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Conceptual and Perceptual Similarity Between Encoding and Retrieval Contexts and Recognition Memory Context Effects in Older and Younger Adults

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We examined the hypothesis that older adults' deficits in contextual memory result from difficulties in contending with partial encoding-to-retrieval changes in the context. We measured effects of contextual change and constancy on recognition memory for words, in older and younger adults. We assessed the ability to adjust to partial contextual changes by manipulating encoding–retrieval context similarity: identical, new and unrelated, conceptually similar, or perceptually similar. For both older and younger adults, identical and conceptually similar contexts benefited recognition of target words, whereas perceptually similar contexts did not. Older adults did not make more false alarms. In contrast, older adults' direct recognition of contextual stimuli was at chance. These results indicate that retrieval processes, rather than encoding or rigidity in the use of contextual cues, are implicated in older adults' difficulties in memory for contextual information.

Key Words: Aging—Context effect—Source memory—Recognition.

THE decline in various aspects of memory with advancing age is well recognized (Salthouse, 2003), but the cognitive processes and related brain structures responsible for these changes have yet to be determined. One widely held notion is that older adults have a specific deficit in associative binding, including associating content and context, concatenating features into a compound memory item, or generating relations between different items (Bayen, Phelps, & Spaniol, 2000; Chalfonte & Johnson, 1996). Such deficits in binding might be responsible for the many reports that source memory—information about the episodic context of a cognitive experience—is more affected by aging than is item memory (Hashtroudi, Johnson, & Chrosniak, 1989; Spencer & Raz, 1994, 1995). A related explanation of the decline of source-memory abilities with advancing age is that aging is marked by a decrease in the use of frontal-lobe-dependent encoding strategies enabling effective acquisition and retention of contextual or source information (Wegesin, Jacobs, Zubin, Ventura, & Stern, 2000).

We may obtain a valuable perspective on the causes of the impairment of source memory in aging by examining the influence of contextual reinstatement versus change on remembering, that is context effects (CEs; Smith, Glenberg, & Bjork, 1978; Vakil, Raz, & Levy, 2007). At retrieval, the presence of the original encoding context serves as a cue that facilitates the strategic or automatic recollection of the target information (Murnane & Phelps, 1994; Steyvers & Malmberg, 2003). Importantly, such CEs provide an indirect indication of the retention of source information: To the extent that memory of that contextual (i.e., source) information and its connection to the memory target is stronger, its reappearance at retrieval will better serve as a cue for remembering the target. Operationally, the same contextual information that is required to be recollected in a source-memory task is presented, withheld, or changed in order to measure CEs on target memory. In other words, source-memory tasks directly assess the same memories that context-effects paradigms indirectly assess.

Several earlier studies have demonstrated that healthy older adults (e.g., Naveh-Benjamin & Craik, 1995; Vakil, Melamed, & Even, 1996), patients with traumatic brain injury (Vakil, Biederman, Liran, Groswasser, & Aberbuch, 1994; Vakil, Golan, Grunbaum, Groswasser, & Aberbuch, 1996; Vakil, Openheim, Falck, Aberbuch, & Groswasser, 1997), and patients with Parkinson's disease (Vingerhoets, Vermeule, & Santens, 2005) who exhibit source-memory deficits may nevertheless derive full benefit from the reinstatement of the encoding context in memory for target stimuli. For example, we have shown that for older adults, the recognition of pictures of common objects was aided by their presentation in their original visual contexts to the same extent as for young adults. In contrast, the older adults' direct memory for those visual contexts was significantly impaired (Vakil, Melamed, & Even, 1996; but see Bayen et al., 2000). Such findings suggest that older adults' and neurological patients' difficulties with source-memory tasks do not result from encoding deficits but rather from retrieval-strategy issues. If encoding were affected, then impairment should have been manifest in indirect as well as in direct expression of memory for context.

In the present study we examine an alternative to the binding-deficit theory, focusing on a retrieval-stage process that characterizes memory demands in many ecological conditions. Retrieval contexts are often similar but not identical to encoding contexts. Older adults might have difficulties in using transformed contextual arrays as effective retrieval cues. To test this hypothesis, we examined the effect of the reinstatement of context (jointly presented visual words that were read aloud but explicitly marked as not being memory targets) on recognition memory for target words, in groups of older and younger adults. Because it has recently been reported that aging impairs conceptually but not perceptually driven retrieval processes (Stuart, Patel, & Bhagrath, 2006), we assessed recognition performance for target words under four conditions: exact reinstatement of the encoding context; presentation of the test word with a context word that was *conceptually* similar to the word that accompanied it at study; presentation of the test word with a context word that was *perceptually* similar to the word that accompanied it at study; and presentation of the test word with a new context word. With this fourfold manipulation of context, we aimed first to replicate and extend our previous finding that CEs are intact in older adults, using words rather than visual objects. Second, we aimed to examine older adults' context-processing abilities. If deficits in contextual memory result from difficulties in effectively utilizing partial contextual information, then only exact context reinstatement should benefit target recognition in older adults, relative to the new-context condition. However, if CEs are exhibited by older adults in the altered-context conditions, then their ability to accommodate partial contextual changes (at least in the verbal realm) would seem not to be the source of their contextual memory deficits. We further aimed to determine whether older adults' performance would be more greatly taxed by conceptual than by perceptual context transformations (as would be predicted by the findings of Stuart et al., 2006).

In the second part of this experiment, we directly assessed memory for the context words themselves in a two-alternative forced-choice recognition task. This test is arguably easier than the yes–no recognition used in other studies, and it should benefit the older adults' performance. These two tests enable us to optimally compare direct and indirect expressions of source or context memory. On the basis of our prior findings (Vakil, Melamed, & Even, 1996), we expected to find dissociation in older adults between intact CEs (for the original contexts) and impaired direct memory for contexts.

Methods

Participants

There were 60 volunteer participants in this study, recruited from two age groups. All participants were self-reportedly in good health, and specifically they neither suffered from neurological or psychiatric ailments nor had they experienced head trauma that caused memory impairment. There were 28 younger adults (22 women and 6 men), with a mean age of 29.8 years (range = 21–35 years, $SD = 3.7$) and a mean education level of 16 years ($SD = 1.5$). There were 28 older adults (10 men and 18 women), with a mean age of 75.1 years (range = 65–91 years, $SD = 6.5$) and a mean education level (adjusted for war disruption and subsequent vocational training) of 11.1 years ($SD = 4.2$). We excluded the 4 other participants (2 younger and 2 older) from our analyses because we considered them to be outliers (their information showed a deviation > 2 *SD* from their group means). All of the younger adults were students at Bar-Ilan University, and the older adults were recruited primarily from the Jezreel Valley area in Israel. We obtained written informed consent from all participants for a protocol approved by the Bar-Ilan University Institutional Review Board.

Materials

The stimuli consisted of 240 concrete Hebrew nouns, which we selected from the lists prepared by Rubenstein, Anaki, Henik, Drori, and Paran (2005), presented in pairs. One member of the word pair was marked by an arrow as the target for remembering and the other word served as context. This manipulation established attentional disparity between the words and created a target–context relationship (Vakil et al., 2007). In the encoding phase, the researcher presented 120 words that were semantically and perceptually unrelated to each other (60 pairs); the researcher presented 120 additional words with them at test. At test, the researcher presented seven types of word pairs.

The first type of word pair consisted of 15 of the originally studied pairs, which we refer to as target old, context old (TOCO).

The second type consisted of 15 pairs in which a studied target probe was accompanied by a word that was conceptually related to its originally paired context word. We refer to this type as target old, context similar–conceptual (TOCS-C). To give an equivalent English example, if the target *lamp* had been presented at study together with the context word *dog*, then at test it would have been presented with the context word *cat*. We selected these pairs from normed lists used by Vakil and Sigal (1997) and by Bergerbest and Goshen-Gottstein (2005).

The third type of word pair consisted of 15 pairs in which a studied target probe was accompanied by a word that was perceptually (phonetically) similar to its originally paired context word; we refer to this as target old, context similar–perceptual (TOCS-P). For example, if the target *grass* had been presented at study together with the context word *fan*, then at test it would have been presented with the context word *can*.

The fourth type of word pair consisted of 15 pairs in which a studied target probe was accompanied by a word that was conceptually and perceptually dissimilar to its originally paired context word. We refer to this type of pair as target old, context new (TOCN).

The fifth type of word pair consisted of 30 pairs in which an unstudied foil probe was accompanied by a word that had been presented as a context word at study. We refer to this type as target new, context old (TNCO).

The sixth type consisted of 30 pairs of new, unstudied foil probe and context words, or target new, context new (TNCN).

For the seventh type of word pair, for a separate test of direct memory for context, we constructed 15 word pairs, each containing a studied context word and an unstudied foil word (context direct). These context words were not used in the other lists.

Procedure

In the encoding phase, participants saw 60 word pairs on a computer screen for 4 seconds each, with each word appearing in a separate window on screen. An arrow under the window marked the target word. For half of the participants, the word appearing in the left window was consistently marked

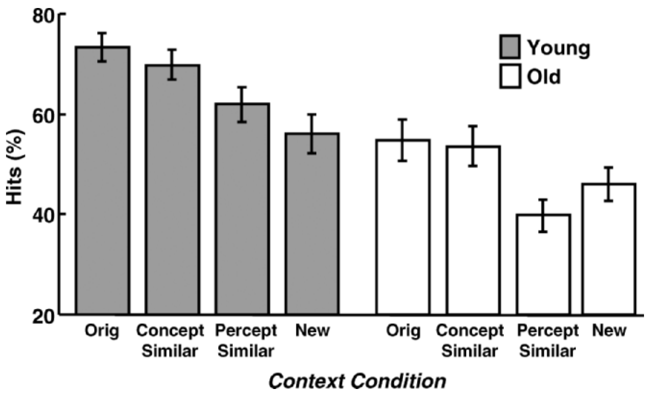

Figure 1. Percentage of hits for target word recognition by older and younger adults (both $n = 28$) under different retrieval context conditions: Original context words (Orig), conceptually similar context words (Concept), perceptually similar context words (Percept), and new context words. Bars indicate the standard error of the mean.

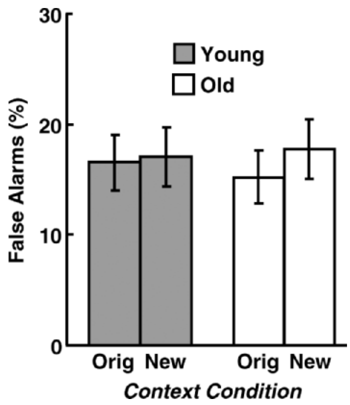

Figure 2. Percentage of false alarms for new probes under different retrieval context conditions (Orig = original context words). Bars indicate the standard error of the mean.

as the target, and for the other half, the right window held the marked target. Participants were told that they would be tested on "selective" memory for the target words, and they were instructed to read both words aloud but to remember only the marked targets.

Following an approximately 5-minute delay, during which the researcher collected demographic information, participants were tested on their recognition memory for the words marked as targets by an arrow. The participants saw 120 word pairs on the computer screen, with each word again appearing in a separate window on screen, and with the target word marked by an arrow, as at study. The word pairs were of the first six target–context types already described. Once again we had the researcher ask the participants to read the words aloud, first to ensure that they were aware of the context word, and second to better enable the phonetic similarity of the TOCS-P context words to have an effect. The researcher then asked the participants to indicate by button press whether the target word had appeared previously (old) or not (new). The rate of presentation of test trials was self-paced, with the response triggering the following trial.

After completing the test of recognition memory for target words, participants were shown 15 word pairs of the last type just described (type G), consisting of studied context words and an unstudied foil. The researcher asked the participants to indicate by button press which of the words had appeared in the encoding phase as a context word. This is a two-alternative forced-choice direct appraisal of recognition memory for the context words.

We randomized the order of presentation of the word pairs in both the study phase and the test phase over participants.

Results

Overall target-recognition measures for both groups in each condition are portrayed in Figures 1 and 2. In order to evaluate the CEs on hits and on false alarms in both age groups, we conducted two separate mixed-design analyses of variance (ANOVAs). For hits, a 2 × 4 ANOVA tested the effects of age (a between-subjects factor) and context type (a within-subjects factor). This revealed a significant main effect of age, $F(1, 54) = 15.82$, $p < .01$, $\eta^2_p = .227$. As one can see in Figure 1, the younger participants correctly recognized more of the previously seen target words as such than did the older participants (overall, 65.2% vs 48.5%). The effect of context type was also significant, $F(3, 162) = 22.31$, $p < .01$, $\eta^2_p = .292$, as was the interaction of Age × Context Type, $F(3, 162) = 2.99$, $p < .05$, $\eta^2_p = .052$. To examine the source of the interaction, we conducted two simple analyses: 2 × 3 (Age × Context Types: old, conceptually similar, and perceptually similar) and 2 × 2 (Age × Context Types: perceptually similar and new). The first ANOVA yielded significant effects of group and condition (ps $< .01$), but no interaction, $F(2, 108) = 1.14$, $p > .3$, $\eta^2_p = .021$. The second yielded significant effects of group and condition (ps $< .01$), and additionally a significant interaction, $F(2, 54) = 8.18$, $p < .01$, $\eta^2_p = .132$. This interaction reflects the recognition of targets accompanied by perceptually similar contexts being poorer than those accompanied by new contexts for the older adults only.

We did not obtain the consistent age difference in target detection in rejection of new foil targets (Figure 2). A 2 × 2 mixed-design repeated measures ANOVA revealed no significant differences between age groups, $F(1, 54) < 1.0$, or context types, $F(1, 54) = 1.29$, $p = .26$, $\eta^2_p = .023$. This suggests that the age difference in target detection was not a function of response bias.

For purposes of comparison with other studies, we examined the effect of basic old-context reinstatement on discrimination ability (d') in the two age groups. For younger adults, the discrimination of target and foil probes accompanied by old-context (TOCO-TNCO) $d' = 1.79$; accompanied by new-context (TOCN-TNCN) $d' = 1.25$, yielding a CEs d' difference of 0.54. For older adults, old-context (TOCO-TNCO) $d' = 1.26$, and new-context (TOCN-TNCN) $d' = 0.92$, yielding a CEs d' difference of 0.34. A 2 × 2 mixed-design repeated measures ANOVA tested the effects of age and context type on dependent variable d', revealing significant main effects of age, $F(1, 54) = 11.09$, $p < .01$, $\eta^2_p = .170$, and of context type, $F(1, 54) = 22.70$, $p < .01$, $\eta^2_p = .296$, but no interaction between them, $F(1, 54) = 1.15$, $p > .28$, $\eta^2_p = .021$ (though the analysis might have lacked the power to detect such an interaction). Thus, despite age differences in discrimination ability, context reinstatement benefited such discrimination for both age groups, possibly with no significant group differences.

In the direct recognition test for context words, the older participants performed, on average, at chance; they had 50.5% correct as opposed to 65.0% correct for the younger group, $t(54) = 3.71$, $p < .01$.

Discussion

This study of CEs on recognition memory for words in older and younger adults yielded a number of findings of interest. First, we observed a basic context effect: reinstating the encoding context benefited the target word recognition, relative to presenting the targets at test with unrelated new context. This effect was quite robust for both older and younger adults, despite the fact that the older adults' overall hit rate was diminished relative to that of younger adults. Second, when retrieval context words were *conceptually* related to the encoding context words, target recognition benefited just as much as for the reinstatement of the original context. This effect was obtained for older and younger adults equally. Third, when the retrieval context words were *perceptually* related to the encoding context words, target recognition did not benefit at all relative to unrelated new context; for the older adults, the perceptually similar context words actually slightly impaired target recognition relative to new-context baseline. Finally, these CEs were obtained for the older adults despite the fact that their performance on a direct memory test for context words was at chance. The severe impairment of the older participants in memory for context words is noteworthy, given that the two-alternative forced-choice format is considered to be less taxing than yes–no recognition (Lockhart, 2000).

These findings expand on previous research in several ways. First, the preserved CEs in older adults, despite their impaired source memory, which we had previously documented for object pictures (Vakil, Melamed, & Even, 1996), is here demonstrated for words (serving as both targets and contexts). Second, unlike earlier studies in which CEs were found for exact contextual reinstatement, here both younger and older adults were able to benefit from conceptually similar contexts. Third, contrary to our expectations, neither age group was able to derive memory benefits from perceptually similar transformed contexts—at least when that similarity took the form of phonological resemblance to original context words. The effects of perceptual similarity with regard to the visual form of words might differ from that for other sorts of perceptual similarity (e.g., objects, faces) in several ways. For example, for words, the perceptual form is typically irrelevant, whereas this is not so for objects and faces. In addition, the perceptual form of a "similar word" conveys not only perceptual information but also new (noncongruent) conceptual information relating to the word's referent. It is unclear why older adults produced significantly fewer hits for targets accompanied by perceptually similar contexts than for completely new ones, but this might be related to the taxing cognitive load resulting from attempts to resolve such incongruities.

The presentation of context words at test that were conceptually similar to those accompanying targets at study might have affected probe recognition in various ways. They might have cued explicit retrieval of original study context-cues, which in turn affected judgments regarding the test probes. Alternatively, they might have caused semantic priming of those original context words, such that their representations, episodically bound to the probe words at study, affected probe recognition without explicit recall of the original context words. Because the older adults performed at chance in direct context-memory recognition, the second alternative is more likely. In either case, the phenomenon may be seen as a simple model of ecological remembering: Surface changes in a cognitive context that preserve functional equivalence may nevertheless influence recognition. It is instructive that this influence is found for older as well as for younger adults. This age equivalence given a conceptual manipulation contrasts with the study of Stuart and colleagues (2006), in which in implicit (as well as explicit) tests of verbal memory with conceptually based retrieval cues, older adults were weaker than younger adults. The comparison is interesting, as the implicit retrieval condition (in that case, category exemplar production) shares with CEs the property of being an indirect appraisal of memory strength. The difference in findings might be accounted for by the fact that Stuart and colleagues employed deep (semantic) encoding, whereas in the present study our encoding was shallow. Alternatively, in the category exemplar production task employed by Stuart and colleagues, the active production of responses is required. As the older adults were less successful in generating appropriate category responses in general, irrespective of whether they used new or old words, the difference in conceptual priming might have been a function of overall generation differences.

The results reported here are relevant to several of the aforementioned views regarding the causes of memory deficits for source or context in older adults. Using the ICE (Item, Context, Ensemble) model (Murnane, Phelps, & Malmberg, 1999), Bayen and colleagues (2000) claimed that older adults successfully encode and use item information and context information but do not bind them as well as do younger adults. They based this claim on their finding that, although context reinstatement increased target hits and false alarms, it did not improve discriminability (as reflected by d' scores) for older adults, whereas younger adults exhibited significant benefits under that condition (Bayen et al.). In contrast, in our current study we found significant discriminability benefits (as reflected by CEs on d' scores) for the older adults as well. Furthermore, our present findings of intact CEs and severely impaired direct memory for context (similar to the report of Vakil, Melamed, & Even, 1996) suggests that, unlike the suggestion of Wegesin and colleagues (2000), the causes of older adults' contextual memory deficits are to be sought in retrieval processes, not in encoding processes. Were the problem an encoding deficit, we would expect to find deficiencies in indirect as well as direct retrieval measures. It is possible, however, that older adults did perform less effective encoding, leaving them with weakened representations of contextual stimuli that were strong enough to affect probe recognition judgments that they accompanied, but not strong enough to allow their direct retrieval.

Finally, it is also interesting to note that in this experiment the older adults did not display a higher false alarm rate than did younger adults, even in trials in which the foils were accompanied by old context words, which are arguably more misleading. This is in consonance with other recent studies demonstrating that older adults are not necessarily more prone to false alarms than are young adults (e.g., Light, Chung, Pendergrass, & Van Ocker, 2006; Swick, Senkfor, & Van Petten, 2006), unlike earlier claims that an increased rate of false alarms is characteristic of older adults' memory performance (e.g., Flicker, Ferris, Crook, & Bartus, 1989; Trahan, Larrabee, & Levin, 1986). Indeed, the fact that both groups were not misled into false alarms by the presence of the old contexts is a further indication that target–context ensembles were bound together at encoding by older as well as by younger adults.

Further research may reveal whether conceptual context similarity also yields benefit to the recognition of nonverbal materials, such as visual objects, and whether perceptual context similarity will yield benefits for such objects even though it was not found for words. Additionally, it may be revealing to directly assess participants' awareness of the contextual ensemble by explicitly testing direct memory for original versus rearranged target–context pairs.

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