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Forgetting in context: The effects of age, emotion, and social factors on retrieval-induced forgetting

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Abstract Retrieval-induced forgetting (RIF) refers to the finding that selectively retrieving some information impairs subsequent memory for related but nonretrieved information. This occurs both for the individual doing the remembering (i.e., within-individual retrieval-induced forgetting: WI-RIF), as well as for individuals merely listening to those recollections (i.e., socially shared retrieval-induced forgetting: SS-RIF). In the present study, we examined how the contextual factors of age and emotion independently and interactively affect both WI-RIF and SS-RIF. The results indicated that both WI-RIF and SS-RIF occurred at equivalent levels, both for younger and older adults and for neutral and emotional information. However, we identified a boundary condition to this effect: People only exhibited SS-RIF when the speaker that they were listening to was of the same sex as themselves. Given that participants reported feeling closer to same-sex speakers, this suggests that people co-retrieve more, and therefore exhibit increased SS-RIF, with close others. In everyday life, these RIF effects should influence what information is remembered versus forgotten in individual and collective memories.

Keywords Retrieval-induced forgetting · Socially shared retrieval-induced forgetting · Aging · Emotion · Interference/inhibition · Memory retrieval

Across the lifespan, people reminisce with others about past emotional events. Imagine, for example, friends reunited at a 50th annual high school reunion discussing their childhood experiences, or family members coping with grief by sharing pleasant memories about their deceased loved one. Although these shared conversations can lead to benefits, such as creating shared representations of the past within the group (e.g., Barber, Rajaram, & Fox, 2012; see also Echterhoff, Higgins, & Levine, 2009), they also come with costs (see Barnier, Sutton, Harris, & Wilson, 2008; Rajaram, 2011). One cost arises because of the silences involved in recollections. Research has shown that when people selectively remember some details about an event, they inadvertently forget related but nonrecalled details. This is known as *retrieval-induced forgetting* (henceforth denoted RIF; M. C. Anderson, Bjork, & Bjork, 1994; for reviews, see M. C. Anderson, 2003; Bäuml, Pastötter, & Hanslmayr, 2010). In the present study, we examined whether this effect varies as a function of age, emotion, and social factors.

Retrieval-induced forgetting is typically studied using the retrieval practice paradigm, in which participants first learn categorized lists of words (e.g., fruits – *apple*, *orange*, *pear*, *banana*; animals – *bear*, *elephant*, *mouse*, *rabbit*). Participants then engage in retrieval practice for half of the items from half of the categories, via a cued stem-recall test (e.g., *fruits–ap___?*, *fruits–ba____?*). Later, participants are tested on all of the items, and performance on this test is examined separately for three types of items. First, some items were practiced during the retrieval practice phase (e.g., *apple*, *banana*). These items are denoted as Rp+, as they received retrieval practice. Second, some items were not practiced but were from a category that was practiced (e.g., *orange*, *pear*). These items are denoted as Rp–, as their category received retrieval practice, but they themselves did not. Finally, some items were from a category that was not practiced (e.g., *all of the animal words*). These items are denoted as NRp, since they received no retrieval practice. Not surprisingly, retrieval practice facilitates

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subsequent recall. Participants are more likely to recall the Rp + than the NRp items during the final memory test. More interestingly, retrieval practice also impairs recall for the related, but not practiced, items. Participants are *less* likely to recall the Rp– than the NRp items during the final memory test. This is known as retrieval-induced forgetting, and henceforth will be denoted as RIF. (M. C. Anderson et al., 1994).

Why does RIF occur? On the one hand, many have argued that RIF is due to item suppression. This inhibitory explanation assumes that during the retrieval practice phase, the Rp– items compete with the Rp + items for conscious recall. To reduce this interference, the Rp– items are inhibited. This weakens their memory representations and renders them less likely to be subsequently recalled or recognized (e.g., M. C. Anderson & Spellman, 1995). On the other hand, others have argued that RIF is due to response competition. Here, retrieval practice is assumed to strengthen associations between the category cue and the Rp + items. Later, in response to the category cue, the strengthened Rp + items compete with the Rp– items for conscious recall and block access to recall of the Rp– items (e.g., J. R. Anderson, 1983; Mensink & Raaijmakers, 1988; Raaijmakers & Shiffrin, 1981).

Although there is evidence in favor of both accounts, the preponderance of evidence has favored the inhibitory explanation of RIF. For example, according to the inhibitory account, the Rp– items are suppressed during retrieval practice, and should therefore be more difficult to retrieve no matter what retrieval cue is used to test them. Consistent with this, RIF occurs not only during a free recall or category-cued recall test (e.g., M. C. Anderson et al., 1994; M. C. Anderson & Spellman, 1995), but also during recognition memory tests (e.g., Hicks & Starns, 2004; Spitzer & Bäuml, 2007; Verde, 2004) or when items are tested using novel, independent cues (e.g., M. C. Anderson & Bell, 2001; M. C. Anderson, Green, & McCulloch, 2000; M. C. Anderson & Spellman, 1995; Aslan, Bäuml, & Pastötter, 2007; Radvansky, 1999; but see Butler, Williams, Zacks, & Maki, 2001; Camp, Pecher, & Schmidt, 2007; Perfect, Moulin, Conway, & Perry, 2002). Furthermore, recent cognitive neuroscience research has also supported the inhibitory account of RIF (e.g., Johansson, Aslan, Bäuml, Gäbel, & Mecklinger, 2007; Kuhl, Dudukovic, Kahn, & Wagner, 2007; Spitzer, Hanslmayr, Opitz, Mecklinger, & Bäuml, 2009). For example, the magnitude of activity observed in inhibitory-control-associated brain regions during retrieval practice is associated with the magnitude of subsequent RIF (Wimber, Rutschmann, Greenlee, & Bäuml, 2009).

Given that RIF is due to inhibition, one might expect attenuated RIF in populations that experience inhibitory difficulties. Although this is a matter of debate (e.g., Burke, 1997; McDowd, 1997), one such population may be older adults (see Hasher, Zacks, & May, 1999). This conclusion is based on numerous experimental results in which inhibitory deficits have been reported in older, as compared to younger, adults (see M. C. Anderson, Reinholz, Kuhl, & Mayr, 2011; Bedard et al., 2002; Earles & Kersten, 2002; Hartman & Hasher, 1991; Olincy, Ross, Young, & Freedman, 1997; Spieler, Balota, & Faust, 1996; but for results suggesting preserved inhibition, see Sego, Golding, & Gottlob, 2006; Zellner & Bäuml, 2006). However, in contrast to expectations, research has consistently shown that RIF is preserved with age. That is, despite their documented declines in inhibitory control, older adults exhibit RIF equivalent to that of younger adults (Aslan et al., 2007; Collette, Germain, Hogge, & Van der Linden, 2009; Gómez-Ariza, Pelegrina, Lechuga, Suárez, & Bajo, 2009; Hogge, Adam, & Collette, 2008; Koutstaal, Schachter, Johnson, & Galluccio, 1999). This is in line with additional research showing intact RIF in other populations with inhibitory control deficits, such as children (Ford, Keating, & Patel, 2004; Lechuga, Moreno, Pelegrina, Gómez-Ariza, & Bajo, 2006; but see Aslan & Bäuml, 2010), people with frontal-lobe damage (Conway & Fthenaki, 2003), and people with schizophrenia (AhnAllen, Nestor, McCarley, & Shenton, 2007; Racsmány et al., 2008; but see Soriano, Jiménez, Román, & Bajo, 2009).

Two explanations have emerged as to why older adults exhibit intact RIF despite their inhibitory control deficits. One of these explanations posits that inhibition can be subdivided into two forms: one that requires conscious control to implement and one that is triggered more automatically (see Andrés, Guerrini, Phillips, & Perfect, 2008; Conway & Fthenaki, 2003; Harnishfeger, 1995). It has further been argued that intentional inhibition, which requires cognitive control (e.g., on tasks such as directed forgetting or think/no think), declines with age. In contrast, unintentional inhibition (e.g., on tasks such as RIF or negative priming), which is less reliant on cognitive control, is preserved with age (see Collette et al., 2009). An alternative explanation of preserved RIF in older adults is that because retrieval is not very cognitively costly, inhibition is possible even for populations who have inhibitory deficits. In support of this idea, when retrieval is made more difficult, age differences in RIF emerge (Ortega, Gómez-Ariza, Román, & Bajo, 2012).

Although research has shown preservation of RIF across adulthood (either because it is an unintentional form of inhibition or because retrieval is not very cognitively costly), all previous studies have examined individuals, working alone, trying to remember neutral information. Given that both emotional and social processing change with age (e.g., Carstensen, Isaacowitz, & Charles, 1999), we examined whether age differences in RIF emerge as a function of these factors. In particular, we examined (1) how emotion affects RIF and whether this varies by age, and (2) whether age differences in RIF (and especially in RIF of emotional information) emerge when retrieval is carried out in a social, rather than an individual, setting. In the following sections, we first describe the research examining how emotion

influences RIF in younger adults, and then describe how age-related changes could change the influence of emotion on RIF in older adults. Next, we examine the role of social context: We describe how RIF occurs in social settings for younger adults, before describing how age-related changes could result in a different pattern of RIF—and, in particular, of RIF for emotional information—in social settings for older adults.

The role of emotion on RIF

Almost all previous studies have examined RIF using neutral information. However, emotion is a key factor affecting many aspects of memory (e.g., Mather, 2009; Mather & Sutherland, 2011), and it is important to understand whether emotion affects memory inhibition. Unfortunately, within the retrieval practice paradigm, there is currently no clear answer to this question. That is, studies addressing the effects of emotion on RIF in younger adults have yielded contradictory results. Some have found RIF for neutral but not for emotional information (Dehli & Brennen, 2009; Moulds & Kandris, 2006), but this effect has been inconsistently observed across different types of measurements (Blix & Brennen, 2012). Others have found RIF for positive, but not negative, information (Hauer & Wessel, 2006), and others for negative, but not positive, information (Harris, Sharman, Barnier, & Moulds, 2010). Finally, others have found equivalent levels of RIF for neutral and emotional information (Amir, Coles, Brigidi, & Foa, 2001; Barnier, Hung, & Conway, 2004; Kuhbandner, Bäuml, & Stiedl, 2009).

Contradictory results have also been observed when examining how affective states affect RIF in younger adults. On the one hand, inducing a negative mood can sometimes (Bäuml & Kuhbandner, 2007), but not always (Rusted & Alvares, 2008), attenuate RIF. Similarly, individual differences in depression can also sometimes (e.g., Groome & Sterkaj, 2010), but not always (e.g., Harris, Barnier, Sutton, & Keil, 2010; Moulds & Kandris, 2006), moderate RIF.

The reason for these contradictory findings is unclear. One possible explanation centers on the fact that most studies have not counterbalanced items across valence conditions. That is, across participants the negative (or neutral) items were always negative (or neutral). Because the magnitude of RIF depends on how strongly items are associated with their studied categories (M. C. Anderson et al., 1994), it is possible that differences in RIF might emerge as a function of emotion only when there are differences in category association strength as a function of emotion. In support of this theory, the only previous study in which items were counterbalanced across valence conditions showed no effect of negative versus neutral valence on RIF (Kuhbandner et al., 2009). Alternately, it is possible that the discrepancies have been driven by differences in the emotional intensity of the study items: The studies documenting an attenuation of RIF for emotional information may have simply used more emotionally intense stimuli (see Kuhbandner et al., 2009, for a discussion of emotional intensity and RIF).

In the present study, we further examined the relationship between emotion and RIF. A novel aspect of the present study, however, is that we did this in both younger and older adults. To circumvent the problems described above, we modeled our study materials after those used by Kuhbandner et al. (2009). As we describe in more depth in the Materials section, neutral category exemplars were paired with either neutral or emotional pictures. This allowed us to counterbalance the emotional valence of items across participants, and hence to control for category association strength. Furthermore, we used emotional pictures (rather than words), as they are likely more emotionally intense.

Two possibilities were examined. On the one hand, emotion may not modulate RIF when the stimuli are more tightly controlled and valence is counterbalanced across participants (see Kuhbandner et al., 2009). That is, in the present study, RIF might not vary as a function of emotion in either younger or older adults. This would suggest that the previous results documenting differences in RIF as a function of emotion may have been due to differences in category relatedness as a function of emotion.

On the other hand, it is possible that emotion could modulate RIF in the present study, since the stimuli are relatively intense emotionally. Typically, when researchers have observed attenuation in RIF as a function of emotion, they have attributed it to the fact that emotion affects information processing. Emotional items tend to be retrieved with more item-specific details than are neutral items (e.g., Ochsner, 2000), and we know that attending to the distinctive elements of studied items differentiates items that are otherwise similar. This increase in item-specific processing leads to reduced response competition during retrieval, and hence to reduced RIF (Smith & Hunt, 2000). In other words, because people naturally attend to the distinctive features of emotional items, there may be less response competition between emotional items during retrieval, and hence reduced RIF.

If additional item-specific processing of emotional items attenuates RIF, an interaction should exist between the item's emotional valence and the effect of a participant's age on the magnitude of RIF. Previous research has shown that whereas younger adults focus more on negative than on positive information (see Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Rozin & Royzman, 2001), older adults focus more on positive than on negative information (see Mather, 2004). For example, older adults allocate proportionally more attention to

positive information, and less to negative information, than do younger adults (e.g., Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Knight et al., 2007; Mather & Carstensen, 2003; Rösler et al., 2005). Because of these age-related changes in how attention is allocated, older adults likely devote more attention to positive than to negative information, and hence may engage in more item-specific processing of the positive than of the negative information. The reverse is likely true for younger adults. Because item-specific processing is the way that emotional valence is proposed to reduce RIF, this would in turn leave older adults *more* susceptible to RIF for negative information, and younger adults *more* susceptible to RIF for positive information.

To summarize, our first aim was to examine how emotion affects RIF, and whether this may vary by age. Using relatively intense emotional stimuli that were balanced with the neutral stimuli for category association strength, we first examined whether emotion modulates RIF under these circumstances. We also tested whether any potential attenuation in RIF as a function of emotion varies as a function of age and stimulus valence. Together, these analyses will shed light on how emotion affects inhibitory processes in both younger and older adults.

Socially shared RIF

So far, we have discussed ways that emotion and age may influence RIF within the rememberers themselves (i.e., within-individual retrieval-induced forgetting: WI-RIF). However, memory is often a social process (for reviews, see Rajaram, 2011; Rajaram & Pereira-Pasarin, 2010; Weldon, 2001), and social interaction influences memory. For example, a speaker's recollections can strengthen the memory representations of a listener (e.g., Basden, Basden, & Henry, 2000; Blumen & Rajaram, 2008), or when a speaker's recollections are incorrect, they can introduce errors into a listener's memory (e.g., Meade & Roediger, 2002; Roediger, Meade, & Bergman, 2001). Of present relevance, the recollections of a speaker can also induce RIF within a listener (Cuc, Koppel, & Hirst, 2007; for a review, see Stone, Coman, Brown, Koppel, & Hirst, 2012). This is known as *socially shared retrieval-induced forgetting*, and will henceforth be denoted SS-RIF.

To study SS-RIF, a modification of the retrieval practice paradigm is often used. In these studies, two participants individually learn a series of categorized words. One individual (the speaker) then proceeds with the typical retrieval practice paradigm by selectively practicing half of the items from half of the categories (i.e., the Rp + items). The other individual (the listener) listens to the speaker completing this task. Later, during the final memory test, both the speaker and the listener exhibit RIF: Memory is better for the nonpracticed items from the nonpracticed categories (the NRp items) than for the nonpracticed items from the practiced categories (the Rp– items). To be clear, within this modification of the retrieval practice paradigm, conclusions about WI-RIF are based on the speaker's data, whereas conclusions about SS-RIF effects are based on the listener's data.

Critically, SS-RIF only occurs when listeners covertly co-retrieve with the speakers during the retrieval practice phase. When co-retrieval does not occur, SS-RIF is eliminated. For example, when listeners are asked to attend to the smoothness of the speaker's voice during retrieval practice, SS-RIF is eliminated (Cuc et al., 2007, Exp. 1). The second aim of this study was to examine whether age and emotion modulate the likelihood that listeners will engage in co-retrieval, and hence influence the magnitude of SS-RIF.

To our knowledge, no study has yet examined SS-RIF in older adults. However, age may influence SS-RIF. Research has suggested that older adults have difficulty initiating retrieval on their own (Craik & Jennings, 1992) and compensate by relying on those they interact with (Dixon & Gould, 1998; Rauers, Riediger, Schmiedek, & Lindenberger, 2011; Strough & Margrett, 2002; see also Dixon, Rust, Feltmate, & See, 2007). Because of this, as compared to younger adults, older adults may be less inclined to co-retrieve with their partner. This would be evidenced as attenuated SS-RIF for older, as compared to younger, adults.

We also examined whether emotion interacts with age in modulating SS-RIF. Although research has demonstrated SS-RIF for both neutral information (e.g., A. D. Brown, Kramer, Romano, & Hirst, 2012; Cuc et al., 2007; Stone, Barnier, Sutton, & Hirst, 2010) and emotional information (e.g., Coman, Manier, & Hirst, 2009; Harris et al., 2010), it is unclear whether magnitude differences exist in SS-RIF for neutral and emotional information.[1] In the service of emotion regulation goals, listeners may be less likely to co-retrieve negative, as compared with positive, information. This may be especially true for older adults, who generally avoid directing attention to negative stimuli (e.g., Mather & Carstensen, 2005). This would be evidenced as attenuation in SS-RIF for negative, relative to either neutral or positive, information, especially for older adults.

Summary of research aims

In this study, we examined the interactions of age, emotion, and social interaction on RIF. Our first aim was to examine how emotion affects WI-RIF and whether this varies by age. The previous research examining the relationship between

[1] A. D. Brown, Kramer, Romano, and Hirst (2012) demonstrated equivalent SS-RIF for neutral and combat-related information in healthy adults. However, the emotionality of the combat-related information in their study is unclear.

emotion and WI-RIF in younger adults has been contradictory. One possibility is that the previous results suggesting modulation of WI-RIF as a function of emotion have actually been due to variations in category association strength as a function of emotion. In this case, using more tightly controlled stimuli should lead participants to exhibit WI-RIF for all stimuli, regardless of their emotional valence. On the other hand, the previous results in which researchers have failed to find modulation of WI-RIF as a function of emotion may have simply been based on stimuli that were insufficiently intense emotionally. In this case, using relatively intense emotional stimuli should lead younger adults to exhibit attenuated WI-RIF for emotional information, especially for *negative* items. In contrast, older adults should also exhibit attenuated WI-RIF, but especially for *positive* information. This age-by-valence interaction is predicted because of age differences in how people allocate attentional resources (Mather & Carstensen, 2005).

Our second aim was to examine the roles of age and emotion in modulating SS-RIF. All previous SS-RIF studies have been conducted with younger adults. Because older adults have difficulty initiating retrieval (see Craik & Jennings, 1992), they may be less likely to engage in co-retrieval during retrieval practice, and hence may exhibit attenuated SS-RIF. This may be especially true with negative information, since older adults avoid devoting attention to negative stimuli (Mather & Carstensen, 2005).

Method

Design

A 3 (valence) × 3 (retrieval practice) × 2 (age) × 2 (speaker status) design was used. The valence of the studied items was manipulated within subjects, since all participants encoded positive, neutral, and negative lists. Also, retrieval practice was manipulated within subjects, with list items being practiced members of a practiced category (Rp + items), unpracticed members of a practiced category (Rp– items), or unpracticed items of an unpracticed category (NRp items).

The remaining two factors, Age and Speaker Status, were manipulated between subjects. Each session involved a pair of either younger or older adults. Within each pair, one individual served as the speaker during the retrieval practice phase, and the other individual served as the listener. The proportions of items correctly recalled by the speaker as a function of retrieval practice status served as our measure of WI-RIF, and the proportions recalled by the listener served as our measure of SS-RIF.

Participants

A group of 96 adults (48 older and 48 younger) participated in this study. According to G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007), this sample size yields 95 % power to detect an interaction of at least $f = 0.18$ between retrieval practice, valence, and age (assuming a correlation of 0.5 between the repeated measures). According to Cohen's (1988) effect size conventions, 0.40, 0.25, and 0.10 indicate large, medium, and small effect sizes, respectively. Thus, we had the power to detect medium and large effects.

Older adults (54 % women, 46 % men; 8 % African American, 8 % Asian, 2 % biracial, and 73 % Caucasian) were on average 72.29 years old ($SD = 5.23$; range 65–86 years old). Younger adults (79 % women, 21 % men; 6 % African American, 40 % Asian, 8 % biracial, 38 % Caucasian, 2 % Pacific Islander) were on average 19.98 years old ($SD = 1.52$, range 18–24 years old). The older adults had completed more years of education ($M = 17.06$) than had the younger adults ($M = 14.02$), who were primarily still students at the time of this study, $t(94) = 6.37$, $p < .001$. The older adults also had higher vocabulary scores ($M = 19.02$) than did the younger adults ($M = 13.35$), $t(94) = 7.13$, $p < .001$. All participants were healthy, and the older adults rated themselves as being subjectively healthier ($M = 7.77$) than did the younger adults ($M = 7.26$) (in answer to the question "How would you rate your overall health?," where 1 corresponded to *very poor health* and 9 corresponded to *excellent health*), $t(94) = 2.30$, $p = .02$.

Participants were recruited through the University of Southern California (USC) psychology participant pool and through a list of research volunteers recruited via newspaper and online ads, fliers at senior centers and public places, and letters to USC alumni. During recruitment, the older adults were screened for cognitive impairment using a modified version of the Telephone Interview for Cognitive Status (TICS-m; Welsch, Breitner, & Magruder-Habib, 1993). TICS-m scores are highly correlated with the Mini-Mental State Exam and have excellent sensitivity (99 %) and specificity (86 %) in classifying participants with Alzheimer's disease from normal individuals (Beeri, Werner, Davidson, Schmidler, & Silverman, 2003; Welsch et al., 1993). Only people who scored above, or equal to, the cut point of 27 (Gallo & Breitner, 1995) were included in this study. Upon completion of the study, participants were compensated either 1 credit/h toward their course requirements or $15/h. All of the participants completed the study with another same-age-group participant, and these pairs were always unacquainted with one another before the study.

Materials

The study items consisted of six categorized lists of 10 exemplars (see the Appendix), each drawn from the Van

Overschelde, Rawson, and Dunlosky (2004) norms (an update of Battig & Montague, 1969). Feature similarity between the exemplars was minimized wherever possible to increase RIF (see M. C. Anderson et al., 2000; Bäuml & Hartinger, 2002). Exemplar frequency (i.e., category relatedness) was matched across the lists. On average, the exemplars were produced by 27.2 % of people surveyed in the Van Overschelde et al. (2004) norms (*SD* = 21.6 %, range of 5 %–93 %). The exemplars were at least four letters in length. Within each list, exemplars began with a unique first two letters, so that these letters could be used as cues during retrieval practice.

To manipulate valence, each exemplar was paired with a picture (see Fig. 1; see also Kuhbandner et al., 2009). The pictures were positive, neutral, or negative. Picture valence was counterbalanced such that each exemplar appeared equally often as emotional or neutral. For example, the picture for the exemplar *pencil* (from the category "carpenter's tools") was equally often a woman with a pencil behind her ear (a neutral picture) and a man with a pencil protruding from a neck stab wound (a negative picture). Similarly, the picture for the exemplar *horse* (from the category "four-footed animals") was equally often a cowboy leading a horse (a neutral picture) and a child with a miniature horse (a positive picture). To be clear, exemplars did *not* appear equally often as positive, neutral, and negative. Rather, they appeared equally often as emotional (either positive or negative) and neutral. All of the pictures were color photographs and were drawn primarily from the Internet.

In addition to counterbalancing valence, we also counterbalanced retrieval practice. Across participants, each category appeared equally often during the retrieval practice phase or as a nonpracticed category (Rp vs. NRp). Furthermore, when a category was practiced, each exemplar appeared equally often as practiced (Rp+) and unpracticed (Rp–).

Procedure

Demographics At the beginning of the experiment, the participants completed a demographics form in which they indicated their age, sex, and educational background and answered health-related questions.

Study phase Pairs of participants were seated in front of one computer and were asked to learn a series of categorized words (paired with pictures) for a later, unspecified memory test. The participants were instructed that while learning they should think about how well each word matched its category. They were also warned that some pictures would be emotional and were asked not to speak to one another.

The participants were then shown the exemplars from all six categories (two positive, two neutral, and two negative). Each exemplar's picture was shown for 6 s in the middle of the screen with its category and exemplar name above it (see

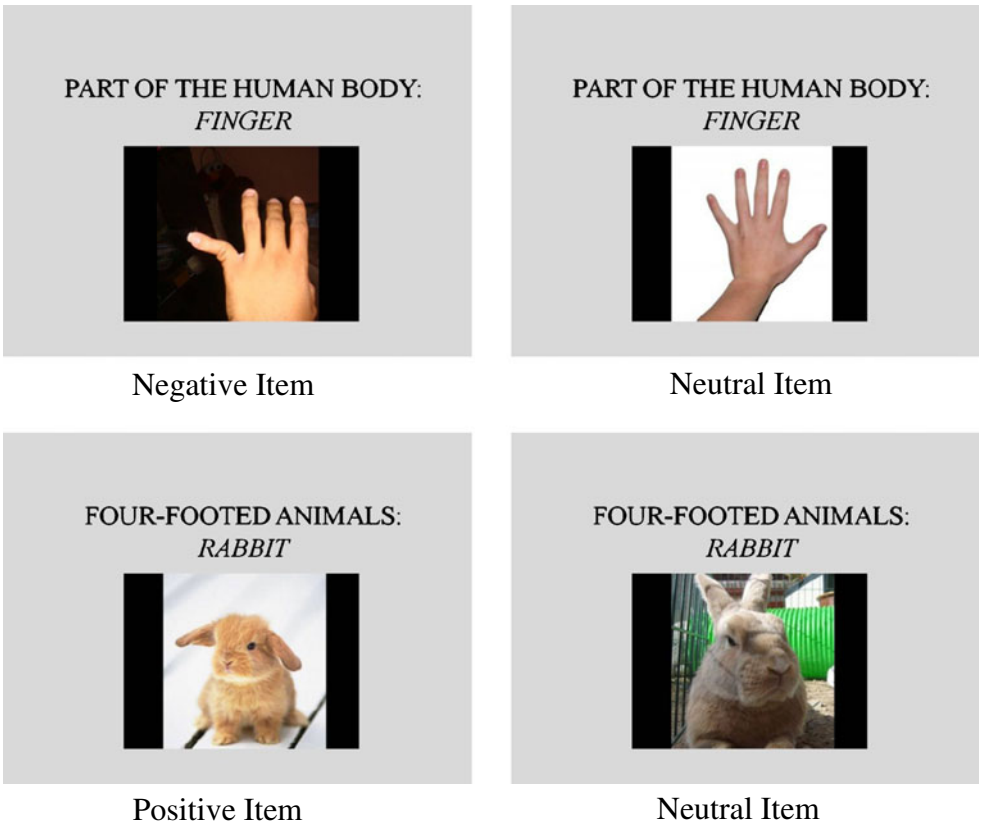

Fig. 1 Examples of our stimuli. Counterbalancing was used such that items appeared equally often as emotional (either negative or positive) or neutral during the study phase

Fig. 1). A random sequence was used such that one exemplar from each of the categories was presented before the second exemplars were presented. This was repeated until the participants had seen all 10 exemplars from all six categories.

Retrieval practice phase After a 30-s filled delay, participants moved onto the retrieval practice phase. During this phase, one participant from each pair was randomly selected to be the "speaker" who would complete a memory test. During this test, the speaker was presented (for 5 s) with a category name and the first two letters of a previously studied exemplar (e.g., *four-footed animals–ho___*). The speaker was asked to state aloud the studied exemplar that began with those letters and was from that category (e.g., *horse*). Half of the exemplars from half of the categories were tested. The speakers were tested on one positive-, one neutral-, and one negative-valenced category, and each exemplar was tested three times. The experimenter noted the speaker's responses, but no feedback was provided.

The other participant served as the "listener." This participant was asked to listen carefully to the speaker's responses and to think about the speaker's general accuracy. To our knowledge, all previous SS-RIF studies using categorized lists have required listeners to covertly note whether the speakers were accurate for each answer. We did not do this. As noted earlier, SS-RIF only occurs when listeners co-retrieve with the speakers (Cuc et al., 2007). By requiring listeners to note the accuracy of each response, we would have required the listener to co-retrieve all information. In contrast, by asking listeners to think about the speakers' general accuracy, we allowed the listeners to choose not to co-retrieve all information.

Delay phase All participants individually completed puzzles for 2 min.

Category-cued recall test The participants then individually completed a category-cued recall test. They were given 1 min per category to recall as many of the items as possible from that category. The categories were tested in a random order across participants.

Final questionnaires The participants next completed a series of questionnaires. Vocabulary skills were assessed via the Nelson–Denny test (J. I. Brown, Fishco, & Hanna, 1993). The participants also answered questions addressing their thoughts about each phase of the study. Included in this questionnaire was the Subjective Closeness Index (Berscheid, Snyder, & Omoto, 1989), which assessed how participants felt about the other individual who had participated with them. This measure consists of two questions: "Relative to all your other relationships (both same and opposite sex), how would you characterize your relationship with this person?" and "Relative to what you know about other peoples' close relationships, how would you characterize your relationship with this person?" Questions were answered on a scale from 1 (*not at all close*) to 7 (*extremely close*).

Valence and arousal ratings Finally, the participants rated the emotionality of the pictures seen at study. They first rated all 60 pictures for their valence. The pictures were presented in a random order, and participants used the Self-Assessment Manikin (SAM) scale to make their assessments. Devised by Lang (1980), this scale presents a graphic depiction of emotional reactions. For the valence scale, the depictions ranged from a smiling figure (a value of 1) to a frowning figure (a value of 9). After completing the valence ratings, the participants then rated the pictures' arousal levels, with the pictures presented in a new random order. This time, the SAM scale depictions ranged from an excited, wide-eyed figure (value of 1) to a bored, sleepy-eyed figure (value of 9). Both the valence and arousal ratings were self-paced.

The valence ratings were in line with our manipulation (see Table 1). A 3 (valence: positive vs. neutral vs. negative) × 2 (age: younger vs. older adults) analysis of variance (ANOVA) on the valence ratings yielded a main effect of valence, $F(2, 188) = 202.32$, $MSE = 1.85$, $p < .001$, $\eta_p^2 = .68$, which did not interact with age, $F(2, 188) < 1$. Negative items were rated as more negative than the neutral items, $F(1, 94) = 202.32$, $MSE = 2.11$, $p < .001$, $\eta_p^2 = .68$, which were rated as more negative than the positive items, $F(1, 94) = 36.13$, $MSE = .73$, $p < .001$, $\eta_p^2 = .28$.

The arousal ratings were also in line with our manipulation (see Table 1). A 3 (valence: positive vs. neutral vs. negative) × 2 (age: younger vs. older adults) on the arousal ratings yielded a main effect of valence, $F(2, 188) = 79.50$, $MSE = 2.61$, $p < .001$, $\eta_p^2 = .46$, which interacted with participant age, $F(2, 188) = 5.47$, $MSE = 2.61$, $p = .005$, $\eta_p^2 = .06$. Both younger and older adults rated the negative items as more arousing than the positive items [$F(1, 47) = 8.87$, $MSE = 1.90$, $p = .005$, $\eta_p^2 = .16$, and $F(1, 47) = 27.09$, $MSE = 5.01$, $p < .001$, $\eta_p^2 = .37$] and the positive items as more arousing than the neutral items [$F(1, 47) = 58.06$, $MSE = 1.18$, $p < .001$, $\eta_p^2 = .55$, and $F(1, 47) = 17.52$, $MSE = 1.28$, $p < .001$, $\eta_p^2 = .27$]. However, age differences emerged in the ratings of the negative items. Older adults rated the negative items as more arousing than did the younger adults, $F(1, 94) = 6.48$, $MSE = 3.93$, $p = .01$, $\eta_p^2 = .06$. In summary, participants perceived the stimuli in line with our manipulation.

Results

Retrieval practice accuracy

A 3 (valence: positive vs. neutral vs. negative) × 2 (age: younger vs. older adults) ANOVA on the proportions of

Table 1 Valence and arousal ratings as a function of valence and age

		Valence Ratings		Arousal Ratings	
		Younger Adults	Older Adults	Younger Adults	Older Adults
Negative Items	Mean	7.14	7.14	4.76	3.73
	Standard Deviation	1.29	1.58	1.93	2.03
Neutral Items	Mean	4.37	3.96	7.29	7.08
	Standard Deviation	0.76	1.09	1.28	1.45
Positive Items	Mean	3.38	3.46	5.60	6.11
	Standard Deviation	0.98	1.48	1.59	1.79

Valence ratings were made on a 1–9 scale. A minimum score of 1 corresponded to a smiling, happy figure, whereas a maximum score of 9 corresponded to a frowning, unhappy figure. Arousal ratings were also made on a 1–9 scale. Here, a minimum score of 1 corresponded to an excited, wide-eyed figure, whereas a maximum score of 9 corresponded to a bored, sleepy-eyed figure.

items correctly recalled during retrieval practice revealed a main effect of age. Younger adults successfully retrieved more items (M = .81) than did the older adults (M = .68), $F(1, 46) = 10.49$, MSE = .05, p = .002, η_p^2 = .19. There were no other significant effects. It is important to note that these age differences in retrieval practice accuracy should not impact the magnitude of RIF subsequently observed. That is, while RIF is dependent on retrieval practice *attempts*, it is not dependent on retrieval practice *accuracy* (Storm, Bjork, Bjork, & Nestojko, 2006; Storm & Nestojko, 2010). For example, in a study by Storm et al. (2006), equivalent RIF was observed when retrieval practice was easy (retrieval practice accuracy = 62 %) and when retrieval practice was difficult (accuracy = 7 %).

Cued-recall test scoring

For each participant, two independent raters (one blind to all of the study hypotheses) calculated the proportions of items correctly recalled as a function of retrieval practice (Rp+vs. Rp– vs. NRp) and valence (positive vs. neutral vs. negative). A lenient scoring criterion was used, in which variants of studied items (e.g., *feet* rather than *foot*) were considered correct. Consistency between the raters was high, with 94.8 % agreement. Scores from the first rater only were used in subsequent analyses.

Speaker data: WI-RIF effects

We first examined how retrieval practice affected memory in the *speakers* by conducting a 3 (retrieval practice: Rp+vs. Rp– vs. NRp) × 3 (valence: positive vs. neutral vs. negative) × 2 (age: younger vs. older adults) ANOVA on the proportions of items correctly recalled by speakers (see Table 2). As expected, this analysis revealed a main effect of retrieval practice, $F(2, 92) = 126.54$, MSE = .03, $p < .001$, η_p^2 = .73. In subsequent analyses, we explored this effect by testing whether retrieval practice led to facilitation of the practiced Rp+items as well as to WI-RIF of the Rp– items.

Retrieval practice improved memory for the Rp + items. A 2 (retrieval practice: Rp + vs. NRp) × 3 (valence: positive vs. neutral vs. negative) × 2 (age: younger vs. older adults) ANOVA yielded a main effect of practice; the speakers recalled more Rp + (M = .76) than NRp (M = .56) items, $F(1, 46) = 155.25$, MSE = .02, $p < .001$, η_p^2 = .77. However, this effect was qualified by a marginally significant interaction between retrieval practice and valence, $F(2, 92) = 2.99$, MSE = .02, p = .06, η_p^2 = .06. Unexpectedly, retrieval practice benefited the neutral items more than the positive items, $F(1, 46) = 5.85$, MSE = .02, p = .02, η_p^2 = .11. However, it did not benefit the negative items more than the positive items, $F(1, 46) = 2.15$, MSE = .03, p = .15, or the neutral items more than the negative items, $F(1, 46) < 1$. There were no interactions with age in these effects.

We next turned our attention to the detrimental effects of retrieval practice by examining how practice can simultaneously lead to WI-RIF. We did this by conducting a 2 (retrieval practice: Rp– vs. NRp) × 3 (valence: positive vs. neutral vs. negative) × 2 (age: younger vs. older adults) ANOVA on the proportions of items correctly recalled by the speakers. As expected, speakers recalled fewer Rp– (M = .46) than NRp (M = .56) items, $F(1, 46) = 29.16$, MSE = .03, $p < .001$, η_p^2 = .39. Thus, we replicated the standard WI-RIF effect.

Our first aim was to examine whether emotion affects WI-RIF and whether this effect varies by age. The results revealed that emotion does not affect WI-RIF, regardless of age. In the ANOVA just described, there was neither a significant interactions between retrieval practice and age, $F(1, 46) = 1.33$, MSE = .03, p = .25, nor retrieval practice and valence, $F < 1$. Furthermore, no significant three-way interaction occurred between retrieval practice, age, and valence, $F(2, 92) = 1.92$, MSE = .02, p = .15. This was confirmed in follow-up analyses. Neither younger adults, $F < 1$, nor older adults, $F(2, 46) = 1.59$, MSE = .02, p = .22, exhibited an interaction

Table 2 Category-cued recall as a function of retrieval practice, valence, age, and speaker status

		Speaker (WI-RIF Data)		Listener (SS-RIF Data)	
		Younger Adults	Older Adults	Younger Adults	Older Adults
Negative Items	Rp+	.83	.72	.89	.73
	Rp–	.55	.42	.57	.39
	NRp	.64	.49	.61	.50
	Size of RIF (NRp – Rp–)	.09	.08	.05	.10
Neutral Items	Rp+	.86	.71	.85	.71
	Rp–	.50	.36	.51	.38
	NRp	.60	.47	.60	.48
	Size of RIF (NRp – Rp–)	.10	.11	.09	.10
Positive Items	Rp+	.77	.68	.83	.70
	Rp–	.58	.35	.59	.37
	NRp	.63	.53	.62	.46
	Size of RIF (NRp – Rp–)	.05	.18	.03	.09

The data from the speakers were used as our index of WI-RIF. The data from the listeners were used as our index of SS-RIF.

between retrieval practice and valence. Furthermore, for both age groups, correlation analyses suggested that the magnitude of WI-RIF for emotional information was unrelated to the arousal or valence ratings provided by the speakers.[2]

Listener data: SS-RIF effects

We next turned to the second focus of this study: Do age and emotion modulate SS-RIF? To answer this question, we examined how retrieval practice affected memory in the *listeners* by conducting a 3 (retrieval practice: Rp + vs. Rp– vs. NRp) × 3 (valence: positive vs. neutral vs. negative) × 2 (age: younger vs. older adults) ANOVA on the proportions of items correctly recalled by each listener (see Table 2). As expected, we found a main effect of retrieval practice, $F(2, 92) = 108.27$, $MSE = .04$, $p < .001$, $\eta_p^2 = .70$. We explored this further by testing whether retrieval practice led to facilitation of the practiced Rp + items as well as to SS-RIF of the Rp– items.

Retrieval practice by the speakers improved memory for the practiced items in the listeners. That is, a 2 (retrieval practice: Rp + vs. NRp) × 3 (valence: positive vs. neutral vs. negative) × 2 (age: younger vs. older adults) ANOVA on the proportions of items correctly recalled by each listener yielded a main effect of practice: Listeners recalled more Rp + items ($M = .79$) than NRp items ($M = .54$), $F(1, 46) = 128.25$, $MSE = .03$, $p < .001$, $\eta_p^2 = .74$. This practice benefit did not interact with valence or age.

We next examined SS-RIF by conducting a 2 (retrieval practice: Rp– vs. NRp) × 3 (valence: positive vs. neutral vs. negative) × 2 (age: younger vs. older adults) ANOVA on the proportions of items correctly recalled by each listener (see Table 2). This revealed a main effect of retrieval practice, $F(1, 46) = 15.25$, $MSE = .03$, $p < .001$, $\eta_p^2 = .25$: Listeners recalled fewer Rp– items ($M = .47$) than NRp items ($M = .54$). Thus, we replicated the SS-RIF effect.

As noted, our second aim was to examine whether age and emotion modulate SS-RIF. In light of the previous literature, we predicted that SS-RIF might be attenuated, especially for negative items, with age. However, the results revealed that SS-RIF is preserved with age and does not depend on emotional valence. In the ANOVA just described, there was neither a significant interaction between retrieval practice and age, $F(1, 46) = 1.29$, $MSE = .03$, $p = .26$, nor between

[2] In a study by Kuhbandner et al. (2009), no interaction was found between retrieval practice and whether items were negative or neutral. However, subsequent analyses revealed that this result depended on the items' emotional "intensity," in that RIF decreased as emotional intensity increased. However, this correlation is difficult to interpret, given that there was no interaction between retrieval practice and valence. For example, the result could suggest that low-intensity emotional items were *more* susceptible to RIF than were neutral items. Despite these difficulties in interpretation, we also examined whether emotional intensity modulated RIF. We did this in many ways: The intensities of emotional valence and arousal were *unrelated* to Rp– recall, WI-RIF, or SS-RIF when intensity was conceptualized as (a) the ratings for each item provided by each participant, (b) the average ratings for each item provided by all participants, or (c) the average ratings for each item provided by all participants when the item was neutral versus emotional (i.e., the analysis used by Kuhbandner et al., 2009). Only one of the many conceptualizations of intensity showed a relationship with RIF: Younger adult speakers exhibited reduced WI-RIF for both negative, $r = –.45$, $p = .03$, and positive , $r = –.41$, $p = .05$, items when they had rated the emotional arousal (but not the valence) of the Rp– items that they had seen as being more intense than that of the NRp items that they had seen. This relationship was absent for older adults and absent for both younger and older adults when examining SS-RIF. Therefore, we concluded that emotional intensity had little impact on RIF in this study.

retrieval practice and valence, $F < 1$. Furthermore, no significant three-way interaction occurred between retrieval practice, age, and valence, $F < 1$. These results were confirmed in follow-up analyses. Both younger, $F(1, 23) = 4.56$, $MSE = .02$, $p = .04$, $\eta_p^2 = .17$, and older, $F(1, 23) = 10.96$, $MSE = .03$, $p = .003$, $\eta_p^2 = .32$, adults exhibited SS-RIF. However, in neither age group did we find an interaction between retrieval practice and valence, both Fs < 1. Furthermore, correlation analyses suggested that SS-RIF did not decrease as the intensity of the arousal or valence ratings provided by the listeners increased.[3] Thus, as with WI-RIF, SS-RIF is preserved with age and does not interact with valence.

In analyzing the SS-RIF data, an unanticipated pattern emerged such that SS-RIF depended on whether or not the speaker and listener were of the same sex (see Fig. 2). A 2 (retrieval practice: Rp– vs. NRp) × 3 (valence: positive vs. neutral vs. negative) × 2 (age: younger vs. older adults) × 2 (partner sex: same as vs. different from the listener's) ANOVA on the proportions of items correctly recalled by listeners revealed a significant interaction between retrieval practice and partner sex, $F(1, 44) = 10.21$, $MSE = .02$, $p = .003$, $\eta_p^2 = .19$, and the interaction did not interact with age, $F(1, 44) = 1.80$, $MSE = .02$, $p = .19$, or with valence, $F < 1$.[4] Follow-up analyses collapsing across age revealed that listeners exhibited SS-RIF when the speaker was of the same sex as themselves, $F(1, 22) = 22.57$, $MSE = .03$, $p < .001$, $\eta_p^2 = .51$, but not when the speaker was of the opposite sex, $F(1, 24) = 1.12$, $MSE = .02$, $p = .30$ (see Fig. 2). This may have been due to differences in self-perceived closeness. At the end of the experiment, the participants rated how close they felt to the other participant. A 2 (partner sex: same as vs. different from the listener's) × 2 (age: younger vs. older adults) revealed that listeners self-reported feeling closer to speakers who were of the same sex as themselves ($M = 3.04$; 1 = *not at all close* and 14 = *extremely close*) than to speakers who were of a different sex ($M = 2.38$; one participant was removed whose reported closeness was more than 3 *SD*s above the mean), $F(1, 45) = 4.03$, $MSE = 1.30$, $p = .05$, $\eta_p^2 = .08$. Thus, listeners may be more inclined to co-retrieve with speakers they feel close to, and therefore may be more susceptible to SS-RIF when the speaker is a close other. However, this unanticipated pattern of results will require closer examination in future research.

[3] Within these analyses, only one correlation emerged as significant. However, it was in the reverse direction from the one predicted. In younger adults, more intense positive valence ratings were associated with *increased* SS-RIF of that information, $r = –.60$, $p = .002$ (lower valence scores corresponded to items rated as more positively intense).

[4] We repeated this analysis including the listener's sex. Here, the interaction between retrieval practice and partner sex remained significant and did not interact with the listener's sex.

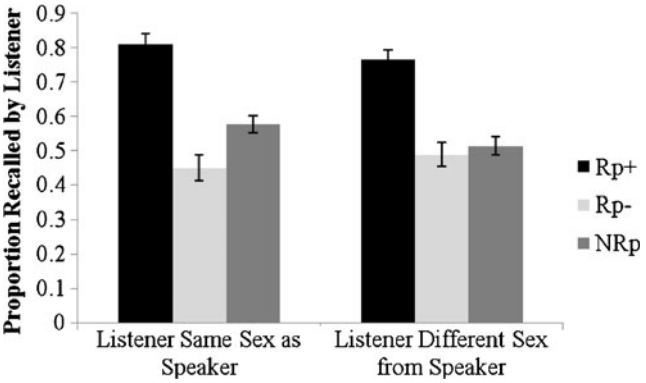

Fig. 2 Proportions of items recalled by listeners as a function of retrieval practice and of whether the speaker was of the same or of the opposite sex from the listener. Socially shared retrieval-induced forgetting (i.e., recall of NRp>recall of Rp–) was only observed when the listener and speaker were of the same sex. Error bars indicate ±1 *SE*

Additional analyses: Output order interference

In this study, we used category-cued recall to assess WI-RIF and SS-RIF. Thus, our effects may have been due to *output order interference*. This is the finding that the first items produced during recall can interfere with the retrieval of related information (Roediger & Schmidt, 1980; Tulving & Arbuckle, 1963). If participants tended to recall the Rp + items early during recall, this could have interfered with their ability to recall Rp– items. In the present study, the participants did tend to recall the Rp + items early during recall: 84 % of the recall protocols began with an Rp + item. However, subsequent analyses showed that the relative order of Rp + and Rp– recall was unrelated to the magnitude of the RIF observed. Using a method described by Macrae and MacLeod (1999), for each participant we calculated the average serial position of the Rp + and Rp– items recalled. Using a grand median split, we then categorized participants either as tending to have early Rp + recall or early Rp– recall. This was done separately for the positive, neutral, and negative lists. If our results were due to output interference, RIF should be greater for participants in the early Rp + group than in the early Rp– group. Looking first at the speakers' data (i.e., the WI-RIF effect), we found no evidence that output order interference played a role in the magnitude of the RIF observed. That is, a series of 2 (Rp + group: early Rp + recall vs. early Rp– recall) × 2 (age: younger vs. older adults) ANOVAs on the magnitudes of the positive, neutral, and negative WI-RIF effects (calculated as NRp minus Rp– recall) yielded no main effect of Rp + group [positive items, $F < 1$; neutral items, $F < 1$; negative items, $F(1, 44) = 1.39$, $MSE = .05$, $p = .25$].

Similar patterns were found when examining the listeners' data (i.e., the SS-RIF effect). Here, a series of 2 (Rp + group: early Rp + recall vs. early Rp– recall) × 2 (age:

younger vs. older adults) ANOVAs on the magnitudes of the positive, neutral, and negative SS-RIF effects (calculated as NRp minus Rp– recall) yielded no significant effect of Rp + group [positive items, $F < 1$; neutral items, $F(1, 44) = 1.15$, $MSE = .06$, $p = .29$; negative items, $F(1, 44) = 1.23$, $MSE = .05$, $p = .27$]. Thus, the previously reported RIF results are likely not due to output order interference.

Discussion

Remembering can cause forgetting. When people selectively recall some information, they inadvertently inhibit related but nonrecalled information. Known as *retrieval-induced forgetting*, this occurs across many types of study materials and for a wide variety of populations. In fact, RIF can occur both for people doing the remembering (i.e., WI-RIF) and also for people listening to those recollections (i.e., SS-RIF). The primary goals of this study were to investigate the individual and interactive influences of emotion and age on both WI-RIF and SS-RIF.

We first examined how emotion and age affect WI-RIF. Previous research examining the relationship of emotion on WI-RIF in younger adults had yielded contradictory results. Using materials that controlled for category association strength, we observed equivalent levels of WI-RIF both for emotional and neutral information (see also Kuhbandner et al., 2009) and for younger and older adults (see also Aslan et al., 2007). That is, all participants, regardless of their age, exhibited WI-RIF for all of the studied information, regardless of its valence. These results suggest that (a) emotion may not affect WI-RIF when category association strength is controlled, and (b) the inhibitory mechanism underlying WI-RIF is preserved with age, even for emotional information.

We also examined how emotion and age affect SS-RIF. Although research had demonstrated SS-RIF for both neutral (e.g., Cuc et al., 2007; Stone et al., 2010) and emotional (e.g., Coman et al., 2009; Harris et al., 2010) information, the relative magnitudes of these effects had remained untested. Furthermore, no study had examined whether SS-RIF occurs for older adults. We hypothesized that SS-RIF might be attenuated with age due to older adults' difficulty initiating retrieval (Craik & Jennings, 1992), and that this might be especially true for negative information, since older adults generally avoid devoting attention to negative information (Mather & Carstensen, 2005). In contrast to these predictions, we observed equivalent levels of SS-RIF for emotional and neutral information, and these levels were not dependent on age.[5] Thus, we demonstrated that older adults are as susceptible as younger adults to SS-RIF, even when examining emotional information.

Given that we did not observe differences in either WI-RIF or SS-RIF as a function of emotion, it is important to note that our manipulation of emotion was effective. As noted earlier, participants rated the valence and arousal of the stimuli in line with our intended manipulation. Furthermore, we also observed differences in overall memory performance as a function of emotion. Collapsing across retrieval practice status, a 2 (age: younger vs. older adults) × 2 (speaker status: speaker vs. listener) × 2 (valence: emotional vs. neutral) ANOVA revealed that participants recalled more emotional information than neutral information, $F(1, 92) = 3.73$, $MSE = .005$, $p = .03$ (one-tailed), $\eta_p^2 = .04$. This finding did not interact with either age or speaker status.

Finally, we also identified a social factor that exerted a significant impact on the magnitude of SS-RIF: the sex of the participants. When participants were of the same sex, SS-RIF was observed. In contrast, when participants were of different sexes, SS-RIF was eliminated. This unanticipated result may have been due to differences in closeness: Listeners rated their relationships with the speakers as being subjectively closer when the speaker was of the same sex as themselves. On the basis of this result, future research will need to examine whether SS-RIF is more likely to occur for close others, such as friends or couples, than for strangers. Furthermore, given that participant sex exerted such a strong influence on SS-RIF, future research should examine how other social factors may also influence SS-RIF. For example, factors such as group size, diffusion of responsibility, or individual differences in competitiveness or conscientiousness may influence the magnitude of SS-RIF.

This boundary condition for SS-RIF may have important social implications. One downstream consequence of SS-RIF is that it creates collective memories, such that speakers and listeners subsequently come to both remember, and forget, the same information (Stone et al., 2010). Given that humans are motivated to experience commonalities with one another in their perceptions, feelings, and memories (Echterhoff et al., 2009), the benefit of creating shared memories with one's partner may be absent for people working with an opposite-sex stranger. That is, the characteristics of the social interaction likely influence when memories are spread throughout a group of individuals and when they are not. This is in line with research suggesting that the characteristics of the speaker and of the listener influence the likelihood that social contagion will occur—another way that groups come to have shared, or overlapping, memories (see Hirst & Echterhoff, 2008).

In conclusion, the majority of memory studies have focused on younger adults learning and remembering neutral information in isolation. However, many real-world

[5] In preparing this article, we became aware that Stone, Barnier, Sutton, and Hirst (2011) have also recently shown equivalent SS-RIF for emotional and neutral information.

situations involve people of a variety of ages learning and remembering emotional information in group contexts. In the present study, we focused on how these three contextual factors (age, emotion, and social interaction) may independently and interactively affect memory inhibition in the form of RIF. Although RIF is a robust phenomenon that occurs for both younger and older adults, for both emotional and neutral stimuli, and for both speakers and listeners, we did identify one boundary condition for when RIF is eliminated: People only exhibit SS-RIF when the partner is the same sex as themselves. This issue remains open for future research to explore additional emotional and social factors to determine when such factors may increase, decrease, or have no effect on memory inhibition.

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Appendix: Stimuli used in the present study

Categories that were either positive or neutral

FOUR-FOOTED ANIMALS:

bear, deer, elephant, giraffe, goat, horse, lion, rabbit, sheep, squirrel

NATURAL EARTH FORMATIONS:

beach, canyon, cliff, desert, glacier, lake, mountain, ocean, river, waterfall

ARTICLE OF CLOTHING:

blouse, boxers, dress, gloves, jacket, jeans, shoes, skirt, sweater, underwear

Categories that were either negative or neutral

CARPENTER'S TOOLS:

drill, hammer, knife, nail, pencil, pliers, ruler, screwdriver, wood, wrench

PART OF THE HUMAN BODY:

ankle, back, chest, face, finger, foot, mouth, nose, teeth, tongue

TYPE OF FRUIT:

banana, lemon, nectarine, pear, plum, raspberry, strawberry, tangerine, tomato, watermelon

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