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A Benefit of Context Reinstatement to Recognition Memory in Aging: The Role of Familiarity Processes

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Abstract

Reinstatement of encoding context facilitates memory for targets in young and older individuals (e.g., a word studied on a particular background scene is more likely to be remembered later if it is presented on the same rather than a different scene or no scene), yet older adults are typically inferior at recalling and recognizing target-context pairings. This study examined the mechanisms of the context effect in normal aging. Age differences in word recognition by context condition (original, switched, none, new), and the ability to explicitly remember target-context pairings were investigated using word-scene pairs (Experiment 1) and word-word pairs (Experiment 2). Both age groups benefited from context reinstatement in item recognition, although older adults were significantly worse than young adults at identifying original pairings and at discriminating between original and switched pairings. In Experiment 3, participants were given a three-alternative forced-choice recognition task that allowed older individuals to draw upon intact familiarity processes in selecting original pairings. Performance was age-equivalent. Findings suggest that heightened familiarity associated with context reinstatement is useful for boosting recognition memory in aging.

Keywords: aging, context reinstatement, recognition, familiarity, implicit memory

A Benefit of Context Reinstatement to Recognition Memory in Aging: The Role of Familiarity Processes

Declines in recall and recognition with age are well documented (reviewed in Fleischman, 2007). One factor that may be beneficial to these forms of memory in normal aging is the reinstatement of encoding context (e.g., Bayen, Phelps, & Spaniol, 2000; Craik & Schloerscheidt, 2011; Gutchess et al., 2007; Naveh-Benjamin & Craik, 1995; Park, Puglisi, Smith, & Dudley, 1987). Global matching of context refers to when the surroundings in which encoding takes place are reinstated at test. This can include matching of the physical environment (e.g., Dalton, 1993; Fernandez & Glenberg, 1985; Godden & Baddeley, 1975, 1980; Smith, 1979, 1985, 1986; Smith, Glenber, & Bjork, 1978), or matching aspects of the stimulus presentation, such as the background color on which a target is shown (e.g., Dulsky, 1935; Murnane & Phelps, 1993, 1994, 1995; Weiss & Margolius, 1954). A number of studies have demonstrated a positive effect of global context matching on memory recall, but the effect on recognition memory has been relatively inconsistent, with some studies reporting a context effect (e.g., Dalton, 1993; Geiselman & Bjork, 1980; Geiselman & Glenny, 1977; Murnane & Phelps, 1993, 1994, 1995; Smith, 1986; Smith & Vela, 1992), and others not (e.g., Fernandez & Glenberg, 1985; Godden & Baddeley, 1980; Jacoby, 1983; Smith, 1986; Smith et al., 1978).

In their recent study, Craik and Schloerscheidt (2011) found that context reinstatement was beneficial to recognition in older adults. Young and older participants were presented with object names (Experiment 1A) or pictures (Experiment 1B) superimposed on background scenes under instructions to make an association between the word/picture and the scene, and remember the pairing. At test, participants were shown targets (words/pictures) on original background scenes, different scenes (switched or new context), or no scene, and asked to judge whether the target had been shown in the earlier study phase regardless of the current scene pairing. Recognition in both groups was greatest for targets on original background scenes, but older adults exhibited a stronger context effect. Moreover, although recognition was generally lower in older than in young adults, the age difference was reduced for items presented in their original context. In another study using incidental encoding, Gutchess et al. (2007) reported greater recognition in young and older adults for images presented on the background scene on which they were originally studied, relative to a novel scene.

The finding that older adults show a similar (e.g., Bayen et al., 2000) or greater (e.g., Craik & Schloerscheidt, 2011) benefit of context reinstatement compared to young adults is surprising given that they are generally worse at binding or associating separate pieces of information (Chalfonte & Johnson, 1996; Craik, Luo, & Sakuta, 2010; Naveh-Benjamin, 2000). Indeed, in Experiment 2 of Craik and Schloerscheidt (2011), older adults were significantly worse than young adults at recalling and recognizing original context pairings, as well as at discriminating between original and switched pairs. This paradox calls into question the mechanisms underlying the context effect in normal aging: how is it that older individuals benefit from context reinstatement while at the same time being poor at remembering target-context pairs? One possibility is that associations between targets and contexts are implicitly encoded by older individuals. It is widely believed that implicit (unconscious/automatic) memory processes are preserved with age, in contrast to a decline in explicit (conscious/effortful) memory processes (reviewed in Fleischman, 2007; Fleischman & Gabrieli, 1998; Mitchell, 1989; Ward, Berry, & Shanks, 2013b). Thus, while explicit recall or recognition of target-context pairs may require the type of elaborate and effortful memorial processing that is impaired with age, the beneficial use of contextual information in item recognition may call upon implicit processes that remain intact. Many advocate that implicit and explicit forms of memory are qualitatively distinct and driven by functionally independent systems (e.g., Gabrieli, 1998; Schacter, 1987; Schacter & Tulving, 1994; Squire, 1994, 2004, 2009; Tulving & Schacter, 1990), so the idea that target-context associations are implicitly encoded by older individuals leads to the prediction that such associations will not be explicitly available to them.

Another explanation for the beneficial effect of context reinstatement in aging concerns how the processes of recollection (detailed conscious memory of some specific information) and familiarity (the feeling that some specific information is familiar) (e.g., Jacoby, 1991; Rotello, Macmillan, & Reeder, 2004; Wixted, 2007; Yonelinas, 2002; Yonelinas & Levy, 2002) are differentially affected by age. The effortful process of recollection declines in normal aging, while familiarity-based processing is spared (e.g., Jennings & Jacoby, 1993; Light, Prull, La Voie, & Healy, 2000; Parks, DeCarli, Jacoby, & Yonelinas, 2010; Prull, Dawes, Martin, Rosenberg, & Light, 2006; but see Duarte, Ranganath, Trujillo, & Knight, 2006). Since older adults are generally believed to rely more heavily on familiarity than recollection processes, this may explain why they benefit from context reinstatement despite showing poor memory for target-context pairs: When encoding context is reinstated, global familiarity of the stimulus may be sufficiently high to elicit a positive recognition judgement in relation to the target, yet recall or recognition of the specific target-context pairing may require elaborative recollective processing of the association. Indeed, in Gutchess et al. (2007), older adults made more false alarms than did young adults to new items presented on a familiar context at test. Moreover, in Craik and Schloerscheidt (2011), older adults exhibited a high false alarm rate for items on a switched context in the same/different pairing judgement (Experiment 2), and this condition is associated with high familiarity since both the target and context had been previously studied (albeit not in combination). Overall, this familiarity account of the context effect in normal aging leads to the alternative prediction that memory for target-context pairs will be available to older individuals on an explicit test that allows them to draw upon intact familiarity processes.

This study aimed to elucidate the mechanisms of the context effect on recognition memory in normal aging. Specifically, we examined the role of intact familiarity processes in older adults. Two initial experiments examined young and older adults' item recognition by context (original, switched, none, new), and their ability to explicitly identify original target-context pairs. To preview, both age groups benefited from context reinstatement, despite significantly reduced memory for target-context pairs in older compared with young adults. In a third experiment we examined whether older adults' memory for target-context pairings is improved when the explicit test permits them to draw upon familiarity-based processing (a forced-choice recognition task).

Experiment 1

In Experiment 1 we examined age differences in word recognition by context condition, and memory for word-context pairs trial-by-trial in a single experiment, as this has never before been attempted. Participants studied word-scene pairs before being exposed to previously studied and new words within one of four context conditions (original pairing, switched pairing, no pairing, new pairing), and on each trial they were asked to judge (1) whether the word was presented in the study phase irrespective of the current background scene, and then (2) whether the current word-scene pairing was the same or different to that in the study phase (studied-item trials only). Unlike in previous studies, the two consecutive decisions (yes/no recognition then same/different pairing judgement) allowed us to examine whether, for correctly recognized words, participants can explicitly remember the contextual association. In other words, the experiment will more clearly establish whether, at the item level, older adults benefit from context reinstatement while at the same time being impaired at remembering target-context associations.

Method

Participants

Twenty-four young adults (ten male) and 24 older adults (six male) participated. Young adults were students from Middlesex University, London, who participated in exchange for course credit, and older adults were local residents and members of the University of the Third Age (U3A) organization, who responded to an advertisement. All participants were fluent in the English language and reported good health. See Table 1 for participant demographic information.

Design and Stimuli

The between-participants factor was age (young or older), and the within-participants factor was context (original, switched, none, new). Stimuli consisted of 80 common object names, and twenty background scenes. Words were taken from the MRC Psycholinguistics Database (Coltheart, 1981), presented in black capitalized Calibri 25-point font. Scenes were digitized color photographs of cityscapes and landscapes. Scenes were visually diverse, for example, different types of building for cityscapes, and different types of terrain for landscapes. In the study phase, participants viewed 40 word-scene pairs on a computer screen. Words were centered on a 3x3 cm gray box with a yellow border, superimposed in the center of a 10x10 cm background scene. Ten scenes were used in the study phase (five cityscapes and five landscapes), meaning that each scene was paired with four different words. At test participants were presented with 80 words – 40 previously studied, and 40 new. Ten of the previously studied words were presented on their original scene, ten on a switched scene (a scene that was shown in the study phase, but with different words), ten on no scene, and ten on a new scene. New scenes included five cityscapes and five landscapes that were not previously shown in the experiment. The switched and new pairs used scenes from the same domain as those originally studied (e.g., target words shown in the switched and new conditions at test were paired with switched/new cityscapes if they were originally studied with a cityscape, or switched/new landscapes if they were originally studied with a landscape). Of the new words presented in the test phase, 20 were shown on a previously studied scene (ten assigned to the original condition and ten to the switched condition, although these labels were arbitrary), ten on no scene, and ten on a new scene. Stimuli were rotated between participants such that the 40 words and ten background scenes viewed in the study phase by one half of the participants served as new items for the other half of the participants.

Procedure

Participants were tested individually in a session that lasted approximately 90 minutes. In the study phase, participants studied 40 word-scene pairs. Each item was presented for 7500 ms, and participants were instructed to try to make a connection between the item and its background, and remember the pairing for a later memory test. Many prior studies have used incidental encoding of contextual information, but intentional encoding was used in all experiments in this study because, as noted by Craik and Schloerscheidt (2011), context may play a more important role in this situation, causing any age differences to become more pronounced.

At test, immediately following encoding, participants were shown previously studied and new words presented either on their original scene (previously studied words only), no scene, or a different scene (brand new or switched). On each trial participants were asked to decide whether or not the word was previously studied, irrespective of the background scene, on a 6-point scale where 1 = *very sure no*; 2 = *fairly sure no*; 3 = *guess no*; 4 = *guess yes*; 5 = *fairly sure yes*; 6 = *very sure yes*. It was made clear that half of the words were shown in the previous phase, and half were new. Upon keypress, or once 7500 ms had elapsed if no response had yet been made, participants were informed on-screen of whether the word was previously studied or new, and on studied-item trials they were then asked to decide whether the current word-scene pairing was the same or different to that in the initial study phase on a 6-point scale where 1 = *sure same*, 2 = *think same*, 3 = *guess same*, 4 = *guess different*, 5 = *think different*, 6 = *sure different*. A keypress initiated a 1000-ms blank screen prior to the next trial, but if no response had been made after 7500 ms the next trial was automatically presented. On new-item trials or studied-item trials assigned to the 'no context' condition, the next trial was automatically presented following a 1000-ms blank screen (after the on-screen information about whether the item was previously studied or new).

Upon completion of the computer task, participants completed a near vision test in which they indicated the smallest set of letters on the Near Vision Test Card (Schneider, 2002) that they could comfortably read at a distance of 16 inches. Participants also completed the Wechsler Test of Adult Reading (WTAR), the Vocabulary and Digit Symbol Substitution subtests of the Wechsler Adult Intelligence Scale III (WAIS-III), and older adults also completed the Mini Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975).

Results

In this and subsequent experiments, we planned to exclude item recognition judgements and same/different pairing judgements associated with no response at the 7500-ms time-out point, but there were no such instances.

Word recognition. Responses 1-3 ('no' recognition judgement) and 4-6 ('yes' recognition judgement) on the scale were collapsed.[1] The proportions of hits and false alarms are given in Table 2, and corrected recognition (hits minus false alarms) is shown in Figure 1A. A mixed analysis of variance (ANOVA) on corrected recognition uncovered a main effect of context, $F(3, 138) = 3.66$, $p = .012$, $\eta_p^2 = .17$, a main effect of age, $F(1, 46) = 5.12$, $p = .029$, $\eta_p^2 = .10$, but no significant interaction, $F < 1$. Recognition of words on no scene was significantly lower than recognition of words on original scenes, $t(47) = 2.45$, $p = .018$, $d = 0.33$, as well as words on switched scenes, $t(47) = 3.60$, $p = .001$, $d = 0.47$, and words on new scenes, $t(47) = 2.03$, $p = .048$, $d = 0.28$. However, recognition did not significantly differ between the original and switched or original and new conditions, both ts(47) < 1, ps > .05.

Associative memory for word-scene pairings. Only trials associated with correct word recognition judgements were included in this analysis. Responses 1-3 ('same' pairing judgement) and 4-6 (‘different’ pairing judgement) on the scale were collapsed. The proportions of correct and incorrect responses were recorded (Table 3). A measure of participants’ ability to identify original pairs is given by subtracting false alarms to new pairings from hits to original pairings. Mean corrected hit rates were .60 (*SD* = .25) and .42 (*SD* = .32) in young and older adults, respectively, and this difference was significant, $t(46) = 2.27$, $p = .028$, $d = 0.62$. We also examined participants’ ability to discriminate between switched and original pairs, given by subtracting false alarms to switched pairs from hits to original pairs. Mean scores were .40 (*SD* = .27) and .17 (*SD* = .29) for young and older adults, respectively, $t(46) = 2.84$, $p = .007$, $d = 0.80$.

Discussion

Providing a background scene (original, switched, new context) at test boosted word recognition in young and older adults compared to when no background (no context) was provided. As outlined in the Introduction, the effect of context on recognition memory has been notoriously inconsistent in the literature, but the present observations are consistent with a number of prior studies: For example, in Hockley (2008), hit and false alarm rates were similar for original and switched pairs, and this was also the case for new contexts that were physically similar to old contexts. Similarly, Murnane and Phelps (1994) found no difference between original and switched contexts. However, in Craik and Schloerscheidt (2011), the original context condition produced the greatest benefit, and the new context condition was associated with the lowest level of word recognition (numerically in young adults and significantly in older adults in Experiment 1A; but for picture stimuli in Experiment 1B the effect was numerically reversed in young adults). Although every effort was made to create a similar stimulus set, it is possible that our scenes were not as unique as those used by Craik and Schloerscheidt, and that this weakened the context effect observed here. Also, Craik and Schloerscheidt randomized the location of words on background scenes, whereas in the present study we placed words centrally on background scenes. It is unlikely that this would have differentially influenced the context effect, because in both studies it was only the context that varied between study and test, so in both cases word location provided no additional contextual information. Nevertheless, to provide generally better control over the characteristics of the contexts, we conducted a second experiment (Experiment 2) using word-word pairs rather than word-scene pairs.

Experiment 2

Experiment 2 was similar to the first experiment, except that the stimuli were changed to unrelated word pairs. As well as overcoming the points above, this also served to address a potential issue with the repeated use of scenes; in Experiment 1, similarly to prior studies (e.g., Craik & Schloerscheidt, 2011), the background scenes were paired with several different words during encoding, and a potential problem is that young adults may have been better at creating associations between items on shared scenes (e.g., Horner & Burgess, 2013). This may have bolstered their performance in the associative memory judgement within the test phase. For example, if a participant was to forget the scene on which a particular word was presented, they may have still been able to retrieve the link if they remembered that the word was originally presented on the same scene as another word.

Method

Participants

There were 24 young participants (nine male) from Middlesex University, and 24 older participants (six male), from the local area and the U3A network in London (see Table 1 for demographic details). All participants were fluent in English and reported good health.

Design, Stimuli and Procedure

Experiment 2 was virtually identical to Experiment 1 in design and procedure, but unrelated word pairs were used rather than word-scene pairs. In addition to the 80 words used in Experiment 1, 80 further common nouns from the MRC Psycholinguistics Database were sourced to create the word pairs. Overall word frequency was in the mid-range (5.2-7.2 log

HAL), and word length ranged from four to eight letters. Words within each pair were unrelated, and matched as far as possible in length and number of syllables. The procedure for the study phase was identical to that described previously, except the instructions asked participants to learn the two words and make an association between them. In the test phase, word pairs (original, switched, and new context conditions) and single words (no context condition) were presented and participants were asked to decide whether the word on the left of the pair was shown in the study phase, or in the case of single words (i.e., in the no-context condition), whether the word was shown in the study phase. The same response scale as in Experiment 1 was used. Once a recognition judgement had been made or 7500 ms had elapsed, participants were informed of the correct answer, and on all studied-item trials apart from those assigned to the no-context condition, they were asked to judge whether the current pairing was the same or different to that originally studied. After the computer task, participants completed a near vision test, the WTAR, the WAIS-III Vocabulary and Digit Symbol Substitution test, and the MMSE (older adults only).

Results and Discussion

Word recognition. See Table 2 for proportions of hits and false alarms and Figure 1B for corrected recognition. Once again there was a main effect of context, $F(3, 138) = 4.09$, $p = .008$, $\eta_p^2 = .08$, a main effect of age, $F(1, 46) = 5.61$, $p = .022$, $\eta_p^2 = .11$, and no significant interaction, $F < 1$. Recognition of single words (no context) was significantly lower than recognition of words in original pairs, $t(47) = 3.20$, $p = .002$, $d = 0.55$, and words in switched pairs, $t(47) = 2.04$, $p = .047$, $d = 0.33$. Original pairs were associated with marginally greater word recognition than new pairs, $t(47) = 1.87$, $p = .068$, $d = 0.34$, and switched pairs, $t(47) = 1.73$, $p = .090$, $d = 0.27$.

Associative memory for word pairings. See Table 3 for proportions of hits and false alarms in the same/different judgement task. Mean corrected hit rates were .77 (*SD* = .29) and .44 (*SD* = .50) for young and older adults, respectively, and this difference was significant,

$t(46) = 2.75$, $p = .008$, $d = 0.78$. There was also a significant age difference in the ability to discriminate between switched and original pairings (proportion hits to original pairs minus false alarms to switched pairs, .65 ($SD = .34$) and .37 ($SD = .46$) for young and older adults, respectively), $t(46) = 2.47$, $p = .017$, $d = 0.71$.

Thus, participants exhibited enhanced recognition of words presented in their original encoding context, despite older adults being significantly worse than young adults at identifying original target-context pairs and at discriminating between original and switched pairs. The results therefore confirm previous findings that older adults have difficulty explicitly retrieving contextual information, but are nevertheless able to use this information to boost item memory. As outlined in the Introduction, one explanation for why older adults benefit from context reinstatement despite showing poor memory for target-context associations is that the associations are implicitly encoded. Facilitated processing due to prior exposure to a matched stimulus may evoke a fluency effect, leading to a correct positive recognition judgement in relation to the target word (e.g., Conroy, Hopkins, & Squire, 2005; Jacoby & Whitehouse, 1989). However, a purely implicit representation would not aid explicit remembering of the word-scene pairing, given the view that this involves a distinct memory system (e.g., Gabrieli, 1998; Squire, 1994, 2004, 2009).

Another possibility is that older adults' reliance on familiarity-based processing explains why they benefit from context reinstatement but exhibit poor associative memory for target-context pairs. Original context reinstatement is associated with high global stimulus familiarity (a word and scene previously studied in combination; e.g., Murnane & Phelps, 1993; Murnane, Phelps, & Malmberg, 1999), and although this may be sufficient to elicit a correct positive recognition judgement in relation to a target (decision 1 in Experiments 1 and 2), the ability to remember the specific target-context pair, that is, rate the pairing as the 'same' (decision 2 in Experiments 1 and 2) requires elaborate recollective processing, which is impaired in normal aging. Older adults' reliance on familiarity processing is supported by the present observation that, similarly to Craik and Schloerscheidt (2011, Experiment 2), older adults exhibited a high false alarm rate for items with a switched context in the same/different pairing judgement – a condition that is also associated with high familiarity as both the target and context were previously studied. Moreover, in Gutchess et al. (2007), older adults made more false alarms than did young adults to new items presented on a familiar context at test. This view leads to the prediction that target-context associations will be explicitly available to older individuals on a memory test that allows them to draw upon intact familiarity processes. To test this, Experiment 3 examined whether older adults are able to correctly identify target-context pairs using a three-alternative forced-choice (3AFC) recognition task in which stimulus familiarity varied across choice options.

Experiment 3

Following an identical study phase to Experiment 2, young and older participants performed a 3AFC recognition task. On each trial, participants were given a choice of three word pairs – original, switched, new – and asked to select the original. This design ensured that the target word, which was held constant on the left of each pair, was equally familiar across the three options, and the original and switched contexts were equally familiar as both were previously studied. However, overall stimulus familiarity varied across options: it was highest in the original condition, which provided a global match to the originally encoded stimulus, and lowest in the new condition in which only the target word was previously studied. In the switched condition, the target word and paired word were equally familiar, but overall familiarity was lower than in the original condition because the two aspects were not previously studied in combination (e.g., Murnane & Phelps, 1993; Murnane et al., 1999). If older adults possess internal representations of target-stimulus associations that they have difficulty accessing using elaborate recollective processing, but are able to tap into using intact familiarity processes, then they should show a preference for selecting the highly familiar original pairs in this design. This would provide evidence that they possess explicit associative memory for target-context pairs, and therefore suggest that the context effect is not mediated by purely implicit/unconscious processes. The 3AFC recognition task purposefully differs considerably from the same/different judgement task used in Experiments 1 and 2 – it allows a novel and appropriate manipulation of global stimulus familiarity: Participants are able to directly compare choice options that vary in familiarity, whereas the same/different judgement involves effortful recollection based on appraisal of a single presented item on each trial.

Method

Participants

Twenty-four young adults (six male, students from Middlesex University, London) and 24 older adults (six male, local residents and members of the U3A) participated (Table 1). All participants were fluent in English and reported good health.

Design, Stimuli and Procedure

The same word pairs from Experiment 2 were used, plus two additional newly sourced pairs. The procedure for the study phase was identical, but the number of trials was raised to 42 to allow for an equal number of original, switched, and new pairings in the test phase. On each test phase trial, participants were shown a choice of three word pairs (original, switched, new) and were asked to select the original pairing from the study phase. Participants were informed that the word on the left (which was held constant across the three choices) was shown in the study phase, but only one of the options was the correct original pairing. The three word pairs were presented in the center of the computer screen, one above the other, numbered 1-3, and participants were instructed to use the respective number keys to make their selection. The location of the original pairing (top, middle, bottom) was randomized. As in Experiment 2, we used rearranged pairs – the switched condition comprised a target word paired with a different previously studied word, and the new condition involved a target word paired with a brand new word that had not previously appeared in the experiment (e.g., AB, CD, EF, etc. at study, and AB, AD, AZ for original, switched, and new pairs on a single test trial). As such, context words appeared once as an original pair, and once as a switched pair in the test phase. After making a keypress, participants were asked to rate their confidence in their decision on a 4-point scale where 1 = *very confident*, 2 = *confident*, 3 = *unconfident*, 4 = *very unconfident/guess*. Participants were given a maximum of 7500 ms to respond to both decisions. The second keypress initiated a 1000-ms blank screen prior to the next trial. Upon completion of the computer task, participants performed the various other tests as outlined previously.

Results and Discussion

Both groups made more correct responses (identifications of original pairings) than erroneous responses (incorrect selections of switched or new pairs) (Table 4, top panel), $t(23) = 10.04$, $p < .001$, $d = 4.09$, and $t(23) = 10.24$, $p < .001$, $d = 4.18$, for young and older adults, respectively. Moreover, the two groups did not significantly differ in the number of correct responses, $t(46) = 0.10$, $p = .921$. This lack of an age difference in the ability to correctly select original pairings stands in contrast to Experiments 1 and 2, in which older adults demonstrated significantly reduced associative memory for target-context pairs relative to young adults. Thus, older adults are able to remember original pairings when probed using an explicit memory test that allows them to draw upon intact familiarity processes.

Incorrect responses made by young adults were equally distributed between switched and new pairs, $t(23) = 0.55$, $p = .588$, whereas older adults were significantly more likely to select switched relative to new pairs, $t(23) = 2.27$, $p = .033$, $d = 0.48$. This further suggests that older adults are heavily reliant upon familiarity processes when making recognition judgements; as the switched condition is associated with greater familiarity than the new condition, we would expect older adults to show a preference for the former.

Moreover, if older adults rely upon familiarity processes and young adults on recollection, we would expect young adults to make more high-confidence correct responses compared to older adults, and this was observed in the present experiment, $t(46) = 2.23$, $p = .031$, $d = 0.64$ (Table 4, bottom panel). In contrast, older adults made more low-confidence correct responses compared with young adults, $t(46) = 2.72$, $p = .009$, $d = 0.79$. For these analyses, responses 1/2 (very confident/confident) and 3/4 (unconfident/guess) on the scale were collapsed. Recollection is associated with detailed conscious retrieval of information accompanied by relevant episodic detail, and therefore one would expect responses based on this form of processing to be associated with a higher level of certainty/confidence than familiarity-based processing, which merely reflects a feeling that a specific piece of information is familiar in the absence of any specific episodic information (but see Wixted & Mickes, 2010).

As stated in the Method, context words appeared twice in the test phase – once as an original pair, and once as a switched pair. As the order of presentation of the test trials was randomized, it is possible that the relative familiarity of the contexts may have fluctuated if there was a difference in lag between when some were presented as original and switched pairs than others. However, the test phase was on the whole relatively short in duration, so it is unlikely that this would have caused a substantial difference in familiarity that could have affected the results.

General Discussion

This study investigated the mechanisms of the context effect in normal aging. We asked whether the effect is driven by a greater reliance on familiarity-based processing in older adults. Across two experiments, young adults were significantly better than older adults at identifying original target-context pairs and at discriminating between original and switched pairs. In Experiment 3 we examined participants' ability to select original pairings using a 3AFC recognition task in which stimulus familiarity varied across conditions (original, switched, new pairing). Overall familiarity was highest in the original condition (global match), and lowest in the new condition. Correct selections of original pairs did not significantly differ between age groups, providing evidence that older individuals possess memory for contextual associations that they can draw upon using intact familiarity processes (i.e., they selected the option with the greatest familiarity just as often as did young individuals).

Prior studies suggest that familiarity processes are spared in normal aging, in contrast to a decline in the effortful process of recollection (e.g., Jennings & Jacoby, 1993; Light et al., 2000; Parks et al., 2010; Prull et al., 2006; but see Duarte et al., 2006). Thus, when encoding context is reinstated and overall stimulus familiarity is high, there is an increased probability that older individuals will make a positive recognition judgement in relation to a target. This is consistent with global activation theories, which argue that memory performance reflects how well the total amount of information stored is matched at retrieval (Murnane & Phelps, 1993; Murnane et al., 1999). When it comes to recognition of target-context associations, a yes/no task requires elaborative recollective processing of the association between a target and its context, which is impaired in normal aging; however, older individuals can correctly select original target-context pairs when the explicit task allows them to draw upon familiarity processing, such as in the forced-choice format task used in the present Experiment 3.

On the whole, the findings suggest that the context effect in older adults is not mediated by implicit target-context associations. It is widely believed that implicit memory is preserved in normal aging, in contrast to reduced explicit memory (reviewed in Fleischman, 2007; but see Ward, Berry, & Shanks, 2013a, 2013b; Ward, de Mornay Davies, & Politimou, 2015). It has been suggested that the beneficial use of context information in item recognition involves implicit processes, whereas recall/recognition of target-context associations involves explicit processes. Many advocate that explicit and implicit forms of memory are driven by functionally distinct systems (e.g., Gabrieli, 1998; Schacter, 1987; Schacter & Tulving, 1994; Squire, 1994, 2004, 2009; Tulving & Schacter, 1990; but see Berry, Shanks, Speekenbrink, &

Henson, 2012), and this leads to the prediction that target-context associations will not be explicitly available to older individuals, given their specific impairment in this form of memory. In contrast, the present study provides evidence that, with appropriate task support, older adults do have explicit access to the originally encoded target-context associations. That is, the fact that older adults demonstrate comparable levels of recognition of contextual information to young adults on a forced-choice task that allows them to tap into familiarity processing provides evidence that this information is not represented in a purely implicit manner.

It is noted that the extent to which familiarity should be considered wholly explicit, and independent from implicit memory, is debated. While we interpret the observations to suggest that older adults are able to draw upon intact familiarity processes, some may debate whether this is a source of implicit memory. However, there is evidence that implicit memory does not reliably affect performance on recognition tasks (e.g., Hamann & Squire, 1997; Stark & Squire, 2000). Moreover, although some endorse the idea of a contribution of implicit memory to forced-choice recognition, it has been stipulated that the conditions under which this occurs are highly specific – including when there is a high level of perceptual similarity between targets and foils, when the stimuli are non-verbal, and when the task requires speeded responding (Jeneson, Kirwan, & Squire, 2010; Voss & Paller, 2008). Thus, under the present testing conditions, a contribution of implicit memory to the explicit task is unlikely.

Preserved familiarity processes with age can also explain the present lack of an age difference in word recognition in the switched condition. High familiarity associated with this condition may prompt older adults to make positive recognition judgements (hits for previously studied words; false alarms for new words). A similar finding was previously reported by Gutchess et al. (2007). Moreover, in the present study and that of Craik and Schloerscheidt (2011; Experiment 2), older adults exhibited a high false alarm rate for items on a switched context in the same/different pairing judgement. An interesting question, however, concerns why older adults were apparently unable to draw upon efficient familiarity processes to enhance their associative memory for target-context pairs in the same/different judgement task in Experiments 1 and 2. Older individuals appear to be unable to accurately judge target-context pairs as the 'same' or 'different' to those originally studied by weighing up whether the absolute familiarity of a stimulus exceeds or falls below that of a certain criterion, but when faced with a forced-choice format task, they can correctly select original pairs by appraising the relative familiarity of the options. It seems, therefore, that older adults are impaired at making absolute but not relative judgements of familiarity.

In the present experiments, similarly to a range of prior investigations (e.g., Hockley, 2008; Murnane & Phelps, 1994), word recognition did not differ between the original and switched conditions. This suggests that the specific association between a target and its context does not play as much of a fundamental role as the combined familiarity of the distinct aspects of the stimulus. It is also interesting that despite the low familiarity associated with the new context condition, item memory in this condition was similar to that in the original and switched conditions in Experiment 1. One explanation, which is consistent with Hockley (2008), concerns the fact that the new test scenes used in this study were physically similar to studied scenes. Although the landscapes and cityscapes were visually diverse, they inherently shared many features, and a target presented in the new condition at test was always paired with a new cityscape if it was originally studied with a cityscape, or a new landscape if it was originally studied with a landscape. Presenting a new but similar context therefore appears to bolster item recognition. Indeed, in Experiment 2 when each new context was unique, item memory was lower in the new condition compared to the original and switched conditions. However, if a new but similar context is capable of boosting item recognition, it is a puzzle why this condition was associated with generally lower false alarm rates in the same-different combination judgement. In essence, a new but similar context benefitted item memory, yet participants knew that it was a different pairing. A speculative explanation is that a new context may prompt participants to recall the original context, enabling both accurate item recognition and memory for the pairing. This would very likely be difficult for older adults, however. Item recognition was generally lowest for words presented with no context at test. Perhaps even a unique new context (as in Experiment 2) provides a globally more similar contextual match compared to no context, as no words were initially studied in the absence of a context. On the whole, the context effect may depend upon encoding of the target together with ensemble contextual information, but unless the latter is encoded in great detail, reinstatement of any similar context may benefit remembering of the target.

It is worth noting a few methodological differences in the way in which context was operationalized in the present study compared with several prior studies. First, contexts are typically thought to serve as the background for current processing (e.g., Ranganath, 2010), but in the current study there was associative binding of targets and contexts. We asked participants to make a connection between targets and contexts during encoding because, as pointed out by Craik and Schloerscheidt (2011), under intentional encoding context may play a more important role, causing age differences to become more pronounced. Because our goal was to examine age differences in item memory across different context conditions, and age differences in associative memory for target-context pairs, we opted for intentional encoding to ensure the greatest effect size. Second, contexts are typically thought to be an integrative framework in which items may appear, and although in Experiment 1 scenes were paired with several different targets, in Experiments 2 and 3 unique word pairs were used. The word pairs provided generally better control over the characteristics of the contexts, and overcame the possibility that young adults were better than older adults at creating associations between targets and shared scenes, which may differentially affect memory for the pairings. However, although the contexts were different in Experiments 2 and 3 compared with Experiment 1, there was a true distinction between targets and contexts in all cases: participants were aware that the target was on top of the scene (Experiment 1) or on the left of the word pair (Experiments 2 and 3), and moreover there is unlikely to have been differences in the way in which the pairs were treated by participants, as in all cases participants had to build novel associations.

A final point to consider is the concurrent nature of the item recognition and associative memory judgements in Experiments 1 and 2. The two measures were independent in the sense that participants had to make two distinct responses separated in time, but it is possible that they appraised all available information and made the two judgements simultaneously. We did not ask participants about strategy, so can only speculate about this, but we note that it would be less effort to simply follow instructions and make the two judgements independently. Even if this is not the case, we do not believe it is likely that the two judgements would have contaminated one another. Another possibility is that participants purposefully attempted to use the contextual information to help them make item recognition judgements, but we believe this is unlikely because they were aware that on studied-item trials the pairing would not always be the same as that originally studied. In conclusion, although older adults are significantly worse than young adults at identifying original target-context pairs and discriminating between original and switched pairs, they are just as good as young adults at selecting original pairs in a forced-choice format task in which overall stimulus familiarity varies across choice options. This study therefore provides new evidence that older adults can successfully employ intact familiarity processes in order to correctly identify original target-context combinations under these explicit memory test conditions. Further work is needed to establish whether the context effect in young adults is similarly dependent upon familiarity processes – it has previously been concluded, based on investigations on young adults, that context reinstatement affects recognition accompanied by conscious recollection, but not recognition based on familiarity (e.g., Macken, 2002; Perfect, Mayes, Downes, & Van Eijk, 1996), but this appears not to be the case, at least for older adults. Further work is also needed to clarify the effect of providing an exact versus a similar contextual match at test. A growing body of evidence suggests that providing a new but similar context can boost item recognition, but an important question is whether an exact match becomes necessary if a specific association is encoded, rather than individual components of a stimulus (target and context). If a specific association is not encoded, then this may explain why an exact match sometimes produces no additional benefit.

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Footnote

[1] The purpose of using the response scales for the yes/no item recognition and same/different pairing judgement in Experiments 1 and 2 was to try to capture a broad range of responses, and limit potential problems with individual differences in response bias, but we planned a priori to collapse responses into a dichotomous measure for the main analyses. Despite encouraging participants to use the whole scale, there were too few responses in the 'fairly sure' and 'guess' options to allow meaningful further analyses to be performed on a breakdown of confidence.

Table 1

Participant Characteristics for Experiments 1-3

	Experiment 1		Experiment 2		Experiment 3	
	Young	Older	Young	Older	Young	Older
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Age (years)	22.30 (3.74)	72.50 (5.82)	21.75 (1.87)	71.74 (5.90)	21.71 (1.97)	71.21 (6.12)
Education (years)	15.00 (1.22)	15.58 (2.24)	15.08 (1.67)	16.30 (3.40)	15.13 (1.80)*	17.09 (3.79)
Visual acuity	28.17 (5.47)*	38.67 (11.23)	29.50 (4.69)*	44.39 (10.55)	29.00 (3.96)*	46.33 (14.73)
Wechsler Adult Intelligence Scale (WAIS-III)						
Vocabulary	39.88 (9.83)*	61.29 (8.17)	35.42 (10.52)*	59.39 (6.46)	41.21 (8.91)*	57.88 (7.53)
Digit Symbol Substitution	79.50 (15.42)*	66.75 (19.82)	75.21 (12.29)	70.39 (16.07)	79.71 (17.99)*	67.58 (16.23)
Wechsler Test of Adult Reading (WTAR)	38.46 (6.84)*	48.08 (6.36)	36.75 (4.72)*	46.50 (5.69)	43.25 (5.17)	45.00 (5.74)
Mini Mental State Exam (MMSE)	-	29.67 (0.56)	-	29.35 (0.83)	-	29.29 (0.81)

Note. Different participants were used in Experiments 1-3. Visual acuity was measured using the Near Vision Test Card (Schneider, 2002), viewed at a distance of 16 inches while wearing corrective glasses if required. Scores can range from 16 (highest acuity) to 160 (lowest acuity).

The WAIS-III Vocabulary and Digit Symbol Substitution subtests have maximum scores of 66 and 133, respectively, and the maximum score on the WTAR is 50. The maximum score on the MMSE is 30, and a score of 23 or lower indicates probable cognitive impairment. No participants in the experiments presented here scored below 28.

* Significant difference between groups, $p < .05$

Table 2

Mean Proportions of Hits and False Alarms (FA) in Young and Older adults in the Word Recognition Task in Experiments 1 and 2

	Young		Older	
Experiment 1	Hit	FA	Hit	FA
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Original	.75 (.20)	.16 (.14)	.72 (.21)	.23 (.11)
Switched	.77 (.17)	.16 (.14)	.78 (.20)	.23 (.11)
None	.71 (.18)	.16 (.19)	.67 (.15)	.25 (.19)
New	.74 (.16)	.15 (.15)	.70 (.21)	.19 (.15)
Experiment 2	Hit	FA	Hit	FA
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Original	.85 (.14)	.16 (.15)	.75 (.21)	.19 (.17)
Switched	.76 (.18)	.16 (.15)	.71 (.18)	.19 (.17)
None	.79 (.18)	.23 (.20)	.74 (.21)	.35 (.26)
New	.75 (.21)	.16 (.19)	.73 (.16)	.24 (.17)

Note. A single FA rate for original and switched items was computed, representing the proportion of positive recognitions in relation to new words paired with previously studied background scenes (for such items, the labels ‘original’ and ‘switched’ are arbitrary).

Table 3

Mean Proportions of Hits and False Alarms (FA) in Young and Older Adults in the Same/Different Pairing Judgement in Experiments 1 and 2

	Young	Older
Experiment 1	*M* (*SD*)	*M* (*SD*)
Original – Hit	.73 (.21)	.67 (.26)
Switched – FA	.34 (.22)	.50 (.25)
New – FA	.13 (.15)	.25 (.23)
Experiment 2		
Original – Hit	.87 (.16)	.65 (.30)
Switched – FA	.22 (.22)	.28 (.29)
New – FA	.11 (.19)	.21 (.30)

Table 4

Number of Selections of Original, Switched, and New Pairs by Young and Older Adults in the Forced-Choice Recognition Task in Experiment 3 (Top Panel), and Number of Correct and Incorrect Responses by Young and Older Adults Broken Down by Confidence (Bottom Panel)

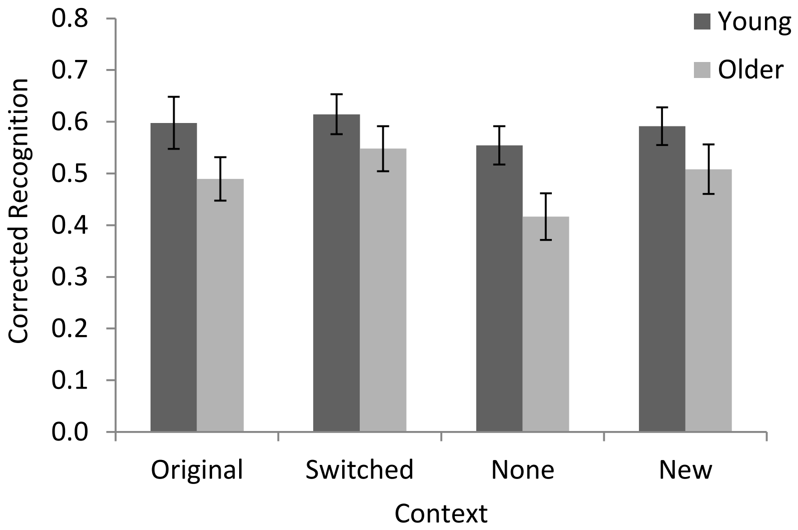
	Young	Older
	M (*SD*)	*M* (*SD*)
Original	33.08 (5.90)	32.92 (5.70)
Switched	4.58 (3.16)	5.33 (3.75)
New	4.34 (3.14)	3.75 (2.83)

	Young		Older	
	High confidence	Low Confidence	High confidence	Low Confidence
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Correct	30.29 (7.42)	2.79 (3.18)	24.17 (11.22)	8.75 (10.25)
Incorrect	3.83 (4.31)	5.08 (4.40)	3.83 (3.45)	5.25 (4.68)

Note. High confidence = responses 1 (very confident) and 2 (confident) on the 4-point scale; Low confidence = responses 3 (unconfident) and 4 (guess) on the scale.

Figure 1. Corrected recognition (hits minus false alarms) in young and older adults in Experiment 1 (A) and Experiment 2 (B). Error bars indicate ±1 standard error of the mean.

A



B