

# Collaborative Remembering in Older Adults: Age-Invariant Outcomes in the Context of Episodic Recall Deficits

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Rapidly growing research reveals complex yet systematic consequences of collaboration on memory in young adults, but much less is known about this phenomenon in older adults. Young and older adults studied a list of categorized words and took three successive recall tests. Test 1 and 3 were always taken individually, and Test 2 was done either in triads or alone. Despite older adults recalling less overall than young adults, both age groups exhibited similar costs and benefits of collaboration: Collaboration reduced both correct and false recall during collaborative remembering, was associated with more positive beliefs about its value, and produced reminiscence, collective memory, and some forgetting in its cascading effects on postcollaborative recall. We examine the role of retrieval organization in these effects. As environmental support may play a substantial role in healthy aging, the relatively preserved effects of collaboration on memory in older adults hold promise for testing judicious uses of group remembering in aging.

*Keywords:* collaborative memory, aging and recall, retrieval organization, collective memory, beliefs about collaboration

People report using different strategies to compensate for age-related declines in memory and cognition, such as increased reliance on external memory aids, increased time and effort when trying to remember, and greater use of intentional mnemonic strategies (Dixon, de Frias, & Backman, 2001). One readily available resource for older adults is a collaborator. Collaboration as a way to optimize performance and compensate for age-related cognitive change has been studied in several domains, including problem solving, reasoning and decision making, and storytelling (Berg et al., 2007; Gould & Dixon, 1993; Margrett & Marsiske, 2002; Meegan & Berg, 2002; Smith et al., 2009; Strough, Cheng, & Swenson, 2002; Strough, McFall, Flinn, & Schuller, 2008). Collaboration is important to study in the context of memory because people often learn and remember in a social context, and it may provide environmental support in the form of external cues that can help reduce age-related memory deficits (Craig & Anderson, 1999).

In the last decade, a rapidly growing literature has examined the impact of collaboration on memory in young adults (Barnier & Sutton, 2008; Weldon, 2001). Predictably, collaborative recall is higher than individual recall, attesting to the adage that two heads are better than one (Yuker, 1955). But as we recently described in a comprehensive review (Rajaram & Pereira-Pasarin, 2010), the emerging picture is in fact complex in the costs and benefits shown both during collaboration and in postcollaborative memory. In brief, while collaboration leads to higher group recall than that of

each of its individual members, it nonetheless *reduces* group recall to being less than its actual potential, a phenomenon known as *collaborative inhibition* (Weldon & Bellinger, 1997). At the same time, collaboration can benefit group recall by reducing recall errors or intrusions. Further, there are postcollaborative consequences: Prior collaboration can increase each group member's later individual recall, but can also lead to forgetting in postcollaborative individual recall. These costs and benefits resulting from collaboration can shape the individual memories of group members in systematic ways such that group members carry forward more overlap in their memories and develop shared or collective memories (Hirst & Manier, 2008). Indeed, while there is fascinating emerging evidence on the formation of such collective memories (Cuc, Ozuru, Manier, & Hirst, 2006), no past research to our knowledge has examined this phenomenon in older adults. Further, in light of these complex social influences both during collaborative recall and in postcollaborative individual recall, it is important to assess whether people subjectively experience the process of collaboration to help or hurt their performance. This question is especially relevant with respect to older adults in that environmental support (Craig & Anderson, 1999) as well as the hypothesized benefits of collaboration for emotional regulation (Wessel & Moulds, 2008) may be particularly important for healthy aging. As currently available evidence is not only scant but also addresses only some of these collaborative memory phenomena in older adults, the present study tested the core aspects of five key issues to help build a systematic evidence base.

We present here a brief overview of the experimental design we devised to address these questions and then present the background and rationale that motivated each major question. Participants read a randomized list of exemplars from various categories, with the top two exemplars from each category not presented so that false recall to them could be studied. All participants performed their first free recall task alone. Half then performed a second recall test

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in groups of three (collaborative recall), and half performed the second test alone (with nominal groups formed by combining the nonredundant recall output of three individuals' Test 2 scores). All participants then completed a final free recall test individually, and this performance was used to assess both postcollaborative individual recall and collective memory.

### Collaborative Inhibition and Retrieval Organization in Group Recall

Perhaps the most counterintuitive key issue to emerge in collaborative memory research with young adults is the finding that collaborative groups consistently recall less than their potential. This phenomenon, known as *collaborative inhibition* (Weldon & Bellinger, 1997), occurs when collaborative groups are compared with nominal groups (i.e., groups in name only that are composed of an equal number of individuals working alone). By nonredundantly pooling together responses made by at least one member of the nominal group, it can be seen that collaboration reduces the recall output of each group member that he or she may have otherwise produced while working alone. This is not due to social loafing or diffusion of responsibility (Weldon, Blair, & Huebsch, 2000) but rather arises because listening to other people's recall order during collaboration disrupts one's own retrieval strategies. Considerable evidence supports this retrieval disruption explanation of the collaborative inhibition effect in young adults. For example, collaborative inhibition increases as group size increases (Basden, Basden, & Henry, 2000; Thorley & Dewhurst, 2007), likely because larger groups bring about more misalignments in the retrieval strategies. Collaborative inhibition is most consistently observed when retrieval tasks rely heavily on idiosyncratic retrieval strategies such as in free recall tasks (Barber, Rajaram, & Aron, 2010; Clark, Hori, Putnam, & Martin, 2000; Finlay, Hitch, & Meudell, 2000), and it is reduced or disappears if participants can develop stronger retrieval organization (i.e., clustering of related information) that can withstand disruptive or distracting effects of responses given by other group members (Basden et al., 1997; Basden et al., 2000; Pereira-Pasarin & Rajaram, 2010).

Given the role of retrieval disruption in producing collaborative inhibition, there are many reasons to suspect that older adults might therefore be especially impaired when remembering collaboratively. For example, older adults are particularly susceptible to disruption and interference and less successful at ignoring distractions (Carlson, Hasher, Zacks, & Connelly, 1995; Hedden & Park, 2001; Spieler, Balota, & Faust, 1996; Yang & Hasher, 2007). But it is also possible that older adults—who typically recall less than young adults (Craik & McDowd, 1987; Zacks & Hasher, 2006)—have less to disrupt during collaboration (Pereira-Pasarin & Rajaram, 2010; Takahashi & Saito, 2004), and thus collaboration may not impair their recall to the same extent.

The empirical literature on collaborative remembering in older adults is modest. Of these studies, three tested only older adults and collectively showed that collaborative inhibition does indeed occur in older adults (Johansson, Andersson, & Ronnberg, 2000; Johansson, Andersson, & Ronnberg, 2005; Ross, Spencer, Linardatos, Lam, & Perunovic, 2004). But these studies did not include young adult comparison groups and hence precluded conclusions about age differences. Two other studies compared young and older adult groups (Dixon & Gould, 1998; Gould, Osborn, Krein,

& Mortenson, 2002) and showed age differences in levels of group recall but again precluded conclusions about age differences in the magnitude of collaborative inhibition as they failed to include nominal groups. Two recently published studies tested both young and older adults in both collaborative and nominal dyadic groups, and both showed that although older adults recalled less than young adults, they in fact showed no greater collaborative inhibition in recall than did young adults (Meade & Roediger, 2009; Ross, Spencer, Blatz, & Restorick, 2008). One question of interest in the present study was whether collaborative inhibition seen in these two studies would remain age-invariant in situations that are known to produce robust levels of inhibition in young adults, namely with triads as group size and strangers as group members. Even among young adults, collaborative inhibition tends to be weaker or nonexistent when dyads (the smallest possible group) are tested (Basden et al., 2000; Meudell, Hitch, & Kirby, 1992; Meudell, Hitch, & Boyle, 1995). Furthermore, familiar collaborators (friends or spouses) often use transactive memory, or division of labor, to develop shorter, nonoverlapping items to recall, which can lessen collaborative inhibition (e.g., Andersson, 2001; Andersson & Ronnberg, 1995; Andersson & Ronnberg, 1996; Ross et al., 2004), thereby obscuring age effects. Thus, we tested whether age differences in the magnitude of collaborative inhibition would be detectable with larger groups composed of strangers.

To better understand the mechanisms underlying collaborative inhibition, we also examined the patterns of retrieval organization in recall as a function of age. Studies with young adults show that increased retrieval organization is associated with a reduction in collaborative inhibition (Basden et al., 1997, 2000; Pereira-Pasarin & Rajaram, 2010), consistent with the retrieval disruption explanation of collaborative inhibition. Poorly organized retrieval is more susceptible to disruption. The question then is whether older adults' recall would be impoverished only in quantity (as indexed by the expected deficits in episodic recall) or also in its organization.

Research findings on organization and structure of older adults' recall have been mixed (see Smith, 2006, for an overview; Tac-onnat et al., 2009) likely due to several factors, including how organization is measured, size of categories, and type of processing required. Older adults showed similar degrees of organization to young adults when the studied categories are sufficiently large, when organization was measured by category clustering rather than by order-based aspects, and when the to-be-remembered materials encouraged processing of relational and category information. We used categorizable study words with reasonably large numbers of members of each category and induced deep processing of information at study (see Brown-Whistler & Freund, 1993). To the extent that older adults achieve preserved organizational clustering of study information, they may withstand the damage during collaboration that is associated with the increased susceptibility to disruption in normal aging, and thereby avert age-related deficits in collaborative recall. Such a finding would be consistent with prior work showing that although older adults' free recall and clustering performance is more negatively impacted than young adults by divided attention at encoding, both groups show similar levels of disruption in free recall and organization when attention is divided at retrieval (Park, Smith, Dudley, & Lafronza, 1989).

## Effects of Collaboration on False Recall

Collaboration can impact not only the quantity but also the accuracy of recall. On the one hand, collaboration may allow people to check their recollections and subsequently produce fewer intrusions as a result of collaborative “error pruning.” On the other hand, collaboration can expose people to items that had not been presented but that a collaborator mistakenly believes were, in essence serving as a contaminating influence, as seen in the *social contagion effect* when people erroneously claim to remember events that were merely suggested in others’ memory reports (Roediger, Meade, & Bergman, 2001). In fact, misinformation provided through social interactions is more influential in producing erroneous memory reports than misinformation originating from other sources (Gabbert, Memon, Allan, & Wright, 2004; Meade & Roediger, 2002).

The findings on collaborative false recall in young adults have yielded mixed patterns (Rajaram & Pereira-Pasarin, 2010) due to a variety of reasons such as overall levels of false recall (Ross et al., 2008b), the types of relationships among collaborators (French, Garry, & Mori, 2008; Peker & Tekcan, 2009; Takahashi, 2007), the size of the collaborating group (Thorley & Dewhurst, 2009), the nature of study materials (Thorley & Dewhurst, 2009), or method of interaction during collaboration (Basden et al., 1997; Barber et al., 2010; Meade & Roediger, 2009; Thorley & Dewhurst, 2007; Weldon & Bellinger, 1997). Evidence on this issue in older adults is sparse but likewise mixed (Meade & Roediger, 2009; Ross et al., 2008b). As Meade and Roediger (2009) have noted, a reduction in collaborative false recall likely occurs with older couples (who might be comfortable correcting each other’s errors) and a free-flowing method of collaboration that allows for discussion and mutual error correction, whereas an increase is likely with strangers (who might hesitate to correct each other) and a turn-taking procedure whereby group members take turns recalling words and do not have the opportunity to discuss or correct mutual responses. Studies with young adults point to the important role of the free-flowing procedure in reducing collaborative memory errors even when the groups consist of strangers (Barber et al., 2010; Thorley & Dewhurst, 2007; Weldon & Bellinger, 1997). We therefore evaluate the effects of age on the propensity for collaborative false recall using groups that are strangers using a free-flowing procedure for collaboration.

## Postcollaborative Individual Recall

Another question of interest in the present study is whether young and older adults experience similar or different after-effects of collaboration on subsequent memory tests. A growing body of research shows that despite suffering from retrieval disruption *during* collaboration, young adults show an increase in individual recall *following* collaboration (Blumen & Rajaram, 2008; Weldon & Bellinger, 1997; but see Finlay et al., 2000). This increase exceeds hypermnesia, which is a net increase in recall accuracy from simply taking recall tests repeatedly (Payne, 1987), and reflects a net benefit in reminiscence or gains (items recalled later but not recalled previously) over forgetting or losses (items forgotten later though recalled previously). These net improvements in postcollaborative individual recall additionally reflect re-exposure benefits that result from hearing other members’ recall

outputs because such re-exposure essentially affords a second “study” opportunity (Blumen & Rajaram, 2008). To what extent do older adults show similar benefits, and are there consequences, such as forgetting of responses made earlier individually? Our design enabled a targeted assessment of these issues for both correct and false recall.

Some evidence suggests that collaboration can increase subsequent false recall in older adults (Meade & Roediger, 2009). However, that study used a turn-taking procedure, which can increase false recall in collaborative groups, thus we explored this question with a free-flowing procedure that allows for error-pruning.

## Formation of Collective Memories

Collaboration plays a critical role in another aspect of postcollaborative individual recall: the emergence of shared or overlapping memories that individuals develop as a function of collaboration and that shape the identity of an individual, known as collective memories (Hirst & Manier, 2008). Within the cognitive domain, research on collective memory has only recently started and has focused on the emergence of overlapping memories (Coman et al., 2009; Cuc et al., 2006; Cuc et al., 2007; Reese & Fivush, 2008; Stone, Barnier, Sutton, & Hirst, 2010; Wang, 2008). To our knowledge no published study has examined this phenomenon in older adults. Our three-sequential tests design readily allowed us to examine the extent to which older adults converge on one another’s responses through the re-exposure benefits, the forgetting of their own responses, and the error pruning (see Rajaram & Pereira-Pasarin, 2010) that can occur during collaboration such that members of a group come to share more overlapping memories if they previously collaborated than if they did not collaborate. Although older adults might develop collective memories with long-term friends and partners, a strong test of the effects of age in the formation of collective memories requires groups composed of strangers, as done in the present study.

## Beliefs About Collaboration as a Memory Aid

The final key issue in our study concerns not people’s objective memory performance as a function of collaboration, but their beliefs about the value of collaboration. Prior work on beliefs is limited, and the extant surveys show that although in the context of eyewitness memory people endorsed the view that separate memory tests would yield better memory (Magnussen et al., 2006), in more general contexts both young and older adults viewed collaboration as more beneficial than working alone when the collaborator is someone they know well, especially a spouse (Gagnon, cited in Dixon, Gagnon, & Crow, 1998). Thus, both age groups differentiated between the potential value and contributions of others based on varying levels of familiarity. Despite this positive view of collaboration, in healthy adults reliance on others was the least frequently reported of five probed memory compensatory techniques: reliance on others, use of external memory aids, increased effort, increased time, and internally generated mnemonics (Dixon et al., 2001), reflecting perhaps some misgivings about the use of collaboration. The questionnaire in the present study builds upon past reports in an important way as we probed beliefs of both young and older adults who had just engaged in collaborative

recall, and thus had recent experience where working with others in fact did not always help contributions during group recall. At the same time, people might experience benefits from re-exposure and error pruning, and from a sense of coming to a shared representation through collaboration. The question of interest was whether participants would consider collaboration as a helpful memory tool in light of the complex costs and benefits of collaboration tested in our design.

## Method

### Participants

Young adults were 96 undergraduates (29 men, 67 women, 3 unspecified) from the northeast who participated for course credit or pay (18 to 27 years,  $M = 20.25$ ,  $SD = 1.73$ , median = 20). Older adults were 96 community-dwelling individuals (27 men, 69 women) also from the northeast region who participated for pay (66 to 92 years,  $M = 79.15$ ,  $SD = 5.71$ , median = 79). For each age group, 48 participants were tested in groups of three (16 collaborative triads), and 48 were tested individually (to later form 16 nominal triads). The older adults were relatively well educated and high functioning, with more years of formal education ( $M = 15.38$ ) than the young adults ( $M = 14.73$ ),  $t(183) = 2.49$ ,  $p < .01$ , higher scores on a standardized vocabulary test (76.67% vs. 47.04%),  $t(190) = 14.42$ ,  $p < .001$ , and better recall of President's names on a filler task (19.28 vs. 13.19),  $t(190) = 7.21$ ,  $p < .001$ .

### Materials

Stimuli were 72 words representing nine different categories, with eight exemplars per category (Van Overschelde, Rawson, & Dunlosky, 2004). The top two exemplars from each category (e.g., "chair" and "table" from category "furniture") were not presented so that their intrusions in recall (i.e., false recall) could be examined. Two different quasi-randomized orders of the 72 words constituted the study list, with a minimum of three trials between any two members of the same category. Four additional exemplars from an unrelated category appeared at the beginning and end of the list as fillers, and two additional exemplars from an unrelated category were used for practice trials. The words were presented via E\*Prime (Psychological Software Tools, 2002).

A "Perceptions About Collaboration" questionnaire was created, with some questions derived from the Memory Compensation Questionnaire (de Frias & Dixon, 2005) and the Metamemory in Adulthood Questionnaire (Dixon, Hultsch, & Hertzog, 1988). Twelve questions asked about how often respondents engage in collaboration in their everyday lives and what factors would make collaborative remembering helpful, harmful, or have no effect (e.g., size of collaborating group, age of the collaborators, relationship with collaborators) on everyday remembering tasks and on the specific word list recall task performed in the lab (see Table 2 & 3). Finally, the Nelson-Denny vocabulary test was used (Brown, Fishco, & Hanna, 1993).

### Design

This was a  $2 \times 2$  between-subjects design with age (older adults and young adults) and group type (collaborative and

Table 1  
*Changes From Test 1 To Test 3: Mean Proportion of Items Gained and Lost (SD in Parentheses)*

	Gains		Losses	
	Young adults	Older adults	Young adults	Older adults
Nominal	.08 (.06)	.08 (.05)	.04 (.02)	.05 (.04)
Collaborative	.18 (.07)	.13 (.06)	.06 (.04)	.06 (.04)

*Note.* Gains = items not recalled on Test 1 but recalled on Test 3; Losses = items recalled on Test 1 but not recalled on Test 3.

nominal) as independent variables. The test phase in each condition involved three sequential recall tests: Individual-Individual-Individual (III) in the nominal condition or Individual-Collaborative-Individual (ICI) in the collaborative condition. The key dependent variables included group recall (collaborative or nominal), individual recall (when all participants recalled alone), recall intrusions, retrieval organization in group recall as well as in individual recall, and collective memory (overlapping items in postcollaborative recall).

### Procedure

Participants were told they would perform several tasks, sometimes alone and sometimes in a small group. The encoding task was always completed individually. Participants rated a series of words for how pleasant they thought each was (1 = *very unpleasant*, 3 = *neutral*, 5 = *very pleasant*), and were asked to remember them for a later test. Following two practice trials, the four filler and 72 critical words were presented one at a time for 5 seconds each, with a 3-second rating period between each word.

During a 5-minute distracter task, participants wrote down as many U.S. President's names as they could recollect. Next, three recall tasks were presented in succession for 7 minutes each, and participants were asked to write down as many words as they could remember. Participants completed Test 1 individually. For Test 2, half the participants in each age level were tested individually, and half were tested in groups of three. The members of the collaborative group were always strangers from the same age level (three young adults or three older adults). Participants tested individually for Test 2 constituted the nominal group condition (and were never within hearing range from each other during the recall task). The experimenter served as the scribe during Test 2 to equate the procedure across nominal and collaborative groups and ensured that the recall sheet was always clearly visible to all. In the collaborative condition, the three participants sat in a semi-circle around the experimenter and recalled as many words as they could, including words they had written on Test 1 as well as any additional items they could now remember. They were told that they would work as a group to do this task and resolve disagreements, if any, on their own. Following Test 2, all participants individually wrote down in Test 3 as many words as they could recall from the rating task. They were also told to include studied words that they themselves or another group member had provided earlier on either of the two tests. Next, they individually completed the

**Table 2**  
*Mean Ratings on Perceptions of Collaboration as a Function of Age Group and Collaborative Condition*

	Young adults			Older adults		
	Nominal	Collaborative	Nominal	Collaborative	Nominal	Significant main effects
Q1. How helpful to remember in group on word list task ( <i>1 = very harmful . . . 5 = very helpful</i> )	3.26	4.42	3.44	4.08	3.44	nominal < collaborative
Q2. How helpful to remember in group on everyday memory tasks ( <i>1 = very harmful . . . 5 = very helpful</i> )	3.65	4.35	3.96	4.40	3.96	nominal < collaborative
Q3. Age of most successful collaborators on word list task ( <i>1 = 20s, 2 = 30s, 3 = 40s, 4 = 50s, 5 = 60s, 7 = 70s</i> )	1.06	1.08	3.22	3.28	3.22	young < older
Q4. Age of most successful collaborators on everyday memory tasks ( <i>1 = 20s, 2 = 30s, 3 = 40s, 4 = 50s, 5 = 60s, 7 = 70s</i> )	1.37	1.10	3.23	3.19	3.23	young < older
Q5. Ideal # of collaborators for success on word list task ( <i>1 = alone, 2 = one person, 3 = two people, 4 = three people, 5 = four or more people</i> )	2.04	3.69	2.52	3.46	2.52	nominal < collaborative
Q6. Ideal # of collaborators for success on everyday memory tasks ( <i>1 = alone, 2 = one person, 3 = two people, 4 = three people, 5 = four or more people</i> )	2.21	3.07	2.58	3.17	2.58	nominal < collaborative
Q7. Preference to remember alone without relying on others to remind me ( <i>1 = strongly agree . . . 5 = strongly disagree</i> )	2.28	2.39	1.88	2.15	1.88	young > older
Q8. Frequency ask for reminders to do future task ( <i>1 = never . . . 5 = very often</i> )	2.54	2.65	3.25	2.64	3.25	
Q9. Frequency rely on others to remember info ( <i>1 = never . . . 5 = very often</i> )	2.49	2.57	2.42	2.43	2.42	
Q10. Change in frequency of relying on others to remember things in past 10 years ( <i>1 = much more often . . . 5 = much less often</i> )	3.09	3.02	2.67	2.55	2.67	young < older

*Note.* Separate 2 × 2 ANOVAs were conducted to examine the influence of age group and collaborative condition on ratings for each individual question, using an alpha level of .05. Significant main effects for condition or for age group are denoted in the far right column. No interactions were significant.

Perceptions About Collaboration questionnaire, a demographic information sheet, and a standardized vocabulary task.

**Results**

Memory performance on each of the three recall tests was assessed by examining separately the proportion of items correctly recalled (out of the 72 presented items) and the proportion of nonpresented critical exemplars that were falsely recalled (out of 18).

**Collaborative Recall: Performance on Recall Test 2**

A key aim here was to assess whether correct and false recall in young and older adults would show similar patterns as a function of collaboration. Collaborative groups consisted of actual triads who worked together. Nominal triads were formed by grouping three randomly selected individuals and pooling their nonredundant responses.<sup>1</sup>

A 2 × 2 ANOVA of age (young adults, older adults) and group type (nominal, collaborative) on correct group recall showed that collaborative inhibition occurred in both age groups (middle columns, Figure 1). The nonredundant pooled recall of nominal triads was significantly higher (.72) than the group recall of collaborative triads (.64),  $F(1, 60) = 0.78, MSe = 0.09, p < .002$ . Young adults recalled significantly more (.72) than older adults (.63),  $F(1, 60) = 13.44, MSe = 0.11, p < .001$ , but there was no Age × Group Type interaction,  $F(1, 60) = 0.25, MSe = 0.01, p = .62$ . Thus despite older adults recalling less overall, collaboration costs were similar for both age groups.

Because young adults recalled more than did older adults, we also examined age-related differences in the degree of collaborative inhibition within the context of that age group's level of recall. Within each age group, Z scores were computed for each of the 16 collaborative triads by using the mean and standard deviation of correct recall for that same age group in the nominal condition on Test 2. There was no significant difference between young collaborative triads ( $M = -.94$ ) and older collaborative triads ( $M =$

<sup>1</sup> T tests confirmed that the mean recall on Test 1 of the individuals in a given age group who were grouped into the nominal triads for Test 2 was equivalent to the mean recall on Test 1 of the individuals from that same age group who were grouped into collaborative triads on Test 2. The standard deviations were equivalent as well, as were the false recall rates. Another technique was also used to form nominal triads by rank ordering the recall performance on Test 1 of the individuals in a given age group who were subsequently tested in collaborative triads, rank ordering the recall performance on Test 1 of the individuals who were subsequently tested in nominal triads, and then matching the two groups based on those rank orderings (e.g., a collaborative triad composed of young adults with the 4th highest, 33rd highest, and 42nd highest Test 1 recall scores of the 48 young adults in the collaborative condition led to a matching nominal triad composed of young adults with the 4th highest, 33rd highest, and 42nd highest Test 1 recall scores of the young adults in the nominal condition). T tests confirmed the equivalence within each age group of the nominal and collaborative conditions in terms of their Test 1 recall performance, false alarm rates, and variability. Subsequent analyses based on each of these two techniques of forming nominal triads yielded the same patterns of significance when examining collaborative inhibition and false recall rates on Test 2, and hence for the sake of brevity, only analyses based on the randomly assigned triads are reported in the paper.

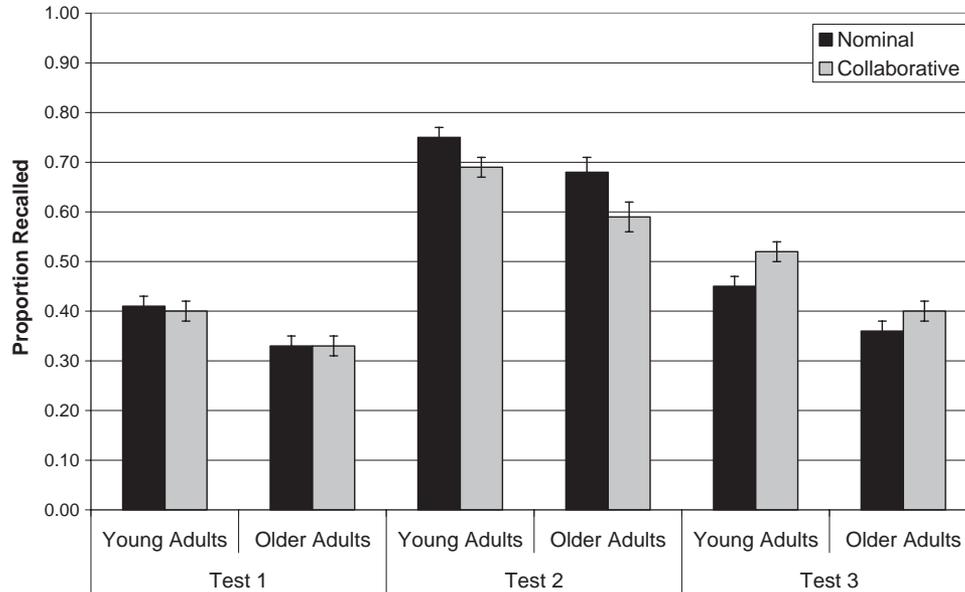


Figure 1. Proportion of studied items correctly recalled on each of the three recall tests as a function of age group and collaborative condition. Error bars indicate *SE*. Note: Test 1 and Test 3 performance is based on memory performance for each individual within a given age group and condition. Test 2 performance is based on nonredundant pooled responses within a collaborative or nominal triad.

$-0.79$ ),  $t(30) = 0.41$ ,  $p = .69$ . Thus, collaborative inhibition is not particularly sensitive to age even when age-related recall differences are normalized and a larger group size of triads (as opposed to dyads used in previous studies) is used.

Collaboration also reduced false recall such that collaborative triads produced fewer nonpresented critical exemplars (.03) than did nominal triads (.10),  $F(1, 60) = 20.39$ ,  $MSe = 0.08$ ,  $p < .001$  (see middle of Figure 2). Older adults made significantly more

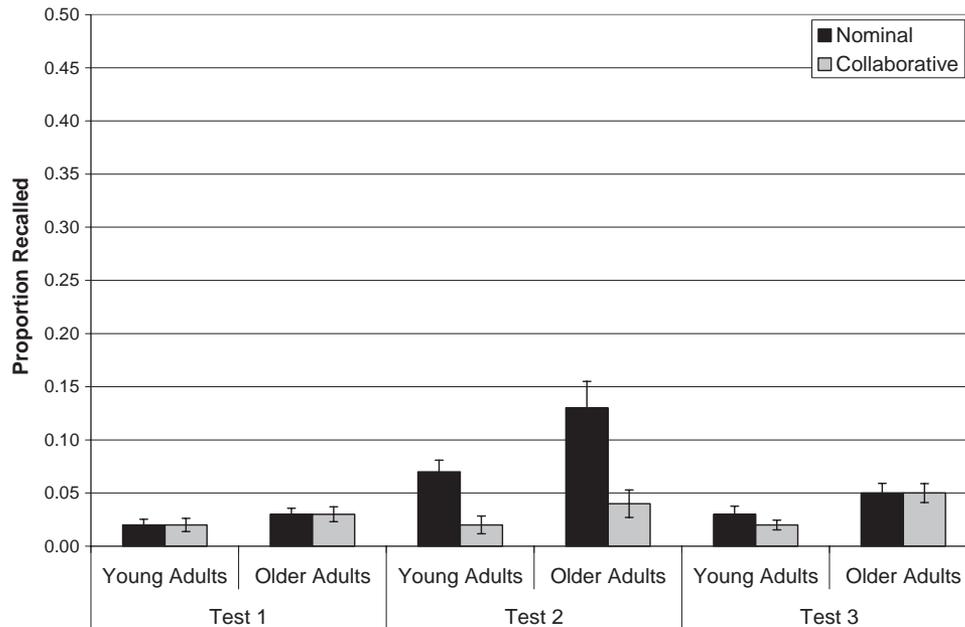


Figure 2. Proportion of nonpresented critical exemplars falsely recalled on each of the three recall tests as a function of age group and collaborative condition. Error bars indicate *SE*. Note: Test 1 and Test 3 performance is based on memory performance for each individual within a given age group and condition. Test 2 performance is based on nonredundant pooled responses within a collaborative or nominal triad.

intrusions overall (.09) than did young adults (.05),  $F(1, 60) = 6.41$ ,  $MSe = 0.03$ ,  $p < .01$ , with no significant interaction between age and group type,  $F(1, 60) = 0.98$ ,  $MSe = 0.01$ ,  $p = .33$ .

### Postcollaborative Recall: Performance on Recall Test 3

Another key question of interest was whether older and young adults would show similar after effects of collaboration as a function of prior collaboration. A 2 (age: young or older adults)  $\times$  2 (prior group type: nominal or collaborative) ANOVA on the proportion of studied items correctly recalled on Test 3 by each individual showed that young adults correctly recalled significantly more items (.49) than did older adults (.38),  $F(1, 188) = 27.74$ ,  $MSe = 0.60$ ,  $p < .001$ . Prior collaboration resulted in significantly higher Test 3 recall (.46) than did working alone in the nominal condition (.41),  $F(1, 188) = 6.10$ ,  $MSe = 0.13$ ,  $p < .01$ . Critically, young and older adults benefited equivalently from prior collaboration (far right columns, Figure 1), with no significant interaction between age and prior group type,  $F(1, 188) = 0.37$ ,  $MSe = 0.01$ ,  $p = .55$ . Thus, as with the collaborative inhibition effect and error pruning in recall, the impact of collaboration on postcollaborative recall is also not strongly impacted by age.

The false recall of nonpresented critical exemplars in individual recall in Test 3 (see far right columns of Figure 2) was low. A 2  $\times$  2 ANOVA of age level and prior group type showed that older adults incorrectly recalled significantly more critical exemplars on Test 3 (.05) than did young adults (.03),  $F(1, 188) = 8.43$ ,  $MSe = 0.02$ ,  $p < .004$ . Prior collaboration resulted in similar rates of false recall on Test 3 (.04) to those shown by individuals who worked alone in the nominal condition (.04),  $F(1, 188) = 0.67$ ,  $MSe = 0.01$ ,  $p = .41$ , with no significant interaction between age and prior group type,  $F(1, 188) = 0.94$ ,  $MSe = 0.01$ ,  $p = .33$ .

### Hypermnesia, Re-Exposure, Reminiscence, and Forgetting: Changes From Test 1 to Test 3

Another way to examine the aftermath of collaboration is to examine changes in performance from Test 1 to Test 3, and our use of a baseline individual recall test made this analysis particularly informative.<sup>2</sup> Research on hypermnesia shows that in general, people exhibit net gains in the number of items recalled on later tests (see Payne, 1987). Older adults do not always show such hypermnesia, and when they do, often show relatively less improvement than do young adults (e.g., Henkel, 2007; Henkel, 2008). This pattern was replicated here in the nominal condition where all three tests involved individual recall. A two-way ANOVA of age group and test period on correct recall showed significant main effects of both variables,  $F(1, 94) = 10.09$ ,  $MSe = 0.05$ ,  $p = .002$ ;  $F(2, 188) = 26.99$ ,  $MSe = 0.01$ ,  $p < .001$ , respectively. Young adults recalled significantly more (.43) than did older adults (.35), and recall increased from Test 1 (.37) to Test 3 (.41). Further, a significant interaction was found,  $F(2, 188) = 3.71$ ,  $MSe = 0.01$ ,  $p = .03$ , and follow up comparisons showed that hypermnesia was greater for young adults (.41, .46) than for older adults (.34, .36).

To what extent do changes in correct recall from Test 1 to Test 3 reflect re-exposure benefits, or the influence of collaboration over and above that observed with hypermnesia? It is important to

examine two different critical aspects that constitute hypermnesia because the aggregate measure of hypermnesia can mask potential age-related variations in the extent to which collaboration leads to costs versus benefits in postcollaborative recall. *Reminiscence* or *gains* refers to the proportion of items that were not recalled on Test 1 but were recalled on Test 3, whereas *forgetting* or *losses* refers to the proportion of items that were recalled on Test 1 but were not recalled on Test 3 (Payne, 1987).

**Reminiscence: Gains from Test 1 to Test 3.** A significant main effect of age was found on the proportion of items not recalled on Test 1 but recalled on Test 3,  $F(1, 188) = 10.36$ ,  $MSe = 0.04$ ,  $p < .002$ , with younger adults showing more gains (.13) than older adults (.11). A significant main effect of collaborative condition was also found,  $F(1, 188) = 82.38$ ,  $MSe = 0.29$ ,  $p < .001$ , with subjects who collaborated during Test 2 showing more gains (.16) than subjects who worked alone (.08). This finding replicates the cascading benefits of collaboration reported for young adults (Blumen & Rajaram, 2008; Weldon & Bellinger, 1997). A significant interaction was also found,  $F(1, 188) = 5.13$ ,  $MSe = 0.02$ ,  $p < .02$  (see Table 1). Young and older adults both showed an increase in gains following collaboration relative to having earlier worked alone. But for older adults the increase was less marked, demonstrating that the re-exposure benefits in older adults are attenuated owing to the age-related deficits widely reported in standard measures of individual recall (Zacks & Hasher, 2006) and also observed in Test 1 Recall here.

**Forgetting: Losses from Test 1 to Test 3.** A significant main effect of age was found on the proportion of items recalled on Test 1 but not recalled on Test 3,  $F(1, 188) = 5.44$ ,  $MSe = 0.01$ ,  $p < .02$ , with young adults showing fewer losses (.04) than older adults (.06). A significant main effect of collaborative condition was also found,  $F(1, 188) = 10.25$ ,  $MSe = 0.02$ ,  $p < .002$ , with subjects who collaborated during Test 2 showing more losses (.06) than those who worked alone (.04). The interaction was not significant,  $F(1, 188) = 0.50$ ,  $MSe = 0.01$ ,  $p = .48$  (see Table 1), thus older adults showed no greater forgetting as a function of collaboration than young adults.

Taken together, these findings suggest that collaboration produces re-exposure benefits in that it produces gains in recall above and beyond what occurs simply through hypermnesia, although it also has some negative consequences, as seen in the greater losses following collaboration. By and large, participants seem to gain items from having heard other participants recalling them during collaborative recall. Consistent with this conjecture, a separate analysis examining responses across all three tests periods showed that the proportion of recalled items that were not recalled on Test 1 but were recalled on Test 2 and on Test 3 was significantly higher when Test 2 was collaborative (.15) than individual (.04),  $F(1, 188) = 198.69$ ,  $MSe = 0.01$ ,  $p < .0001$ .

### Clustering Across the Three Recall Tests

Category clustering in recall was measured using the standard method of Adjusted Ratio of Clustering (ARC) Score (Roenker,

<sup>2</sup> Participants who were later tested in collaborative triads did not differ in their initial correct or false recall performance from those who were later tested individually (the nominal condition), and this pattern was true within each age group (see the leftmost columns of Figure 2).

Thompson, & Brown, 1971; see also Basden et al., 1997). We used a conservative method where only the 72 presented items were counted as category instances (correct recall), whereas intrusions of the 18 nonpresented critical exemplars were not counted as instances of that category. ARC scores equal to 0 indicate clustering at chance levels, and scores closer to 1.0 indicate progressively above chance levels of clustering. In the nominal condition, ARC scores were computed based on individual performance on each of the three tests. In the collaborative condition, ARC scores were computed based on individual performance on Test 1 and Test 3 and based on triad performance on Test 2. There was a noticeable increase in ARC scores across the three tests for both young adults (.60, .66, .71) and for older adults (.59, .69, .75), and these rates (collapsed across group type) indicate increasingly above chance clustering. For the sake of economy, we report only significant effects.

On Test 1 recall, consistent with past research (Smith, 2006) young and older adults showed similar degrees of above-chance clustering (young = .60, old = .59). Thus, although older adults had lower recall, their recall was organized to the same extent as that of young adults. On Test 2 where participants engaged in either collaborative or individual recall, only the main effect of collaboration was significant. Thus young and older adults showed similar levels of clustering again (young = .66; old = .69), and those who collaborated showed less clustering (.64) than those who worked individually (.71),  $F(1, 187) = 10.05$ ,  $MSe = 0.03$ ,  $p = .002$ . The finding that working in a group disrupted the organization that individuals might otherwise have attained when recalling on their own replicates previous research with young adults (Basden et al., 1997). What was of particular interest was whether older adults would be especially disrupted, and they were not. No significant interaction was found,  $F(1, 187) = 0.08$ ,  $MSe = 0.01$ ,  $p = .78$ . This finding, along with the equivalent ARC scores for young and older adults in Test 1 recall, explains why older adults do not exhibit greater collaborative inhibition despite poorer episodic recall. While older adults may recall less, what they recall is just as well organized in terms of clustering as young adults. As clustering organization is linked to the extent to which individuals might suffer from retrieval disruption and thereby recall less during collaboration (Basden et al., 1997), the preserved organization in older adults explains why collaborative inhibition does not increase with age.

We also assessed whether prior collaboration might have a cascading consequence in disrupting organization on Test 3. A  $2 \times 2$  ANOVA examining the impact of prior collaborative condition and age group on ARC scores revealed that young and older adults again showed similar levels of clustering on Test 3 (young = .71, old = .75) and that the prior collaboration did indeed result in significantly lower ARC scores (collaborative condition = .70; nominal condition = .76),  $F(1, 187) = 5.33$ ,  $MSe = 0.04$ ,  $p < .02$ . The interaction was not significant,  $F(1, 187) = 0.51$ ,  $MSe = 0.02$ ,  $p = .48$ . Thus, collaboration was disruptive to organization in postcollaborative recall, and equally so for both age groups.

### The Formation of Collective Memory

Collaboration can shape the extent to which group members incorporate each other's responses into their own memory, and thus come to share more overlapping memories after collaboration

than they did before, and this was assessed by examining whether people who had recalled collaboratively on Test 2 showed more overlap in their Test 3 individual responses than did people who recalled individually on Test 2. The proportion of studied words recalled by at least two of the individuals who had formed the collaborative or nominal triads for Test 2 out of all the words recalled by that triad was calculated separately for Test 1 (baseline) and for Test 3 as a measure of collective memory (see Cuc et al., 2006) and was examined in a  $2$  (recall period: Test 1, Test 3)  $\times$   $2$  (group type: nominal, collaborative)  $\times$   $2$  (age: young, old) ANOVA. As seen in Figure 3, young adults overall developed more collective memories (.57) than did older adults (.45),  $F(1, 60) = 18.36$ ,  $MSe = 0.02$ ,  $p < .001$ . The effect of collaboration in promoting collective memories was illustrated by a significant main effect for group type,  $F(1, 60) = 9.32$ ,  $MSe = 0.02$ ,  $p < .001$ , which was qualified by the significant Recall Period  $\times$  Group Type interaction,  $F(1, 60) = 56.39$ ,  $MSe = 0.01$ ,  $p < .001$ . As expected, for participants who recalled individually on Test 2 (nominal group) the proportion of collective memories did not differ across precollaborative Test 1 (.46) and postcollaborative Test 3 (.48). Similarly, collective memories did not differ on precollaborative Test 1 across participants who later collaborated on Test 2 (.44) and those who were later in the nominal condition (.46). But critically, those who collaborated on Test 2 showed a significant increase in the proportion of collective memories on Test 3 (.66), which is evidence for the formation of collective memories as a function of collaboration. Important for the novel purpose of this study, there was no interaction with age,  $F(1, 60) = 0.01$ ,  $MSe = 0.01$ ,  $p = .92$ , thus, collaboration promoted the formation of collective memories equivalently in young and older adults.

### Beliefs About Memory and Collaboration

Our final question of interest concerned age-related differences in beliefs about the efficacy of collaborative remembering, and whether such beliefs were shaped by the recent experience of having worked collaboratively. Ratings for each separate question on the Perceptions About Collaboration questionnaire were analyzed in a  $2 \times 2$  ANOVA with age group and collaborative condition as between-subjects factors. Although for many questions there were significant main effects for condition, and some for age as well, none of the interactions were significant. For the sake of brevity, rather than list the results of the 10  $2 \times 2$  ANOVAs, means and standard deviations for all questions are reported in Tables 2 and 3;  $<$  and  $>$  symbols are used there to denote the patterns seen in the significant main effects.

**How helpful is collaboration?** Questions 1 and 2 asked participants to rate how helpful they found working in groups or alone on the memory task to be, and how helpful in general they view collaborative remembering to be on everyday life memory tasks such as trying to remember grocery lists or the names of state capitals. Both young and older adults gave significantly higher helpfulness ratings when they had been tested in the collaborative condition than when they had been tested in the nominal condition. Consistent with these patterns, partial correlations controlling for age examined the relation between the perceived helpfulness of working with others (Question 1) and actual memory performance. Significant positive correlations ( $p < .01$ ) were found between helpfulness ratings and both Test 2 recall ( $r = .25$ ) and Test 3

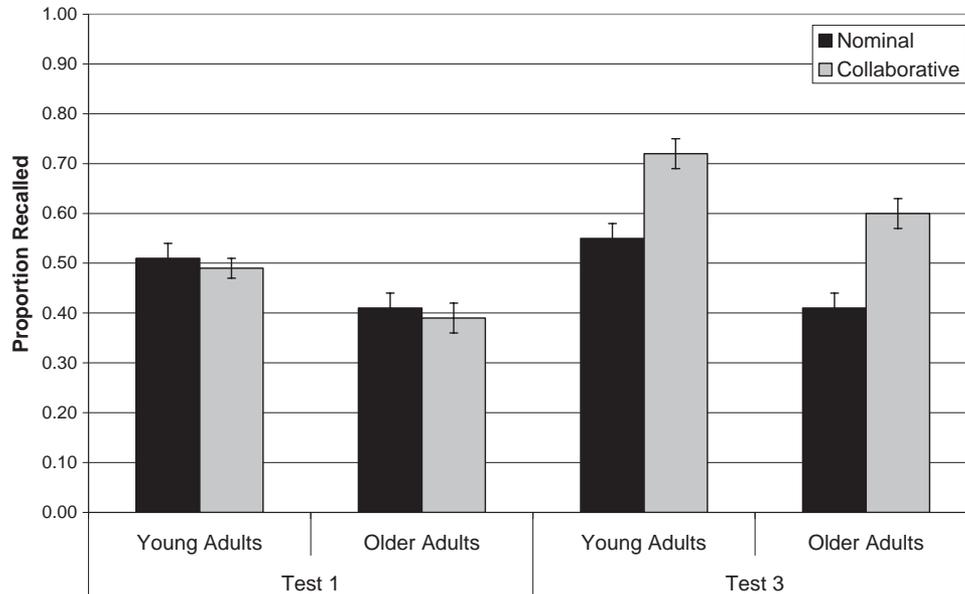


Figure 3. Proportion of studied items correctly recalled on Test 1 and Test 3 by at least two group members (i.e., collective memory) as a function of age group and Test 2 collaborative condition. Error bars indicate SE.

recall ( $r = .27$ ) for people who actually collaborated, but not for those in the nominal condition for either Test 2 ( $r = -.03$ ) or Test 3 ( $r = .01$ ). Correlations between perceived helpfulness and recall rates for young adults were significant for both test periods ( $r = .50$  and  $.32$ ), whereas for older adults, perceived helpfulness was positively correlated with Test 2 recall ( $r = .26$ ) but not Test 3 recall ( $r = .13$ ).

**What age are the best collaborators?** Responses here did not differ as a function of whether participants had been earlier tested in collaborative or nominal condition but instead reflected an ageism bias (Perdue & Gurtman, 1990). Young adults gave significantly lower ratings than older adults about what age group collaboration would be most successful with on word list memory tasks (Question 3). In fact, 95% of the young adults indicated that they believed collaboration would be most successful with people 20–30 years old. Older adults' responses were more split: 18% chose 20–30 year olds, 9% chose 30–40 year olds, 26% chose 40–50 year olds, 20% chose 50–60 year olds, 11% chose 60–70 year olds, and 8% chose 70–80 year olds (7% did not reply or

chose multiple options). Similar results were obtained for collaborative remembering for everyday memory tasks (Question 4).

**How many collaborators are best?** For questions about what size group collaboration would be most successful with on either word list tasks (Question 5) or on memory tasks found in everyday life (Question 6), both young and older adults gave significantly higher numbers when they had earlier been tested in the collaborative condition than in the nominal condition. Thus people who collaborated hold that more people would be even better than fewer people, and this is true for both young and older adults.

**What kinds of relations lead to the best collaborating?** Because of the nonordinal categorical response options to two other questions, data were analyzed with a  $\chi^2$  analysis (see Table 3). No differences were found as a function of whether participants had earlier been tested in the collaborative or nominal condition for either age group, but the young and older adults had differing opinions as to who collaboration would be most successful with,  $\chi^2(5) = 157.61, p < .001$ . Over half the older adults claimed that

Table 3  
Proportion of Young and Older Adults Indicating the Kind of Collaborators They Would Be Most Successful Working With on Different Memory Tasks

	On word recall task		On everyday memory tasks	
	Young adults	Older adults	Young adults	Older adults
Strangers	9.7	12.9	7.5	5.4
People I am slightly familiar with	6.5	4.3	2.2	4.3
Casual acquaintances of mine	9.7	4.3	6.5	3.2
Close friends of mine	39.8	21.5	47.3	3.2
Long-term partner/spouse	7.5	3.2	17.2	10.8
None of the above (who the collaborator is does not influence how much is remembered)	26.9	53.8	19.4	44.1

equal success would be found regardless of the relationship, whereas little more than a quarter of the young adults chose this option. Instead young adults expected the most success with close friends. Similar patterns were found for the question focused on everyday memory tasks,  $\chi^2(5) = 158.26, p < .001$ .

**Other views about collaboration.** As seen in Table 2, on Question 7, older adults showed significantly stronger agreement than did young adults with the statement that they prefer to remember things on their own without relying on other people, and on Question 10 older adults reported that they more frequently ask other people to help them remember things compared to 10 years ago. Of course, young adults are comparing themselves to remembering when they were adolescents, whereas older adults are comparing themselves to when they were in their 60s or 70s. No effects of prior collaboration occurred for either age group on Questions 8 and 9, which asked about how often respondents asked other people to remind them to do something in the future and how often they asked other people to help them remember things in general.

## Discussion

Numerous lifespan psychology models examine optimization and compensation processes as adults age (e.g., Baltes, Staudinger, & Lindenberger, 1999), and prior work has shown that older adults report increases in reliance on collaborators, use of external memory aids, and internally generated mnemonics, though reliance on others was the least frequently reported of the probed techniques (Dixon et al., 2001). Collaboration could be a potentially useful tool for older adults in the face of declines in memory associated with normal aging, especially given that much of our learning and remembering occurs in a social context. However, relatively few studies have directly addressed the benefits and costs of collaboration for older adults. The present study is the first to comprehensively and simultaneously compare across young and older adults within one design collaborative inhibition in group recall and its relation to retrieval organization, the influence of collaboration on recall intrusions and on the cascading costs and benefits in postcollaborative individual recall in terms of gains, losses, retrieval organization, and collective memory, and the relation between the beliefs people hold about collaboration and their performance. Clear and consistent findings emerged: Although older adults correctly recalled far less than did young adults, both age groups exhibited similar costs and benefits of collaboration.

To begin with, we replicated the age-invariance effect in the magnitude of *collaborative inhibition* in group recall. In so doing, we extended this outcome to a larger group size with respect to past studies and established it in triads composed of strangers (as opposed to related members such as spouses). Furthermore, novel to our study, we secured this finding by first equating individual recall across nominal and collaborative conditions within each age group, and also normalizing it against the age-differences in episodic recall deficits that occurred. Thus, it is clear that older and young adults show comparable degrees of collaborative inhibition. Age differences, if they exist in collaborative inhibition, are minimal or are not easily detectable, which is interesting because older adults' susceptibility to interference (e.g., Hedden & Park, 2001) suggests that collaboration should be especially disruptive for them. However, there are other research findings consistent with

the notion that older adults may not in fact experience greater collaborative inhibition than young adults. Although older adults can be especially susceptible to disruption when attention is divided at encoding, they are generally not more susceptible than young adults to interference when attention is divided at retrieval (e.g., Anderson, Craik, & Naveh-Benjamin, 1998; Park et al., 1989). Given that collaborative inhibition is a retrieval phenomenon, the absence of age differences in the present study is consistent with such findings. In addition, the part-list cuing deficit in individual recall (Basden et al., 1997) is generally equivalent across young and older adults in episodic recall tasks (Andres, 2009; Marsh et al., 2004). Because collaborative inhibition is assumed to arise from the same mechanism as the part-list cuing deficit, namely retrieval disruption, there should be minimal if any age differences in collaborative inhibition.

To explore this, we directly examined retrieval organization as it relates to collaborative memory performance in both young and older adults. Our results show that one reason that collaborative inhibition may be age-invariant is that despite age-related episodic recall deficits, older adults' retrieval organization is not deficient in some situations. Research shows that while older adults can be impaired at displaying preserved order effects in successive recalls, they usually perform equally well at clustering of related information during recall (Smith, 2006). Our methodology specifically measured such clustering in recall through the use of categorized stimuli, as this measure is implicated in collaborative inhibition. Our findings thus provide a candidate explanation for the age-invariant nature of collaborative inhibition: When older adults develop sufficient clustering in recall, they are no more vulnerable to collaborative inhibition than are young adults.

Another key question of interest was how collaboration shapes *memory errors* in older adults. This was assessed both at the time of collaborative recall (Test 2) where group collaboration could potentially enable error pruning, and at the time of postcollaborative individual recall (Test 3) where the downstream effects of earlier group responses could shape the production of memory errors in individual recall. Past studies on older adults have produced mixed findings (Meade & Roediger, 2009; Ross et al., 2008b), and our use of a free-flowing method of collaboration and collaborative triads composed of strangers rather than friends or spouses allowed us to disambiguate them. Our results showed that older adults were equally adept at using collaboration to prune false recall. Equivalent reduction in intrusions for young and older adults was observed both in collaborative group recall (Test 2) and in postcollaborative individual recall (Test 3).

Another benefit of collaboration was seen in postcollaborative individual memory. Although the memory gains through the re-exposure effect from collaboration were lower for older adults (due to their general deficits in recall), such gains did occur. Further, the losses (or forgetting) on Test 3 as a function of disruption that occurred during prior collaboration did not increase with age. Thus, although the main cost of collaboration occurs in the form of retrieval disruption from which items bounce back on later recall tests, collaboration can also lead to some inhibition that results in postcollaborative forgetting (Coman et al., 2009; Cuc et al., 2007). Important for present purposes, older adults showed no greater forgetting as a function of collaboration than young adults. Thus, collaboration can be an effective tool for older adults in as much as they can benefit from it within the constraints of age-

related episodic recall deficits and, at the same time, are not disproportionately hurt by it.

We examined yet another consequence of collaboration on later memory about which little is known with respect to older adults, namely the *formation of collective memory*. Collaborative retrieval has the power to reconstruct the past in a such a way that collaborating members come to “share” more memories than they did before (Cuc et al., 2006; Coman et al., 2009; Hirst & Manier, 2008; Wertsch & Roediger, 2008). This process may occur because of many components operating simultaneously—partners may relearn memories narrated by others, forget their own memories to align with others’ representations, may correct each others’ errors, or may even implant new memory errors (social contagion) into other’s recalls (Rajaram & Pereira-Pasarin, 2010). Our findings show that under controlled conditions the process of developing collective memories remains unaffected by normal aging.

Finally, in addition to these objective measures of the effects of collaboration on memory, we included a survey on the *beliefs people hold about memory and collaboration* that captured young and older adults’ beliefs after they had experienced both individual and collaborative recall. By and large, both young and older adults reported similar beliefs about the utility of collaboration on memory, and five main conclusions emerged. One, regardless of age people indicated collaboration to be more beneficial than remembering alone, a pattern consistent with prior findings (Dixon et al., 1998). Two, regardless of age people believed that working with more people is even more helpful than fewer people for reaping the benefits of collaboration. Three, prior collaboration generally increased the likelihood that people reported collaboration to be more helpful than working alone, though the relation between belief and performance was stronger in young than in older adults. Four, older adults expected success in collaboration regardless of their familiarity with the collaborators, whereas young adults expected the most success with close friends as collaborators. Interestingly, long-term partners were not rated among the top choices with whom collaboration would be successful, as found in prior work (Dixon et al., 1998). This may be because we provided the option of selecting “anyone” and because our participants actually worked with strangers prior to providing their responses. Finally, and somewhat surprisingly in light of the earlier points, older adults preferred working alone to working with others. Exploration of concerns about losing one’s independence and views of self-worth and self-efficacy in conjunction with collaborative remembering would seem a worthwhile avenue for additional work, especially in conjunction with issues regarding stereotype threat, which can create additional problems for older adults in many everyday and laboratory situations.

Together, our findings on a comprehensive set of memory measures start to reveal why people continue to believe that collaboration is helpful despite widespread evidence that it disrupts and lowers individual contributions during collaboration, and that it can even cause some forgetting and disrupted retrieval organization. As our beliefs survey showed, people subjectively experience collaboration to be helpful under a variety of circumstances, and this experience holds true for older adults as well. As Ross et al. (2008b) have argued, even though couples recall less in collaborative situations, their subjective experience is based on the fact that as a couple the recalled information is much greater than what each spouse might have recalled alone, and in everyday life

the practical value of this collaborative product is relevant. Our findings also demonstrate that collaboration can reduce memory errors (see also Ross et al., 2008b), and further that it also produces postcollaborative memory gains, phenomena that would enhance the subjective experiences of collaborative benefits. Just as important may be the formation of collective memories measured in our study. Collective memories index the increase in the overlap in the way people represent their joint past. In as much as people need to align their perceptions, beliefs, and memories (Echterhoff, Higgins, & Levine, 2009), the harmony gained from overlapping memories makes collaborative remembering a valued experience (see also Smith et al., 2009).

Although certain basic cognitive mechanisms decline with age (e.g., episodic memory, processing speed), older adults possess greater social knowledge and abilities that allow them to function effectively in many situations (Blanchard-Fields & Kalinauskas, 2009; Carstensen, Fung, & Charles, 2003). Age-related changes in emotion regulation and social competence may impact collaboration itself and perceptions of its costs and benefits. For example, older adults may be better attuned to the social dynamics that can promote benefits of collaboration (e.g., as seen in work on preference for different partners in collaborative problem solving tasks; Strough et al., 2002; Strough et al., 2008). Consistent with this, our results showed that older adults viewed people across a wider range of ages and relationships as potentially useful collaborators than did young adults. Both young and older adults showed similar levels of agreement that collaborating with more people would increase success on recall tasks. Future research should further explore how age differences in emotion regulation and social competence may contribute to collaborative remembering, especially given other work showing some benefits for collaborating with long-time partners (e.g., Johansson et al., 2000). As noted by Ross, Blatz, & Schryer (2008), collaboration can be used to help compensate for age-related declines in memory and cognition in older adults in everyday memory situations and is a readily available resource.

In conclusion, our findings not only provide important theoretical insights into the nature of collaborative memory in normal aging, they also have implications for the practical utility of collaboration as a form of environmental support that can enhance older adults’ life. In as much as older adults subjectively experience collaboration to be beneficial for memory and in as much as costs and benefits of collaboration on memory remain invariant in older adults, collaboration can be a useful tool for dealing with age-related declines in individual episodic recall. While these age-invariant effects of collaboration that occurred across a variety of memory measures are impressive, it is nonetheless important to bear in mind that age differences may well emerge under other contexts and variables that tap into age-related deficits, vulnerabilities, and biases. Such factors may include the proportion of likely intrusions (we limited such intrusions to only a few exemplars in our design), the relations between the collaborating partners, the goals and methods of collaboration, the ageism bias, susceptibility to suggestion, stereotype threat, and gender differences to name a few. The significance of the present study lies in the fact that its findings establish the core patterns related to the cognitive abilities that are preserved in normal aging, and thus provides a foundation for examining how the costs or benefits of

collaboration may be enhanced for older adults across a variety of situations.

## References

- Anderson, N. D., Craik, F. I. M., & Naveh-Benjamin, M. (1998). The attentional demands of encoding and retrieval in younger and older adults: I. Evidence from divided attention costs. *Psychology and Aging, 13*, 405–423. doi:10.1037/0882-7974.13.3.405
- Andersson, J. (2001). Net effect of memory collaboration: How is collaboration affected by factors such as friendship, gender and age? *Scandinavian Journal of Psychology, 42*, 367–375. doi:10.1111/1467-9450.00248
- Andersson, J., & Rönnerberg, J. (1995). Recall suffers from collaboration: Joint recall effects of friendship and task complexity. *Applied Cognitive Psychology, 9*, 199–211. doi:10.1002/acp.2350090303
- Andersson, J., & Rönnerberg, J. (1996). Collaboration and memory: Effects of dyadic retrieval on different memory tasks. *Applied Cognitive Psychology, 10*, 171–181. doi:10.1002/(SICI)1099-0720(199604)10:2<171::AID-ACP385>3.0.CO;2-D
- Andres, P. (2009). Equivalent part set cueing effects in younger and older adults. *European Journal of Cognitive Psychology, 21*, 176–191. doi:10.1080/09541440802033980
- Baltes, P. B., Staudinger, U. M., & Lindenberger, U. (1999). Lifespan psychology: Theory and application to intellectual functioning. *Annual Review of Psychology, 50*, 471–507. doi:10.1146/annurev.psych.50.1.471
- Barber, S. J., Rajaram, S., & Aron, A. (2010). When two is too many: Collaborative encoding impairs memory. *Memory & Cognition, 38*, 255–264. doi:10.3758/MC.38.3.255
- Barnier, A. J., & Sutton, J. (2008). From individual to collective memory: Theoretical and empirical perspectives. *Memory, 16*, 177–182. doi:10.1080/09541440701828274
- Basden, B. H., Basden, D. R., Bryner, S., & Thomas, R. L. (1997). A comparison of group and individual remembering: Does collaboration disrupt retrieval strategies? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 1176–1191. doi:10.1037/0278-7393.23.5.1176
- Basden, B. H., Basden, D. R., & Henry, S. (2000). Costs and benefits of collaborative remembering. *Applied Cognitive Psychology, 14*, 497–507. doi:10.1002/1099-0720(200011/12)14:6<497::AID-ACP665>3.0.CO;2-4
- Berg, C. A., Smith, T. W., Ko, K. J., Henry, N. J. M., Florsheim, P., Pearce, G., . . . Glazer, K. (2007). Task control and cognitive abilities of self and spouse in collaboration in middle-aged and older couples. *Psychology and Aging, 3*, 420–427. doi:10.1037/0882-7974.22.3.420
- Blanchard-Fields, F., & Kalinauskas, A. (2009). Theoretical perspectives on social context, cognition, and aging. In V. Bengtson, D. Gans, N. Pulney, M. Silverstein (Eds.), *Handbook of theories of aging* (2nd ed., pp. 261–276). New York: Springer.
- Blumen, H. M., & Rajaram, S. (2008). Influence of re-exposure and retrieval disruption during group collaboration on later individual recall. *Memory, 16*, 231–244. doi:10.1080/09541440701804495
- Brown, J. I., Fishco, V. V., & Hanna, G. (1993). *Nelson-Denny reading test: Manual for scoring and interpretation*. Chicago: Riverside.
- Brown-Whistler, S., & Freund, J. (1993). Age differences in free recall and clustering as a function of list length and trials. *Bulletin of the Psychonomic Society, 31*, 7–10.
- Carlson, M., Hasher, L., Zacks, R., & Connelly, S. (1995). Aging, distraction, and the benefits of predictable location. *Psychology and Aging, 10*, 427–436. doi:10.1037/0882-7974.10.3.427
- Carstensen, L., Fung, H., & Charles, S. (2003). Socioemotional selectivity theory and the regulation of emotion in the second half of life. *Motivation and Emotion, 27*, 103–123. doi:10.1023/A:1024569803230
- Clark, S. E., Hori, A., Putnam, A., & Martin, T. P. (2000). Group collaboration in recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 1578–1588. doi:10.1037/0278-7393.26.6.1578
- Coman, A., Manier, D., & Hirst, W. (2009). Forgetting the unforgettable through conversation: Socially shared retrieval-induced forgetting of September 11 memories. *Psychological Science, 20*, 627–633. doi:10.1111/j.1467-9280.2009.02343.x
- Craik, F. I. M., & Anderson, N. (1999). *Applying cognitive research to problems of aging*. Attention and performance XVII: Cognitive regulation of performance: Interaction of theory and application (pp. 583–615). Cambridge, MA: The MIT Press.
- Craik, F. I. M., & McDowd, J. (1987). Age differences in recall and recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13*, 474–479. doi:10.1037/0278-7393.13.3.474
- Cuc, A., Koppel, J., & Hirst, W. (2007). Silence is not golden: A case for socially shared retrieval-induced forgetting. *Psychological Science, 18*, 727–733. doi:10.1111/j.1467-9280.2007.01967.x
- Cuc, A., Ozuru, Y., Manier, D., & Hirst, W. (2006). On the formation of collective memories: The role of a dominant narrator. *Memory & Cognition, 34*, 752–762. doi:10.3758/BF03193423
- de Frias, C., & Dixon, R. (2005). Confirmatory factor structure and measurement invariance of the Memory Compensation Questionnaire. *Psychological Assessment, 17*, 168–178. doi:10.1037/1040-3590.17.2.168
- Dixon, R. A., de Frias, C., & Bäckman, L. (2001). Characteristics of self-reported memory compensation in older adults. *Journal of Clinical and Experimental Neuropsychology, 23*, 650–661. doi:10.1076/jcen.23.5.650.1242
- Dixon, R. A., Gagnon, L., & Crow, C. (1998). Collaborative memory accuracy and distortion: Performance and beliefs. In M. J. Intons-Peterson & D. L. Best (Eds.), *Memory distortions and their prevention* (pp. 63–88). Mahwah, NJ: Erlbaum.
- Dixon, R. A., & Gould, O. (1998). Younger and older adults collaborating on retelling everyday stories. *Applied Developmental Science, 2*, 160–171. doi:10.1207/s1532480xads0203\_4
- Dixon, R. A., Hultsch, D. F., & Hertzog, C. (1988). The Metamemory in Adulthood (MIA) Questionnaire. *Psychopharmacology Bulletin, 24*, 671–688.
- Echterhoff, G., Higgins, E. T., & Levine, J. M. (2009). Shared reality: Experiencing commonality with others' inner states about the world. *Perspectives on Psychological Science, 4*, 496–521. doi:10.1111/j.1745-6924.2009.01161.x
- Finlay, F., Hitch, G. J., & Meudell, P. R. (2000). Mutual inhibition in collaborative recall: Evidence for a retrieval-based account. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 1556–1567. doi:10.1037/0278-7393.26.6.1556
- French, L., Garry, M., & Mori, K. (2008). You say tomato? Collaborative remembering leads to more false memories for intimate couples than for strangers. *Memory, 16*, 262–273. doi:10.1080/09541440701801491
- Gabbert, F., Memon, A., Allan, K., & Wright, D. (2004). Say it to my face: Examining the effects of socially encountered misinformation. *Legal and Criminological Psychology, 9*, 215–227. doi:10.1348/1355325041719428
- Gould, O., & Dixon, R. (1993). How we spent our vacation: Collaborative storytelling by young and old adults. *Psychology and Aging, 8*, 10–17. doi:10.1037/0882-7974.8.1.10
- Gould, O., Osborn, C., Krein, H., & Mortenson, M. (2002). Collaborative recall in married and unacquainted dyads. *International Journal of Behavioral Development, 26*, 36–44. doi:10.1080/01650250143000292
- Hedden, T., & Park, D. (2001). Aging and interference in verbal working memory. *Psychology & Aging, 16*, 666–681. doi:10.1037/0882-7974.16.4.666
- Henkel, L. (2007). The benefits and costs of repeated memory tests for

- young and older adults. *Psychology & Aging*, 22, 580–595. doi:10.1037/0882-7974.22.3.580
- Henkel, L. (2008). Maximizing the benefits and minimizing the costs of repeated memory tests for older adults. *Psychology & Aging*, 23, 250–262. doi:10.1037/0882-7974.23.2.250
- Hirst, W., & Manier, D. (2008). Towards a psychology of collective memory. *Memory*, 16, 183–200. doi:10.1080/09658210701811912
- Johansson, O., Andersson, J., & Rönnerberg, J. (2000). Do elderly couples have a better prospective memory than other elderly people when they collaborate? *Applied Cognitive Psychology*, 14, 121–133. doi:10.1002/(SICI)1099-0720(200003/04)14:2<121::AID-ACP626>3.0.CO;2-A
- Johansson, O., Andersson, J., & Rönnerberg, J. (2005). Compensating strategies in collaborative remembering in very old couples. *Scandinavian Journal of Psychology*, 46, 349–359. doi:10.1111/j.1467-9450.2005.00465.x
- Magnussen, S., Andersson, J., Cornoldi, C., De Beni, R., Endestad, T., Goodman, G., . . . Zimmer, H. (2006). What people believe about memory. *Memory*, 14, 595–613. doi:10.1080/09658210600646716
- Margrett, J., & Marsiske, M. (2002). Gender differences in older adults' everyday cognitive collaboration. *International Journal of Behavioral Development*, 26, 45–59. doi:10.1080/01650250143000319
- Marsh, E., Dolan, P., Balota, D., & Roediger, H. (2004). Part-set cuing effects in younger and older Adults. *Psychology & Aging*, 19, 134–144. doi:10.1037/0882-7974.19.1.134
- Meade, M. L., & Roediger, H. L., III. (2002). Explorations in the social contagion of memory. *Memory & Cognition*, 30, 995–1009. doi:10.3758/BF03194318
- Meade, M. L., & Roediger, H. L., III. (2009). Age differences in collaborative memory: The role of retrieval manipulations. *Memory & Cognition*, 37, 962–975. doi:10.3758/MC.37.7.962
- Meegan, S., & Berg, C. (2002). Contexts, functions, forms, and processes of collaborative everyday problem solving in older adulthood. *International Journal of Behavioral Development*, 26, 6–15. doi:10.1080/01650250143000283
- Meudell, P. R., Hitch, G. J., & Boyle, M. M. (1995). Collaboration in recall: Do pairs of people cross-cue each other to produce new memories? *Quarterly Journal of Experimental Psychology A: Human Experimental Psychology*, 48, 141–152.
- Meudell, P. R., Hitch, G. J., & Kirby, P. (1992). Are two heads better than one? Experimental investigations of the social facilitation of memory. *Applied Cognitive Psychology*, 6, 525–543. doi:10.1002/acp.2350060606
- Park, D. C., Smith, A. D., Dudley, W. N., & Lafronza. (1989). Effects of age and a divided attention task presented during encoding and retrieval on memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 15, 1185–1191. doi:10.1037/0278-7393.15.6.1185
- Payne, D. G. (1987). Hypermnnesia and reminiscence in recall: A historical and empirical review. *Psychological Bulletin*, 101, 5–27. doi:10.1037/0033-2909.101.1.5
- Peker, M., & Tekcan, A. (2009). The role of familiarity among group members in collaborative inhibition and social contagion. *Social Psychology*, 40, 111–118. doi:10.1027/1864-9335.40.3.111
- Perdue, C., & Gurtman, M. (1990). Evidence for the automaticity of ageism. *Journal of Experimental Social Psychology*, 26, 199–216. doi:10.1016/0022-1031(90)90035-K
- Pereira-Pasarin, L. P., & Rajaram, S. (2010). *Repeated Encoding and Divided Attention: The Role of Conceptual Processes in Collaborative Recall*. Manuscript under revision.
- Psychological Software Tools. (2002). *E-Prime (Version 1.1)*. [Computer software]. Pittsburgh, PA: Author.
- Rajaram, S., & Pereira-Pasarin, L. P. (2010). Collaborative memory: Cognitive research and theory. *Perspectives on Psychological Science*, 5, 649–663. doi:10.1177/1745691610388763
- Reese, E., & Fivush, R. (2008). The development of collective remembering. *Memory*, 16, 201–212. doi:10.1080/09658210701806516
- Roediger, H. L., III, Meade, M., & Bergman, E. (2001). Social contagion of memory. *Psychonomic Bulletin & Review*, 8, 365–371. doi:10.3758/BF03196174
- Roenker, D., Thompson, C., & Brown, S. (1971). Comparison of measures for the estimation of clustering in free recall. *Psychological Bulletin*, 76, 45–48. doi:10.1037/h0031355
- Ross, M., Blatz, C. W., & Shryer, E. (2008a). Social memory processes. In H. L. Roediger, III (Volume Editor), *Cognitive Psychology*. In J. H. Byrne (Ed.), *Learning and Memory – A Comprehensive Reference* (pp. 911–926). Oxford, England: Elsevier.
- Ross, M., Spencer, S., Linardatos, L., Lam, K., & Perunovic, M. (2004). Going shopping and identifying landmarks: Does collaboration improve older people's memory? *Applied Cognitive Psychology*, 18, 683–696. doi:10.1002/acp.1023
- Ross, M., Spencer, S. J., Blatz, C. W., & Restorick, E. (2008b). Collaboration reduces the frequency of false memories in older and younger adults. *Psychology & Aging*, 23, 85–92. doi:10.1037/0882-7974.23.1.85
- Smith, R. (2006). Adult age differences in episodic memory: Item-specific, relational, and distinctive processing. In R. R. Hunt & J. B. Worthen (Eds.), *Distinctiveness and memory* (pp. 259–287). New York: Oxford University Press.
- Smith, T. W., Berg, C. A., Florsheim, P., Uchone, B. N., Pearce, G., Hawkins, M., . . . Olsen-Cerny, C. (2009). Conflict and collaboration in middle-aged and older couples: I. Age differences in agency and communion during marital interaction. *Psychology & Aging*, 24, 259–273. doi:10.1037/a0015609
- Spieler, D., Balota, D., & Faust, M. (1996). Stroop performance in healthy younger and older adults and in individuals with dementia of the Alzheimer's type. *Journal of Experimental Psychology: Human Perception and Performance*, 22, 461–479. doi:10.1037/0096-1523.22.2.461
- Stone, C., Barnier, A., Sutton, J., & Hirst, W. (2010). Building consensus about the past: Schema consistency and convergence in socially shared retrieval-induced forgetting. *Memory*, 18, 170–184. doi:10.1080/09658210903159003
- Strough, J., Cheng, S., & Swenson, L. (2002). Preferences for collaborative and individual everyday problem solving in later adulthood. *International Journal of Behavioral Development*, 26, 26–35. doi:10.1080/01650250143000337
- Strough, J., McFall, J. P., Flinn, J. A., & Schuller, K. L. (2008). Collaborative everyday problems solving among same-gender friends in early and later adulthood. *Psychology and Aging*, 23, 517–503. doi:10.1037/a0012830
- Taconnat, L., Raz, N., Toczé, C., Bouazzaoui, B., Sauzéon, H., Fay, S., . . . Isingrini, M. (2009). Aging and organization strategies in free recall: The role of cognitive flexibility. *European Journal of Cognitive Psychology*, 21, 347–365. doi:10.1080/09541440802296413
- Takahashi, M. (2007). Does collaborative remembering reduce false memories? *British Journal of Psychology*, 98, 1–13. doi:10.1348/000712606X101628
- Takahashi, M., & Saito, S. (2004). Does test delay eliminate collaborative inhibition? *Memory*, 12, 722–731. doi:10.1080/09658210344000521
- Thorley, C., & Dewhurst, S. A. (2007). Collaborative false recall in the DRM procedure: Effects of group size and group pressure. *European Journal of Cognitive Psychology*, 19, 867–881. doi:10.1080/09541440600872068
- Thorley, C., & Dewhurst, S. A. (2009). False and veridical collaborative recognition. *Memory*, 17, 17–25. doi:10.1080/09658210802484817
- Van Overschelde, J., Rawson, K., & Dunlosky, J. (2004). Category norms: An updated and expanded version of the Battig and Montague (1969). *Journal of Memory and Language*, 50, 289–335. doi:10.1016/j.jml.2003.10.003

- Wang, Q. (2008). On the cultural constitution of collective memory. *Memory, 16*, 305–317. doi:10.1080/09658210701801467
- Weldon, M. S. (2001). Remembering as a social process. In D. L. Medin (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 40, pp. 67–120). San Diego, CA: Academic Press.
- Weldon, M. S., & Bellinger, K. D. (1997). Collective memory: Collaborative and individual processes in remembering. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 1160–1175. doi:10.1037/0278-7393.23.5.1160
- Weldon, M. S., Blair, C., & Huebsch, D. (2000). Group remembering: Does social loafing underlie collaborative inhibition? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 1568–1577. doi:10.1037/0278-7393.26.6.1568
- Wertsch, J. V., & Roediger, H. L. (2008). Collective memory: Conceptual foundations and theoretical approaches. *Memory, 16*, 318–326. doi:10.1080/09658210701801434
- Wessel, I., & Moulds, M. (2008). Collective memory: A perspective from (experimental) clinical psychology. *Memory, 16*, 288–304. doi:10.1080/09658210701811813
- Yang, L., & Hasher, L. (2007). The enhancing effects of pictorial distraction in older adults. *The Journals of Gerontology: Series B: Psychological Sciences and Social Sciences, 62B*, P230–P233.
- Yuker, H. E. (1955). Group atmosphere and memory. *Journal of Abnormal and Social Psychology, 51*, 117–123. doi:10.1037/h0046464
- Zacks, R. T., & Hasher, L. (2006). Aging and long-term memory: Deficits are not inevitable. In E. Bialystok & F. I. M. Craik (Eds.), *Lifespan cognition: Mechanisms of change* (pp. 162–177). New York: Oxford University Press.

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