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Continued effects of context reinstatement in recognition

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Abstract The *context reinstatement effect* refers to the enhanced memory performance found when the context information paired with a target item at study is re-presented at test. Here we investigated the consequences of the way that context information is processed in such a setting that gives rise to its beneficial effect on item recognition memory. Specifically, we assessed whether reinstating context in a recognition test facilitates subsequent memory for this context, beyond the facilitation conferred by presentation of the same context with a different study item. Reinstating the study context at test led to better accuracy in two-alternative forced choice recognition for target faces than did re-pairing those faces with another context encountered during the study phase. The advantage for reinstated over re-paired conditions occurred for both within-subjects (Exp. 1) and between-subjects (Exp. 2) manipulations. Critically, in a subsequent recognition test for the contexts themselves, contexts that had previously served in the reinstated condition were recognized better than contexts that had previously served in the re-paired context condition. This constitutes the first demonstration of continuous effects of context reinstatement on memory for context.

Keywords Context effects · Recognition · Recollection

When an item that one tries to memorize occurs in a certain context, reinstating this particular context at the time of the test may enhance memory performance. Decades of research has documented that such an enhancement is readily observed when the memory test takes the shape of free recall (see Smith & Vela, 2001, for a review). However, the results are less consistent with respect to recognition. Although instances of improved recognition discrimination due to context reinstatement have been reported (e.g., Murnane, Phelps, & Malmberg, 1999; Rutherford, 2004), there are also numerous examples of studies in which reinstating study context at the time of a recognition test has failed to enhance discrimination (e.g., Dodson & Shimamura, 2000; Hockley, Bancroft, & Bryant, 2012; Murnane & Phelps, 1993, 1995; Reder et al., 2013).

A recent comprehensive investigation into the context reinstatement effect in recognition (Hockley, 2008) demonstrated that a reinstated context is likely to aid discrimination only when the study instructions emphasize interactive encoding of the context and study items. Hockley compared item recognition across conditions using reinstated contexts and re-paired contexts taken from a different study item. Across five experiments, in which participants were not asked to attend to context information at encoding, item discrimination was the same in the reinstated and re-paired context conditions. By contrast, in the final experiment, in which participants were asked to associate studied words with their picture backgrounds (contexts), reinstating pictures at the time of the recognition test reliably improved recognition discrimination as compared to presenting test items with re-paired picture backgrounds. These results remain consistent with the observation that the majority of studies documenting the context reinstatement effect have employed instructions that specifically aimed at facilitating the interactive encoding of items and their contexts (e.g., Gruppuso, Lindsay, & Masson, 2007; Koen, Aly, Wang, & Yonelinas, 2013; but see Macken, 2002; Russo, Ward, Geurts, & Sheres, 1999) or that required intentional encoding of both studied items and their contexts (Hanczakowski, Zawadzka, & Coote, 2014).

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The observation that interactive encoding increases the likelihood of observing the context reinstatement effect in recognition suggests that context is capable of augmenting item recognition only when it is strongly integrated with this item. In this case, reinstating context at test allows people to access a linked representation of both an item and its context, supporting the correct identification of the tested item as a target. In contrast, presenting test items with re-paired contexts means that an integrated representation of an item and the original study context of this item is relatively less likely to be accessed, and people need to rely solely on memory for the item.

Evidence for the simultaneous memory access to both an item and its context when the context is reinstated at test has come from studies analyzing the context reinstatement effect from the perspective of dual-process models of recognition. Dual-process models postulate that the identification of a target in a recognition test may occur either by an assessment of the item information only—a process termed *familiarity*—or by retrieval of the context features associated with an item—a process termed *recollection* (e.g., Mandler, 1980; Yonelinas, 1994; see Yonelinas, 2002, for a review). In this approach, memory access to both item and context information should manifest as recollection of the test item, and indeed, studies of context reinstatement have demonstrated that the benefits of reinstating context for item memory, whenever they are observed, come via the recollective component of recognition. Hockley (2008) and Macken (2002) demonstrated this by showing that the benefits of context reinstatement are revealed in recognition decisions accompanied by "remember" responses—a commonly used indicator of recollective access (but see Wixted & Stretch, 2004, for a different view). Furthermore, Reder et al. (2013) showed that the benefits of context reinstatement in the recognition of famous faces are specific to conditions of low contextual fan, when specific contexts are associated with a single item. Again, sensitivity to the fan effect is a hallmark of recollective processes in recognition (Diana, Reder, Arndt, & Park, 2006), supporting the argument that reinstating context may augment item recognition by facilitating recollective retrieval of both an item and its context.

The studies on context-dependent recognition conducted thus far have been preoccupied with delineating the conditions under which context is likely to affect recognition decisions concerning the tested item, and the way in which the context information itself is processed at retrieval has been inferred indirectly from its influence on item recognition. However, the idea that context-dependent recognition boils down to simultaneous access to the integrated item and context information indicates that context reinstatement may have important consequences not only for memory of the tested item, but also for the memory of the context itself. Specifically, it is possible that context reinstatement may not only benefit item recognition, but may also strengthen the memory representation of the context more than does processing the same context with a different study item (in the re-paired context condition). This idea has come from a growing body of research concerning the consequences of retrieval from memory. A broad literature on a so-called *testing effect* (e.g., Kornell, Bjork, & Garcia, 2011; Lehman, Smith, & Karpicke, 2014) has shown that the act of recollection is a particularly powerful way of strengthening memory representations. Specifically, what the testing effect demonstrates is that retrieval is more beneficial for memory than is simply restudying the information. Thus, if memory information for a reinstated context is retrieved alongside item information when a context is reinstated, this could lead to better subsequent memory for this context than for a condition in which the context is presented again but not retrieved.

A second strand of evidence supporting the idea that context reinstatement may affect memory for context via successful retrieval has come from the literature on reminding. Recent studies have shown that when cue–target pairs of words are studied in one list and then a second list is presented, in which the same cues are paired with different targets, retrieval of an original target in response to the novel cue–target pair leads to strengthening of the memory for this original target (e.g., Wahlheim & Jacoby, 2013; see also MacLeod, Pottruff, Forrin, & Masson, 2012; Whalheim, Maddox, & Jacoby, 2014, for related findings). Thus, presenting cues for the second time leads to a strengthening of memory for the original targets for these cues, even under conditions under which participants are not explicitly directed toward retrieval of the targets. This is related to the issue of context reinstatement, inasmuch as participants in the context reinstatement studies are also not directed toward the retrieval of context information. To the extent, however, that covert reminding of the original targets during study of related cue–target pairs is similar to covert retrieval of memory for the reinstated context, this line of research also suggests that the effects of context reinstatement may extend beyond facilitating item recognition, to augmenting the long-term retention of context information.

In the present study, we examined the effect of context reinstatement on subsequent memory of the context itself. We used the basic context reinstatement procedure, based on our previous study of this effect (Hanczakowski et al., 2014). Thus, participants first studied, under intentional encoding instructions, photographs of faces paired with contextual photographs of landscapes. In a subsequent two-alternative forced choice (2AFC) recognition test, participants on each trial were presented with two faces, one studied and one new, and were asked to indicate the studied face. A context photograph was presented in the recognition test between the photographs of the faces. This context could be the context photograph presented with the target face at study (the reinstated context condition), a context photograph that had been presented with

a different face at study (the re-paired context condition), or a context photograph not presented earlier (the novel context condition). For the present investigation, the comparison of the reinstated and re-paired context conditions was crucial. In this comparison, the number of presentations of the contexts was held equal, and only their item pairings during the recognition test were varied. Any difference in recognition performance between the reinstated and re-paired conditions would constitute a context reinstatement effect. The novel element of the procedure—a second recognition test—was administered after the first test was over. In the second two-alternative recognition test, participants' memory for the contexts that had previously served in the reinstated and re-paired context conditions was assessed. Thus, contexts used in the reinstated and re-paired context conditions of the first test were presented along with new contexts that had not been used in any of the previous phases of the experiment, and participants were asked to endorse the context that they had seen before. Since contexts that had appeared in both the re-paired and reinstated test forms in the preceding recognition test would have been encountered equally often during the procedure, any difference in their recognizability would directly reveal the effects of context reinstatement on context memory.

In the present study, we also supplemented the 2AFC tests with the requirement for participants to provide confidence judgments and decide whether to volunteer or withhold a response in the recognition test. The primary motivation for these additional measures here was to provide a more detailed picture of the influence of context information on performance at the various stages of the procedure, since it has been shown elsewhere that effects of context may emerge in metacognitive judgments even when they are absent on measures of discrimination accuracy (Hanczakowski et al., 2014). We expected to replicate previous results that had shown reliable effects of context reinstatement for recognition, at least in the metamemory measures. We further assessed whether context reinstatement would enhance subsequent recognition of the contexts themselves. In Experiment 1, we used the same design as in Experiment 1 of Hanczakowski et al. (2014)—that is, context conditions were manipulated within a single study–test list—but here we presented an additional second test of recognition for contexts that had previously been used in the reinstated and re-paired context conditions. In Experiment 2, we investigated the same issues in a between-subjects design.

Experiment 1

Method

Participants Forty-six undergraduates of Cardiff University participated for course credit.

Materials and design A set of 96 black-and-white photographs of male and female faces (in equal proportions) was taken from the Psychological Image Collection at Stirling University. A novel set of 96 black-and-white context photographs depicting landscapes, buildings, and animals was assembled from various Internet sources.

Faces were divided into two sets of 48, and each face was yoked with a face from the other set as well as with a unique context photograph. At study, the faces from one set (counterbalanced across participants) were presented with their context photographs. The first recognition test immediately followed the study list. All studied faces were presented with yoked faces that served as foils in a recognition test. Three within-subjects context conditions, with 16 trials per condition, were included: reinstated (the studied face represented with the same context as at study), re-paired (context photographs were presented with a different face), and novel (with 16 context photographs not yoked with any faces, and that thus had not been presented at study). The assignment of faces to context conditions was counterbalanced. The novel context condition was not crucial for the present study, which focused on a comparison of reinstated and re-paired context conditions, but was included in order to ascertain that the results of Hanczakowski et al. (2014) would fully replicate with the present set of materials.

For the present study, we adopted the testing procedure used in Hanczakowski et al. (2014; see also Beaman, Hanczakowski, & Jones, 2014; Hanczakowski, Pasek, Zawadzka, & Mazzoni, 2013). This testing procedure included, apart from the usual 2AFC recognition test, two additional steps that required participants to make metamemory decisions. Thus, each trial of the test included three steps. In the *free-report* step, participants were presented with two faces and the context photograph, and three response options were available. Participants could endorse the face on the left by pressing the "a" key, endorse the face on the right by pressing the "l" key, or respond "don't know" (DK) by pressing the spacebar. In the immediately following *forced-report* step, which corresponded to the usual 2AFC recognition test, the same faces and context photographs were presented, and only two response options were available: Participants could only endorse the face on the left or the face on the right. Finally, in the third step, participants were asked to provide a *confidence judgment* for their forced-report response, on a scale from 1 (*guessing*) to 6 (*very sure*). Three dependent measures were derived from this procedure: the rate of DK responses in the free-report step, the hit rate (accuracy) in the forced-report step, and the mean of the confidence judgments. The three-step testing procedure was used here because the results obtained by Hanczakowski et al. (2014, Exp. 1) showed that metacognitive measures—that is, the rate of DK responses in the free-report test and the mean of the confidence

judgments—may be more sensitive to the effects of context reinstatement than is the measure of hit rates in the common 2AFC test. Also, both the rate of DK responses and the mean of the confidence judgments were examined despite their conceptual similarity, because these two measures were not always consistent in the study of Hanczakowski et al. (2014; see Exp. 2).

The first test of face recognition was immediately followed by a second recognition test in which memory for the contexts was probed. Thirty-two context photographs that had been used in the reinstated and re-paired context conditions were presented individually with 32 new context photographs, not used in any of the previous phases of the experiment. The procedure for the second test was the same as that for the face recognition test, with the same three steps of responding: free report, forced report, and confidence judgment.

Procedure At study, 48 face–context compounds (with the face always presented to the right of the context photograph) were presented individually for 5 s each. Participants were specifically asked to study both pictures for an unspecified memory test. In the first test, two faces—a target and a foil—were presented on two sides of the screen (with equal numbers of targets on both sides), and a context photograph was presented in between. Participants were clearly instructed that their recognition decisions should concern the faces alone. The faces and contexts remained on screen throughout the free- and forced-report steps, but were removed during the confidence judgment step. The confidence judgment was made on a 1 (*guessing*)–6 (*very confident*) scale. The responses for each step were self-paced. In the following recognition test for context, the studied contexts and novel foils were presented on two sides of the screen (with equal numbers of studied contexts on both sides), and participants made the same three judgments as in the first recognition test.

Results and discussion

The descriptive statistics for the rates of DK responses, confidence judgment means, and forced-report recognition accuracy can be found in Table 1. We first analyzed performance in the face recognition test across the reinstated, re-paired, and novel context conditions, and then we analyzed the aftereffects of processing the context in the reinstated and re-paired context conditions on subsequent context recognition.

Face recognition The full analysis of the face recognition results was conducted with a set of one-way analyses of variance (ANOVAs) with three levels—reinstated, re-paired, and novel context—that looked at the rate of DK responses for the free-report recognition, hit rates in the forced-report recognition, and the means of the confidence judgments.[1] All of these ANOVAs were significant: $F(2, 90) = 14.39$, $MSE = .02$, $p < .001$, $\eta_p^2 = .24$, for the rate of DK responses; $F(2, 90) = 11.14$, $MSE = .02$, $p < .001$, $\eta_p^2 = .20$, for the 2AFC recognition hit rates; and $F(2, 90) = 24.79$, $MSE = .31$, $p < .001$, $\eta_p^2 = .36$, for the means of the confidence judgments. We conducted planned comparisons contrasting first the novel and re-paired context conditions, and then the re-paired and reinstated context conditions. The former comparison was not crucial for the purpose of the study and served mostly to replicate the full pattern reported in Hanczakowski et al. (2014). The main focus here is on the latter comparison, which speaks directly to the presence or absence of the context reinstatement effect.

The comparison of the novel and re-paired context conditions in terms of metamemory measures revealed that participants responded DK more often in the novel than in the re-paired context condition, $t(45) = 2.20$, $SE = .03$, $p = .03$, $d = 0.34$, and also that they were more confident in their forced-report recognition decisions in the re-paired than in the novel context condition, $t(45) = 2.86$, $SE = 0.09$, $p = .01$, $d = 0.41$. By contrast, the comparison of the hit rates in forced-report recognition revealed no difference between the conditions, $t(45) = 1.24$, $SE = .03$, $p = .22$, $d = 0.21$. This is the pattern of results documented in Hanczakowski et al. (2014), which shows that familiar contexts affected the metamemory measures but not forced-report recognition performance, leading to a confidence–accuracy dissociation.

The comparison of re-paired and reinstated context conditions in terms of metamemory measures revealed that participants responded DK more often in the re-paired than in the reinstated context condition, $t(45) = 3.21$, $SE = .03$, $p = .002$, $d = 0.49$, and also that they were more confident in their forced-report recognition decisions in the reinstated than in the re-paired context condition, $t(45) = 4.45$, $SE = .12$, $p < .001$, $d = 0.66$. Furthermore, the comparison of the hit rates in forced-report recognition revealed that discrimination was better in the reinstated than in the re-paired context condition, $t(45) = 3.26$, $SE = .03$, $p = .002$, $d = 0.49$. These results are broadly consistent with the results reported by Hanczakowski et al. (2014), inasmuch as they show that context reinstatement reliably affected face recognition performance in this setup. Although in our previous investigation using the same procedure (albeit with a different set of materials) we had found a reliable effect of context reinstatement only in the metamemory measures (see Exp. 1 in Hanczakowski et al., 2014), our other experiments had also shown such effects in the measure of

[1] Across this article, we report the analyses of confidence judgments collapsed across correct and incorrect responses in the preceding forced-report recognition step. Analyses of the mean confidence judgments only for trials on which a correct answer had been given in the forced-report recognition test produced the same pattern of results in all tests for both experiments.

Table 1 Rates of "don't know" (DK) responses, means of confidence judgments, and mean hit rates in the forced-report step in Experiments 1 and 2, presented as a function of test (the first test of face recognition and the second of context recognition) and context condition (reinstated, re-paired, and novel for the face recognition test, and reinstated and re-paired for the context recognition test)

	Face Recognition			Context Recognition	
	Reinstated Context	Re-paired Context	Novel Context	Reinstated Context	Re-paired Context
Experiment 1					
DK responses	.31 (.04)	.41 (.04)	.47 (.05)	.20 (.03)	.21 (.03)
Confidence	3.62 (0.13)	3.07 (0.13)	2.83 (0.13)	4.70 (0.15)	4.66 (0.15)
Hit rate	.72 (.02)	.62 (.03)	.58 (.03)	.89 (.02)	.86 (.02)
Experiment 2					
DK responses	.31 (.03)	.43 (.05)	–	.16 (.02)	.27 (.03)
Confidence	3.84 (0.13)	3.14 (0.14)	–	4.98 (0.11)	4.61 (0.12)
Hit rate	.73 (.01)	.67 (.02)	–	.93 (.01)	.89 (.01)

The novel context condition was not included in the design of Experiment 2. Experiment 1 had a within-subjects design, whereas Experiment 2 had a between-subjects design. Standard errors of the means are given in parentheses

recognition discrimination (Exps. 2 and 3 in Hanczakowski et al., 2014; see also Russo et al., 1999). To summarize, the present results clearly demonstrate that reinstating context aids recognition performance.

Context recognition The comparison of recognition performance for the contexts that had previously served in the reinstated and re-paired context conditions was also performed both for the metamemory measures and the forced-report recognition hit rates. Analyses of the metamemory measures failed to demonstrate any differences between the conditions in either the measure of confidence or response withholding (DK), both *t*s < 1. By contrast, context recognition hit rates in the forced-report step were higher for contexts that had previously served in the reinstated context condition than for contexts that had previously served in the re-paired context condition, $t(45) = 2.18$, $SE = .02$, $p = .034$, $d = 0.31$. This result indicates that memory for a context is augmented when this context serves in the reinstated context condition, beyond the strengthening resulting from a mere re-presentation of the context in the re-paired context condition. This observation remains consistent with the hypothesis according to which reinstating context in a recognition test results in memory access to the traces of both the item and its context.

For exploratory purposes, we also analyzed performance in the context recognition task, conditionalized on item recognition performance in the presence of the same contexts. The descriptive statistics for this analysis can be found in Table 2. Thus, we divided context recognition trials into sets of trials on which the tested context had accompanied successful and unsuccessful item recognition in the first test. Four participants were excluded due to missing cells. The resulting 2 (Context Condition: reinstated vs. re-paired) × 2 (Item Recognition: successful vs. unsuccessful) ANOVA yielded a significant main effect of context condition, $F(1, 41) = 4.28$, $MSE = .01$, $p = .045$, $\eta_p^2 = .09$, with generally higher context recognition performance for the context that had previously served in the reinstated context condition. The main effect of item recognition was also significant, $F(1, 41) = 4.44$, $MSE = .01$, $p = .041$, $\eta_p^2 = .10$, with higher context recognition performance for the context that had previously accompanied successful item recognition. The interaction was not significant, $F < 1$. Interestingly, these results suggest that there may be a benefit of reinstating context for context memory, even when participants fail to capitalize on the context reinstatement in terms of item recognition performance. This finding, however, needs to be treated with caution, because a direct contrast between the reinstated and re-paired contexts for which an incorrect item recognition decision had been made in the first test was not significant, $t(41) = 1.14$, $p = .26$.

Overall, the results of the present experiment point to clear benefits of context reinstatement in recognition. Not only did reinstating context affect metamemory measures by increasing confidence and reducing DK responding, but it also clearly augmented recognition performance in the 2AFC test, a result that has often been elusive in the recognition literature

Table 2 Mean hit rates in forced-report context recognition as a function of context condition and face recognition performance in Experiments 1 and 2

	Reinstated Context		Re-paired Context	
	Face Recognition Hit	Face Recognition Miss	Face Recognition Hit	Face Recognition Miss
Experiment 1	.90 (.02)	.86 (.02)	.86 (.02)	.83 (.03)
Experiment 2	.94 (.01)	.91 (.02)	.89 (.01)	.88 (.02)

Standard errors of the means are given in parentheses

(e.g., Hockley, 2008; Reder et al., 2013). The novel contribution provided here lies, however, in the examination of the consequences of reinstating a context for subsequent memory of this context. This analysis revealed that reinstated contexts are subsequently remembered better than re-paired contexts. This result indicates that memory access to the representations of reinstated contexts strengthens these representations, supporting a subsequently better ability to discriminate these contexts from novel ones, over and above the advantage that accrues merely from encountering the contexts in a recognition test (and at study).

The support for the benefits of memory retrieval of context information comes, however, with a caveat: The benefits of context reinstatement for context memory were observed here in the recognition accuracy measure, but not in the metamemory measures. The reason for this pattern is unclear. Metamemory is often conceived of as a by-product of memory processes themselves (Koriat, 2012), and thus, differences in memory performance more often than not are accompanied by differences in metamemory measures. It seems thus possible that the lack of metamemory effects in the present study may reflect a shortage of statistical power rather than some fundamental memory–metamemory dissociation.

In order to investigate whether this pattern, and—more importantly—the observation of continued benefits of context reinstatement, would replicate, we conducted a second experiment in which we manipulated the item-to-context pairings in a between-subjects design. Thus, for one group all contexts encountered at the first test (and then tested in the second test) were reinstated with their original face, whereas the other group of participants were presented only with re-paired context–face test cues. We reasoned that in the reinstated context group, contexts presented at test would be able to consistently support face recognition, which could induce participants in this group to rely more on context information at test. By contrast, the contexts in the re-paired context group would be consistently unable to support face recognition, discouraging reliance on context information. This difference could lead to more consistent context reinstatement effects, helping to clarify the issue of a discrepant pattern of findings concerning memory and metamemory measures in the recognition test for contexts that we had observed in Experiment 1.

Experiment 2

Method

Participants Eighty undergraduates at Cardiff University participated for course credit. They were randomly assigned to reinstated and re-paired context groups, with 40 participants in each group.

Materials, design, and procedure All elements of the present experiment were the same as in Experiment 1, except for the change of the design. Using the between-subjects design meant that in the reinstated context group, all 48 target faces in the first test were presented with their yoked context photographs as well as with a novel face, whereas in the re-paired context group, all 48 target faces in the first test were presented with context photographs that had been yoked with a different face. The novel context condition was not included in the present study, which meant that 16 of the context photographs that had been used for this condition in Experiment 1 were dropped from the materials.

Results and discussion

The descriptive statistics for the rates of DK responses, mean confidence judgments, and forced-report recognition accuracy can be found in Table 1.

Face recognition The analyses of metamemory measures on the first test revealed that the rate of DK responses was lower and confidence in the forced-report responses was higher when the context was reinstated rather than re-paired, $t(78) = 2.01$, $SE = .05$, $p = .041$, $d = 0.50$, and $t(78) = 3.70$, $SE = .19$, $p < .001$, $d = 0.83$, respectively. In the forced-report step, recognition accuracy was better in the reinstated than in the re-paired context group, $t(78) = 2.21$, $SE = .02$, $p = .03$, $d = 0.57$. These results replicated those of Experiment 1.

Context recognition The analysis of metamemory measures revealed that the rate of DK responses was lower and confidence in the forced-report responses was higher for previously reinstated than for previously re-paired contexts, $t(78) = 2.82$, $SE = .04$, $p = .006$, $d = 0.65$, and $t(78) = 2.28$, $SE = .16$, $p = .025$, $d = 0.51$, respectively. Finally, the analysis of the hit rates in the forced-report step revealed that participants were better at recognizing previously reinstated than at recognizing previously re-paired contexts, $t(78) = 2.46$, $SE = .02$, $p = .016$, $d = 0.50$.

For the present experiment, we again analyzed context recognition conditionalized on item recognition on trials on which these contexts were presented. The descriptive statistics for this analysis can be found in Table 2. A 2 (Context Condition: reinstated vs. re-paired) × 2 (Item Recognition: successful vs. unsuccessful) mixed ANOVA yielded a significant main effect of context condition, $F(1, 78) = 4.20$, $MSE = .01$, $p = .044$, $\eta_p^2 = .05$, with better performance for contexts that had previously served in the reinstated context condition. The main effect of item recognition was also significant, $F(1, 78) = 4.83$, $MSE = .004$, $p = .031$, $\eta_p^2 = .06$, with overall higher context recognition for contexts that had previously accompanied a successfully recognized item. The interaction was not significant, $F(1, 78) = 1.52$, $p = .22$. As in Experiment 1, these

results may suggest that reinstating context can benefit context memory even when participants fail to correctly recognize items accompanied by reinstated contexts. However, once more, this result needs to be treated with caution, since a direct contrast between reinstated and re-paired contexts for which an incorrect item recognition decision had been made in the first test was not significant, $t(78) = 1.06$, $p = .29$.

Overall, the recognition accuracy results for contexts replicate those found in Experiment 1, once again showing that contexts that had served in the reinstated condition were subsequently recognized more accurately than contexts that had served in the re-paired condition. This occurred despite each type of context having been encountered equally often during the procedure. This result again indicated that the memory representations of reinstated contexts had been retrieved at the time of a recognition test, leading to better memory for these contexts, an effect that accompanied the benefits of context reinstatement for item recognition. In the present experiment, this conclusion, derived in Experiment 1 only from the recognition accuracy measure, was augmented by the results from the metamemory measures. In contrast to Experiment 1, in which recognition accuracy and the metamemory measures had produced inconsistent results, in the present experiment both types of measures pointed to stronger memory representations for contexts that had previously been reinstated rather than re-paired. This finding suggests that the lack of an effect on metamemory measures in Experiment 1 likely had been due to insufficient statistical power.

Although the present results are accounted for well by the hypothesis postulating retrieval-based enhancement of context memory, an alternative explanation was also possible. As we argued earlier, the use of the between-subjects design in the present experiment could have induced participants to rely on context more in the reinstated than in the re-paired context group. This increased reliance on context may have also meant that participants in the reinstated context group spent longer scrutinizing the context photographs at test than did participants in the re-paired context group. Thus, the differences in memory for context in the present experiment could be at least partially explained by the duration of exposure to the context photographs, rather than to the way that associative retrieval affected the reinstated contexts. To assess this possibility, we analyzed the response latencies for the free- and forced-report steps of the face recognition test. A 2 (Test Step) × 2 (Context Group) mixed ANOVA revealed a significant main effect of test step, $F(1, 78) = 1{,}159.47$, $p < .001$, which unsurprisingly demonstrated that participants were faster to respond in the second, forced-report step of the test. Importantly, neither the main effect of condition nor the interaction was significant, Fs < 1, and, if anything, the mean response latencies were numerically *shorter* in the reinstated than in the re-paired context group ($M = 2{,}876$ ms vs. $M = 2{,}983$ ms, collapsed across test steps). Thus, as well as the contexts being encountered equal numbers of times, it is clear that the subsequent recognition advantage for reinstated versus re-paired contexts cannot have been due to additional time spent processing those contexts, but rather must have been due to the particular item–context configuration in which they had been encountered in the face recognition test.

General discussion

In the present study, we investigated the consequences of reinstating context at the time of a recognition test for memory of the context itself. Previous investigations had revealed that reinstated context may augment item recognition discrimination, particularly when participants integrate the item and context information at study (Hockley, 2008). The present investigation confirmed the reliability of this context reinstatement effect under encoding instructions emphasizing intentional processing of both the studied items and their contexts. Going beyond these previous findings, the present study also revealed lasting aftereffects of processing a reinstated context on the memory of contexts. These continued effects of context reinstatement took the shape of enhanced subsequent memory for contexts, relative to contexts that were presented at test repaired with different items than those with which they had been paired at study.

The first point discussed here concerns the basic context reinstatement effect. The present study documented reliable context reinstatement effects for recognition discrimination, which remains in contrast to several previous studies in which this effect has failed to materialize (e.g., Dodson & Shimamura, 2000; Murnane & Phelps, 1993, 1995). Indeed, in the present study we used the procedure developed for our previous investigation of the context effects in recognition (Hanczakowski et al., 2014, Exp. 1), in which similar study and testing conditions revealed the context reinstatement effect in metamemory measures, but not in the measure of recognition discrimination. Apart from the experiments presented here and previously in Hanczakowski et al. (2014), our group has conducted several as yet unpublished experiments using both faces and words as study materials, with encoding instructions either that ask participants to intentionally encode the context information or that do not mention context information at all. All of these experiments have shown a reliable context reinstatement effect in metamemory measures, such as the mean of retrospective confidence judgments. At the same time, the context reinstatement effect was sometimes present and sometimes absent from the measure of recognition discrimination, without any obvious relation to the type of materials or encoding instructions. Following the suggestions formulated in Hanczakowski et al. (2014), we again stipulate that context reinstatement reliably affects recognition processes,

which is more easily detected in metamemory measures, but because the effect is relatively subtle, it may not always be detected by the seemingly insensitive measure of recognition discrimination. At the same time, we do not deny that factors such as encoding instructions (see Hockley, 2008) or the distinctiveness of a context (see Murnane et al., 1999) may well play important roles in determining the magnitude of the context reinstatement effect, roles that could be further elucidated with the use of metamemory measures.

It is worth noting that context effects on metamemory measures not only are convenient means of investigating how context affects memory processing, but also may be related to final test performance. In the present experiment, we assessed recognition performance as hit rates on forced-report recognition, which is considered a relatively pure measure of memory quality (e.g., Hanczakowski et al., 2014). However, another way of looking at performance in a memory task would be to focus only on responses volunteered in a free-report test. We performed such an analysis for Experiment 1, again comparing the reinstated and re-paired context conditions, but also the re-paired and novel context conditions (two participants were removed due to missing cells). The first comparison again revealed a context reinstatement effect, with higher accuracy of the volunteered responses in the reinstated (M = .76, SD = .18) than in the re-paired (M = .67, SD = .23) context condition, $t(43) = 2.32$, $p = .025$. More importantly, and contrary to the results reported earlier for forced-report accuracy, this time a comparison of the re-paired and novel context conditions revealed a marginally significant difference, with higher performance in the re-paired (M = 67, SD = .23) than in the novel (M = .60, SD = .26) context condition, $t(43) = 1.92$, $p = .061$. To understand this apparent discrepancy between free- and forced-report results, it is vital to note that the measure of hit rates in free-report recognition depends not only on memory, but also on a number of metacognitive factors, such as overall confidence, the propensity to use DK responses, and the accuracy of metacognitive monitoring (see Higham, 2007; Koriat & Goldsmith, 1996, for models of free- and forced-report performance). Although discussion of such complex relationships is beyond the scope of the present study, it is still useful to acknowledge here that context effects may affect free-report performance while having no discernible effect on actual memory quality.

Finally, returning to the basic observation that context reinstatement does enhance item recognition memory, it is also worth noting that previous studies on the context reinstatement effect that have used unique contexts for each studied item have invariably employed a within-subjects design. The present study extends the demonstrations of the context reinstatement effect in such a setting to a between-subjects design. It is often the case that the empirical patterns observed in within- and between-subjects designs can differ. In fact, McDaniel and Bugg (2008) argued that a vast number of manipulations known to enhance memory often do so only in a within-subjects design. A striking example comes from a recent investigation by Jones and Pyc (2013) of the production effect—an enhancement of memory performance due to speaking aloud studied items. Jones and Pyc not only showed that the production effect is absent from the between-subjects design (but see Bodner, Taikh, & Fawcett, 2014, for different results), but also demonstrated that the relative benefits of words spoken aloud in a within-subjects design actually derive from an impairment to memory for words read silently in the within-subjects as compared to the between-subjects design. Against this background, it is reassuring that context reinstatement can reliably augment recognition when it is contrasted with re-paired context conditions both within and between subjects.

The main novel contribution of the present study lies in revealing that whether a context serves in reinstated or re-paired context conditions has important consequences for subsequent memory for this context: Specifically, reinstating the exact item–context probe at a recognition test augments subsequent recognition of this context. We argue that this observation of enhanced memory for contexts that have served in the reinstated condition is related to recent investigations into the effects of testing (cf. Kornell et al., 2011), as well as the research on the memorial benefits of reminding (MacLeod et al., 2012). The common feature of these lines of investigation is that re-presentation of previously studied information is not sufficient to confer full benefits for subsequent memory performance. The testing effect demonstrates that active retrieval of information from memory is better than simple restudy, whereas the effect of reminding shows that additional presentations of study stimuli benefit memory most if they lead to the retrieval of previous presentations (e.g., Wahlheim et al., 2014). The present study links these recent lines of investigations to the literature on the context reinstatement effect.

The effects of context reinstatement in recognition are often considered from the perspective of dual-process theories of recognition. It has been argued that reinstating context may at least sometimes lead to recollection of item–context associations (e.g., Koen et al., 2013; Macken, 2002). The recollection account of the context reinstatement effect remains consistent with our finding of continued effects of context reinstatement. Recollection is often described as a memory process of retrieving both item and contextual information, and memory access to contextual information is precisely the mechanism that we deem responsible for augmenting memory for context in our study.

Importantly, a second mechanism is sometimes postulated to be responsible for the effects of context reinstatement. Winograd, Karchmer, and Russell (1971) argued that context reinstatement benefits may occur if a context becomes so integrated with item information that the two become unitized

(see also Levy, Rabinyan, & Vakil, 2008; Tibon, Vakil, Goldstein, & Levy, 2012). In this scenario, reinstating context at test means presenting the full unitized representation, which results in a stronger feeling of familiarity than does a situation in which an item is presented out of context. Although in principle it is possible that such unitized processing could have contributed to the context reinstatement effect in our study, we consider such a possibility unlikely. First, our materials included random pairings of separate faces and landscape photographs that would most likely be difficult to unitize. Second, unitized processing of an item and context may lead to better recognition of a unit, but some recent observations have indicated that such facilitation comes at a cost to memory for parts of the unit (Ahmad & Hockley, 2014; Pilgrim, Murray, & Donaldson, 2012). In our study, we tested memory for isolated contexts in the second test, and if the benefits to item memory in the first test came from unitized processing, this would suggest that we should have detected costs to memory for contexts in the second test, when these contexts were presented in isolation. In fact, we found a benefit, which seems inconsistent with the unitized-processing hypothesis. Further studies could pursue this line of reasoning by employing study conditions more favorable for item–context unitization and investigating whether reinstating context under such conditions would lead to a cost in memory for the context.

To summarize, our study has demonstrated that context reinstatement plays an important role in recognition, affecting both memory for tested items and memory for context itself, as well as metamemory processes building on memory information. The next step in research on the immediate and continued effects of processing a reinstated context could be directed toward integrating various measures (e.g., memory accuracy, metamemory measures, or such introspective measures as remember–know procedure) and specific effects (e.g., context reinstatement, continued effects of context reinstatement, or the fan effect) that have been used to gain insight into the nature of the context reinstatement effect.

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