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Forgotten but not gone: Context effects on recognition do not require explicit memory for context

Daniel A. Levy [ab]; Elinor Rabinyan [a]; Eli Vakil [c]
[a] Gonda Multidisciplinary Brain Research Center, Bar-Ilan University, Ramat-Gan, Israel [b] Department of Neurobiology, Weizmann Institute of Science, Rechovot, Israel [c] Department of Psychology and Gonda Multidisciplinary Brain Research Center, Bar-Ilan University, Ramat-Gan, Israel

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Short article

Forgotten but not gone: Context effects on recognition do not require explicit memory for context

Daniel A. Levy
Gonda Multidisciplinary Brain Research Center, Bar-Ilan University, Ramat-Gan, Israel, and Department of Neurobiology, Weizmann Institute of Science, Rechovot, Israel

Elinor Rabinyan
Gonda Multidisciplinary Brain Research Center, Bar-Ilan University, Ramat-Gan, Israel

Eli Vakil
Department of Psychology and Gonda Multidisciplinary Brain Research Center, Bar-Ilan University, Ramat-Gan, Israel

Context effects on recognition memory provide an important indirect assay of associative learning and source memory. Neuropsychological studies have indicated that such context effects may obtain even if the contexts themselves are not remembered—for example, in individuals impaired on direct tests of memory for contextual information. In contrast, a recent study indicated that the effects of temporal context reinstatement on visual recognition obtain only when the contextual information itself was explicitly recollected. Here we report that the effects of reinstatement of spatial-simultaneous context on visual object recognition memory obtain irrespective of whether those context stimuli are explicitly recognized. We suggest that spatial-simultaneous context effects might be based on ensemble unitization of target and context stimuli at encoding, whereas temporal context effects may require recollective processes.

Keywords: Memory; Context; Binding; Recognition; Source memory; Association.

Constancy or change in our experiential context may greatly affect our memory for objects and events. The basic memory context effect (CE) is that target information is better recalled and recognized at test in the presence of elements of the encoding context (e.g., Murnane, Phelps, & Malmberg, 1999; Smith, Glenberg, & Bjork, 1978; Smith & Vela, 2001). Interestingly, there are indications that the presence of contextual features influences memory performance even if

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Correspondence should be addressed to Daniel A. Levy, Gonda Multidisciplinary Brain Research Center, Bar-Ilan University, Ramat Gan 52900, Israel. E-mail: daniel.levy@weizmann.ac.il

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direct memory of such contextual information is impaired. For example, patients with closed-head injuries who exhibit general declarative memory impairments, including deficits in source memory, nevertheless benefit in recognition memory performance from context reinstatement at retrieval (Vakil, Golan, Grunbaum, Groswasser, & Aberbuch, 1996a; Vakil, Openheim, Falck, Aberbuch, & Groswasser, 1997). Furthermore, elderly individuals, whose source memory may be differentially impaired relative to younger people, nevertheless equally benefit from context reinstatement (Naveh-Benjamin & Craik, 1995; Vakil, Melamed, & Even, 1996b). Furthermore, healthy younger individuals used contextual contingencies when making recognition judgements even if they were not able to verbalize such contingencies (Manier, Apetroaia, Pappas, & Hirst, 2004).

In contrast, a recent study of recognition memory for scenic photographs (Schwartz, Howard, Jing, & Kahana, 2005) manipulated context reinstatement by having some probes immediately preceded at test by others that had been in proximity to them in the study sequence. Notably, such precedence at test by photos that had appeared at study even as many as eight trials before or after a target probe increased the high-confidence recognition rate of the targets—but only if the contextual photos were similarly recognized with a high degree of confidence. This finding was interpreted as indicating the dependence of such context effects on recollective processes.

In the paradigm employed by Schwartz and colleagues (2005), the context structure was temporal—that is, stimuli appearing before or after the targets, rather than simultaneously (albeit peripherally) as in most CE studies. It is possible that such temporal context affects memory differently from spatial-simultaneous context. Furthermore, Schwartz and colleagues questioned participants serially about all stimuli. Each probe was both the target of a direct memory query and the context for the adjacent probes. In contrast, in earlier CE studies, independence between direct and indirect measures of context was inferred indirectly, based on impairment in direct memory for a small sample of contextual information in a separate test. A more rigorous trial-by-trial measurement of memory for context stimuli, in the presence of the targets with which they appeared at study, might reveal a dependence of CE on explicit memory even for spatial/simultaneous context. Additionally, the above-mentioned studies examined CEs in populations (closed head injury and aged adults) with various memory impairments. It has not yet been determined whether CEs on visual recognition memory may be independent of explicit memory for context in healthy young adults. Additionally, there are several different possible levels of context. Context may be environmental (e.g., the room in which an encoding episode occurred; Smith & Vela, 2001) or take the form of peripheral characteristics of target stimuli (e.g., the font colour, Macken, 2002, in which a study list of words was presented). Alternatively, context may be local—discrete, often trial-unique stimuli that accompany memory targets at encoding (e.g., Vakil, Raz, & Levy, 2007; Winograd & Rivers-Bulkeley, 1977). The temporal context paradigm of Schwartz et al. (2005) utilizes sequential trial-unique pictures, such that each target has a particular local temporal context matrix. The above-mentioned studies that demonstrated intact CEs in the absence of explicit memory for context utilized global contexts (e.g., font type or voice; Naveh-Benjamin & Craik, 1995). It remains to be shown whether spatial-simultaneous local contexts yield CEs even when they are not explicitly remembered.

Accordingly, in the present study, we attempted to determine whether CEs of spatial-simultaneous context on visual recognition memory in healthy young adults require explicit memory for contextual information. Participants studied serially presented pairs of coloured drawings of common objects, of which one was marked as the target for a subsequent memory test. Participants subsequently made recognition judgements on test pairs that included original pairs (repeat condition), previously viewed pictures paired with different old (re-pair condition) or new (target old–context new or target new–context old conditions) pictures, or pairs of new pictures (target new–context new condition). Importantly, at test, participants were queried on every test trial about both target-position and context-position pictures. This provides the same specificity of assessment as in the study of Schwartz et al. (2005). Since CEs on judgements of foils are potentially informative about the memory strength for context (Vakil et al., 2007), we analyse the data for hits and false alarms separately, rather than combining these measures in the form of *d′* or corrected hits. Among other considerations, the false-alarm rate by which the hit rate would be adjusted is the same for repeat and re-pair conditions, so no insight into the strength of CEs is gained by such correction.

Based on our prior findings (Vakil et al., 2007), we predicted that the presence of old context pictures would increase the probability of recognition of old target pictures (and of false-alarm responses to foils in the target positions). Furthermore, the test format enabled us to ascertain whether a parallel effect would obtain: whether old targets would increase recognition of old contexts and false alarms for foils in the context position. Most importantly, based on the studies mentioned above, we predicted that CEs would not depend on explicit recognition of the context pair members—that is, of the context stimulus when the target was the recognition probe and of the target when the context stimulus was the recognition probe. Since in a given trial it cannot be determined whether recognition was abetted by the reinstated pair member or would have been successful even without it, we examined the overall relationship between CEs in the various test conditions and explicit memory for the relevant pair members, between and across participants.

Materials and method

Participants

Participants were 28 young adults (5 males; mean age 22.9 years, range 21–26), with normal or adjusted-to-normal vision. All were undergraduate students who volunteered in return for academic requirement credit or payment. Informed consent was obtained from all participants for a protocol approved by the Bar Ilan University Institutional Review Board.

Materials

Stimuli were 360 colour drawings of common objects obtained from various Internet sources, including fruits and vegetables, tools, sporting goods, electrical and electronic devices, animals, furniture, and clothing, each approximately 8 × 6 cm on-screen size. A total of 180 pictures were quasi-randomly paired to form 90 study pairs, each comprising different object categories. One pair member was marked as the target for remembering and the other as local context (see below). An additional 180 pictures supplemented them to form the various test pair combinations.

Five types of picture pairs were presented at test:

1. 30 originally studied pairs (target old, context old–same; "repeat" condition);
2. 30 pairs of studied target pictures with pictures seen at study as the context of other targets (target old, context old–different; "re-pair" condition);
3. 30 pairs of studied target pictures with new pictures in context positions (target old, context new; TOCN condition);
4. 30 pairs of new target-position pictures with pictures seen at study as contexts (target new, context old, TNCO condition);
5. 60 pairs of new object pictures in both target and context positions (target new, context new, TNCN condition).

Procedure

At encoding, participants serially viewed 90 object picture pairs on computer screen for 4 s each, using SuperLab (Cedrus, Inc.). Responses and response times were recorded by the program. In each screen, the upper picture was marked as the memory target by a 2-cm blue border, and the context picture appeared 5 cm below it without a border. Participants were instructed to perform an interactive encoding task (Baddeley, 1982) to enhance their memory of the target picture—namely, to judge whether the portrayed objects were likely to be found in the same location under normal circumstances. Yes/no responses were given by keypress after the disappearance of the two pictures and immediately revealed the next set of pictures. There were four training trials. A 2-min halfway break was provided.

During a 20-min delay period, participants performed a verbal fluency task and forward and backward digit span tasks (not reported here). Before the test, participants were told that they would see studied and unstudied pictures, accompanied by the same or different studied and unstudied pictures. They were instructed to indicate by rapid and accurate key press if the probe picture had appeared at study (old) or not (new), irrespective of the other picture now accompanying it, and to guess if unsure. They then saw 180 picture pairs (Types 1–5 above) in pseudorandom order, with two serial screen displays for each pair. In the first screen, the upper (target position) picture was flanked by the legends "appeared" (in a green font) or "did not appear" (in a red font) on either side, and participants were instructed to respond using keys marked in corresponding colours and sides in an upper row of the keyboard. In the second screen, the legends flanked the lower picture (context position), and a second response was required, using two other red/green marked keys on the corresponding sides in a lower row of the keyboard. The target position probe was always queried before the context position probe in order to maintain the target–context relationship established at encoding. Test trials were self-paced, with responses triggering a 1-s blank screen, followed by the next probe screen or trial.

Results

Hits and false alarms in the various context conditions are portrayed in Figure 1. As explained above, we analysed CEs on hits and false alarms separately, to provide unconfounded assessments of context memory strength. For hits, we performed a two-way repeated measures analysis of variance (ANOVA), with factors of context condition (repeat vs. re-pair vs. TOCN, for targets/TNCO, for contexts) and encoding role (target vs. context). This revealed a significant effect of context condition, $F(2, 54) = 24.07, p < .01$, and a significant effect of encoding role, $F(1, 27) = 13.22, p < .01$, without significant interaction between these effects, $F(2, 54) = 1.17, p > .3$. We then performed separate repeated measures ANOVAs and planned repeated contrasts separately for target and context hit rates. For targets, there was a significant main effect of context condition, $F(2, 54) = 11.90, p < .01$. Repeated contrasts showed that target recognition in the repeat condition was significantly greater than that in the re-pair condition, $F(1, 27) = 16.75, p < .01$, but there was no difference between re-pair and TOCN conditions, $F(1, 27) < 1.0$. For contexts, there was a significant main effect of context condition, $F(2, 54) = 18.97, p < .01$. Repeated contrasts showed that context recognition in the repeat condition was significantly greater than that in the re-pair condition, $F(1, 27) = 26.48, p < .01$, but there was no difference between re-pair and TNCO conditions, $F(1, 27) < 1.0$. Thus, for both target and contexts, there were significantly more hits in the repeat than in the re-pair conditions, but the re-pair condition did not significantly differ from the "new" conditions (TOCN for target probes, TNCO for context probes).

We then examined CEs on false alarms by conducting a two-way repeated measures ANOVA with factors of context condition (TNCO, for target-position foils/TOCN, for context-position foils vs. TNCN) and test position (foils in the target vs. the context positions). This revealed a significant effect of context condition, $F(1, 27) = 53.50, p < .01$, no effect of test position $F(1, 27) < 1.0$, and a significant interaction between these factors, $F(1, 27) = 7.71, p = .01$. This interaction reflects the fact that there were more false alarms for context-position foils accompanied by old targets (11.4%) than for target-position foils accompanied by old contexts (8.9%), but fewer false alarms for context-position foils accompanied by target-position foils (4.2%) than

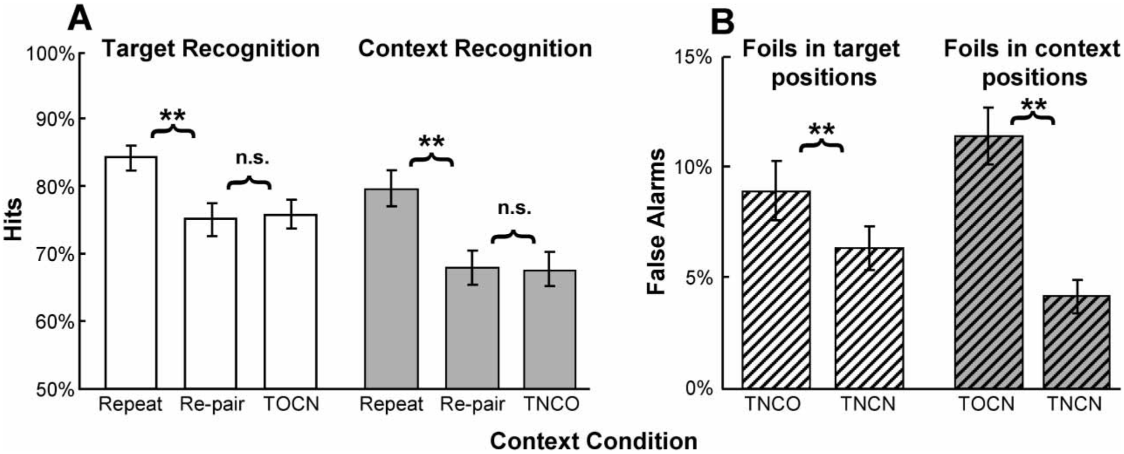

Figure 1. *Recognition memory for coloured object pictures in various probe + contextual pair-associate (CPA) combinations: repeat (target old, context old; same pairing); re-pair (target old, context old; different pairing); TOCN (target old, context new); TNCO (target new, context old); TNCN (target new, context new). (A) Percentage of hits for target and context stimuli under various conditions. The context effects are the differences between the condition in which the CPA accompanying the probe picture was identical to that in the encoding trial (repeat) and those in which it was rearranged (re-pair) or new (TOCN for target recognition and TNCO for context recognition). (B) Percentage of false alarms to new foil pictures in target or context positions. The context effect is the difference between conditions of context reinstatement (TNCO for target-position foils, TOCN for context-position foils) or change (TNCN). Brackets indicate standard error of the mean.* $^{**}p < .01$.

for target-position foils accompanied by context-position foils (6.4%). Possibly this was because context-position stimuli were always queried after target-position stimuli.

Having found highly significant CEs on both hits and false alarms, we then explored the degree of dependence of these CEs on explicit memory for context pair members. We used two analyses for this purpose. First, looking at group data as a whole, we examined the mean conditional probabilities of probe hits or false alarms as a function of whether their context pair members were endorsed (Table 1). These probabilities were derived by calculating (a) probability target hit if context endorsed, $\mathrm{pTHIT}\cap\mathrm{CHIT}/(\mathrm{pTMISS}\cap\mathrm{CHIT} + \mathrm{pTHIT}\cap\mathrm{CHIT})$, for repeat and re-pair conditions, or $\mathrm{pTHIT}\cap\mathrm{CFA}/(\mathrm{pTMISS}\cap\mathrm{CFA} + \mathrm{pTHIT}\cap\mathrm{CFA})$, for the TOCN condition; (b) probability target hit if context *not* endorsed, $\mathrm{pTHIT}\cap\mathrm{CMISS}/(\mathrm{pTMISS}\cap\mathrm{CMISS} + \mathrm{pTHIT}\cap\mathrm{CMISS})$, for repeat and re-pair conditions, or $\mathrm{pTHIT}\cap\mathrm{CCR}/(\mathrm{pTMISS}\cap\mathrm{CCR} + \mathrm{pTHIT}\cap\mathrm{CCR})$, for the TOCN condition; (c) probability context hit if target endorsed, $\mathrm{pCHIT}\cap\mathrm{THIT}/(\mathrm{pCMISS}\cap\mathrm{THIT} + \mathrm{pCHIT}\cap\mathrm{THIT})$, for repeat and re-pair conditions, or $\mathrm{pCHIT}\cap\mathrm{TFA}/(\mathrm{pCMISS}\cap\mathrm{TFA} + \mathrm{pCHIT}\cap\mathrm{TFA})$, for the TNCO condition; and (d) probability context hit if target *not* endorsed, $\mathrm{pCHIT}\cap\mathrm{TMISS}/(\mathrm{pCMISS}\cap\mathrm{TMISS} + \mathrm{pCHIT}\cap\mathrm{TMISS})$, for repeat and re-pair conditions, or $\mathrm{pCHIT}\cap\mathrm{TCR}/(\mathrm{pCMISS}\cap\mathrm{TCR} + \mathrm{pCHIT}\cap\mathrm{TCR})$, for the TNCO condition.

We then conducted two-way repeated measures ANOVAs, with factors of pair member endorsement (hit or miss) and context condition (repeat vs. re-pair), first for target hits and then for context hits (the two leftmost columns of Table 1). For targets, this analysis revealed a significant main effect of endorsement, $F(1, 27) = 7.45$, $p = .01$, a significant main effect of context condition, $F(1, 27) = 18.45$, $p < .01$, and no interaction effect, $F(1, 27) < 1.0$. Similarly, for contexts this analysis revealed a significant main effect of endorsement, $F(1, 27) = 13.65$, $p < .01$, a significant main effect of context condition,

Table 1. *Mean conditional probabilities of recognition in various context conditions*

	Condition			
	Repeat	*Re-pair*	*TOCN*	*TNCO*
Probability target hit if context endorsed	.858 (.018)	.780 (.026)	.800 (.057)	
Probability target hit if context *not* endorsed	.750 (.037)	.669 (.038)	.745 (.023)	
Probability context hit if target endorsed	.817 (.027)	.710 (.028)		.623 (.076)
Probability context hit if target *not* endorsed	.714 (.040)	.581 (.043)		.670 (.027)

Note: TOCN = target old and context new (foil). TNCO = target new (foil) and context old. *SEM* (standard error of the mean) in parentheses. For formulae employed, see text.

$F(1, 27) = 13.60, p < .01$, and no interaction effect, $F(1, 27) < 1.0$. Thus, although explicit recognition of a context pair member is associated with higher probabilities of the endorsement of its paired probe, significant CEs obtain even without such explicit recognition.

An additional analysis tested the correlations between the strength of each participant's CEs and the proportion of the relevant probes accompanied by hits for those probes' pair members. As mentioned above, if explicit memory for pair members were required for CE, there should be a positive correlation across participants between each of those proportions and relevant CEs. However, correlational analysis indicates that was not the case. The Pearson product–moment correlation between participants' repeat versus re-pair CE on targets and their proportions of target hits accompanied by context hits was nominally (but not significantly) negative, $r(26) = -.136, p = .5$. The correlation between repeat versus re-pair CE on contexts and their proportions of context hits accompanied by target hits was negligible, $r(26) = .104, p = .6$. Thus, explicit recollection of context pair members indeed did not predict CE strength for individual participants; it even showed a very slight tendency to predict the opposite pattern.

The results portrayed in Figure 1 indicate no differences between the TOCN-target or TNCO-context hit rates and those of their respective re-pair conditions. However, those hit rates include both cases in which new context pair members were correctly rejected and cases in which they were falsely endorsed. By examining Table 1, we can compare hit rates for conditions in which actual old context pair members were hit (repeat and re-pair on the first and third lines) with those in which new context pair members were correctly rejected (for target hits: TOCN, the second line of the table; for context hits: TNCO, the fourth line of the table). A two-way repeated measures ANOVA with the factors context condition (repeat, re-pair, and TOCN/TNCO) and stimulus role (target or context) yielded a significant main effect of context condition, $F(2, 54) = 23.86, p < .01$, a significant main effect of stimulus role, $F(1, 27) = 12.83$, $p < .01$, and no interaction, $F(2, 54) < 1.0$. Repeated within-subject contrasts between context conditions confirmed that the difference between repeat and re-pair conditions was significant, $F(1, 27) = 20.21, p < .01$, as was seen in the analysis of the data portrayed in Figure 1. Importantly, the re-pair versus combined TOCN and TNCO contrast also indicated a significant difference between conditions, $F(1, 27) = 4.58$, $p < .05$. Thus, after removing cases in which new context pair members were mistakenly endorsed, there obtained an overall graded CE pattern, repeat > re-pair > TOCN/TNCO.

Discussion

This experiment demonstrated that effects of spatial-simultaneous context on visual recognition memory do not require explicit memory for those contexts. Such memory context effects (CEs) obtained both for probes that had been presented at study as encoding targets and for probes that had originally appeared as contexts. Probes accompanied at test by their encoding context pair members were more likely to be correctly recognized than probes accompanied by other context pairs, irrespective of whether the context pair member was recognized. This finding contrasts with the report that temporal CEs obtain only when the contextual stimulus is recognized with a high degree of confidence (Schwartz et al., 2005). Though earlier studies had suggested that spatial-simultaneous CEs are independent of conscious recognition of contexts (Manier et al., 2004; Naveh-Benjamin & Craik, 1995; Vakil et al., 1996a, 1997), the current study is the first that demonstrates that such is the case for local contextual stimuli in healthy young adults, via assessment of all contextual stimuli in the experimental session.

The present results contrast with some of those reported by Humphreys and colleagues (Bain & Humphreys, 1988; Humphreys, 1978; Humphreys & Bain, 1983). They found that in recognition of members of word pairs, the "double miss rate" (i.e., when old pair members are both not recognized) does not differ between what we call repeat and re-pair conditions. If CEs are expected to obtain regardless of explicit memory of the context, we would expect that more targets would be remembered when accompanied at test by their original contexts than when accompanied by other old contexts, thus leading to a lower double miss rate for repeat than for re-pair conditions. However, there are several differences between the present study and those of Humphreys and colleagues that might account for the differences. One is that their studies used word pairs while this study uses visual objects. Another is that participants in those studies responded to the word pairs simultaneously rather than in serial order as in the current study. Most importantly, however, in those studies the encoding of the word pairs was either not interactive (words of the pair were studied one at a time), or shallow (rote repetition of the pairs), while the encoding in the present experiment was interactive and deep (requiring formation of a cognitive representation of the relationship between the two portrayed objects). It is indeed possible that under conditions of shallow encoding the ensemble formed between target and context is not sufficiently strong to yield CEs if the contexts are not explicitly recognized. Notably, when Humphreys and colleagues instructed participants to engage in deep encoding (an interactive image generation task; Bain & Humphreys, 1988), they found a difference in the double miss rate between repeat and re-pair conditions, in consonance with the current findings.

Why might temporal CEs be dependent on explicit memory for contextual stimuli while spatial-simultaneous CEs are not? One possibility is that spatial-simultaneous stimuli may undergo a process of unitization, especially if encoded interactively (as in the present study). This process is akin to the formation of an ensemble representation posited to be requisite for memory contexts effects by ICE (item, context, ensemble) theory (Murnane et al., 1999). The presentation of one stimulus would then increase the activation of the other, raising the likelihood of probe recognition via increased familiarity strength, without recollection via relational representations (Quamme, Yonelinas, & Norman, 2007). Alternatively, spatial-simultaneous CEs might utilize a familiarity signal capable of indexing memory not only for individual items but also for within-domain associations (Mayes, Montaldi, & Migo, 2007). Such familiarity strength may be sufficient to affect recognition judgements for a unitized probe, even if it does not lead to a judgement of recognition of the contextual stimulus itself. In contrast, for sequentially presented stimuli, such unitization, ensemble formation, or within-domain familiarity-based association might not be possible.

It has been proposed that these two types of processes that may differentially underlie spatial-simultaneous CE and temporal CE are supported by different brain regions. The processes of unitization or formation of within-domain associative familiarity are purported to be executed by extrahippocampal medial temporal lobe regions such as the perirhinal cortex (Mayes et al., 2007; Quamme et al., 2007). In contrast, the effects of temporal context are said to be mediated by hippocampal processing, which in response to repetition of a stimulus reconstructs patterns of context that were present in other medial temporal lobe areas (such as entorhinal cortex) at the time of its initial presentation. That recovered context representation then serves as a cue for the recognition of a subsequent probe (Howard, Fotedar, Datey, & Hasselmo, 2005). Patients with limited hippocampal lesions might therefore specifically show diminished effects of temporal context reinstatement, but intact spatial-simultaneous CEs, while more extensive medial temporal lobe damage would impair both kinds of CE.

In a previous study (Vakil et al., 2007), we have noted that memory CEs appear to reflect multiple cognitive factors. This conclusion resulted from our observation of additive CEs, expressed by a step-increase in hit rate from conditions of no context to new context (reflecting the addition of stimulus array constancy) to re-pair (reflecting the additive familiarity of old contexts even when presented with different targets than at study) to repeat (reflecting target–context binding). In the current study, the no-context condition was not employed, since it is not relevant to the temporal context structures. Among the conditions employed, we once again found robust binding effects (repeat vs. re-pair). The effect of additive familiarity (re-pair vs. TOCN for target probes and re-pair vs. TNCO for context probes), while not apparent in the overall performance measures (Figure 1), was found when correcting for false endorsement of new context pair members.

As we report here (and in Vakil et al., 2007), context reinstatement increases not only recognition hits, but also false alarms. At first glance, this may lead one to conclude that memory CEs are simply a manipulation of response bias and therefore of little interest. It is therefore important to stress that CEs are important not because they show how context reinstatement *improves* memory, but because they show how it *affects* memory. Precisely those effects—beneficial or detrimental—provide an important estimate of the memory for the contextual information itself: an indirect appraisal of memory complementing direct assessments via source memory or pair-associate learning studies. The current results, in which CEs are independent of explicit memory for context, bolster this claim.

In the CE paradigm, both memory for the context information itself and the memory for its association with its paired target may be appraised without explicit queries and, therefore, without the application of retrieval strategies that may occur in more explicit tests. We believe this is why CEs are preserved, while direct measures of source/contextual memory are impaired, in patients with closed head injuries, which generally involve frontal lobe damage (Vakil et al., 1996a). The findings of the current study provide additional evidence for the robustness of recognition memory CEs and indicate the usefulness of the CE paradigm for the investigation of associative learning and source memory.

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REFERENCES

Baddeley, A. (1982). Domains of recollection. *Psychological Review*, *89*, 708–729.

Bain, J. D., & Humphreys, M. S. (1988). Relational context: Independent cues, meanings or configurations? In G. M. Davies & D. M. Thomson (Eds.), *Memory in context: Context in memory* (pp. 97–137). Oxford, UK: John Wiley & Sons.

Howard, M. W., Fotedar, M. S., Datey, A. V., & Hasselmo, M. E. (2005). The temporal context model in spatial navigation and relational learning: Toward a common explanation of medial temporal lobe function across domains. *Psychological Review*, *112*, 75–112.

Humphreys, M. S. (1978). Item and relational information: A case for context independent retrieval. *Journal of Verbal Learning and Verbal Behavior*, *17*, 175–187.

Humphreys, M. S., & Bain, J. D. (1983). Recognition memory: A cue and information analysis. *Memory & Cognition*, *11*, 583–600.

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.

Manier, D., Apetroaia, I., Pappas, Z., & Hirst, W. (2004). Implicit contributions of context to recognition. *Consciousness and Cognition*, *13*, 471–483.

Mayes, A. R., Montaldi, D., & Migo, E. (2007). Associative memory and the medial temporal lobes. *Trends in Cognitive Sciences*, *11*, 126–135.

Murnane, K., Phelps, M., & Malmberg, K. (1999). Context-dependent recognition memory: The ICE theory. *Journal of Experimental Psychology: General*, *128*, 403–415.

Naveh-Benjamin, M., & Craik, F. I. (1995). Memory for context and its use in item memory: Comparisons of younger and older persons. *Psychology and Aging*, *10*, 284–293.

Quamme, J. R., Yonelinas, A. P., & Norman, K. A. (2007). Effect of unitization on associative recognition in amnesia. *Hippocampus*, *17*, 192–200.

Schwartz, G., Howard, M. H., Jing, B., & Kahana, M. J. (2005). Shadows of the past: Temporal retrieval effects in recognition memory. *Psychological Science*, *16*, 898–904.

Smith, S. M., Glenberg, A., & Bjork, R. A. (1978). Environmental context and human memory. *Memory & Cognition*, *6*, 342–353.

Smith, S. M., & Vela, E. (2001). Environmental context-dependent memory: A review and meta-analysis. *Psychonomic Bulletin & Review*, *8*, 203–220.

Vakil, E., Golan, H., Grunbaum, E. Groswasser, Z., & Aberbuch, S. (1996a). Direct and indirect measures of contextual information in brain-injured patients. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology*, *9*, 176–181.

Vakil, E., Melamed, M., & Even, N. (1996b). Direct and indirect measures of contextual information: Older versus young adult subjects. *Aging, Neuropsychology, and Cognition*, *3*, 30–36.

Vakil, E., Openheim, M., Falck, D., Aberbuch, S., & Groswasser, Z. (1997). Indirect influence on modality on direct memory for words and their modality: Closed-head-injured and control participants. *Neuropsychology*, *11*, 545–551.

Vakil, E., Raz, T., & Levy, D. A. (2007). Multifactorial context effects on visual recognition memory. *Quarterly Journal of Experimental Psychology*, *60*, 916–923.

Winograd, E., & Rivers-Bulkeley, N. T. (1977). Effects of changing context on remembering faces. *Journal of Experimental Psychology: Human, Learning and Memory*, *3*, 397–405.