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Memory for Age–Face Associations in Younger and Older Adults: The Role of Generation and Schematic Support

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Memory for ages of unfamiliar faces was examined in an associative memory task to determine whether generation as well as schematic support (cues from faces) would enhance later cued recall of the age information and reduce older adults' associative deficit. Participants studied faces and were either presented with the age or first had to guess before being shown the correct age. Later, participants were given a cued-recall test. Both younger and older adults exhibited associative memory enhancements from first generating the ages at encoding (a generation effect) despite the fact the initial generation was often inaccurate. Although older adults recalled fewer ages overall compared with younger adults, older adults were able to remember the age information for older faces equally as well as younger adults. However, when errors committed during generation were large and when schematic support was not available to support encoding and retrieval (when the age information was inconsistent given the cues from the face), generating was no longer beneficial for either older or younger adults. Thus, although older adults display an associative deficit when remembering specific age–face associations, this can be reduced through the use of prior knowledge and generation at encoding.

Keywords: aging, memory, generation effect, schematic support, errorful learning

Older adults often display associative memory deficits, making it difficult to create new associations between event information or individual items, thus limiting their ability to encode information effectively and later retrieve it (Chalfonte & Johnson, 1996; MacKay, Miller, & Schuster, 1994). Naveh-Benjamin and colleagues proposed the associative deficit hypothesis (Naveh-Benjamin, 2000; Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003), which postulates that a major contributor to older adults' episodic memory deficits is their relative inability to form and retrieve links among single pieces of information. This finding has been shown in a variety of settings, including memory for unrelated word pairs (e.g., Castel & Craik, 2003), name–face associations (e.g., Naveh-Benjamin, Guez, Kilb, & Reedy, 2004), face–word associations (Overman & Becker, 2009), and face–face associations (e.g., Rhodes, Castel, & Jacoby, 2008). Furthermore, a meta-analysis by Old and Naveh-Benjamin (2008) showed that older adults demonstrated substantial associative memory impairments compared with younger adults across a variety of materials and tasks.

The present study examined whether the associative deficit could be reduced through the use of generation and schematic support when trying to remember faces and the age of the face. We examined this using a novel age–face associative memory task, in which participants had to either guess or generate the age of the face or were simply presented with the age. Specifically, we asked whether conditions in which older adults can use schematic support as well as generate responses, both of which have been shown to improve older adults' memory performance (Bertsch, Pesta, Wiscott, & McDaniel, 2007; Castel, 2005), would allow them to overcome the memory deficits so often observed in associative memory tasks.

In addition to associative memory deficits, older adults also suffer disproportionately from the effects of interference (Hasher, Quig, & May, 1997). Older adults often display heightened access to the no-longer-relevant information, which could result from an inefficient inhibitory mechanism (Hasher et al., 1997). That is, if first required to learn *A - B* (first guessing an age of an unfamiliar face), older adults may then have difficulty updating information and remembering *A–C* (remembering the actual age as opposed to the guessed age of the face). Furthermore, older adults show a tendency to falsely remember information (Jacoby, Bishara, Hessels, & Toth, 2005; Jacoby & Rhodes, 2006) and may be particularly susceptible to misleading cues or primes (Jacoby et al., 2005). These findings suggest that the effects of interference may be particularly detrimental to older adults' ability to accurately recall information.

Memory Enhancing Processes: The Generation Effect

A number of processes can be implemented that lead to better memory performance, which might be especially helpful for remedying associative memory impairments. For example, the *generation effect* refers to the finding that information will be better remembered if an active role is taken in producing that information

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(if it is self-generated) rather than if it is simply read (Slamecka & Graf, 1978). Slamecka and Graf (1978) suggested that generation involves more elaborative processing, which can enhance memory performance, as opposed to the more passive and automatic processing in read conditions. The multifactor transfer appropriate processing account (deWinstanley, Bjork, & Bjork, 1996; McDaniel, Waddill, & Einstein, 1988) states that generation requires participants to focus on a specific type of information needed to solve the task, and the generation effect depends on whether or not the later memory test is sensitive to the specific type of information that was enhanced during initial generation (much like the idea of transfer appropriate processing). Thus, when the type of information processed to solve the generation task and the type of information needed on the later test are incongruent, the generation effect does not occur (deWinstanley et al., 1996).

The Role of Errors During Learning and Their Impact on Memory

The generation effect can also be conceptualized in terms of errorless versus errorful learning. Errorless learning occurs when participants are not allowed to produce any errors and the to-be-remembered material is the only information introduced (much like read conditions). During errorful learning, participants are often given only part of the correct answer or material and are asked to guess or self-generate a response, and learning occurs through trial and error or through corrective feedback. Although experimental conditions requiring generation are often designed to reduce the possibility of errors (correct responses are fairly obvious), they can and do occur, and this could have important implications for learning, especially for older adults who have difficulty updating information (Hasher et al., 1997).

Slamecka and Fevreiski (1983) were one of the first researchers to directly examine what impact errors committed during generation had on later memory performance. A significant generation effect was found regardless of initial generation success or failure during learning, indicating that errorful learning can be as good as, if not better, than errorless learning. Slamecka and Fevreiski further hypothesized that generation failures were actually better conceptualized as "incomplete generations." That is, even if the word was not produced, semantic attributes of the word were likely elicited and the availability of these semantic-associative attributes contributed to later successful recall. Furthermore, Metcalfe and Kornell (2007) also found that errors committed during study phases did not seem to have an impact on later memory performance and thus were not detrimental to learning, provided that those initial errors had been corrected.

Anderson and Craik (2006) examined explicit and implicit memory processes in errorless and errorful learning in younger and older adults. Both younger and older adults benefitted from errorless learning in that it reduced familiarity-based errors; however, in younger adults, errorless learning also reduced performance on recollection tests, possibly due to the lack of elaborative processing inherent to these conditions. Therefore, errorless learning may not be beneficial for individuals with strong, intact explicit memory, such as younger adults. Errorless learning could, however, be beneficial in overcoming familiarity-based errors and lead to more accurate recollection in those with reduced or compromised explicit memory functioning, such as older adults. Anderson and Craik's findings suggest that older adults may not benefit from errorful learning. Kessels and de Hann (2003) examined errorless and errorful learning in older and younger adults on a name–face learning task, and found that neither older nor younger adults benefitted from errorful learning. This suggests that on very difficult tasks, such as learning names of unfamiliar faces, individuals (particularly older adults) may benefit more from errorless learning, and that errorful learning is detrimental for later episodic memory.

Memory and the Use of Schematic Support

As of yet, errorless and errorful learning have not been examined within the context of schematic support and associative memory in older adults. *Schematic support* refers to the hypothesis that schemas or prior knowledge within a domain can serve to enhance memory by supporting encoding and retrieval operations within that domain (Craik & Bosman, 1992). Schema-consistent information is often better remembered, and activation of schemas (particularly during encoding) can facilitate the binding of information for younger and older adults (Besken & Gulgoz, 2009). The presence of schematic support or prior knowledge within a domain may also reduce the reliance on effortful, self-initiated processes (which may be detrimentally effected in aging), as well as enhance processing efficiency (Soederberg Miller, 2009), all of which serve to enhance the ability to accurately remember information.

Castel (2005) examined older and younger adults' ability to accurately recall realistic (market value) and unrealistic (unusual) price information for grocery items. Older adults performed as well as younger adults on a test of market-priced items, but not for the unrealistic items. This lends evidence to the finding that age differences in memory tasks can be minimized when memory tasks use meaningful information, and that these types of materials may allow individuals to enhance their memory through the use of schematic support. In addition, it may be the case that realistic materials that are deemed as more personally relevant serve to enhance processing and motivation to remember. Hess and colleagues have demonstrated that older adults show an increased memory benefit for information that is more personally relevant to older individuals (e.g., moving to a retirement community) as well as scenarios that depict an older target person versus a younger target person (Germain & Hess, 2007; Hess, Rosenberg, & Waters, 2001), whereas younger adults show the opposite pattern. This suggests that conditions in which people evaluate information that is consistent with prior knowledge, or deemed as more relevant to the learner, can often lead to enhanced memory performance.

Age Estimation and Own-Age Biases

There are many instances where we use or rely on prior knowledge to inform our current judgments, and one such area may be age estimation. Rhodes (2009) concluded that individuals are fairly accurate when estimating the ages of unfamiliar faces, with errors typically falling within a 7-year range. The human face contains a number of cues as to a person's age, and these cues inherent in the face allow individuals to differentiate between someone who looks 20 versus someone who looks 40 or 70. In addition, these cues may aid in the binding of age–face information for unfamiliar faces in that they can facilitate the use of schematic support, an issue we were particularly interested in testing in the present study. Although individuals may be fairly accurate when it comes to estimating ages, there may be an own-age bias. Individuals are often better at recognizing faces that are within their respective age groups (Anastasi & Rhodes, 2005, 2006). Furthermore, this own-age bias is consistent with the findings that older and younger adults better remember information related to target persons within their own respective age group (Germain & Hess, 2007; Hess et al., 2001). Although there is a literature regarding how people estimate age (Rhodes, 2009), to our knowledge, there are no studies that examine how people later remember this age information, and whether this differs based on the age of the face and the age of the person trying to remember the age. This represents an interesting and important issue regarding associative memory, especially in terms of how older adults can use facial information to facilitate later cued recall.

The Current Study

In the current study, we examined age-related changes in associative memory in the context of generation and errorful and errorless learning as well as schematic support using a task that required individuals to remember specific age information. In the present experiments, participants were asked to remember ages of unfamiliar faces. For half of the faces, participants were asked to first guess the age of the person (generate condition) and were then presented with the actual age. For the other half of the faces, participants were shown the age paired with the face (read condition). Participants were later asked to recall the age of the individual when cued with the face. Given the literature regarding older adults' associative memory deficits (MacKay & Burke, 1990; MacKay et al., 1994; Naveh-Benjamin, 2000; Naveh-Benjamin et al., 2003; Overman & Becker, 2009) as well as the literature suggesting an increased tendency to falsely remember information (Jacoby et al., 2005; Jacoby & Rhodes, 2006), one might expect older adults to perform poorly on this task, especially in comparison to younger adults. Despite the use of realistic materials, older adults may show difficulty binding the age and face information and may show susceptibility to interference (Hasher et al., 1997; Kessels & de Haan, 2003) between the guessed age and actual age of the face. Nevertheless, the generation effect (Bertsch et al., 2007; Slamecka & Graf, 1978) and schematic support (Castel, 2005; Craik & Bosman, 1992) literature suggests that older adults may perform well. Generation and use of stimuli that allow for schematic support could allow older adults to engage in a greater degree of processing that could in turn enhance binding and bolster memory performance.

Experiment 1

In Experiment 1, we examined the impact of schematic support and generation in an age-estimation task that then tested memory for age information. In particular, we were interested in whether or not participants would benefit from generating even under conditions in which their initially generated guesses would likely be incorrect and thus would need to be updated when provided with corrected feedback. Participants were presented with faces and had to either initially guess the person's age (for 5 s) before being presented with the actual age (for 5 s; the generate trials) or were simply shown the correct age paired with the face for 10 s (the read trials). Later, participants were given a memory test that required them to recall the actual ages of the faces.

We hypothesized that older and younger adults would benefit from generation even if generation often resulted in an error, as long as those errors were corrected. This prediction may seem at odds with the findings that older adults have difficulty updating and inhibiting no-longer-relevant information (Hasher et al., 1997; Jacoby et al., 2005) as well as Anderson and Craik's (2006) finding that older adults do not seem to benefit from errorful learning. However, it should be noted that in the task employed by Anderson and Craik, strong familiarity with the stimuli and responses was created prior to the study phase, whereas in this current task, all stimuli were novel to the participants. Our hypothesis is also reasonable given the findings from Kessels and de Haan (2003), such that when a "cue" used is more informative as to the correct answer (a face is not a helpful cue when guessing a name, whereas it is a helpful cue when guessing an age), errorful learning may be more beneficial. Even though it may be thought that generating an error is not helpful, our stance is that these errors can be considered meaningful in that they are likely to be close to the correct response (Rhodes, 2009). One reason why we predicted that participants' "guesses" would be fairly close to the accurate response is due to the nature of the stimuli. Faces themselves contain a number of cues that indicate a person's age, and participants could rely on those cues and use schematic support processes to inform their estimates (although their guess would rarely be exactly correct). Generating these meaningful errors may actually benefit memory more than conditions where participants are asked to passively read correct responses. In fact, research has shown that a certain degree of difficulty in learning ("desirable difficulties") is actually beneficial to long-term memory (Bjork, 1994), although this has yet to be extended to an older adult population. In addition, we predicted, given the own-age bias literature, that individuals would be more likely to recall the ages of the faces when they were similar to their own age. If own-age biases are present, they could suggest that familiarity and schematic support may be more salient for individuals within one's age group, or perhaps that information about one's peers is deemed as more important or personally relevant, which could in turn enhance memory performance (Castel, 2008; Germain & Hess, 2007; Hess et al., 2001).

Method

Participants. Participants consisted of 25 older adults (14 women and 11 men) and 25 younger adults (19 women, 6 men). Older adults were living in the Los Angeles area and were recruited through flier postings in the community as well as through the UCLA Cognition and Aging Laboratory participant pool. On average, the older adults had good self-reported health ratings ($M = 8.1$ on a scale of 1–10, with 1 indicating *extremely poor health* and 10 indicating *excellent health*) and ranged in age from 70 to 88 years ($M = 78.3$ years, $Mdn = 79$). Older participants were paid $10 an hour for their time and reimbursed for parking expenses. Younger adults were University of California, Los Angeles undergraduates and ranged in age from 18 to 25 years ($M = 20.0$ years, $Mdn = 20$). Subjective health ratings were not collected for the younger adult sample. Younger adults received course credit for their participation. All participants were informed of the study's procedures and signed a consent form prior to their participation.

Materials. The stimuli were presented on a computer using Microsoft PowerPoint. The faces used in the experiment were acquired from the Productive Aging Lab Face Database (Minear & Park, 2004) and all had neutral expressions. The faces were roughly 4 in. × 4 in. and were displayed in their original color format on a white background. There were two faces (one male and one female) from each age decade starting in the teens and going through the 80s for a total of 16 faces, and one of each face from each decade was randomly assigned to either the read or generate trials. The age of the person in the photo was the correct age at the time the photo was taken. For purposes of the own-age biases analyses, "younger" faces were classified as those under 30 years of age ($n = 4$), "middle aged" were between the ages 30 to 59 ($n = 6$), and "older" faces were 60 or over ($n = 6$).

Procedure. Participants were told that they would be shown faces of people who were various ages, and would either need to guess the age of the person (after which they would be shown the correct age) or would simply be shown the person's age and would not need to guess. Participants were instructed to try to remember the ages for a later memory test.

As the instructions indicated, for half of the faces (eight of the 16), participants were asked to first guess the age of the person and then were presented with the actual age (generate condition). In these conditions, the faces appeared on the screen and above the face were the instructions "Guess my age." Participants had 5 s in which to guess the age and then were presented with the actual age for 5 s. Reponses were made verbally and were recorded by an experimenter. In the read conditions, the age appeared on the screen with the face for 10 s (see Figure 1). Thus, participants were allowed to view the faces in both generate and read conditions for a total of 10 s, equating overall viewing time (see Carrier & Pashler, 1992). The read and generate items were presented in fixed random order throughout the experiment.

After viewing all of the faces, participants were given a cued-recall memory test. Again, they were shown the faces, one at a time, and were asked to recall the correct age. In addition, participants were asked to provide confidence ratings (on a scale from 1 to 10) in the correctness of their response, with 1 indicating *not confident* and 10 indicating *very confident*. Participants were shown the face and had 8 s in which to give their answer; following this, a prompt ("Rating?") appeared above the face indicating that they should provide a confidence rating (participants were given an additional 5 s to do so). Thus, each face remained on the screen for 13 s while participants recalled the age and gave their confidence ratings. All responses were made verbally and recorded by the experimenter.

Results and Discussion

Figure 2 displays the average number of read and generate items recalled by younger and older adults. Overall, younger adults correctly recalled more ages than older adults, but both groups benefitted from generation, despite the fact that the generation conditions elicited numerous errors. In fact, over 90% of all initial guesses resulted in an error, and participants' "guesses" were off an average of 6.4 years (older adults = 6.5 years; younger adults = 6.2 years).

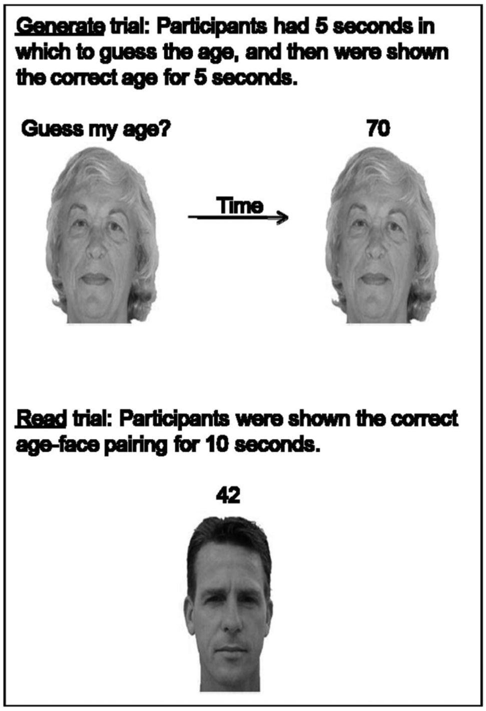

Figure 1. Examples of the generate and read trials. From "A lifespan database of adult facial stimuli" by M. Minear & D. C. Park, 2004, *Behavior Research Methods, Instruments, & Computers* (pp. 630–633). Copyright 2004 by Psychonomic Society. Reprinted with permission.

A 2 (age group) × 2 (study condition) mixed analysis of variance (ANOVA) was conducted, which revealed a main effect of group, showing that, overall, older adults recalled fewer correct ages than did younger adults ($M = 4.3$, $SD = 2.9$, and $M = 7.7$, $SD = 2.0$, respectively) $F(1, 48) = 23.6$, $MSE = 3.1$, $p < .001$, $\eta^2 = .33$. There was a main effect of condition in that participants recalled more of the generate versus read items, $F(1, 48) = 14.3$, $MSE = 1.3$, $p < .001$, $\eta^2 = .23$, despite the fact that in the generate conditions participants were exposed to the correct answer for less time than in the read conditions (5 s vs. 10 s). The Age Group × Study Condition interaction was not significant, $F(1, 48) = 2.23$, $p = .14$.

Younger and older adults benefitted from generating, even though these initial "guesses" were often incorrect. Thus, the results clearly favor the hypothesis that errorful learning can yield significant memory benefits over errorless learning. Confidence ratings did not, however, distinguish between generate and read items (generate $M = 6.5$, $SD = 1.7$, and read $M = 6.2$, $SD = 1.6$), $t(49) = 1.41$, $p = .16$, indicating that participants may not have been aware of the benefits of generation.

To examine own-age biases, we first divided the number of correct responses for younger, middle-aged, and older faces by the total number of faces within that group. This was necessary because there were only four "younger" faces versus six "middle-aged" and six "older" faces. Younger adults recalled a higher proportion of younger faces ($M = .77$, $SD = .22$) than middle-aged ($M = .42$, $SD = .22$) or older faces ($M = .34$, $SD = .18$), whereas older adults remembered similar proportions from the three age

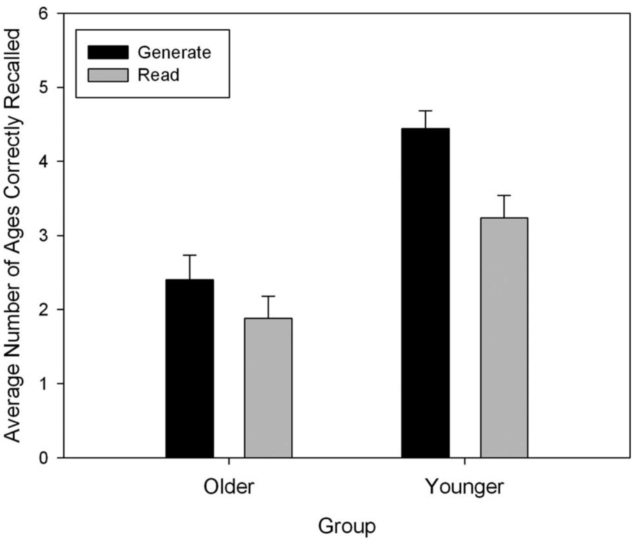

Figure 2. Average number of read and generate items correctly recalled by older and younger adults in Experiment 1. Error bars reflect standard error of the mean.

categories (M = .27, SD = .22; M = .25, SD = .19; and M = .29, SD = .25 for younger, middle-aged, and older faces, respectively). A 2 (age group) × 3 (face age) mixed ANOVA revealed a main effect of group (younger adults recalled more ages than older adults), $F(1, 48) = 31.3$, $MSE = 0.07$, $p < .001$, $\eta^2 = .39$. In addition, there was a main effect of the age of the face (younger, middle-aged, and older faces), revealing that participants were more likely to recall the ages of the younger faces, $F(2, 96) = 19.6$, $MSE = 0.03$, $p < .001$, $\eta^2 = .29$, as well as a significant interaction, $F(2, 96) = 20.3$, $MSE = 0.03$, $p < .001$, $\eta^2 = .30$.

Post hoc analyses revealed that younger adults, compared with older adults, recalled a significantly higher proportion of ages for younger faces, $t(48) = 8.20$, $p < .001$, middle-aged faces, $t(48) = 3.07$, $p < .01$, but not older faces, $t(48) = 0.87$, $p = .39$. Proportions of ages recalled from the three age groups were also analyzed taking into account total number correct. That is, if a participant recalled five ages correctly, what proportion were ages of younger, middle-aged, and older faces? This was done to examine own-age biases while accounting for the overall higher accuracy rate of younger adults. When the data were analyzed in this manner, the main effect of age of the face (younger, middle-aged, or older face) was no longer present, $F = .52$, $p = .47$, whereas a significant Age Group × Face Age interaction persisted, $F(2, 96) = 4.7$, $MSE = 0.04$, $p = .01$, $\eta^2 = .09$. Recall of ages of the younger faces accounted for a larger portion of total recall for the younger compared with the older adults, $t(46) = 2.56$, $p = .01$. However, after analyzing the data in this fashion, memory for the older face ages accounted for a significantly higher proportion of the total amount recalled in the older compared with the younger adult sample, $t(46) = 2.78$, $p < .01$, and group difference for the middle-aged faces was nonsignificant (see Figure 3). Despite the pattern observed in Figure 3, older adults' proportion of total recall did not differ significantly between the three age categories (ps > .20), whereas younger adults did show this effect. Younger adults remembered, on average, more ages for the younger compared with the older faces, $t(24) = 4.64$, $p < .001$, as well as slightly more ages for the middle-aged compared with older faces, $t(24) = 1.72$, $p = .10$ (a small but unreliable difference was found between the younger and middle-aged faces, $p = .13$, favoring memory for ages of the younger faces).

Although older adults tended to recall fewer correct ages than the younger adults, both groups recalled significantly more ages from conditions in which they first had to generate a response. These initial results seem to be highly congruent with the previous research findings regarding the negative impact of age on associative memory (MacKay & Burke, 1990; MacKay et al., 1994; Naveh-Benjamin, 2000; Naveh-Benjamin et al., 2003) as well as the benefits of generating (Bertsch et al., 2007; Slamecka & Graf, 1978). However, the critical finding is that both older and younger adults benefitted from generating, even though they were largely generating errors (over 90% of the time). Older adults have previously been shown to have difficulties updating information and can suffer from the effects of interference (Hasher et al., 1997). The results from the current study seem to indicate that older adults can in fact overcome this particular challenge. In other words, older and younger adults seem to benefit from errorful versus errorless learning within this paradigm.

The effects of schematic support within this task are slightly more difficult to determine. Presumably, some schematic support was available to all participants on every condition given the previous literature on age estimation (Rhodes, 2009). The literature on own-age biases could suggest that individuals may have more schematic support when it comes to guessing or remembering ages of faces within their own general age group (Anastasi & Rhodes, 2005, 2006) in that people might have more experience with people who are their own age. This hypothesis is partially supported by the own-age bias results found in our study for younger adults, who recalled a higher proportion of ages from within their own age group. At present, it is unclear why older adults did not demonstrate a strong own-age bias, although the pattern of results suggests that with more power, this effect may emerge.

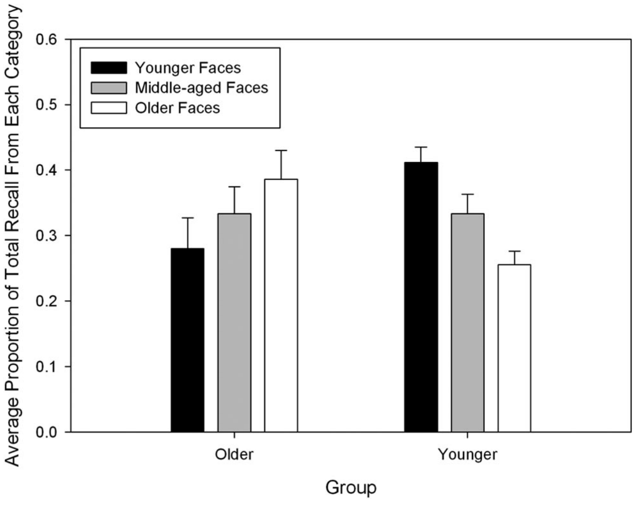

Figure 3. Younger and older adults' average proportion of correct recall, given the total number correct for younger, middle-aged, and older faces in Experiment 1. Error bars reflect standard error of the mean.

To further investigate the effects of schematic support, we conducted a second experiment. We were interested in examining the extent to which individuals relied on the cues inherent in the faces themselves to aid in accurate recollection. That is, if some faces had ages that were incongruent with expectations, would this impair later memory performance? Furthermore, what impact would this adjustment have on the generation effect? Would errorful learning still be beneficial under conditions in which individuals are likely to generate errors that are farther away from the correct target response and receive feedback that is not always in line with expectations? The multifactor transfer appropriate processing account (deWinstanley et al., 1996; McDaniel et al., 1988) argues that when the type of information processed to solve the generation task and the type of information needed on the later test are incongruent, the generation effect will not occur. Thus, if individuals are relying on the cues of the face to make their initial estimates, they would then be unable to rely solely on this information during recall if the to-be-remembered age was incongruent with the cues from the face.

Experiment 2

Experiment 2 was conducted to further investigate the impact of schematic support and the impact of errors and updating on memory performance. In this study, half of the faces had 15 years either added or subtracted from the actual age, creating an "incongruent" condition. Presumably, in Experiment 1 the correct ages of the faces were consistent with expectations. In Experiment 2, however, the age information provided was often inconsistent with expectations, and thus may require additional effort or processing to update the information and recall the age accurately. This general concept is similar to that used in Castel's (2005) grocery price experiment in which older (and younger) adults' memory performance was greatly reduced for unrealistically priced grocery items compared with market value (or realistic) items. In eliminating the ability to use schematic support both in generating and in recall (for half of the faces), we predicted that memory performance would decrease in both read and generate conditions, but that this drop would be steepest for the generate items because individuals would no longer be benefitting from these "meaningful" errors. In other words, it is probable that in this experiment errors would be farther from the correct response than in Experiment 1. This in turn may create conditions where the type of information used during generation is somewhat different from the type information needed to support accurate recollection (errorless learning may in fact be more beneficial than errorful learning), and this might especially be the case for older adults. Despite the fact that this experiment created a more challenging task for many individuals, we still hypothesized that older and younger adults might show an own-age bias (perhaps driven by the congruent age–face pairs).

Method

Participants. Participants consisted of 25 older adults (19 women and 6 men) and 25 younger adults (18 women, 7 men), none of whom participated in Experiment 1. All older adults had good self-reported health ratings ($M = 7.8$ of 10; subjective health data were not collected for younger adults). Younger and older adults were recruited in the same manner described in Experiment 1. Older adults ranged in age from 61 to 86 years ($M = 74.7$ years, $Mdn = 76$) and younger adults ranged in age from 18 to 26 years ($M = 20.0$ years, $Mdn = 19$). All participants were informed of the study's procedures and signed a consent form prior to their participation and were reimbursed in the same manner described in Experiment 1.

Materials. All of the face stimuli used in Experiment 2 were identical to Experiment 1 and were presented in the same fashion. However, for half of the faces (eight of 16), the actual age was adjusted by either adding or subtracting 15 years. We chose 15 years because it was a large enough difference to be obvious to participants that it was not realistic, but not so large as to be completely illogical (we did not want to make a 35-year-old now 80). In addition, as stated in the previous experiment, there was an equal number of male and female faces, and we classified four faces as young, six as middle aged, and six as older. In adjusting the ages, we took care in making sure an equal number of male and female, read and generate, and young, middle-aged, and older faces were altered in both directions (adding and subtracting 15 years). However, given the fact that subtracting 15 years from the ages of the younger faces would create conditions in which participants would be told the person was younger than 10 years old, we only added years to these younger faces. This was done because we thought that having people younger than 10 years old could create a pop-out effect (especially given that all the rest were double-digit ages) and could artificially increase memory performance.

Procedure. The procedures were identical to those described in Experiment 1, with one key exception. One modification was made to the instructions, and that was the addition of the following sentence: "Some people may look older or younger than their stated age." This sentence was added to give participants a warning that some of the ages would seem quite unrealistic. Again, in the generate conditions, participants had 5 s in which to guess the age, and then they were presented with the correct age for 5 s. In the read condition, the correct age appeared on the screen with the face for 10 s, equating overall viewing time. During the recall test, participants had a total of 8 s in which to give the answer and 5 s to indicate their confidence rating. As in Experiment 1, all responses were made verbally and recorded by the experimenter.

Results and Discussion

Similar to Experiment 1, data were analyzed for both read and generate items, as well as the age of the face (younger, middle-aged, older faces). This experiment, however, introduced the additional condition of "congruent" and "incongruent" age–face pairings. That is, for half of the faces, the ages remained unchanged (congruent), whereas the other half had 15 years added to or subtracted from the actual age (incongruent).

As expected, the introduction of incongruent age–face pairs had a significant impact on individuals' ability to accurately guess the initial age. In Experiment 1, participants' initial "guesses" were incorrect over 90% of the time and were off by an average of 6.4 years. In Experiment 2, participants' initial guesses were incorrect over 96% of the time and were off by an average of 11.2 years. Older adults' guesses were off an average of 10.5 years (congruent age–face pairs = 6.3 years; incongruent age–face pairs = 15.2

years), whereas younger adults guesses were off an average of 11.3 years (congruent age–face pairs = 9.3 years; incongruent age–face pairs = 13.4 years). To test our hypothesis that guesses farther from the correct response would not be as beneficial to later memory performance (the errors are less meaningful), we computed correlations between recall performance and the amount (in years) that initial guesses were off. Across all participants, a negative correlation was observed ($r = -.13$), and this pattern was found to be slightly stronger among younger adults ($r = -.16$) compared with older adults ($r = -.10$), although not significantly so, suggesting that when initial errors during learning are quite large, errorful learning is not as beneficial.

A 2 (age group) × 2 (study condition) × 2 (congruency) mixed ANOVA was conducted to examine the impact of generation as well as congruency on memory for age–face pairs in older and younger adults. The results revealed a marginally nonsignificant effect of group showing that older adults recalled fewer correct ages than did younger adults ($M = 4.8$, $SD = 2.0$, and $M = 6.1$, $SD = 2.5$, respectively), $F(1, 48) = 3.6$, $p = .06$. Unlike Experiment 1, there was no effect of condition (read vs. generate), $F(1, 48) = 1.4$, $p = .25$. There was, however, a large effect of congruency in that a majority of the ages recalled were from conditions in which the age was congruent with the face, $F(1, 48) = 31.0$, $MSE = 0.64$, $p < .001$, $\eta^2 = .39$.

Despite the lack of an effect of condition (read versus generation), there was a sizable Age Group × Study Condition interaction, $F(1, 48) = 7.4$, $MSE = 0.82$, $p < .01$, $\eta^2 = .13$ (see Figure 4). Additional analyses revealed that younger adults recalled more ages compared with older adults for the read items only, $t(48) = 3.36$, $p < .01$, whereas older and younger adults recalled a similar number of ages for the generate items, $t(48) = 0.18$, $p = .85$. Older adults continued to benefit from generating, recalling more ages in the generate condition ($M = 2.9$, $SD = 1.5$) than in the read condition ($M = 1.9$, $SD = 1.4$), $t(24) = 2.47$, $p < .05$, whereas younger adults, in fact, recalled more read ($M = 3.2$, $SD = 1.4$) than generate items ($M = 2.8$, $SD = 1.6$), although this difference was not significant, $t(24) = 1.27$, $p = .22$.

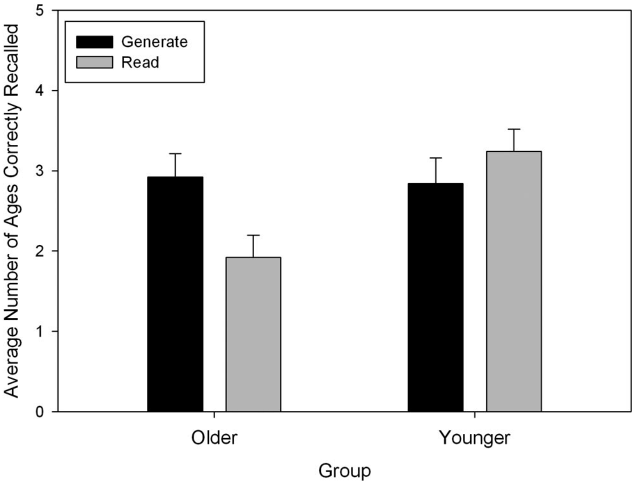

Figure 4. Average number of read and generate items correctly recalled by older and younger adults in Experiment 2. Error bars reflect standard error of the mean.

The analyses further revealed that congruency did not interact with study condition, $F(1, 48) = 0.32$, $p = .58$, indicating that congruent age–face pairs were better remembered than incongruent pairs within both the read and generate conditions. In addition, no significant Age Group × Congruency interaction was observed, $F(1, 48) = 1.8$, $p = .19$. Although this interaction was nonsignificant, preplanned comparisons were conducted to examine whether the effects of incongruent feedback were more detrimental to either younger or older adults. It is interesting that when the ages were congruent with the faces, older and younger adults performed comparably, $t(48) = 0.84$, $p = .40$, but younger adults recalled more ages than older adults when the ages were incongruent with the faces, $t(48) = 2.23$, $p < .05$.

Despite the findings that congruency did not interact with either age group or study condition, a marginally significant Age Group × Study Condition × Congruency interaction was observed, $F(1, 48) = 2.84$, $MSE = 2.84$, $p < .10$ (see Figure 5). Additional analyses revealed that older and younger adults performed similarly for congruent and incongruent generate items, $t(48) = 1.48$, $p = .18$, and $t(48) = 1.07$, $p = .29$, respectively, but younger adults recalled more ages from both the congruent and incongruent read items compared with older adults, $t(48) = 2.75$, $p < .01$, and $t(48) = 2.59$, $p \leq .01$, respectively. Older adults recalled more ages from the generate and read conditions when the ages were congruent with the faces compared with when they were incongruent with the face, $t(24) = 4.27$, $p < .001$, and $t(24) = 2.78$, $p \leq .01$, respectively, whereas younger adults recalled more from only the read condition and not the generate condition when the ages were congruent compared with when they were incongruent, $t(24) = 3.92$, $p \leq .001$, and $t(24) = 0.67$, $p = .51$, respectively. This suggests that under these particular conditions, schematic support, in the form of congruency, benefited older adults during errorless as well as errorful learning, whereas younger adults only seemed to benefit during errorless learning.

To examine own-age biases, we divided the number of correct responses for younger, middle-aged, and older faces by the total number of faces within that group for the same reason as described in Experiment 1. Younger adults recalled a higher proportion of younger faces ($M = .61$, $SD = .25$) than middle-aged ($M = .33$, $SD = .20$) and older faces ($M = .27$, $SD = .20$), whereas older adults remembered higher proportions of older ($M = .38$, $SD = .18$) and younger ($M = .33$, $SD = .22$) faces than middle-aged faces ($M = .17$, $SD = .17$). A 2 (age group) × 3 (face age) mixed ANOVA revealed a main effect of group (younger adults recalled more than older adults), $F(1, 47) = 7.9$, $MSE = 0.06$, $p < .01$, $\eta^2 = .14$. In addition, there was a main effect of face age (ages for younger faces were recalled more than middle-aged and older faces), $F(2, 94) = 18.0$, $MSE = 0.03$, $p < .001$, $\eta^2 = .28$, as well as a significant interaction, $F(2, 94) = 13.6$, $MSE = 0.03$, $p < .001$, $\eta^2 = .23$. Follow-up analyses revealed that younger adults, compared with older adults, recalled a significantly higher proportion of ages for younger faces, $t(48) = 3.83$, $p < .001$, and middle-aged faces, $t(48) = 2.91$, $p < .01$, but older adults recalled slightly higher proportions of older faces than did younger adults, $t(48) = 1.90$, $p = .07$.

Proportions of ages recalled from the three age groups were again analyzed taking into account total number correct. A 2 (age group) × 3 (face age) mixed ANOVA revealed a significant interaction, $F(2, 96) = 9.5$, $MSE = 0.06$, $p < .001$, $\eta^2 = .17$.

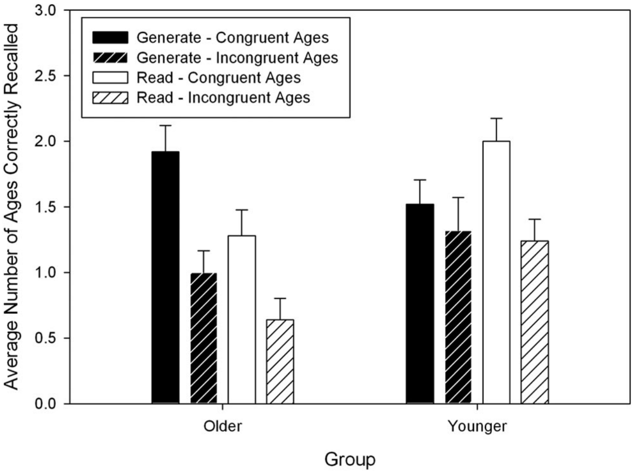

Figure 5. Average number of ages correctly recalled for both read and generate as well as congruent versus incongruent age–face pairings for younger and older adults in Experiment 2. Error bars reflect standard error of the mean.

Younger adults continued to demonstrate an own-age bias in that recall of ages of the younger faces accounted for a larger portion of their total recall compared with older adults, $t(48) = 2.34$, $p < .05$. However, after analyzing the data in this fashion, a strong own-age bias emerged for the older adults, $t(48) = 4.40$, $p < .001$, and group difference for the middle-aged faces largely disappeared, $t(48) = 1.96$, $p = .06$, although younger adults still recalled slightly more for these faces (see Figure 6). Furthermore, within the older adults sample, ages for the older faces accounted for a higher proportion of the total amount recalled compared with either younger faces, $t(24) = 2.36$, $p < .03$, or middle-aged faces, $t(24) = 3.74$, $p = .001$ (no differences between younger and middle-aged faces, $p > .13$). Younger adults displayed the opposite pattern: Ages of younger faces accounted for a significantly higher proportion of the total amount recall compared with either middle-aged faces, $t(24) = 2.22$, $p < .04$, or older faces, $t(24) = 3.00$, $p < .01$ (no differences between older and middle-aged faces, $p > .24$).

Taking away the ability to rely solely on schematic support did have an overall impact on performance in that participants recalled more ages from the congruent versus incongruent age–face pairs, which is similar to the findings from Castel (2005). Furthermore, schematic support in the form of own-age biases was present in that younger adults recalled more ages from the younger faces and older adults recalled more ages from the older faces. However, partially taking away the ability to use schematic support had a sizable impact on younger adults' performance for the generate items, as predicted. Now, under the generate condition, their initial guesses were farther from the correct response than those observed in Experiment 1. Although older adults also experienced this during generation in Experiment 2, this did not seem to have as detrimental an effect on their overall performance, and older adults continued to benefit from generating.

Qualitative observations made during data collection suggest that although older adults were often surprised by the "correct" age for the faces with incongruent age information, it did not seem to discourage them from continuing to guess appropriately and engage in elaborative processing. However, these same types of conditions (being very wrong on the initial guess) presented to younger adults could have led to frustration and caused them to reduce the amount of elaborative processing used during generation. In other words, if younger adults "caught on" quickly that their guesses were not very useful and were often incorrect, they may have stopped trying to accurately estimate the ages and instead focused on the actual age information when it was presented. Similarly, it could also be the case that younger adults may have tried to "modify" their guesses if they were aware that the provided age information was not always accurate. This speculation seems to be partially confirmed by the differences observed in estimated ages by the younger and older adults. For older adults, when the ages were congruent with the faces, their guesses were off by a similar margin as in Experiment 1, and when the ages were incongruent with the face, their guesses were off by appropriate margins. However, younger adults' guesses in Experiment 2 were off by larger margins compared with the older adults as well as with the younger adults in Experiment 1 when the age was congruent with the face, but less so when it was incongruent. Thus, younger adults may have been engaging in ineffective strategies that ultimately led to the reduced generation benefit.

General Discussion

Overall, older adults correctly recalled fewer ages than did younger adults in Experiments 1 and 2. The result that older adults generally recalled less information than younger adults is consistent with the well-documented finding that older adults exhibit memory deficits compared with younger adults, especially on associative memory tasks (Chalfonte & Johnson, 1996; Lavoie & Cobia, 2007; MacKay & Burke, 1990; MacKay et al., 1994; Naveh-Benjamin, 2000; Naveh-Benjamin et al., 2003; Overman & Beckers, 2009; Verhaeghen & Salthouse, 1997). Furthermore, in Experiment 1, older and younger adults benefitted from generation

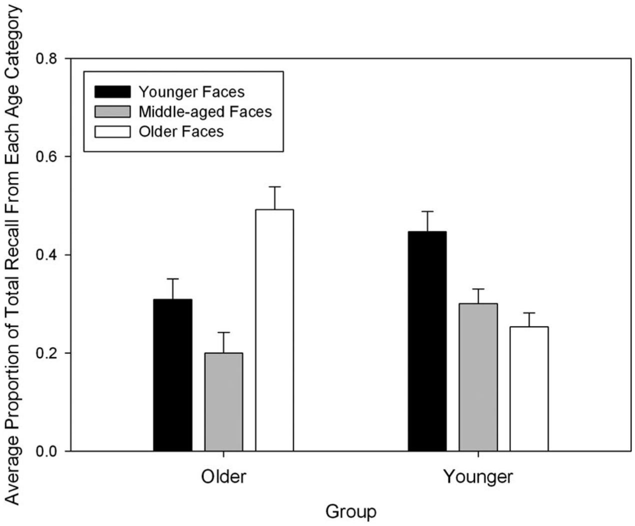

Figure 6. Younger and older adults' average proportion of correct recall given the total number correct for younger, middle-aged, and older faces in Experiment 2. Error bars reflect standard error of the mean.

despite the fact that the participants' initial "guesses" were incorrect over 90% of the time and that they were exposed to the correct response for less time in the generate trials compared with the read trials. These results strongly support not only the finding that the generation effect is a robust phenomenon (Bertsch et al., 2007; Slamecka & Graf, 1978), but also that errorful learning with corrective feedback can be beneficial over errorless learning (Metcalfe & Kornell, 2007; Slamecka & Fevreiski, 1983). These results are in opposition to those of Kessels and de Haan's (2003), who found that errorful name learning for unfamiliar faces is worse than errorless learning. It may be the case that when a "cue" is informative as to the correct answer (a face is a helpful cue when guessing an age, whereas it is not a helpful cue when guessing a name), errorful learning can be more beneficial.

The benefits of errorful learning observed in older adults are contradictory to other previous research as well. Anderson and Craik (2006) found that for individuals who often make more familiarity-based errors (such as older adults), errorless and not errorful learning may be more beneficial. Furthermore, our findings suggest that older adults seem to be able to update their originally incorrect responses to the same extent as younger adults, which supports the conclusion that, in some cases, older adults can successfully inhibit not-to-be-remembered information and do not always suffer disproportionately from the effects of interference (Hasher et al., 1997).

The results from Experiment 2 provide evidence that the extent of the benefits of errorful learning is somewhat limited. The benefits younger adults received from generating and errorful learning in the first experiment were eliminated in Experiment 2. Thus, when younger adults were forced to guess even when their guesses were likely to be incorrect and were given feedback that they were not close to the correct answer or that they knew was likely "deceptive," performance was actually harmed. Furthermore, even though older adults still showed an overall generation effect in Experiment 2, under the conditions when the ages were incongruent with the faces (when schematic support was not available), generation was no longer beneficial. Thus, for both younger and older adults, when initial guesses were not close to the correct response, the associations may have been less meaningful and thus did not serve to enhance later memory performance. The data support this conclusion such that there was a lower probability of correctly recalling an age the farther the initial guess was from the correct response.

These findings seem to coincide with deWinstanley and colleagues' (1996) multifactor transfer appropriate processing account of the generation effect (and extend this to older adults), which states that the generation effect will be present only if the specific type of information needed or processed during generation is the same type of information needed during later recall. During generation, participants are likely relying heavily on the face's cues to estimate an age; however, during testing when prompted to recall the age of an incongruent age–face pair, relying on the cues of the face is no longer useful, and instead participants need to rely on accurate recollection. Furthermore, if younger adults were "adjusting" their guesses during generation because they were aware that the feedback (the age) was often misleading given the cues from the face, this could have served to down-regulate the benefits of generation for the congruent and incongruent age–face pairs.

Younger adults demonstrated an own-age bias across Experiments 1 and 2, whereas a significant own-age bias only emerged in Experiment 2 for older adults (although those data presented in Figure 3 reveal that a similar pattern was present in Experiment 1). The results from these experiments further support the findings from the own-age bias literature (Anastasi & Rhodes, 2005, 2006) in that a higher percentage of younger and, to an extent, older adults' recall was for the ages of faces within their respective age groups.

The review conducted by Rhodes (2009) as well as the findings from the current study suggest that people are fairly accurate in determining the age of an unfamiliar face. That is, it is probable that most individuals do have a general sense of what, for example, someone who is 35 looks like. Given this, schematic support as defined by Craik and Bosman (1992) likely did enhance participants' ability to accurately recall ages in Experiment 1. Although schematic support did not eliminate age-related differences to the extent that has been previously reported (e.g., Castel, 2005), the finding in Experiment 2 that both younger and older adults recalled significantly more ages when the age was congruent with the cues from the face (and in fact performed equally well on those conditions) lends further credence to the powerful effect schematic support can have on memory performance. Specifically, taking away the ability to rely on schematic support (as was the case for the incongruent and unrealistic age–face pairings in Experiment 2) can have a significant negative impact on an individual's ability to accurately recall information. These findings suggest that experimental paradigms that use realistic, meaningful, or relevant materials can serve to enhance memory performance (e.g., Castel, 2005; Hess, 2005), particularly for individuals who may not be able to rely as much on effortful, self-initiated processing, such as older adults.

These own-age biases could also be, at least partially, due to the amount of schematic support available. Hess and colleagues have previously shown that information is better remembered when it is personally relevant and, more specifically, relevant as it relates to the age of the individual (Germain & Hess, 2007; Hess et al., 2001). Individuals may simply have more experience and be more familiar with people their own age and have better developed schemas for specific age-relevant information. On the other hand, older adults might have more experience with all age ranges, whereas the younger adult sample might have more exposure to college-age information, which could explain the finding that own-age biases were stronger within the younger adult samples across the two experiments. Perhaps older adults have better developed schemas for ages of older individuals than do younger adults, but also possess schemas for individuals of younger ages as well (although these could become less well defined as one moves out of a specific age demographic and into another). Nevertheless, the data do suggest that individuals are, to an extent, better able to recall information about individuals who are within a similar age demographic, which is consistent with previous findings (e.g., Anastasi & Rhodes, 2005; Hess et al., 2001).

Although schematic support did not eliminate age-related difference in memory performance in Experiment 1 (when schematic support was, presumably, available on every trial), its benefits observed in Experiment 2 were much more robust. Older and younger adults demonstrated similar memory performance when the ages were congruent with the face, whereas younger adults recalled more ages than older adults when the age was incongruent. Furthermore, older and younger adults benefitted from errorful learning, provided these errors were meaningful and close to the correct response. When initial errors were quite large (farther from the correct response), errorless learning may be more beneficial (and our results would suggest that this is especially true for younger adults). It would be interesting to investigate whether or not participants were aware that their initial guesses were less beneficial in Experiment 2 (as may have been the case for younger adults) by asking participants to make metacognitive judgments at encoding after generating the age.

Given the inconsistent evidence as to the benefits of errorful learning, more investigation as to the boundaries and limitations of the effect is warranted. Within the current set of experiments, only a small number of stimuli were used, and these stimuli may have idiosyncratic characteristics. Any potential special characteristics of the stimuli may have affected the outcome, which could limit the generalizability of our findings. Thus, future research is needed to better examine the boundary conditions of errorful learning, such as determining whether these effects occur with different race faces, which could influence the degree of schematic support. In addition, errorful learning may be beneficial (particularly for older adults) only when a relatively small number of stimuli are used (such as in the current study). However, we would like to note that we purposefully chose a small number of stimuli (only two faces per age decade) to reduce interference and source confusion, which could have negatively affected memory performance for both age groups, particularly older adults. Increasing the number of stimuli, by default, would have increased the number of errors that would have needed to be updated and correctly remembered. Given the difficulties older adults have in inhibiting no-longer-relevant information (e.g., Hasher et al., 1997), errorful learning may prove to be ineffective in situations that require one to learn and remember large amounts of information. In addition, the amount of time between when an error is made and when it is corrected could also have a large impact on the benefits of errorful processing. Longer intervals of time before corrective feedback is given could unduly tax individuals such as older adults with more compromised inhibitory control, and thus could be detrimental to later memory performance. Many questions still remain regarding the type of conditions that lead to benefits of either errorful or errorless learning, and thus this offers an exciting new area of research within the field of learning, memory, and aging.

The present studies provide evidence that individuals are better at remembering associations between stimuli under conditions that engage schematic support (when information is somewhat consistent with expectations and prior knowledge) as well as elaborative processing (having to first guess the answer). These findings have important implications for individuals who may suffer from associative memory impairments, such as older adults. Conditions that require or allow older adults to process information more deeply and allow for the framing of the correct answer within an already developed schema may bolster their ability to accurately form and later recall the new associations within memory. Furthermore, these studies not only provide evidence for older and younger adults' increased memory performance under conditions of errorful learning, but also examine important limitations and boundaries of this type of learning. When individuals have prior knowledge within a domain (schematic support), requiring them to first guess the correct answer can improve later associative memory performance for the to-be-remembered information.

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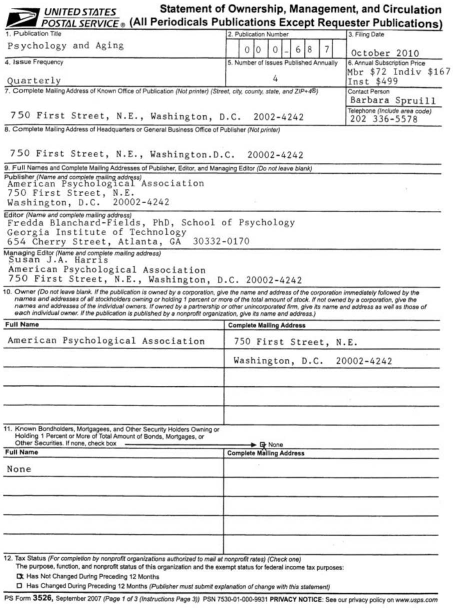

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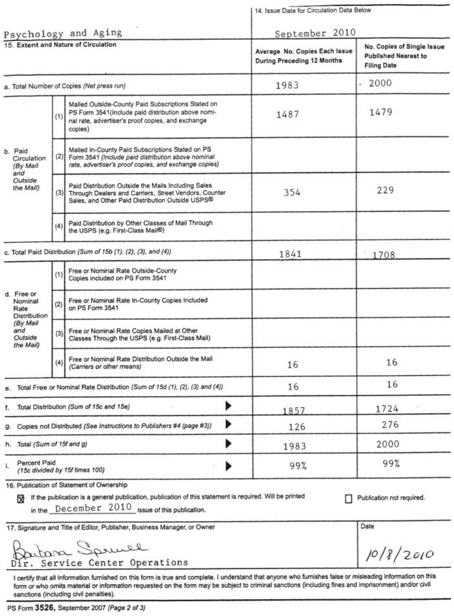

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