Continued effects of context reinstatement in recognition

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Continued effects of context reinstatement in recognition

Maciej Hanczakowski[1], Katarzyna Zawadzka[2], and Bill Macken[1]

[1] Cardiff University, UK

[2] University of Southampton, UK

Running head: CONTINUED CONTEXT EFFECTS

Word count: 6464 (excluding references)

Author Notes

Maciej Hanczakowski, School of Psychology, Cardiff University, UK; Katarzyna

Zawadzka, Psychology, University of Southampton, UK; Bill Macken, School of Psychology,

Cardiff University, UK.

Correspondence concerning this article should be addressed to Maciej

Hanczakowski, School of Psychology, Cardiff University, Tower Building, Cardiff, CF10 3AT,

United Kingdom, email: HanczakowskiM@cardiff.ac.uk, ph: +44 (0) 29 2087 5030.

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

Continued effects of context reinstatement in recognition

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 =

---

[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 ts < 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, $F(1, 78) = 4.20$, $MSE = .01$, $p = .044$, $\eta_p^2 = .05$, with better performance for contexts previously serving in the reinstated context condition. The main effect of item recognition was also significant, $F(1, 78) = 4.83$, $MSE = .004$, $p = .031$, $\eta_p^2 = .06$, 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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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.

References

Ahmad, F. N., & Hockley, W. E. (2014). The role of familiarity in associative recognition of

unitized compound word pairs. *Quarterly Journal of Experimental Psychology*, *67,* 2301-

2324.

Beaman, C. P., Hanczakowski, M., & Jones, D. M. (2014). The effects of distraction on

metacognition and metacognition on distraction: Evidence from recognition memory.

Frontiers in Psychology, 5:439.

Bodner, G. E., Taikh, A., & Fawcett, J. M. (2014). Assessing the costs and benefits of

production in recognition. *Psychonomic Bulletin & Review, 21,* 149-154.

Diana, R. A., Yonelinas, A. P., & Ranganath, C. (2008). The effects of unitization on

familiarity-based source memory: Testing a behavioral prediction derived from

neuroimaging data. *Journal of Experimental Psychology: Learning, Memory, and*

Cognition, 34, 730-740.

Dodson, C. S., & Shimamura, A. P. (2000). Differential effects of cue dependency on item

and source memory. *Journal of Experimental Psychology: Learning, Memory, and*

Cognition, 26, 1023-1044.

Gruppuso, V., Lindsay, D. S., & Masson, M. E. J. (2007). I'd know that face anywhere!

Psychonomic Bulletin & Review, 14, 1085-1089.

Hanczakowski, M., Pasek, T., Zawadzka, K., & Mazzoni, G. (2013). Cue familiarity and 'don't

know' responding in episodic memory tasks. *Journal of Memory and Language, 69,* 368-

383.

Hanczakowski, M., Zawadzka, K., & Coote, L. (2014). Context reinstatement in recognition:

Memory and beyond. *Journal of Memory and Language, 72,* 85-97.

Higham, P. A. (2007). No special K! A signal detection framework for the strategic regulation

of memory accuracy. *Journal of Experimental Psychology: General, 136*, 1-22.

Hockley, W. E. (2008). The effect of environmental context on recognition memory and

claims of remembering. *Journal of Experimental Psychology: Learning, Memory, and

Cognition, 34,* 1412-1429.

Hockley, W. E., Bancroft, T. D., & Bryant, E. (2012). Associative and familiarity-based effects

of environmental context on memory. *Canadian Journal of Experimental Psychology, 66,*

81-89.

Jones, A. C., & Pyc, M. A. (2013). The production effect: Costs and benefits in free recall*.

Journal of Experimental Psychology: Learning, Memory, and Cognition, 40,* 300-305.

Koen, J. D., Aly, M., Wang, W.-C., & Yonelinas, A. P. (2013). Examining the causes of memory

strength variability: Recollection, attention failure, or encoding variability? *Journal of

Experimental Psychology: Learning, Memory, and Cognition, 39,* 1726-1741.

Koriat, A. (2012). The self-consistency model of subjective confidence. *Psychological Review,

119,* 80-113.

Koriat, A., & Goldsmith, M. (1996). Monitoring and control process in the strategic

regulation of memory accuracy. *Psychological Review, 103*, 490-517.

Kornell, N., Bjork, R. A., & Garcia, M. A. (2011). Why tests appear to prevent forgetting: A

distribution-based bifurcation model. *Journal of Memory and Language, 65,* 85-97.

Lehman, M., Smith, M. A., & Karpicke, J. D. (2014). Toward an episodic context account of

retrieval-based learning: Dissociating retrieval practice and elaboration. *Journal of*

Experimental Psychology: Learning, Memory, and Cognition, 40, 1787-1794.

Levy, D. A., Rabinyan, E., & Vakil, E. (2008). Forgotten but not gone: Context effects on

recognition memory do not require explicit context memory. *Quarterly Journal of*

Experimental Psychology, 61, 1620-1628.

Macken, W. J. (2002). Environmental context and recognition: The role of recollection and

familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28,*

153-161.

MacLeod, C. M., Pottruff, M. M., Forrin, N. D., & Masson, M. E. J. (2012). The next

generation: The value of reminding. *Memory & Cognition, 40,* 693-702.

McDaniel, M. A., & Bugg, J. M. (2008). Instability in memory phenomena: A common puzzle

and a unifying explanation. *Psychonomic Bulletin & Review, 15,* 237-255.

Murnane, K., & Phelps, M. P. (1993). A global activation approach to the effects of changes

in environmental context on recognition. *Journal of Experimental Psychology: Learning,*

Memory, and Cognition, 19, 882-894.

Murnane, K., & Phelps, M. P. (1995). Effects of changes in relative cue strength on context-

dependent recognition. *Journal of Experimental Psychology: Learning, Memory, and*

Cognition, 21, 158-172.

Murnane, K., Phelps, M. P., & Malmberg, K. (1999). Context-dependent recognition

memory: The ICE theory. *Journal of Experimental Psychology: General, 128,* 403-415.

Pilgrim, L. K., Murray, J. G., & Donaldson, D. I. (2012). Characterizing episodic memory

retrieval: Electrophysiological evidence for diminished familiarity following unitization.

Journal of Cognitive Neuroscience, 24, 1671-1681.

Reder, L. M., Victoria, L. W., Manelis, A., Oates, J. M., Dutcher, J. M., Bates, J. T., Cook, S.,

Aizenstein, H. A., Quinlan, J., & Gyulai, F. (2013). Why it's easier to remember seeing a

face we already know than one we don't: Pre-existing memory representations facilitate

memory formation. *Psychological Science, 24,* 363-372.

Russo, R., Ward, G., Geurts, H., & Sheres, A. (1999). When unfamiliarity matters: Changing

environmental context between study and test affects recognition memory for unfamiliar

stimuli. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25,* 488-

499.

Rutherford, A. (2004). Environmental context-dependent recognition memory effects: An

examination of ICE model and cue-overload hypotheses. *The Quarterly Journal of*

Experimental Psychology, 57A, 107-127.

Smith, S. M., Vela, E. (2001). Environmental context-dependent memory: A review and

meta-analysis. *Psychonomic Bulletin & Review, 8,* 203-220.

Tibon, R., Vakil, E., Goldstein, A., & Levy, D. A. (2012). Unitization and temporality in

associative memory: Evidence for modulation of context effects. *Journal of Memory and*

Language, 67, 93-105.

Wahlheim, C. N., & Jacoby, L. L. (2013). Remembering change: The critical role of recursive

remindings in proactive interference effects of memory. *Memory & Cognition, 41,* 1-15.

Wahlheim, C. N., Maddox, G. B., & Jacoby, L. L. (2014). The role of reminding in the effects

of spaced repetitions on cued recall: Sufficient but not necessary. *Journal of Experimental*

Psychology: Learning, Memory, and Cognition, 40, 94-105.

Winograd, E., Karchmer, M. A., & Russell, I. S. (1971). Role of encoding unitization in cued

recognition memory. *Journal of Verbal Learning and Verbal Behavior, 10,* 199-206.

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)

Table2. 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)