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 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 facilitation conferred by presentation of the same context with a different study item. Reinstating study context at test led to better accuracy in 2-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 (Experiment 1) and between subjects (Experiment 2) manipulations. Critically, in a subsequent recognition test for the contexts themselves, contexts serving previously in the reinstated condition were recognized better than contexts serving previously in the re-paired context condition. This constitutes the first demonstration of continuous effects of context reinstatement for memory for context.

Keywords: Context effects, Recognition, Recollection

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When an item 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 have 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 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 study instructions emphasize interactive encoding of 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 an observation that the majority of studies documenting the context reinstatement effect employed instructions

which 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 required intentional encoding of both studied items and their contexts (Hanczakowski, Zawadzka, & Coote, 2014).

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 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 item and its context when context is reinstated at test comes from studies analyzing the context reinstatement effect from the perspective of dual-process models of recognition. Dual-process models postulate that identification of a target in a recognition test may occur either by assessment of item information only – a process termed familiarity –or by retrieval of 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 by 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. (2003) showed that benefits of context reinstatement in 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 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 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 memory representation of context more than processing of the same context with a different study item (in the re-paired context condition). This idea comes 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) shows 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 simply restudying the information. Thus, if memory information for a reinstated context is retrieved alongside item information when context is reinstated, then this could lead to better subsequent memory for this context compared to a condition in which this 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 comes from the literature on reminding. Recent studies show 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; Wahlheim, Maddox, & Jacoby, 2014; see also MacLeod, Pottruff, Forrin, & Masson, 2012, for related findings). Thus, presenting cues for the second time leads to strengthening of memory for the original targets for these cues, even under conditions under which participants are not explicitly directed towards retrieval of these targets. This is related to the issue of context reinstatement inasmuch as participants in the context reinstatement studies are also not directed towards retrieval of context information. To the extent, however, to which 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 long-term retention of context information.

The present study examined the effect of context reinstatement for subsequent memory for 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 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 is crucial. This comparison holds the number of presentations of contexts equal and varies only their item pairing during the recognition test. Any difference in recognition performance between the reinstated and re-paired conditions constitutes the 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 contexts that 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 were not 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 appearing in both the re-paired and reinstated test forms in the preceding recognition test will have been encountered equally often during the procedure, any difference in their recognisability will 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 judgements and decide whether to volunteer or withhold a response in recognition test. The primary motivation for these additional measures here is 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 showing reliable effects of context reinstatement for recognition, at least in the metamemory measures. We further assessed whether context reinstatement would enhance subsequent recognition of contexts themselves. Experiment 1 used the same design as Experiment 1 of Hanczakowski et al. (2014), i.e. with context conditions manipulated within a single study-test list, with one exception of an additional second test in which recognition for contexts used previously in the reinstated and re-paired context conditions was tested. Experiment 2 investigated the same issues in a between-participants 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. A

novel set of 96 black-and-white context photographs depicting landscape, 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, 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 which served as foils in a recognition test. Three within-participants context conditions, with 16 trials per condition, were included: reinstated (the studied face re-presented with the same context at study), re-paired (using context photographs presented with a different face), and novel (using 16 context photographs not yoked with any faces and thus not 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) 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 Hanczakowski, Pasek, Zawadzka, & Mazzoni, 2013; Beaman, Hanczakowski, & Jones, 2014). This testing procedure includes, apart from the usual 2AFC recognition test, two additional steps that require 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 corresponds to the usual 2AFC recognition, 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 in their forced-report response on a scale 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 confidence judgments. The three-step testing procedure was used here because the results obtained by Hanczakowski et al. (2014, Experiment 1) showed that metacognitive measures – the rate of DK responses in the free-report test and the mean of confidence judgments – may be more sensitive to the effects of context reinstatement than the measure of hit rates in the common 2AFC test. Also, both the rate of DK responses and the mean of confidence judgments were examined despite their conceptual similarity because these two measures were not always consistent in the study of Hanczakowski et al. (see Experiment 2).

The first test of face recognition was immediately followed by a second recognition test in which memory for context was probed. Thirty-two context photographs 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 the procedure 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 on 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 number of targets on both sides) and a context photograph was presented in between. Participants were clearly instructed that their recognition decisions should concern 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. Responses for each step were self-paced. In the following recognition test for context, studied contexts and novel foils were presented on two sides of the screen (with equal number 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, mean confidence judgements, and forced-report recognition accuracy can be found in Table 1. We first analyzed performance in the face recognition test across reinstated, re-paired and novel context conditions and then we analyzed the aftereffects of processing context in the reinstated and re-paired context conditions on subsequent context recognition.

Face recognition. The full analysis of face recognition results was conducted with a set of one-way 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 forced-report recognition, and the means of confidence judgments[1]. All ANOVAs were significant, $F(2, 90)$ = 14.39, MSE = .02, $p < .001$, η_p^2 = .24, for the rate of DK responses, $F(2, 90)$ = 11.14, MSE =

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

.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 confidence judgments. We conducted planned

comparisons contrasting first novel and re-paired context conditions and then re-paired and

reinstated context conditions. The former comparison is not crucial for the purpose of the

study and serves mostly to replicate the full pattern reported in Hanczakowski et al. (2014).

The main focus here on the latter comparison which speaks directly to the presence or

absence of the context reinstatement effect.

The comparison of novel and re-paired context conditions in terms of metamemory

measures revealed that participants responded DK more often in the novel context than in

the re-paired context condition, $t(45) = 2.20$, $SE = .03$, $p = .03$, $d = 0.34$, and also that

participants were more confident in their forced-report recognition decisions in the re-

paired context 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 context

affect 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 context than in the reinstated context condition, $t(45) = 3.21$, $SE = .03$, $p = .002$, $d =$

0.49, and also that participants were more confident in their forced-report recognition

decisions in the reinstated context than in the re-paired context condition, $t(45) = 4.45$, $SE =$

.12, $p < .001$, $d = 0.66$. Further, the comparison of the hit rates in forced-report recognition

revealed that discrimination was better in the reinstated context than 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 affects face recognition performance in this setup. Although in our previous investigation that used the same procedure (albeit with a different set of materials) we found a reliable effect of context reinstatement only in metamemory measures (see Experiment 1 in Hanczakowski et al., 2014), our other experiments found such effects also in the measure of recognition discrimination (Experiments 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 contexts previously serving in the reinstated context and re-paired context conditions was also performed for both metamemory measures and the measure of forced-report recognition hit rates. The analyses of metamemory measures failed to demonstrate any differences between 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 previously served in the reinstated context condition compared to contexts that 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 context is augmented when this context serves in the reinstated context condition, beyond strengthening resulting from a mere re-presentation of 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 item and its context.

For exploratory purposes, we also analyzed performance in the context recognition task conditionalized on performance on item recognition 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 for which the tested context accompanied successful and unsuccessful item recognition in the first test. Four participants were excluded due to missing cells. A resulting 2 (context condition: reinstated vs. re-paired) x 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 context previously serving 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 context that 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 context reinstatement in terms of item recognition performance. This, however, needs to be treated with caution as a direct contrast between reinstated and re-paired contexts for which an incorrect item recognition decision was 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 which has often been elusive in the recognition literature (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 for this context. This analysis revealed that reinstated contexts are subsequently remembered better than re-paired contexts. This result indicates that memory access to representations of reinstated contexts strengthens these representations, supporting subsequently better ability to discriminate these contexts from novel ones, over and above the advantage that accrues merely from encountering contexts in a recognition test (and at study).

The support for the benefits of memory retrieval of context information comes, however, with a caveat. 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 as a by-product of memory processes themselves (Koriat, 2012) and thus differences in memory performance are more often than not accompanied by differences in metamemory measures. It seems thus possible that the lack of metamemory effects in the present study may reflect 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, replicate, we conducted a second experiment in which we manipulated item-to-context pairings in a between-participants 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 will be able to consistently support face recognition, which could induce participants in this group to rely more on context information at test. By contrast, contexts in the re-paired context group will 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 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-participants design meant that in the reinstated context group all 48 target faces in the first test were presented with their yoked context photographs along with a novel face, whereas in the re-paired context group all 48 target faces in the first test were presented with context photographs yoked with a different face. The novel context condition was not included in the present study which meant that 16 context photographs 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 judgements, 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 forced report responses was higher when 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 replicate those of Experiment 1.

Context recognition. The analysis of metamemory measures revealed that the rate of DK responses was lower and confidence in forced report responses was higher for previously reinstated compared to 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 rate in the forced-report step revealed that participants were better at recognizing previously reinstated than 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) x 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, η_p^2 = .05, with better performance for contexts previously serving in the reinstated context condition. The main effect of item recognition was also significant, $F(1, 78) = 4.83$, *MSE* = .004, *p* = .031, η_p^2 = .06, with overall higher context recognition for context previously accompanying 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 needs to be treated with caution as a direct contrast between reinstated and re-paired contexts for which an incorrect item recognition decision was 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 serving in the reinstated condition are subsequently more accurately recognized than contexts serving in the re-paired condition. This occurs despite each type of context having been encountered equally often during the procedure. This result again indicates that memory representations of reinstated context are retrieved at the time of a recognition test, leading to better memory for these contexts, an effect that accompanies the benefits of context reinstatement for item recognition. In the present experiment this conclusion, derived in Experiment 1 only from the recognition accuracy measure, is augmented by the results from the metamemory measures. In contrast to Experiment 1, where recognition accuracy and metamemory measures produced inconsistent results, in the present experiment both types of measures pointed to stronger memory representation for contexts previously reinstated rather than re-paired. This finding suggests that the lack of effect on metamemory measures in Experiment 1 was likely due to insufficient statistical power.

Although the present results are well accounted for by the hypothesis postulating retrieval-based enhancement of context memory, an alternative explanation is also possible. As argued earlier, the use of the between-participants design in the present experiment could induce participants to rely on context more in the reinstated rather than the re-paired context group. This increased reliance on context may also mean that

participants in the reinstated context group spent longer time scrutinizing context photographs at test than participants in the re-paired context group. Thus, differences in memory for context in the present experiment could be at least partially explained by the duration of exposure to context photographs rather than to the way associative retrieval affected reinstated contexts. To assess this possibility, we analyzed response latencies for free- and forced-report steps of the face recognition test. A 2 (test step) x 2 (context group) mixed ANOVA revealed a significant main effect of test step, $F(1, 78) = 1159.47$, $p < .001$, which unsurprisingly demonstrates that participants were faster to respond in the second, forced-report step of the test. Importantly, both the main effect of condition and the interaction were not significant, Fs < 1, and, if anything, mean response latencies were numerically *shorter* in the reinstated context compared to re-paired context group ($M =$ 2876 ms vs. $M =$ 2983 ms, collapsed across test steps). Thus, as well as the contexts being encountered an equal number of times, it is clear that the subsequent recognition advantage for reinstated versus re-paired contexts cannot be due to additional time spent processing those contexts, but rather must be due to the particular item-context configuration in which they were 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 revealed that reinstated context may augment item recognition discrimination, particularly when participants integrate item and context information at study (Hockley, 2008). The present investigation confirms the reliability of this context reinstatement effect under encoding instructions emphasizing intentional processing of both studied items and their contexts.

Going beyond these previous findings, the present study reveals also lasting aftereffects of processing a reinstated context for memory of contexts. These continued effects of context reinstatement take the shape of enhanced subsequent memory for contexts relative to contexts that were presented at test re-paired with different items to those with which they were 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 failed to materialize (e.g., Dodson & Shimamura, 2002; Murnane & Phelps, 1993; 1995). Indeed, the present study used the procedure developed for our previous investigation of the context effects in recognition (Hanczakowski et al., 2014, Experiment 1), where 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 conducted several as yet unpublished experiments using both faces and words as study materials with encoding instructions either asking participants to intentionally encode context information or instructions not mentioning context information at all. All of these experiments showed 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., 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 seemingly insensitive measure of recognition discrimination. At the same time, we do not deny that factors such as encoding instructions (see Hockley, 2008) or distinctiveness of context (see Murnane et al., 1999) may well play an important role in determining the magnitude of the context reinstatement effect, a role that could be further elucidated with the use of metamemory measures.

It is worth noting that context effects on metamemory measures are not only convenient means of investigating how context affects memory processing but they may also be related to final test performance. In the present experiment, we assessed recognition performance as hit rate 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 is to focus only on responses volunteered in a free-report test. We performed such an analysis for Experiment 1, comparing again reinstated and re-paired context conditions but also re-paired and novel context conditions (two participants were removed due to missing cells). The first comparison again revealed the context reinstatement effect with higher accuracy of volunteered responses in the reinstated (M = .76, SD = .18) than in the re-paired context condition (M = .67, SD = .23, t(43) = 2.32, p = .025). More importantly, and contrary to the results reported earlier for forced-report accuracy, this time a comparison of 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 context condition (M = .60, SD = .26, 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 accuracy of metacognitive monitoring (see Higham, 2007; Koriat & Goldsmith, 1996, for models of free- and forced-report performance). While 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 discernable 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 using unique contexts for each studied item invariably employed a within-participants design. The present study extends the demonstrations of the context reinstatement effect in such a setting to a between-participants design. It is often the case that empirical patterns observed in within- and between-participants 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-participants design. As a striking example comes from a recent investigation by Jones and Pyc (2013) of the production effect – an enhancement in memory performance due to speaking aloud studied items. Jones and Pyc not only showed that the production effect is absent from the between-participants design (but see Bodner, Taikh, & Fawcett, 2014, for different results) but also demonstrated that relative benefits of words spoken aloud in a within-participants design actually derive from an impairment to memory for words read silently in the within-participants design when compared to the between-participants 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 participants.

The main novel contribution of the present study lies in revealing that whether the context serves in the 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 serving 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 retrieval of previous presentations (e.g., Wahlheim, Maddox, & Jacoby, 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 we deem responsible for augmenting memory for context in our study.

Importantly, there is also a second mechanism that 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 context becomes so integrated with item information as to 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 as compared to a situation when item is presented out of context. Although in principle it is possible that such unitized processing could contribute to the context reinstatement effect in our study, we consider such possibility unlikely. First, our materials that included random pairings of separate faces and landscape photographs would most likely be difficult to unitize. Second, unitized processing of item and context may lead to better recognition of a unit but some recent observations indicate that such facilitation comes as 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 benefits to item memory in the first test came from unitized processing, then this would suggest that we should detect 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 favourable for item-context unitization and investigating whether reinstating context under such conditions leads to a cost in memory for context.

To summarize, our study demonstrates 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 towards integrating various measures (e.g., memory accuracy, metamemory measures, introspective measures like remember/know procedure) and specific effects (e.g., context reinstatement, continued effects of context reinstatement, the fan effect) that have been used to gain insight into the nature of the context reinstatement effect.

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Table 1. The rate of 'don't know' 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 test of context recognition) and the context condition (reinstated, re-paired and novel for the face recognition test and reinstated and re-paired for the context recognition test). The novel context condition was not included in the design of Experiment 2. Experiment 1 was a within-participants design whereas Experiment 2 was a between-participants design. Standard errors of the means are given in parentheses.

	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)

Table 2. Mean hit rates in the forced report context recognition as a function of context condition and face recognition performance in Experiments 1 and 2. Standard errors of the means are given in parentheses.

	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)