Reduced Recognition and Priming in Older Relative to Young Adults for Incidental and Intentional information

Emma V. Ward
Middlesex University, London

Author Note

Correspondence concerning this article should be addressed to Emma V. Ward, Psychology Department, School of Science and Technology, Middlesex University, London, NW4 4BT, UK. E.ward@mdx.ac.uk With thanks to Maryam Nour and Kah Weng Yap for their assistance with data collection in Experiment 1.

Abstract

Older adults often show greater implicit/unconscious memory than young adults for incidental information that was task-irrelevant during its acquisition. Shallow/perceptual encoding by older adults may boost performance on implicit tasks that reinstate this type of processing, whereas deeper/conceptual encoding by young adults may support greater explicit/conscious memory. To test this, young and older participants were exposed to incidental words in a text color identification task before the trial-by-trial capture of priming and recognition. In Experiments 1-3 priming and recognition were significantly greater in young than older adults, providing evidence against age differences in encoding style. In Experiments 2-3 older adults were more liberal than young adults in making positive recognition judgments to incidental relative to intentional items, even though source memory was poor in both groups. Findings pinpoint age differences in the utilization of previously incidental versus intentional information on different types of task.

Keywords: aging; implicit memory; explicit memory; priming; recognition; encoding style; retrieval

1. Introduction

There are many situations in which we intentionally try to learn new information for later use, but equally important is our ability to draw upon information learned unintentionally, for instance, when following a route. Age-related declines in the ability to consciously learn and retain new information are well documented, but there are surprising age differences in memory for incidental information that was task irrelevant during its initial acquisition. Older adults show similar or greater implicit (unconscious, nondeclarative) memory for such information compared to young adults, while young adults show greater explicit (conscious, declarative) memory (e.g., Gopie, Craik, & Hasher, 2011; Rowe, Valderrama, Hasher, & Lenartowicz, 2006; Thomas & Hasher, 2012; Ward, de Mornay Davies, & Politimou, 2015). For example, in Gopie et al. (2011), participants indicated the text color of words while ignoring the words themselves. They then performed a word-fragment completion (WFC) task with either indirect memory instructions to complete fragments with the first word that came to mind (implicit task), or direct instructions to complete fragments with words from the previous phase (explicit task). The use of words from the previous phase as solutions was greater in older than young adults in the implicit task, but young adults retrieved more words than older adults in the explicit task.

This pattern of age differences may be caused by qualitatively distinct initial processing of incidental information by young and older adults. Older adults may encode this information at a shallower level than young adults (see Craik, 1983; 1986, for an explanation of how depleted encoding resources with age results in a reduction in the ability to engage in elaborative memorial processing), and since implicit memory tasks generally rely on shallow (typically perceptual) processing, this may explain the superior performance of older adults on this type of task (see Craik, Moscovitch, & McDowd, 1994; Jacoby, 1983; Roediger & Blaxton, 1987). That is, older adults' perceptual encoding style may lead to greater performance on implicit tasks that reinstate this type of processing at retrieval, known as transfer-appropriate processing (Morris, Bransford, & Franks, 1977; Roediger, Weldon, & Challis, 1989). In contrast, deeper encoding by young adults may lead to greater performance on explicit tasks that draw upon this type of processing at retrieval. Indeed, when young participants' in Gopie et al. (2011, Experiment 3) were given a second simultaneous task during the encoding phase to reduce their available processing resources, their performance on the subsequent implicit and explicit WFC tests mirrored that in the older adult group: they showed greater output of the previously presented incidental items on the implicit than the explicit task.

Another possible explanation concerns age differences in retrieval. It is well established that young adults are better than older adults at constraining their retrieval to relevant sources of information (e.g., Jacoby, Shimizu, Velanova, & Rhodes, 2005), as well as suppressing no-longer-relevant information (e.g., Biss, Ngo, Hasher, Campbell, & Rowe, 2013). Greater control over retrieval may mean that young adults suppress previously incidental information that is not deemed relevant on traditional tasks with indirect memory instructions (i.e., tasks in which participants are not instructed to remember / use previously presented information). For example, in WFC, participants are required to complete fragments with the first word that comes to mind, but it is possible that young participants do generate previously encountered items as solutions, but opt for alternatives because the task is framed as unrelated to the prior phase in which the information was presented, and/or because they are concerned that they are supposed to have previously ignored such items. By contrast, older adults may not be as good at suppressing previously presented items, meaning that they output more of them. Of course, this implies that participants may not strictly follow instructions to complete fragments with the first word that comes to mind, but this issue and the fact that tasks such as this allow considerable flexibility in terms of response strategy has been raised in the past (e.g., Buchner & Wippich, 2000; MacLeod, 2008; Ward, Berry, & Shanks., 2013b; Ward, Berry, & Shanks, 2013a).

Recent studies have provided evidence that young adults do indeed suppress previously presented incidental information (sometimes termed previously irrelevant or distracting information) on tasks with indirect memory instructions. For example, Thomas and Hasher (2012) exposed young and older adults to irrelevant words interspersed within short stories, which they were asked to ignore while reading the stories aloud. Participants then studied a list of words, which was half comprised of previously irrelevant items, for free recall. When participants were not made aware that the study list contained items from the initial phase (indirect instruction), the two groups' level of recall was equivalent (Experiment 1). However, when participants were informed that the study list contained words that had appeared earlier in the experiment (direct instruction), young adults' recall exceeded that of older adults' (Experiments 2 and 3). The authors suggested that young adults in the indirect condition limited their retrieval solely to the studied list of words, deeming this to be the only relevant source of information, but when the task instructions pointed to the stories as another relevant source of information (direct condition), they were able to relax their constraint on retrieval in order to access more previously irrelevant items (see also Ward et al., 2015).

The present study aimed to shed greater light on whether the pattern of age differences in memory for incidental information is due to qualitatively distinct encoding by young and older adults, or age differences in retrieval. Participants were presented with words in an initial text color identification task closely modelled on Gopie et al. (2011). Encoding of the words was incidental as participants were required to rapidly identify text color and were unaware that the words themselves would later become relevant. Indices of explicit and implicit memory were subsequently taken using the continuous identification with recognition (CID-R) task (e.g., Conroy, Hopkins, & Squire, 2005; Stark & McClelland, 2000; Ward et al., 2013b), which involves the concurrent capture of perceptual identification (priming) of a previously presented or new word, and a recognition judgment. This paradigm involves a highly perceptual implicit task, and a traditional recognition task requiring the more effortful judgment of whether or not presented items had been shown previously in the experiment. Thus, if young and older adults engage in deep and shallow encoding of incidental information, respectively, then one would expect young adults to outperform older adults on the recognition task and vice versa on the identification task, due to transfer-appropriate processing.

A key feature of the identification task is that it has a single, well-defined goal to identify words as quickly as possible, meaning that participants do not have flexibility in their performance strategy (see Buchner & Wippich, 2000, for a review of the immunity of perceptual identification tasks to intentional memory strategies). Thus, the task is immune to the sort of suppression that, as explained above, may occur on other implicit tasks such as WFC. Hence, the alternative prediction is that if young adults typically engage in greater suppression of incidental items on traditional implicit tasks, they will show greater priming for such items on the present identification task in which the possibility of suppression is eliminated.

2. Experiment 1

2.1. Method

2.1.1. Participants

Forty young (eighteen male) and 40 older (twelve male) adults took part (Table 1). Young participants were students from Middlesex University, London, who participated in exchange for course credit. Older participants were members of the University of the Third

Age (U3A), who responded to an advertisement. All participants were fluent in English language with good vision, no color blindness, and good self-reported health. The study was approved by Middlesex University Research Ethics Committee.

2.1.2. Stimuli

Two 60-item lists of 30 common nouns and 30 random letter strings were rotated between participants. In this and subsequent experiments, words were concrete nouns taken from the MRC Psycholinguistics Database (Coltheart, 1981), and lists were matched in terms of word length, number of syllables, and frequency. All words and letter strings ranged from four to eight letters in length. In the color identification task, words/strings were presented in uppercase 20-point Arial font, in either red, blue, green, or yellow, in the center of a black background screen. Sixty words were presented in the CID-R task: 30 previously shown in the color identification task, and 30 new. In this phase words were presented in white uppercase 20-point Arial font on a black background screen. The priming mask used in the perceptual identification task was a 400 x 400 pixel grid randomly filled with black and white noise.

2.1.3. Procedure

Participants were tested individually in a session that lasted approximately 60 minutes. In the initial phase, participants were told that they would see words (e.g., “HOUSE”) and random letter strings (e.g., “XOTGH”), and asked to ignore the word/string and identify the text color as quickly and accurately as possible, by pressing a corresponding colored key. Letter strings were included to emphasise that the task was about color identification and not reading. A keypress initiated a central fixation cross for 1000 ms prior to the next trial. The first eight trials comprised random letter strings as a primacy buffer, followed by the experimental trials in a random order, and finally eight letter strings as a recency buffer. On each trial the word / letter string was displayed on the screen until a keypress was made.

Following the color identification phase there was a 10 min interval, in which participants completed the Wechsler Adult Intelligence Scale III (WAIS-III) Digit Symbol Substitution Test, and a series of simple algorithmic problems. They then completed the CID-R task. Each trial consisted of a speeded word identification, and a recognition judgment. In this and subsequent experiments, participants received standardised instructions on the computer screen. They were told that on each trial they would first have to identify a word. They were informed that the word would initially be obscured by a grid, but would gradually emerge, and that their task was to press the Enter key as soon as they could make out the word, at which point it would disappear and they would be prompted to type it into a box that would appear on the screen. Speed was emphasised, but participants were asked to try to be as accurate as possible. Each trial was self-initiated by the participant, and began with perceptual identification: The priming mask was initially presented for 500 ms, followed by a word (previously studied or new) for 17 ms (screen refresh duration), and then the mask for 233 ms (making a 250 ms block). These block presentations were repeated, with the duration of word presentations increasing by 17 ms on every alternate block while the total block duration remained constant (e.g., Blocks 1 and 2: 17 ms [word] and 233 ms [mask]; Blocks 3 and 4: 34 ms [word] and 216 ms [mask]). The effect is that the word appears to gradually emerge from the mask. RTs were captured on Enter keypress, at which point the word and mask disappeared and participants were prompted to type the word into a box on the screen. The block presentations ceased at 7500 ms (30 blocks) after initiation if no identification had taken place, and any such trials were discarded.

The on-screen instructions stated that on each trial, after the word had been identified and typed into the box, participants would be asked to decide whether or not the same word was shown previously in the experiment. Participants were required to make this judgment using 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*. No time limit was imposed, and the instructions emphasised that a 'yes' response should be used to indicate the belief that the word was shown in the color identification task and a 'no' response should be used to indicate the belief that the word was not shown in the color identification task. The instructions stated that half the words to appear in this phase were previously shown in the colour identification phase and half were not previously shown in the experiment. Finally, participants completed the near vision test, the Wechsler Test of Adult Reading (WTAR), the WAIS-III Vocabulary test, and older adults completed the Mini Mental State Exam (MMSE).

2.2. Results and Discussion

2.2.1. Color Identification

Accuracy in the color identification task was high and did not significantly differ between groups (young: $M = .98$, $SD = 0.02$; older: $M = .99$, $SD = 0.01$), $t(78) = 1.47$, $p = .147$. Response times (RTs) were at 1003 ms ($SD = 207$) and 1109 ms ($SD = 145$) for young and older adults, respectively, $t(78) = 2.65$, $p = .010$, $d = 0.59$.

2.2.2. Priming

For each participant, trials associated with incorrect word identifications were excluded, as well as trials associated with RTs greater than 2.5 SD from the mean. Mean identification RTs in young adults were at 1905 ($SD = 525$) and 2035 ($SD = 544$), for previously presented and new items, respectively, and RTs in older adults were at 2653 ($SD = 1108$) and 2677 ($SD = 1153$), for previously presented and new items, respectively. Priming (Figure 1) was calculated by subtracting the mean studied item RT from the participants' mean RT for new items, and this was expressed in proportion to the individuals' mean baseline (new item) RT. Priming was significantly greater than zero in young adults, $t(39) = 4.72$, $p < .001$, $d = 0.75$, but not in older adults, $t(39) = 0.18$, $p = .860$, and was significantly greater in young than older adults, $t(78) = 3.46$, $p = .001$, $d = 0.78$.

2.2.3. Recognition

Ratings 4-6 (*'yes'* – studied) and 1-3 (*'no'* – new) were collapsed into a dichotomous measure. Mean hit rates were at .62 ($SD = .25$) and .59 ($SD = .22$) in young and older adults, respectively, and mean false alarm rates were at .20 ($SD = .14$) and .29 ($SD = .21$), in young and older adults, respectively. A discrimination index was derived from the two-high threshold model (Snodgrass & Conwin, 1988), by subtracting the proportion of false alarms from hits to yield corrected recognition (*Pr*). Corrected recognition (Figure 1) was significantly greater than chance (i.e., $Pr > 0$) in both groups (young: $t(39) = 11.65$, $p < .001$, $d = 1.84$; older: $t(39) = 7.80$, $p < .001$, $d = 1.23$), but was significantly greater in young than older adults, $t(78) = 2.25$, $p = .028$, $d = 0.51$.

Thus, both recognition and priming were significantly greater in young than older adults. It has been argued that shallow/perceptual processing of incidental information by older adults boosts performance on subsequent implicit tasks, while deeper encoding by young adults facilitates performance on explicit tasks, due to transfer-appropriate processing (e.g., Gopie et al., 2011). However, the pattern of results from Experiment 1 suggests that there may not necessarily be qualitative age differences in the way in which incidental information is encoded. If young and older adults engage in deep/conceptual and shallow/perceptual encoding, respectively, then older adults would have been better equipped for the implicit task, which was highly perceptual in nature. Moreover, since repetition priming effects are generally greatest when encoded representations match visually presented test stimuli (e.g., Roediger & Blaxton, 1987), conceptually encoded representations (i.e., in young adults) would not have supported greater performance in the priming task.

Some prior studies have reported equivalent or greater implicit memory in older than young adults for incidental information (sometimes called previously irrelevant or distracting information) (e.g., Gopie et al., 2011; Rowe et al., 2006), and instead of this reflecting qualitatively distinct initial processing of this information, it may reflect age differences in retrieval. As outlined in the Introduction, some have argued that young adults suppress previously incidental information on traditional implicit tasks, where it is deemed unnecessary (e.g., Thomas & Hasher, 2012; Ward et al., 2015). In Experiment 1, the possibility of suppression was eliminated with the use of the CID-R task, and priming was significantly greater in young than older adults. In other words, young adults showed greater implicit memory for incidental information compared to older adults when age differences in retrieval strategy were ruled out. A similar finding was reported by Ward et al. (2015) using different materials and encoding phase.

Experiment 2 was conducted in replication of Experiment 1, but with the inclusion of intentional as well as incidental items. The rationale was to provide a stronger test of whether incidental (versus intentional) items are encoded in qualitatively distinct ways by young and older adults. If older adults encode incidental information at a shallow/perceptual level, then intentional information should be encoded at a comparatively deeper level. Hence, a direct comparison of priming for incidental versus intentional items is an important one to make: Given the perceptual nature of the priming task and transfer-appropriate processing, one would expect items encoded at a shallow level (i.e., incidental items) to be associated with greater priming than items encoded at a deeper level (i.e., intentional items).

3. Experiment 2

In Experiment 2 participants once again indicated the text color of words and random letter strings and were not aware that the words would later become relevant. Participants then studied a list of words, which was partly comprised of items from the initial phase, before completing the CID-R task. There were four types of item in the CID-R phase: words that had appeared only in the color identification task (incidental), words that had appeared in both the color identification task and the study list, words that had appeared only in the study list, and new words. The reason for including a subset of items from the colour identification phase in the study list was to avoid a clear distinction to participants between items in the different phases, and this method has been used in the past (e.g., Thomas & Hasher, 2012; Ward et al. 2015). Nevertheless, participants were not made aware that items from the color identification task were shown in other phases of the experiment.

3.1. Method

3.1.1. Participants

Twenty-four young (five male) and 24 older (six male) adults participated (Table 1). Young participants were students from Middlesex University and older participants were local residents and members of the U3A. All participants spoke fluent English, had good vision, no color blindness, and reported good health.

3.1.2. Stimuli

Eighty items were shown in the color identification task – 40 common nouns and 40 random letter strings. In this phase, words/strings were presented in uppercase 20-point Arial font, in red, blue, green, or yellow in the center of a black background screen. Twenty words from the color identification task were presented again in the study list, along with 20 new words, in white 20-point Arial font on a black background screen. One hundred and twenty words were presented in the CID-R phase: 20 that were shown only in the color identification task, 20 that were shown in both the color identification task and study list, 20 that were shown only in the study list, and 60 brand new words. Six lists of words were counterbalanced between participants to achieve this.

3.1.3. Procedure

The procedure for the color identification task was identical to Experiment 1. Participants identified as quickly and accurately as possible the text color of words/letter strings by pressing the corresponding colored button. Eight initial trials comprised letter strings as a primacy buffer, followed by the 80 experimental trials (40 words and 40 strings) in a random order, and finally eight letter strings as a recency buffer.

Immediately after the color identification task participants were told that they would see words on the computer screen, one at a time, and that they should try to visualise the object and remember the words for a later memory test. Each word was presented in white uppercase 20-point Arial font on a black background screen, for 4000 ms. A white central fixation cross was presented for 1000 ms between each word. Participants were not informed that some of the words had appeared in the color identification task. Prior to the test phase there was a 10 min interval in which participants performed the WAIS-III Digit Symbol Substitution Test and solved simple algorithmic problems.

The procedure for the CID-R task was identical to Experiment 1. On each trial participants identified a word as it gradually emerged, before making a recognition judgment using the 6-point scale described previously. In this experiment and Experiment 3, rather than specifying that a 'yes' response indicates the belief that the word was shown in the color identification task, the instructions simply stated that a 'yes' response indicates the belief that the word was shown in a previous phase of the experiment, and a 'no' response indicates that the belief that the word was not previously shown in the experiment. The instructions stated that half of the words were shown previously in the experiment and half were not, but there was no mention of the fact that some items were shown in multiple prior phases. At the end of the task participants were asked whether they had noticed any connection between the various phases, and if so, to describe it. This was to gauge awareness of the fact that some words were shown in both the color identification task and the study list. No participant reported awareness of this. Finally, participants completed the near vision test, the WTAR, the WAIS-III Vocabulary test, and the MMSE (older adults only).

3.2. Results and Discussion

3.2.1. Color identification

Accuracy did not significantly differ between groups in the color identification task (young adults: $M = .95$, $SD = 0.02$; older adults: $M = .99$, $SD = 0.02$), $t(46) = 1.42$, $p = .162$. RTs were at 1074 ms ($SD = 392$) and 1245 ms ($SD = 228$) for young and older adults, respectively, $t(46) = 1.84$, $p = .073$.

3.2.2. Priming

See Table 2 for mean identification RTs. Trials associated with incorrect responses and/or RTs greater than 2.5SD from the mean were excluded. Priming (Figure 2) was significantly above zero for all word types in young adults (t's > 3.68, p's < .001), but not in older adults, (t's < 1.26, p's > .221). A mixed analysis of variance (ANOVA) revealed a significant main effect of word type, $F(2, 92) = 5.17$, $p = 007$, $\eta_p^2 = .10$, a significant main effect of age, $F(1, 46) = 8.00$, $p < .007$, $\eta_p^2 = .14$, and no interaction, $F(2, 92) = 1.68$, $p = 191$. Planned comparisons revealed that, in young adults, words presented only in the color identification task (incidental items) were associated with significantly lower priming than words presented only in the study list, $t(23) = 2.84$, $p = .008$, $d = 0.49$, and words presented in both tasks, $t(23) = 2.16$, $p = .041$, $d = 0.43$. However, there was no significant difference in priming between words that were presented in both tasks versus just the study list, $t(23) = 0.18$, $p = .856$. In older adults, priming did not significantly differ across the different word types (t's < 1.68, p's > .107). Priming was significantly greater in young than older adults for all word types (color identification task only: $t(46) = 2.05$, $p = .046$, $d = 0.60$; study list only: $t(46) = 2.95$, $p = .005$, $d = 0.86$; both tasks: $t(46) = 2.70$, $p = .010$, $d = 0.78$).

3.2.3. Recognition

Corrected recognition (Figure 2; Table 3 for proportions of hits and false alarms) was significantly greater than chance in both groups for all word types (t's > 6.23, p's < .001), apart from in older adults for words presented only in the color identification task, $t(23) = 0.73$, $p = .474$. There was a significant main effect of word type, $F(2, 92) = 105.60$, $p < .001$, $\eta^2_p = .70$, a significant main effect of age, $F(1, 46) = 9.66$, $p = .003$, $\eta^2_p = .17$, and no significant interaction, $F(2, 92) = 0.02$, $p = .979$. In both groups, words presented only in the color identification task (incidental items) were associated with significantly lower recognition than words presented only in the study list (young adults: $t(23) = 9.58$, $p < .001$, $d = 2.23$; older adults: $t(23) = 7.54$, $p < .001$, $d = 1.08$), and words presented in both tasks (young adults: $t(23) = 7.72$, $p < .001$, $d = 2.12$; older adults: $t(23) = 7.34$, $p < .001$, $d = 1.02$). There was no significant difference in recognition between words presented in both tasks and words presented only in the study list (young adults: $t(23) = 0.79$, $p = .437$; older adults: $t(23) = 0.63$, $p = .533$). Compared to older adults, young adults showed greater recognition of words presented only in the color identification task, $t(46) = 2.73$, $p = .009$, $d = 0.78$, words presented only in the study list, $t(46) = 2.75$, $p = .009$, $d = 0.85$, and words presented in both tasks, $t(46) = 2.93$, $p = .005$, $d = 0.79$.

Thus, recognition and priming were significantly greater in young than older adults for all word types. Findings from Experiment 2 therefore replicate and extend Experiment 1, providing further evidence that qualitative age-differences in encoding style do not explain the prior reported dissociations of explicit and implicit memory for incidental information: If older adults had encoded incidental items at a shallower level than young adults, then due to transfer-appropriate processing one would have expected them to show greater priming on the perceptual identification task.

Recognition was significantly greater for intentional than incidental information in both age groups, and this is to be expected given evidence that recognition is influenced by attentional manipulations (e.g., Berry, Shanks, Li, Rains, & Henson, 2010; Butler & Klein, 2009; Vuilleumier Schwartz, Duhoux, Dolan, & Driver, 2005). Words presented in the study list were fully attended and intentionally encoded, so one would expect recognition to be superior for these items compared to incidental items, for which the semantic content was ignored. This pattern was mirrored in priming, albeit only numerically in older adults. There is evidence that priming is affected by attentional manipulations in the same way as recognition (e.g., Berry et al., 2010), and the effect in older adults most likely did not reach significance as priming in this group was very weak (not statistically above zero). These observations suggest that intentional items were encoded with greater memory strength than incidental items in both age groups, but the two types of item were not associated with qualitatively distinct forms of memory representation (e.g., perceptual versus conceptual). If incidental and intentional information had been processed in a perceptual and conceptual manner, respectively, one would have expected priming to be greater for incidental than intentional items, due to transfer-appropriate processing. By the same token, if older adults generally engage in shallow/perceptual processing of incidental information, then their priming for these items would have been greater than that for intentional items.

An important observation is that young adults once again showed greater implicit memory than older adults for incidental information when age differences in retrieval strategy were ruled out by using the CID-R task. This implies that there are age differences in the retrieval / use of this information on other implicit tasks such as WFC (see Introduction), but an important unanswered question concerns why young and older adults respond differently on such tasks. As outlined in the Introduction, one possibility is that young adults are more likely to dismiss previously incidental information on tasks with indirect instructions due to its apparent lack of relevance to the present task. Post-retrieval monitoring (e.g., Koriat & Goldsmith, 1996) allows individuals to select the most appropriate response/s among a number of retrieved candidates; so, while performing a task with no specific instructions to make use of items encountered in a specific prior phase, young adults may reject retrieved items that are deemed irrelevant. That is, in an attempt to avoid using items from a seemingly unrelated prior phase, young participants may disregard items that come to mind if they are judged to have potentially been present in that prior phase, or if they are uncertain about the source of their memory for such items. In contrast, older adults may be more liberal in their output of any recently studied/familiar items that come to mind. Indeed, post-hoc analysis of response bias in Experiment 2 suggested that older adults were more liberal in making positive recognition judgments to incidental items. A bias index was calculated as Br = false alarm rate / (1 – Pr), reflecting participants' tendency to respond '*yes*' to an item when in an uncertain state (values < .5 indicate a conservative bias and values > .5 indicate a liberal bias). There was no significant difference between groups in bias for items that had appeared only in the study list (Young: .66; Older: .70) or in both tasks (Young: .66; Older: .69), t's < 0.46, p's > .646, but older adults were significantly more liberal than young adults in their tendency to respond '*yes*' to items presented solely in the color identification task (Young: .25; Older: .37), $t(46) = 2.40$, $p = .020$, $d = 0.69$.

Experiment 3 was a replication of Experiment 2, but with the inclusion of a source memory judgment (memory for the episodic source in which items were encountered, Johnson, Hashtroudi, & Lindsay, 1993; Schacter, Kaszniak, Kihlstrom, & Valdiserri, 1991) at test. Findings from Experiment 2 suggest that incidental items are encoded with weaker memory strength than intentional items, and it is therefore likely that these items are also associated with greater uncertainty surrounding the phase in which they were encountered. This may be an important factor in the suppression of such items. The source memory judgment was thus included to objectively ascertain whether incidental items are associated with poor memory for the experimental context in which they were presented. On test trials in which participants correctly recognised the target word, they were asked *where* they encountered the item: the color identification task, the study list, or both. It was predicted that source memory would be reduced for incidental compared to intentional items in both groups.

4. Experiment 3

4.1. Method

4.1.1. Participants

There were 24 young (five male) and 24 older (six male) participants (Table 1). Young adults were students from Middlesex University and older adults were local residents and members of the U3A. All participants were fluent in English language, in good health and with good vision and no color blindness.

4.1.2. Stimuli & Procedure

The same set of stimuli from Experiment 2 were used. There were 40 real words and 40 random letter strings in the color identification task, and twenty words from this phase were presented in the study list, alongside 20 new words. Participants were not informed that the study list contained some of the words from the color identification task. At test, following the same 10 min filler task, 60 previously studied words (20 from the color identification task, 20 from the study list, 20 from both tasks) were presented alongside 60 new words. On each trial participants identified a word as it gradually emerged, before making a recognition judgment using the same 6-point scale as in Experiments 1 and 2. Once again the instructions stated that half of the words were shown previously in the experiment and the other half were not. On trials in which the participant correctly responded '*yes*' in the recognition task, they were prompted to make a judgment as to where they had encountered the word: 1 = *First task (color identification)*; 2 = *Second task (study list)*; 3 = *Both tasks (color identification and study list)*, using the respective keyboard number keys. As such, although there was no explicit mention of the fact that some items were shown in multiple prior phases of the experiment, participants could deduce this at this point. It was made clear that half the words were shown in the color identification task and/or the study list, and half were new. After the computer task participants completed the near vision test, the WTAR, the WAIS-III Vocabulary test, and the MMSE (older adults only).

4.2. Results and Discussion

4.2.1. Color Identification

The data of one young participant was removed due to a failure to perform the color identification task with sufficient accuracy (> 10% inaccurate trials). Accuracy in the color identification task in the remaining 23 young and 24 older participants was high and did not significantly differ between groups (young adults: $M = .99$, $SD = .02$; older adults: $M = .99$, $SD = .01$), $t(45) = 1.65$, $p = .106$. RTs were at 950 ms ($SD = 379$) and 1095 ms ($SD = 203$) in young and older adults, respectively, $t(45) = 0.66$, $p = .511$.

4.2.2. Priming

Mean identification RTs can be found in Table 2. Trials associated with incorrect responses and/or RTs greater than 2.5SD from the mean were once again excluded. Priming (Figure 3A) was significantly greater than zero for all word types in young adults (t's > 3.94, p's < .001, d's > 1.17), but older adults only exhibited significant priming for words that were presented solely in the study list, $t(23) = 2.18$, $p = .040$, $d = 0.62$ (color identification task only: $t(23) = 1.63$, $p = .116$; both tasks: $t(23) = 1.62$, $p = .119$). There was a significant main effect of word type, $F(2, 90) = 3.61$, $p = 031$, $\eta_p^2 = .07$, a significant main effect of age, $F(1, 45) = 17.70$, $p < .001$, $\eta_p^2 = .49$, and no significant interaction, $F(2, 90) = 2.34$, $p = 103$. In young adults, words presented only in the color identification task (incidental items) were associated with significantly lower priming than words presented only in the study list, $t(22) = 2.33$, $p = .030$, $d = 0.64$, and words presented in both tasks, $t(22) = 2.67$, $p = .014$, $d = 0.51$. There was no significant difference in priming between words presented in both tasks and words presented in just the study list in young adults, $t(22) = 0.07$, $p = .943$. In older adults, there were no significant differences in priming across word types (t's < 0.65, p's > .520). Priming was significantly greater in young than older adults for all word types (color identification task only: $t(45) = 2.39$, $p = .021$, $d = 0.71$; study list only: $t(45) = 3.24$, $p = .002$, $d = 1.23$; both tasks: $t(45) = 4.25$, $p < .001$, $d = 0.95$).

4.2.3. Recognition

See Table 3 for proportions of hits and false alarms. Corrected recognition (Figure 3B) was significantly greater than chance in young adults (t's > 5.78, p's < .001), and older adults (t's > 2.41, p's < .024). There was a significant main effect of word type, $F(2, 90) = 107.08$, $p < .001$, $\eta_p^2 = .70$, a significant main effect of age, $F(1, 45) = 13.89$, $p = .001$, $\eta_p^2 = .24$, and no interaction, $F(2, 90) = 0.54$, $p = .584$. In both groups, words presented only in the color identification task (incidental items) were associated with significantly lower recognition than words presented only in the study list (young adults: $t(22) = 11.10$, $p < .001$, $d = 2.64$; older adults: $t(23) = 7.28$, $p < .001$, $d = 1.76$), and words presented in both tasks (young adults: $t(22) = 9.37$, $p < .001$, $d = 2.59$; older adults: $t(23) = 6.86$, $p < .001$, $d = 1.32$). There was no significant difference in recognition between words presented in both tasks and those presented only in the study list (young adults: $t(22) = 0.58$, $p = .566$; older adults: $t(23) = 0.83$, $p = .416$). Compared to older adults, young adults showed greater recognition of all word types (color identification task only, $t(45) = 2.88$, $p = .006$, $d = 0.84$; study list only, $t(45) = 3.31$, $p = .002$, $d = 0.96$; both tasks, $t(45) = 2.95$, $p = .005$, $d = 0.87$).

Analysis of *Br* also replicated Experiment 2. Once again there was no significant difference between groups in bias for items that had appeared only in the study list (Young: .72; Older: .73), and both tasks (Young: .71; Older: .70) (t's < 0.11, p's > .912). However, older adults were significantly more liberal than young adults in their tendency to respond '*yes*' to items presented solely in the color identification task (Young: .27; Older: .37), $t(45) = 2.06$, $p = .023$, $d = 0.60$.

4.2.4. Source memory

The proportions of correct judgements (hits) and incorrect judgments (misses) about the phase/s in which words were presented are given in Table 4. For words presented only in the color identification task, there was no difference between the proportion of hits and misses (young: $t(22) = 0.94$, $p = .353$; older: $t(23) = 0.67$, $p = .508$), and groups did not significantly differ in the number of hits, $t(45) = 0.23$, $p = .819$, or misses, $t(45) = 0.27$, $p = .791$. Conversely, the patterns of hits and misses differed across the other word types. Both groups made more hits than misses to words presented only in the study list (young: $t(22) = 7.03$, $p < .001$, $d = 2.23$; older: $t(23) = 8.09$, $p < .001$, $d = 4.04$), but this pattern reversed for items presented in both tasks; both groups made more misses than hits (young: $t(22) = 13.86$, $p < .001$, $d = 2.72$; older: $t(23) = 6.33$, $p < .001$, $d = 2.48$). Groups did not significantly differ in hits or misses to items presented only in the study list (hits: $t(45) = 0.51$, $p = .616$, misses: $t(45) = 0.09$, $p = .930$), or items presented in both tasks (hits: $t(45) = 1.77$, $p = .084$, misses: $t(45) = 1.40$, $p = .169$). A corrected alpha level of .004 was applied to these comparisons.

Thus, findings replicated Experiment 2. Recognition and priming were significantly greater in young than older adults for all word types, providing further evidence that qualitative age-differences in encoding style do not explain age differences in explicit and implicit memory for incidental information. Moreover, although both age groups made significantly more correct than incorrect source judgments to words presented only in the study list (intentional items), source memory for the other word types was poor in both groups, as predicted. Poor memory for the experimental context in which incidental information was encountered could be an important factor in the suppression of such information on traditional implicit tasks, and this is explored further in the General Discussion.

The lack of age difference in source memory stands in contrast to some prior studies (e.g., Dennis, Hayes, Prince, Madden, Huettel, & Cabeza, 2008; Glisky, Rubin, & Davidson, 2001; Schacter et al., 1991), but direct comparisons should be approached with caution as this is the first study to contrast age differences in source memory for incidental and intentional information. In prior studies on source memory participants have typically made associative links between items and encoding contexts. Intentional items were associated with a larger numerical age difference in source memory, but the effect may have been weakened by the fact that some items were repeated in multiple experimental phases. Moreover, prior studies suggest that an age-related reduction in source memory reflects below average frontal function (e.g., Glisky et al., 2001), and all older participants in the present study had good cognitive function as indexed through various measures of pre-morbid intelligence and the MMSE (Table 1).

5. General Discussion

Prior studies have reported greater implicit and worse explicit memory for incidental (previously irrelevant) information in older than young adults, and the aim of the current study was to examine whether this is due to qualitatively distinct encoding of incidental information by young and older adults, or age differences in retrieval. In three experiments participants were exposed to words in a text color identification phase, before completing a CID-R task, which involves a perceptual identification (implicit task) followed by a recognition judgement (explicit task) on each trial. Recognition and priming were consistently greater in young than older adults. Qualitative age differences in the way in which incidental information is encoded do not therefore explain the dissociations reported previously – if young and older adults engage in deep and shallow encoding, respectively, then due to transfer-appropriate processing older adults would have been better equipped for the present implicit task, which was highly perceptual in its processing requirement. Experiments 2 and 3 also contrasted performance for incidental and intentional items, and recognition and priming were greater for intentional than incidental items in both age groups (the effect in priming was numerical in older adults). If older adults had engaged in shallow processing of incidental information, then their priming for these items would have been greater than that for intentional items, which by comparison would have been processed at a deeper level. On the whole, findings suggest that processing of incidental information by young and older adults is quantitatively rather than qualitatively distinct: that is, representations encoded by older adults are simply weaker in memory strength.

Age differences in retrieval can explain the mixed findings across different tasks. As outlined previously, young adults are better than older adults at constraining their retrieval to relevant sources of information and suppressing no-longer-relevant information (e.g., Biss et al., 2013; Jacoby et al., 2005). Young adults may therefore more efficiently suppress incidental items on traditional implicit tasks. WFC is a popular implicit task, but it is possible that young participants do generate previously incidental items as solutions but are more likely than older adults to reject them. Young participants may disregard items that come to mind if they are judged to have been present in an unrelated prior phase or if they are uncertain about the phase in which they were encountered, whereas older adults may be more liberal in their output of any recently studied/familiar items that come to mind. Indeed, findings from Experiment 3 confirmed that incidental items are associated with poor source memory, and response bias indicies in Experiments 2 and 3 showed that older adults are significantly more liberal than young adults in relation to incidental items. On the whole, items may be more readily dismissed by young than older adults in the absence of salient episodic information about the prior encounter/s. However, the identification task used in the present experiments is immune to suppression as participants do not have flexibility in their performance strategy (see Buchner & Wippich, 2000; Ward et al., 2013b), and young adults showed greater priming than older adults for incidental items.

There is direct evidence that some implicit tasks are susceptible to explicit contamination (e.g., see Geraci & Barnhardt, 2010). For example, if participants become aware that previously studied items can be used as solutions on a WFC task (known as test-awareness), they may not follow instructions to complete fragments with the first word that comes to mind, but instead use a conscious retrieval strategy to produce solutions (and as noted above, in the case of incidental items, these may be retrieved and dismissed by young participants). This is exacerbated by the fact that a time limit is not usually imposed on these types of task. Importantly, when explicit contamination is controlled for, priming effects alter (e.g., Barnhardt, 2004; Barnhardt & Geraci, 2008; Geraci & Barnhardt, 2010; Hultsch, Masson, & Small, 1991; Light & Singh, 1987; Winocur, Moscovitch, & Stuss, 1996). By contrast, perceptual identification tasks are not affected by explicit contamination (e.g., Buchner & Wippich, 2000; Ward et al., 2013b). Ward et al. (2013b) showed that manipulations of test-awareness had no effect on priming in the CID-R paradigm. Moreover, priming was equivalent in test-unaware participants and those who were instructed to use an explicit strategy. As Buchner and Wippich (2000) pointed out, the single, clear goal and speeded nature of perceptual identification tasks means that participants tend to follow instructions to identify targets as quickly as possible. So, unlike in tasks such as WFC, participants are not afforded flexibility in terms of strategy, and, where incidental items are concerned, it is unlikely that they would attempt to suppress a perceptual identification response. Indeed, there would be very little time for any type of suppression to occur.

On another methodological note, it should be noted that although WFC and perceptual identification tasks both draw upon perceptual processing, the former requires the production of a response and the latter is based on identification. The issue with age differences in response strategy is likely to be exacerbated on production-based tasks relative to identification, given their greater flexibility. Moreover, the two types of task may be differentially sensitive to the detection of age differences, depending on how age-related cognitive decline affects the particular processes that are engaged. The ability to produce a response is thought to be reduced to a greater extent in aging than identification abilities (e.g., see Rybash, 1996), so identification tasks like that used in the present study are more suitable for age comparisons.

Lastly, the present observation of reduced priming with age provides an important contribution to the memory systems debate. Although it is well-established that explicit memory declines with age (reviewed in Mitchell, 1989; Light, 1991; Kausler, 1994), there have been numerous reports over the past few decades of age-invariant implicit memory in a range of modalities (e.g., Ballesteros, Nilsson, & Lemaire 2009; Ballesteros & Reales, 2004; Fleischman and Gabrieli, 1998; Fleischman et al., 2004; Fleischman, 2007; Light, La Voie, Valencia-Laver, Albertson Owens, & Mean, 1992; Mitchell, 1989; Mitchell, Brown, & Murphy, 1990; Mitchell & Bruss, 2003; Schacter, Cooper, & Valdiserri, 1992). The sparing of implicit memory in the face of declining explicit memory has been heavily cited as providing evidence for functionally independent explicit/implicit cognitive and neural systems (e.g., Schacter, 1987; Tulving & Schacter, 1990; Schacter & Tulving, 1994; Squire, 1994, 2004, 2009; Gabrieli, 1998, 1999). However, the current study is not the first to demonstrate reduced implicit memory with age. A number of prior studies have uncovered significant age-related reductions in priming (e.g., Abbenhuis, Raaijmakers, Raaijmakers, & Van Woerden, 1990; Chiarello & Hoyer, 1988; Hultsch, Mason, & Small, 1991; Ward et al., 2013a; 2013b; Ward et al., 2015). In many studies that have reported preserved priming with age, performance has been numerically reduced in older compared to young adults, meaning there may be a genuine decline that often goes undetected (for a discussion of why age differences in implicit memory may go undetected see Buchner & Wippich, 2000; LeBel & Paunonen, 2011; Ward et al., 2013b). Indeed, La Voie and Light's (1994) extensive meta-analysis uncovered a small but significant age effect on priming. This is consistent with the view that explicit and implicit memory are driven by a single underlying system (e.g., Berry, Shanks, Speekenbrink, & Henson, 2012).

6. Conclusions

Young and older adults do not encode incidental information in qualitatively distinct ways, but this information may be utilized at retrieval in different ways by the two age groups depending upon the task requirements. Young adults show an advantage over older adults for explicitly retrieving previously encountered incidental information, and also show greater priming for this information when age differences in strategy are eliminated. There are parallel effects of age on explicit and implicit memory for incidental information, just as there are for intentional information, in line with the view that the two forms of memory are driven by a single underlying system that is susceptible to age-related decline.

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Table 1
Participant Characteristics in 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)	21.68 (1.73)	73.45 (5.72)	22.96 (3.24)	71.83 (6.36)	20.95 (1.68)	73.96 (5.02)
Education (years)	16.45 (1.60)	16.18 (2.16)	16.67 (2.37)	16.50 (1.98)	16.13 (1.71)	15.22 (2.73)
Visual acuity	33.10 (7.95)	40.53 (12.36)*	31.50 (8.85)	40.33 (14.25)*	34.09 (6.01)	45.21 (15.65)*
WAIS-III						
Vocabulary	41.60 (8.29)	60.80 (8.11)*	38.83 (10.40)	61.33 (7.57)*	31.26 (14.14)	59.08 (9.83)*
Processing Speed	80.13 (15.17)	66.23 (16.91)*	79.71 (16.98)	62.92 (14.24)*	81.87 (13.67)	71.21 (16.52)*
WTAR	34.75 (7.98)	47.95 (4.00)*	34.88 (7.32)	48.17 (2.99)*	35.26 (8.14)	47.57 (5.03)*
MMSE	-	29.65 (0.58)	-	29.58 (0.65)	-	29.71 (0.55)

Note. Visual acuity was measured using the Near Vision Test Card (Schneider, 2002), viewed at a distance of 16 inches while wearing corrective glasses if needed. Scores on this test can range from 16 (highest acuity) to 160 (lowest acuity). WAIS-III = Wechsler Adult Intelligence Scale III. The Vocabulary and Processing Speed (Digit Symbol Substitution) subtests of the WAIS-III have maximum scores of 66 and 133, respectively. WTAR = Wechsler Test of Adult Reading, with a maximum score of 50. MMSE = Mini Mental State Exam, with a maximum score of 30. No participant in the present experiments scored below 28 on the MMSE (i.e., no participant was deemed cognitively impaired).

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

Table 2

Mean RTs (milliseconds) in Young and Older Adults in the Priming Task in Experiments 2 and 3.

Experiment 2	Young	Older
	M (*SD*)	*M* (*SD*)
Color identification	1922 (548)	2823 (978)
Study list	1814 (459)	2773 (828)
Color identification plus study list	1814 (432)	2781 (668)
New	2070 (620)	2898 (890)
Experiment 3		
Color identification	1813 (467)	2264 (718)
Study list	1704 (374)	2247 (703)
Color identification plus study list	1707 (414)	2245 (695)
New	1925 (453)	2306 (738)

Table 3

Mean Proportions of Hits and False Alarms (FA) in Young and Older Adults in the Recognition Task in Experiments 2 and 3.

	Young		Older	
Experiment 2	Hit *M* (*SD*)	FA *M* (*SD*)	Hit *M* (*SD*)	FA *M* (*SD*)
Color identification	.49 (.16)	.18 (.12)	.42 (.21)	.34 (.23)
Study list	.90 (.11)	.18 (.12)	.84 (.22)	.34 (.23)
Color identification plus study list	.88 (.13)	.18 (.12)	.80 (.25)	.34 (.23)
Experiment 3				
Color identification	.43 (.18)	.20 (.10)	.41 (.23)	.34 (.18)
Study list	.90 (.15)	.20 (.10)	.83 (.23)	.34 (.18)
Color identification plus study list	.88 (.14)	.20 (.10)	.79 (.27)	.34 (.18)

Note. A single FA rate, representing the proportion of positive recognition judgments in relation to new word trials, was used to compute corrected recognition (*Pr*) for each word type.

Table 4

Mean Proportions of Hits and Misses in Young and Older Adults in the Source Judgment Task in Experiment 3.

	Young		Older	
	Hit *M* (*SD*)	Miss *M* (*SD*)	Hit *M* (*SD*)	Miss *M* (*SD*)
Color identification	.22 (.16)	.18 (.15)	.21 (.11)	.19 (.15)
Study list	.75 (.21)	.08 (.10)	.63 (.25)	.14 (.18)
Color identification plus study list	.13 (.15)	.67 (.27)	.11 (.13)	.66 (.25)

Figure 1. Left: Mean proportion priming in Young and Older adults in Experiment 1. Right: Corrected recognition in Young and Older adults in Experiment 1. Error bars indicate standard error of the mean (SEM).

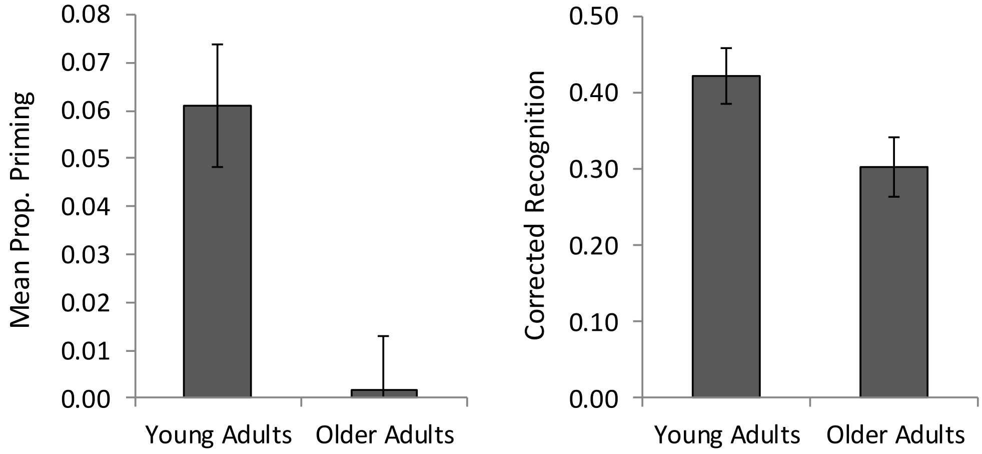

Figure 2. Left: Priming in Young and Older adults for items presented only in the color identification task (color ID [incidental items]), items presented in both the color identification task and the study list (color ID plus study list), and items presented only in the study list (study list) in Experiment 2. Right: Corrected recognition for the various item types in Young and Older adults in Experiment 2. Error bars in indicate SEM.

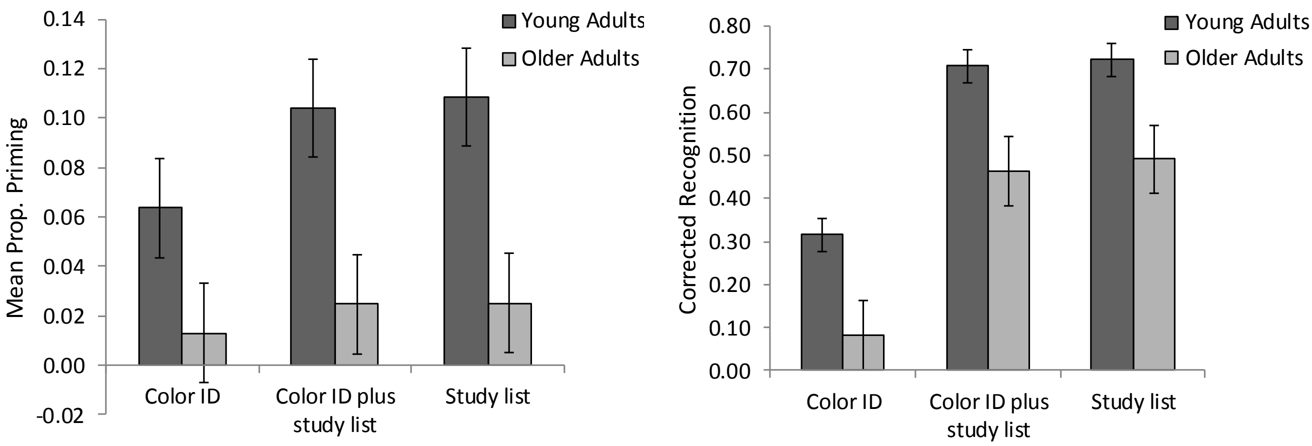

Figure 3. Left: Priming in Young and Older adults for the various item types in Experiment 3. Right: Corrected recognition in Young and Older adults in Experiment 3. Error bars indicate SEM.