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ORIGINAL ARTICLE

In a context of time: the impact of delay and exposure time on the emergence of memory context effects

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Abstract Research on context-mediated facilitation of recognition memory distinguishes between the effects of reinstating the exact same context previously associated with a target and a context that is familiar but not directly associated with the target. As both effects are difficult to produce reliably in recognition experiments, attention has turned to measures that may explain inconsistencies, such as the extent to which instructions encourage association between targets and contexts. The aim of the current study was to examine the distinctive and interactive effects of three factors that may lead to variability in context effects (CEs), namely type of instructions given at learning, delay between learning and test, and exposure time for targets and contexts at learning. Using a comprehensive paradigm developed by Vakil and colleagues, with photographs of faces serving as target and context stimuli, both exposure time and delay were shown to be associated with the occurrence of CEs and appeared to interact with one another in determining the nature of these effects. Unlike several previous studies, false alarms did not increase when foils were presented with familiar contexts. Also unexpectedly, the instruction manipulation did not appear to strengthen target-context binding. It may instead have increased attention to contexts at the expense of targets, as suggested by the finding that direct memory for context improved under associative instruction conditions. Overall, the study demonstrates the importance of understanding and controlling various factors that may potentially influence the emergence of both reinstatement and familiarity-based CEs, among them exposure time and learning-to-test delay.

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Introduction

In the ongoing search for factors that affect the quality and characteristics of human memory, the context in which an item to be remembered is presented has long been considered significant. Though several different conditions have been regarded as context in learning and retrieval paradigms (Smith, & Vela, 2001), context generally refers to stimuli in the periphery of attention, while attention is focused on a memory target (Mayes, MacDonald, Donlan, Pears, & Meudell, 1992; Smith, & Vela, 2001). A context effect (CE) is said to occur when memory performance is improved, diminished, or otherwise influenced by the presence of a contextual stimulus.

Various researchers studying context-mediated facilitation of target memory have distinguished between the effects of reinstating the exact same context previously associated with a target and a context that is familiar but not directly associated with the target (e.g., Gruppuso, Lindsay, & Masson, 2007; Hanczakowski, Zawadzka, & Coote, 2014; Hanczakowski, Zawadzka, & Macken, 2015; Hockley, 2008; Vakil, Raz, & Levy, 2007). One theoretical framework for this distinction is provided by Murnane, Phelps, and Malmberg's (1999) ICE (item, context, and ensemble) model, which predicts that presenting a target (item) during the test phase with a context seen previously during the learning phase will result in a feeling of familiarity for the target. While this familiarity will likely lead

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participants to correctly recognize targets seen in the learning phase, the model also predicts increased reports of erroneous recognition (false alarms) for new targets (foils), such that no discrimination between correct and incorrect responses is expected to occur. Several studies have supported the resultant prediction that context familiarity will not lead to a net benefit in memory performance as compared to new or no context conditions (e.g., Gruppuso et al., 2007; Hanczakowski et al., 2014, 2015; Hockley, 2008; Vakil et al., 2007).

The ICE model further predicts that reinstating the exact context in which a target was presented will confer a benefit in memory performance compared to familiar context conditions, due to the encoding of a specific association (ensemble) between the item (target) and the context (Murnane et al., 1999). As shown empirically in various studies (e.g., Gruppuso et al., 2007; Hanczakowski et al., 2014, 2015; Macken, 2002; Vakil et al., 2007), this condition enables discrimination between targets and foils by improving recognition of the former without leading to false recognition of the latter.

Despite the clear rationale underlying these predictions, as well as the fact that context-mediated facilitation of target memory is widely found when tested by free or cued recall (e.g., Parker, & Gellatly, 1997; Smith, & Manzano, 2010), CEs are difficult to produce reliably in recognition experiments (Hollingworth, 2006; Smith, & Manzano, 2010; Rutherford, 2000). Inconsistencies between studies that report CEs in recognition memory (e.g., Hollingworth, 2006; Russo, Ward, Geurts, & Scheres, 1999) and others that do not (e.g., Godden, & Baddeley, 1980; Murnane, & Phelps, 1993, 1994) contributed to Hanczakowski et al., (2014) proposition that while context reinstatement does reliably affect recognition processes, the effect is subtle and therefore not always detected by the presumably insensitive measure of recognition discrimination.

Of the various attempts to elucidate this discrepancy, a prominent explanation addresses the extent to which instructions given during the learning or encoding stage direct participants to associate targets and contexts. Based on instruction manipulations aimed at maintaining the perception of targets and contexts as separate versus creating or drawing attention to item-context associations, early studies supported the possibility that CEs emerge more reliably in the latter case (Baddeley, 1982; Winograd, & Rivers-Bulkeley, 1977). More recent work has also led researchers to propose that context-based discrimination is largely dependent on the explicit encouragement of such associations (Hanczakowski et al., 2014; Hockley, 2008). Still, even studies using identical paradigms and instruction conditions have produced varying results with respect to the context reinstatement effect (Hanczakowski et al., 2015), such that the influence of instruction manipulation warrants further investigation.

The aim of the current study was to further examine the effects of associative versus non-associative instructions on context memory in combination with two additional factors that may lead to variability in the occurrence of CEs, namely the delay between the learning and test stages and the exposure time of targets and contexts at the learning stage. Broadly, the rationale for examining these two measures is based on Smith and Vela's (2001) assertion that CEs are attenuated when targets are easily remembered, as reliance on context becomes less critical. Specifically, they referred to two phenomena: (1) outshining, in which the presentation during retrieval of a target that served as a probe for recognition is sufficiently strong to render any contextual aid insignificant; and (2) overshadowing, in which deep processing of target information at encoding reduces dependence on contextual information. According to this view, the tendency of recognition tasks to be easier than recall tasks explains the decreased likelihood of finding CEs using recognition-based paradigms. Furthermore, the manipulation of variables presumed to affect task difficulty, among them target-context exposure time and learning-to-test delay, would be expected to influence the occurrence of CEs.

A delay between the learning and test stages, for example, would presumably make it more difficult to remember targets (as compared to testing immediately after the learning stage), increasing dependence on context and thereby making CEs more likely to occur. It has further been suggested that the decline of direct memory for context is more gradual than that for target memory (Mayes, 1988; Shimamura, & Squire, 1991), which would also contribute to greater dependence on context following a delay. Some support for this perspective is provided in a study by Fernandez and Glenberg (1985), who reported CEs when there was a delay between learning and testing, but not when participants were tested immediately after learning.

In the case of exposure time, another mechanism besides manipulation of task difficulty must be taken into account, as exposure time also constitutes the time provided for the creation of target-context associations (Smith, & Vela, 2001). Increasing the time that targets are presented is generally believed to make memory tasks easier, which, according to the aforementioned rationale, would lead to reduced context reinstatement effects. Meanwhile, however, increasing the time provided for the establishment and fortification of specific target-context associations would presumably result in a greater impact of context reinstatement. The conflicting effects of these two processes may also play a role in the inconsistent findings on CEs in recognition.

Table 1 Description of the experimental groups, according to experiment conditions

Group	Exposure time (s)	Delay	Instructions	*N* (males)	Mean age in years (SD)
1	4	Delayed	Non-associative	24 (7)	23.30 (1.89)
2	4	Delayed	Associative	25 (12)	23.90 (2.25)
3	4	Immediate	Non-associative	24 (12)	23.73 (3.05)
4	4	Immediate	Associative	21 (11)	25.70 (3.03)
5	6	Delayed	Non-associative	25 (12)	22.92 (2.16)
6	6	Immediate	Non-associative	28 (9)	22.89 (2.95)
7	6	Immediate	Associative	29 (8)	22.08 (2.02)

In the present study, a comprehensive paradigm developed by Vakil et al. (2007) was adapted to examine the distinctive and interactive effects of associative instructions, learning-to-test delay, and target-context exposure time on the CEs described above. With photographs of faces serving as both target and context stimuli, memory tests were performed for old (i.e., seen at learning) targets presented with the same context at learning and at test ("repeat" condition), old targets presented with contexts that had been paired with different targets at learning and were therefore considered familiar ("re-pair"), old targets presented with entirely new contexts ("new"), and old targets presented with no manipulated context ("none"). Additional conditions geared at examining false alarms included new targets (foils) with either previously seen contexts ("foil old"), new contexts ("foil new"), or no context ("foil none").

Comparison of the re-pair and new/none conditions enabled evaluation of familiarity effects while comparison of the repeat and re-pair conditions allowed us to examine the added advantage of item-context associations over familiarity alone. CEs on false alarms (incorrect recognition of foils) were assessed by comparing the foil old and foil new conditions. Based on the rationale described above, associative instructions and increased learning-to-test delay were expected to result in greater CEs, while exposure time effects were assessed to shed light on whether decreased task difficulty (expect decreased context reinstatement effect) or increased time for item-text associations (expect increased context reinstatement effect) played a stronger role.

In addition to examining CEs, which can be considered indirect tests of memory for context, the study also included assessment of direct memory for contextual stimuli. Research has shown that direct and indirect memory performance is orthogonal (Kelley, Jacoby, & Hollingshead, 1989) and guided by separable processes. Within the framework of the present study, it was believed that assessing the effects of the experimental manipulations on direct memory for context could potentially clarify the mechanisms underlying observed CEs. Overall, it was expected that increased exposure time and decreased delay would increase direct memory for context.

Method

Participants

One hundred and seventy-six undergraduate students from Bar-Ilan University who took part in the experiment to fulfill academic requirements were assigned to one of the seven experimental groups described in Table 1.[1] Written informed consent was obtained from all participants for a protocol approved by the Bar-Ilan University Institutional Review Board.

Materials

Stimuli consisted of 120 full-face color photographs of adults—60 males and 60 females, each with a resolution of 720 × 576 pixels. All faces were photographed under the same light conditions and with neutral facial expressions. The pictures were taken with permission from the XM2VTS database (Messer, Matas, Kittler, Luettin, & Maitre, 1999).

Stimuli were randomly paired to form 36 same gender study pairs, and an additional 48 faces were added to form the various test-pair combinations. Half of the pairs were males and half were females for the different target and context conditions. The stimuli were presented in random order both in the test and study phases. In each pair, the target face was marked with a red border, while the context face was marked with a black border. The location of the target and context faces was counterbalanced between the right and left side of the display. An example of the screen during the learning stage appears in Fig. 1.

[1] A 6-s exposure time/delayed learning-to-test interval/associative instructions group was not included in the study. We performed preliminary analyses of the data before running the experiment on the final participant group under these conditions and found that our instruction manipulation was unequivocally ineffective in producing any context effects. We therefore chose to omit this group from the design, on the grounds that the data from the two instruction conditions would be collapsed in our examination of the remaining independent variables (exposure time, learning-to-test delay, and context).

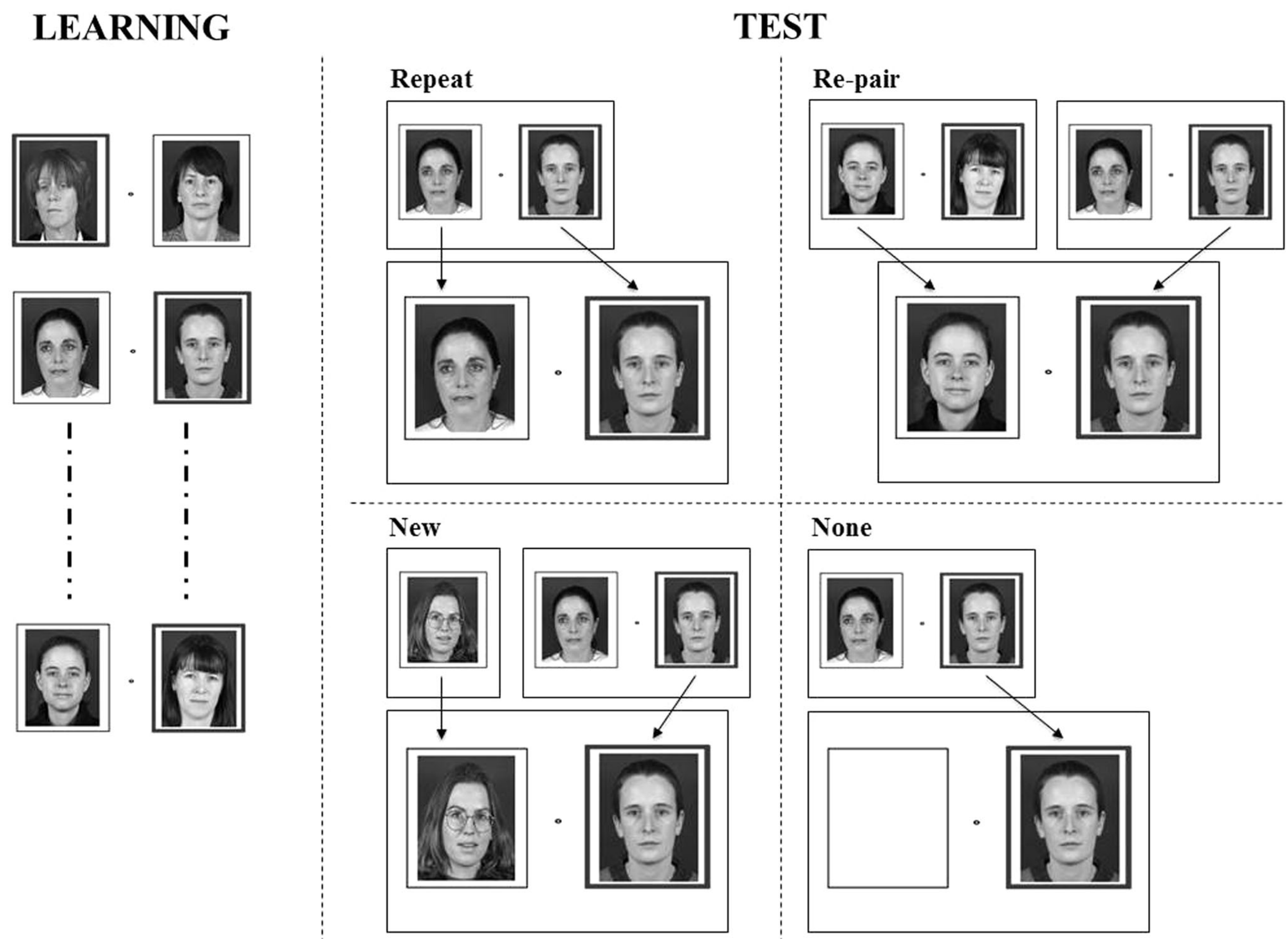

Fig. 1 Graphic representation of learning stage and four target memory trial conditions. During learning, two faces of the same gender are presented side by side. The target face is marked with a *red border* (shown here in *bold outline*) and the second face serves as the context. Constructions of the four test conditions for previously viewed targets (*repeat*, *re-pair*, *new*, and *none*) are shown

Seven types of face pairs or individual faces were presented, each forming a different test condition:

1. Six originally studied pairs ("repeat" condition).
2. Six pairs in which a studied target face was presented with a context face that had been paired with a different target face in the study phase ("re-pair" condition).
3. Six pairs in which a studied target face was presented with a context face that had not been seen during the study phase ("new" condition).
4. Six studied target faces presented alone ("none" condition).

   Examples of the four target recognition conditions are presented in Fig. 1.
5. 12 unstudied foil faces presented with context faces that had been seen in the study phase ("foil old" condition).
6. Six pairs of unstudied foil faces presented with unstudied context faces ("foil new" condition).
7. Six unstudied foil faces presented alone ("foil none" condition).

   An eighth condition was used for a separate test of direct memory for context:
8. 12 studied target faces that did not appear in any of the previous conditions paired with 12 unstudied context faces, as well as with the original context for a forced choice test. Two pairs were presented in each slide, both with the same target face, though paired once with its original context and once with alternative context. The location of the target and the previously presented contexts on the screen was balanced, appearing an equal number of times at the top and bottom of the screen.

Procedure

At the encoding phase, 36 pairs of target-context face pairs were presented for 4 or 6 s each, on a computer screen, using SuperLab (Cedrus, Inc.) to control exposure time. Participants were instructed to remember the faces with the red borders for a subsequent memory test (i.e., target). No instructions were given for the context faces that appeared with a black border alongside the target faces. In the non-associative instruction conditions, no further instructions were given, and the test was administered immediately after studying. Participants in the associative instruction conditions received interactive encoding instructions before learning. They were instructed to verbally report whether they thought the two persons in the photos were related. Participants in the immediate conditions were tested immediately after learning while in the delayed conditions, they were tested 30 min after learning.

During the testing phase, participants were told that they would view previously studied and unstudied faces, marked by a red border. Stickers with the words "yes" and "no" were placed on two keys, "A" and "L", respectively. Participants were instructed to press the key as quickly and accurately as possible, to indicate whether they had seen the face previously during the study phase (old) or not (new), regardless of the face now accompanying it. Participants were instructed to guess if unsure. They were then shown 48 test pairs (types 1–7 above) in pseudo-random order. The test was self-paced, with the participant's response triggering the appearance of the next pair.

Following the face recognition test, an additional test was administered to study recognition of context faces alone. Participants were shown 12 displays of two target-context pairs of faces that appeared one above the other (type 8, above). First was an original target-context pair, while the second was the same target accompanied by a previously unstudied context face. Participants were asked to indicate by key press which of the two pairs originally appeared during the study phase (i.e., two-alternative forced choice recognition memory test for the context faces). In the event that participants were unsure, they were asked to guess.

Results

Memory for contextual information was measured indirectly, as indicated by CEs when participants were asked directly about the target and directly when participants were asked about the context.

Indirect memory for context—context effects

A corrected hit (CH) rate score (Kroll, Yonelinas, Dobbins, & Frederick, 2002) calculated to adjust for the possible influence of response bias served as the dependent measure for memory performance accuracy. For every participant, the percentage of false alarms (FA; incorrectly recognized foils) was subtracted from percentage of hits (correctly recognized targets), for each context condition. Thus, the following variables were created: corrected repeat (repeat minus foil old), corrected re-pair (re-pair minus foil old), corrected new (new minus foil new) and corrected none (none minus foil none).

The four independent variables used in analyzing CEs under the various conditions included instruction type (associative vs. non-associative), exposure time (4 vs. 6 s), learning-to-test delay (immediate vs. delay), and context (for targets: repeat, re-pair, new, and none; for foils: old, new, none).

In a preliminary analysis, we found that instruction type affected only the overall CH rate, $F(1, 174) = 22.575$, $p < 0.01$, $\eta_p^2 = 0.115$, such that a higher CH rate was found under non-associative ($M = 60.93$, SD = 15.82) compared to associative ($M = 44.78$, SD = 15.83) judgment. Thus, to simplify the analyses, data were collapsed over the two instruction conditions.

A mixed-design 2 × 2 × 4 ANOVA was used to analyze the effects of exposure time (6 vs. 4 s), learning-to-test delay (immediate vs. 30-min delay), and context (repeat, re-pair, new, and none) on CH rate. The latter is a within-subject factor. There was a main effect of exposure time, $F(1, 172) = 5.18$, $p < 0.05$, $\eta_p^2 = 0.029$, such that overall, a higher CH rate was shown for 6 s compared to 4 s. The main effect of delay did not reach significance, $F(1, 172) = 0.99$, $p = 0.32$, $\eta_p^2 = 0.006$. The main effect of context was significant, $F(3, 516) = 10.38$, $p < 0.01$, $\eta_p^2 = 0.057$, as were the delay by exposure time interaction, $F(1, 172) = 7.74$, $p < 0.01$, $\eta_p^2 = 0.043$ and the delay by exposure time by context interaction, $F(3, 516) = 2.63$, $p < 0.05$, $\eta_p^2 = 0.015$.

To identify the source of the triple interaction, repeated measures ANOVAs (2 × 4) were conducted for the two delay conditions separately. In the immediate condition, there was no main effect of exposure time, $F(1, 100) = 0.197$, $p = 0.66$, $\eta_p^2 = 0.002$. Context reached significance, $F(3, 300) = 4.79$, $p < 0.01$, $\eta_p^2 = 0.046$. There was an interaction between context and exposure time, $F(3, 300) = 3.19$, $p < 0.05$, $\eta_p^2 = 0.031$. Specifically, in the 6-s condition there was a main effect of context, $F(3, 168) = 7.53$, $p < 0.01$, $\eta_p^2 = 0.119$, with a follow-up analysis using post hoc contrasts (with adjustments for multiple comparisons), showing that CH rate was significantly higher in the repeat condition than in the re-pair, new, and none conditions, $F(1, 56) = 7.39$, $p < 0.01$, $\eta_p^2 = 0.117$. As mentioned above, no main effect was found for context in the 4-s exposure time condition, $F(3, 132) = 0.97$, $p = 0.4$, $\eta_p^2 = 0.022$ (see Fig. 2a).

In the delayed condition, there was a main effect of exposure time, as CH rate was significantly higher under

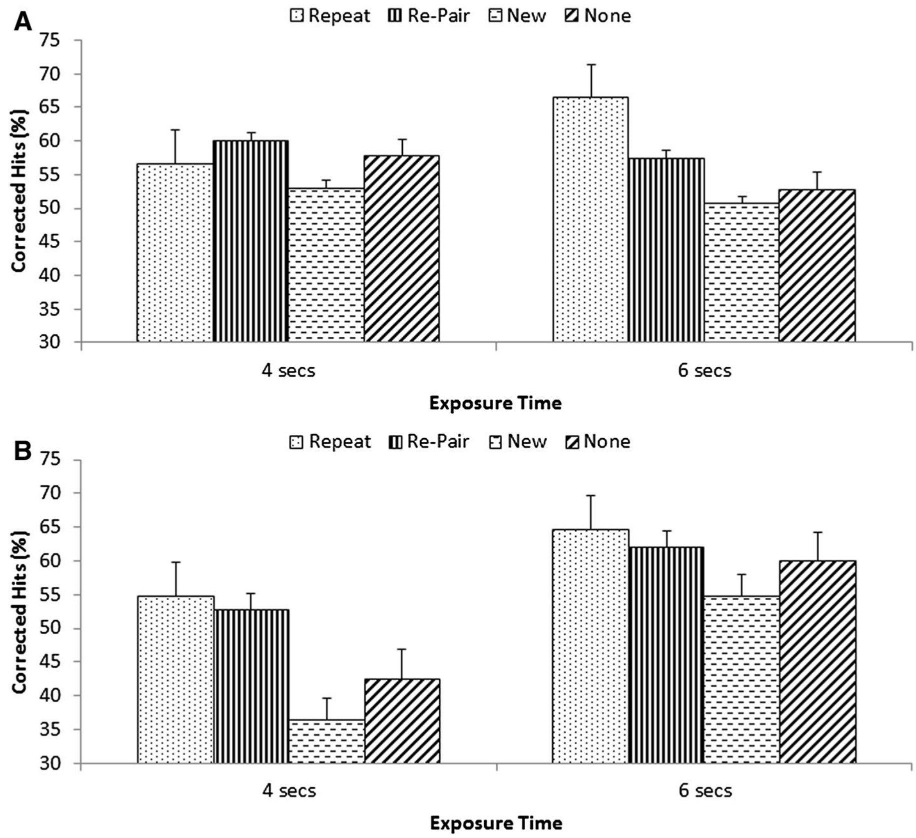

Fig. 2 Percentage of corrected hits as a function of exposure time (4 and 6 s) and context conditions under immediate (**a**) and delayed (**b**) tests

the 6-s condition, $F(1, 72) = 8.43$, $p < 0.01$, $\eta_p^2 = 0.105$. The main effect of context was also significant, $F(3, 216) = 5.49$, $p < 0.01$, $\eta_p^2 = 0.071$. The context by exposure time interaction did not reach significance, $F(3, 216) = 0.78$, $p = 0.5$, $\eta_p^2 = 0.011$. Over exposure times, the CH rate was significantly higher in the re-pair compared to the new condition, $F(1, 73) = 14.74$, $p < 0.01$, $\eta_p^2 = 0.168$. No further comparisons reached significance.

To summarize, it seems that the triple interaction between delay, exposure time, and context type for CH rate stems from the finding that in the immediate condition, CEs emerged only under long (6 s) and not short (4 s) exposure time, while in the delayed condition, CEs emerged under both exposure time conditions (see Fig. 2b). The effect that emerged in the longer exposure time/immediate condition involved an advantage of the repeat over the re-pair context condition, reflecting the advantage of exact context reinstatement or item-context association (Vakil et al., 2007). In contrast, the effect in the delayed condition involved an advantage of the re-pair over the new context condition, reflecting an unexpected familiarity effect on the CH measure (see Fig. 2b).

To assess CEs on false alarms and possibly shed light on the familiarity effect exhibited in the delayed condition, a mixed-design $2 \times 2 \times 2 \times 3$ ANOVA was used to analyze the effects of instruction type (associative vs. non-associative), exposure time (6 vs. 4 s), learning-to-test delay (immediate vs. 30-min delay), and context (foil old, foil new, and foil none) on FA rate.[2] There was main effect of instruction type, with more FAs occurring in the associative than in the non-associative condition, $F(1, 169) = 20.363$, $p < 0.01$, $\eta_p^2 = 0.108$, and a main effect of context, $F(2, 338) = 9.455$, $p < 0.01$, $\eta_p^2 = 0.053$ (see Fig. 3). There were no further significant main effects or interactions. Pairwise comparisons (corrected for multiple comparisons) showed that there were significantly more false alarms in the foil new condition than in both the foil old ($p < 0.05$) and foil none ($p < 0.01$) conditions. There were also significantly more false alarms in the foil old than in the foil none condition ($p < 0.05$). Thus, contrary to predictions, a familiarity effect was not exhibited for false alarms.

None of the other effects were significant, including the main effect of delay, $F(1, 169) = 2.98$, $p = 0.086$, $\eta_p^2 = 0.017$, main effect of exposure time, $F(1, 169) = 0.629$, $\eta_p^2 = 0.004$, delay by exposure time interaction, $F(1, 169) = 0.000$, $p = 0.989$, $\eta_p^2 = 0.000$, and

[2] As previously noted (see footnote 1), a 6-s exposure time/delayed learning-to-test interval/associative instructions group was not included in the study, such that there were only seven experimental groups.

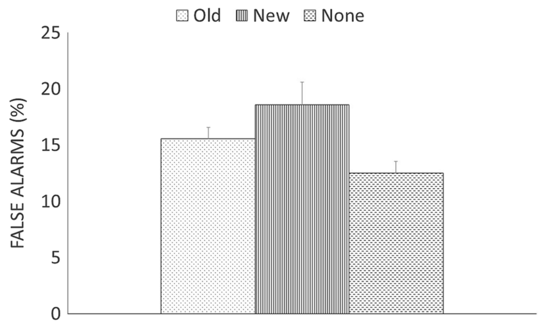

Fig. 3 Percentage of false alarms over instruction type, exposure time, and learning-to-test delay conditions

delay by instruction type interaction, $F(1,\ 169) = 3.738$, $p = 0.055$, $\eta_{\mathrm{p}}^2 = 0.022$.

Direct memory for context

To analyze direct memory for context, a between subjects ANOVA was employed using three variables: instruction type (associative vs. non-associative), learning-to-test delay (immediate vs. delay), and exposure time (4 vs. 6 s). Instruction type had a significant effect on direct memory of context, $F(1,\ 175) = 32.44$, $p < 0.01$, $\eta_{\mathrm{p}}^2 = 0.16$. Higher memory rates were found for associative instructions ($M = 78.44$ %, SD $= 13$) than for non-associative instructions ($M = 65.26$ %, SD $= 13.59$). Neither the delay effect, $F(1,\ 175) = 2.47$, $p = 0.19$, $\eta_{\mathrm{p}}^2 = 0.014$, nor the exposure time effect, $F(1,\ 175) = 0.024$, $p = 0.89$, $\eta_{\mathrm{p}}^2 = 0.000$ were significant. In all groups, direct memory for context information was significantly above chance ($p < 0.01$).

Discussion

To extend research highlighting the inconsistency of CEs in recognition-based memory tests, the present study aimed to examine the contributions of instruction type, learning-to-test delay, and target-context exposure time to context-dependent recognition and discrimination. While some of these variables have previously been investigated separately (e.g., Baddeley, 1982; Fernandez, & Glenberg, 1985), to our knowledge this was the first study to address the relationships and interactions between them.

Most prominently, the findings showed that both exposure time and delay were associated with the occurrence of CEs and appeared to interact with one another in determining the nature of these effects. As detailed below, the specific conditions and manner in which each of these variables affected indirect and direct memory for context may shed light on the mechanisms by which context mediates target memory.

Before considering the findings on delay and exposure time, it should be noted that contrary to predictions and previous reports (e.g., Baddeley, 1982; Winograd, & Rivers-Bulkeley, 1977; Hanczakowski et al., 2014; Hockley, 2008), the instruction manipulation in the current study was not associated with significant CEs. Thus, it appears that instructing participants to report whether the two individuals portrayed in the photographs were related did not cause increased association between target and context. One possible explanation is that these instructions instead led to increased attention to context, at the expense of attention to memory targets. This possibility, which essentially describes a trade-off between target and context, is supported by our finding that overall, memory for targets was better and false alarms were lower following non-associative instructions than following associative instructions, while the opposite was found in the direct test of memory for contextual stimuli.

When data from the two instruction conditions were collapsed, the pattern of results depicting the other independent variables showed that when the test occurred immediately after learning, there was a context reinstatement effect on corrected memory for targets for the 6 s, but not the 4 s, exposure time condition. In contrast, when participants were tested following a 30-min delay, there was a familiarity effect on corrected memory for targets, over exposure times.

Perhaps our most surprising finding involved the emergence of a familiarity effect on the corrected measure of accuracy in target recognition. Previous studies on CEs have consistently reported that previously seen context that has not been directly associated with a target leads to increases in both hits and false alarms (e.g., Gruppuso et al., 2007; Hanczakowski et al., 2014, 2015; Hockley, 2008; Vakil et al., 2007). With no effect on discrimination, corrected accuracy variables that incorporate both of these measures have therefore not shown CEs. In the present study, however, an overall advantage was found for repaired over new context following the longer learning-to-target delay. This effect appeared to stem from the fact that over all other measures, the false alarm rate was lower for foils presented with a familiar context than for foils presented with a new context, and not higher as predicted.

Though not consistent with previous research on CEs, this finding can be understood within the framework of the "recall to reject" phenomenon (Castel, & Craik, 2003). Recall to reject is a memory strategy in which remembering several details aids in the rejection of other details. Applied to the CE paradigm, it would dictate that the identification of familiar contexts could improve participants' ability to reject foils, thereby preventing an increase in false alarms. While the current findings are preliminary, they appear to show that differential conditions in general and learning-to-test delay in particular may be significant in determining whether old contexts will or will not lead to increased false alarms. Notably, Vakil et al., (2010) also reported the emergence of context familiarity effects after a learning-to-test delay.

Though false alarms were higher in the new foil condition than in the old foil condition under immediate test conditions as well, there was not a familiarity effect on corrected hits, likely because the hit rate did not go up as much. Assuming that immediate testing results in an easier task, this is in line with Smith and Vela's (2001) idea that dependence on context (and resulting CEs) is a function of task difficulty.

There was, however, an advantage for repeated target-context associations in the immediate testing condition, specifically for the 6-s exposure time. This occurred despite the presumption that this would be the least difficult condition in terms of both delay and exposure time (indeed, corrected hit rates overall were higher for the 6-s condition than for the 4-s condition). This suggests that, as proposed, extended time to create and strengthen target-context associations in the longer exposure time condition can outweigh the relative ease of the task in determining whether these associations constitute an advantage. Furthermore, the lack of this effect under more difficult delayed testing conditions may support the possibility that memory for item-context associations fades significantly with the half hour following the learning stage.

While the instruction manipulation did not appear to have on CEs, which can be considered indirect illustrations of memory for context, associative instructions were linked to reduced memory for targets, increased false alarms, and increased memory for directly tested context. This is consistent with previous studies that have demonstrated the orthogonality of direct and indirect measures of memory for context in healthy participants (Levy et al., 2008) and in patients who have sustained traumatic brain injuries (Vakil, Biederman, Liran, Groswasser, & Aberbuch, 1994; Vakil, Openheim, Falck, Aberbuch, & Groswasser, 1997).

Overall, this study demonstrates the importance of understanding and controlling the various factors that may potentially influence the emergence of both reinstatement and familiarity-based CEs, among them exposure time at the encoding stage and learning-to-test delay. Specifically, the finding that these two variables affect the extent to which context influences memory may have ecological importance in attempts to improve memory performance through reinstatement of contextual conditions. The results further suggest that instruction manipulations do not always serve the intended purpose of strengthening item-context associations, and may instead result in reduced attention to targets due to a focus on context. Finally, the importance of distinguishing between direct and indirect tests of contextual information tests was highlighted and validated.

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Compliance with ethical standards

Ethical statement The study has been approved by the ethics committee of Bar-Ilan University and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. All participants gave their informed consent prior to their inclusion in the study.

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