similar context cues were very effective for cueing memory relative to different context cues (Experiments 1 and 3) or no cues (Experiment 2), they were not as effective as the original video contexts that had been seen during study. These results are consistent both with predictions of the context reinstatement principle, which states that the more an encoding context is reinstated, the better memory is, and with the theory of encoding specificity, which states that memory depends on the match between the cognitive environments at encoding and retrieval.

In Experiment 3 the context similarity effect was again seen, and further, participants recalled more in the similar/general condition than in the similar/specific condition. The video context test cues were exactly the same for both the similar/general and similar/specific conditions. In the similar/general condition, the context representation biased at encoding (e.g., "ball field") could sensibly match the conceptually similar cue provided at test (a soccer game), but in the similar/specific condition, the biased representation of the encoding context (e.g., "home run") could not sensibly match the conceptually similar test cue (a soccer game). Thus the effectiveness of these

cues depends on the match between the mental representations of the encoding and test contexts.

In the experiments we reported we selected methods that were designed to produce as large and robust context reinstatement effects as possible. Our test of contextual similarity as a moderator of contextual cueing worked so well, in part, because we used a method that produces very large contextual cueing effects. The effectiveness of the method we used depends on several factors, including the fan size for context cues, the direction of attention at encoding to the video contexts, and the use of perceptually rich contexts. Smith and Manzano (2010) showed that fewer memory targets per context (i.e., smaller fan size) produce greater context-dependent memory effects. In the present experiments, fan size was minimised at one target per context. Context effects are known to be stronger when participants attend to encoding contexts (e.g., Eich, 1985; Murnane et al., 1999); at encoding in the present experiments, participants were asked to report the relatedness of each verbal stimulus with its encoding context. Perceptually rich contexts, such as scenes of environments, as compared with simpler contexts, such as background colours, have been shown to be more effective for producing context-dependent memory (e.g., Murnane et al., 1999). Using a method that encouraged attention to content-rich contexts with minimal fan sizes in the present experiments, therefore, provided an optimal design for examining the effects of a moderating variable, context similarity, because it is easier to observe effects of moderating factors for large effects than for the smaller effects of, for example, global incidental context cues (e.g., Smith & Vela, 2001).

Do the results of Experiments 1, 2, and 3 show anything beyond a reductionist interpretation of the results, that is, that these results do not go beyond what has been shown with paired associates? For example, Yum (1931) showed that stimulus words and visual patterns that were similar to those used at study could evoke recall of paired associate responses. It should be noted, however, that participants in Experiments 1–3 were instructed to recall all of the words that had been seen during encoding, not just those corresponding to the video context cues that were provided at test. In the paired associates method a to-be-remembered item is designated at study to be learned as a response to a specific stimulus term, and at test, a specific response for each stimulus is requested; studied responses recalled

for the wrong stimuli are counted as intrusions. In Experiments 1–3 no mention was made of a memory test, and no items were designated as "to-be-remembered" before the incidental encoding phase, and on the free recall test participants were explicitly told to recall all of the words they had seen, not just those corresponding to the video clips shown at test. Furthermore, in Experiment 4 the encoding instructions did not mention the video contexts before the study session, and participants were not told to relate words with the video contexts, as they had been told in Experiments 1–3. Experiment 4 showed that incidental manipulation of the video environmental contexts had a large effect on memory of paired associates, indicating that the video cues did something beyond the verbal stimulus cues of the paired associates. Experiment 4 linked the present experiments better with other published methods for observing environmental context-dependent memory by showing the effect even when encoding instructions did not involve or encourage the interactive association of to-be-learned materials with their contexts; this incidental relationship of contexts with target material has been common in many environmental context-dependent memory studies (see Smith & Vela, 2001). Finally, the use of only one memory target for a context cue is also seen in other published studies of environmental context-dependent memory. For example, Krafka and Penrod (1985) and Smith and Vela (1992) examined eyewitness memory for a single actor who had staged an event, testing either in the staged environment, or in a new place. The method used in our experiments utilises this one-to-one context-to-target relationship, but uses many contexts and targets in order to increase the number of times that an environmental stimulus can cue responses, similar to the procedure reported by Hockley (2008).

The cueing effects of video environmental scenes may be useful for testing theoretical questions. For example, theories which state that deficits in contextual binding are found in schizophrenic patients (e.g., Lamy, Goshon-Kosover, Aviani, Harari, & Levkovitz, 2008; McClure, Barch, Flory, Harvey & Siever, 2008; Talamini & Meeter, 2009) or depressed patients (e.g., Balardin et al., 2009; Barch, Yodkovik, Sypher-Locke, & Hanewinkel, 2008; Lamy et al., 2008; Levens & Gotlib, 2009) might use our methodology with patients to test these theories. Likewise, theories that explain directed forgetting (e.g., Sahakyan & Kelley, 2002), cueing effects of inter-item associations

(e.g., Howard et al., 2005), false memories (e.g., Kimball et al., 2007), or long-term recency effects (e.g., Glenberg & Swanson, 1986) might also be testable with our methods.

Our methods might be useful for applications in education, clinical treatments, and eyewitness memory. If contextual similarity moderates the difficulty of retrieval, and if retrieval practice is an effective means of learning, then video contextual cues might be useful in educational technologies based on desirable difficulties, the principle that more difficult retrieval practice has more long-term retention benefits (Bjork, 1975; Finley, Benjamin, Hays, Bjork, & Kornell, 2011). For example, in the course of learning a new language, new vocabulary words could be studied in video contexts, and practised in similar and new contexts that could make retrieval desirably difficult, thereby enhancing the effectiveness of retrieval practice. Another application of our methods may be in therapeutic settings, such as treatments for desensitisation to phobic stimuli (e.g., Mineka, Mystkowski, Hladek, & Rodriguez, 1999; Mystkowski, Craske, Echiverri, & Labus, 2006). For example, presenting phobic stimuli in contexts that vary in terms of their similarity to the contexts in which fear was acquired could prove to be a useful clinical tool. Finally, because context reinstatement is an essential part of the cognitive interview, which is used to improve eyewitness memory (e.g., Fisher, & Geiselman, 1992; Geiselman, Fisher, MacKinnon, & Holland, 1985), the use of video environmental contexts similar to places where events were witnessed may be useful for enhancing eyewitness memory.

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