American Psychological Association

Psychology and Aging

ISSN: 0882-7974

2020, Vol. 35, No. 7, 963–973
http://dx.doi.org/10.1037/pag0000490

Collaborative Inhibition in Same-Age and Mixed-Age Dyads

Summer R. Whillock, Michelle L. Meade, Keith A. Hutchison, and Megan D. Tsosie
Montana State University

This study examined the influence of same-age and mixed-age dyads on the collaborative inhibition effect (reduced recall in collaborative groups compared to the combined recall of the same number people who recall individually). Younger (age 18–25) and older (age 65+) adults recalled categorized word lists alone or in collaboration with a same-age or a different-age partner. On an initial recall test, the magnitude of collaborative inhibition for veridical recall was similar across dyads, regardless of age. However, age differences emerged in false recall as older adults were less likely to correct each other's errors than younger adults in same-age dyads. Older adults in same-age dyads continued to demonstrate greater false recall on a subsequent recall test, but there were no lasting costs of collaboration on subsequent recall or recognition for same-age or mixed-age dyads. Mixed-age dyads were more likely to provide a simple acknowledgment and less likely to remain silent in response to partner suggestions than were same-age partners, however, this did not affect the magnitude of collaborative inhibition. Any lasting effects of collaboration are invariant across same-age and mixed-age partners. The results demonstrate age-invariance of the retrieval strategy disruption theory and highlight collaborative process variables as complementary mechanisms of collaborative inhibition.

Keywords: collaborative inhibition, mixed-age dyads, false memory, collaborative process variables

We live in a social world, with many opportunities to remember collaboratively. For instance, one might remember childhood stories with a cousin or recount the U.S. Open with an acquaintance. Collaborative remembering is especially relevant to aging, as it is increasingly important to understand contextual influences on older adults' cognition (e.g., Harris, Barnier, Sutton, & Keil, 2014; Hess, 2005). Further, in light of older adults' individual memory deficits (e.g., Park et al., 2002), working with a collaborator may help older adults compensate for cognitive decline (Blumen, Rajaram, & Henkel, 2013; Dixon, 1999). Importantly, however, further research is necessary to identify patterns of gains and losses associated with collaborative memory and aging across contexts (cf. Meade, Harris, Van Bergen, Sutton, & Barnier, 2018). In the current experiment, we examine possible age differences in collaborative remembering by comparing young and older adults' memories when collaborating with a same-age partner or a different-age partner. Is collaboration equally disruptive and/or beneficial to memory across same-age and mixed-age dyads? Further, how does remembering with a same-age or different-age partner influence how information is exchanged and acknowledged during collaboration?

In a typical collaborative memory experiment, participants study information such as stories or word lists with the goal of recalling the material. Participants then recall the information either alone or in collaboration with a partner(s; see, e.g., Baltes & Staudinger, 1996; Meade et al., 2018, for discussion of collaboration across a wider range of tasks and contexts). Collaborative groups generally recall more than single individuals, thus supporting the "two heads are better than one" mantra (e.g., Dixon, 1999; Weldon & Bellinger, 1997). However, counterintuitively, collaborative groups generally recall less than nominal groups (the nonredundant, pooled recall of individuals working separately), a phenomenon called *collaborative inhibition* (Weldon & Bellinger, 1997; see Marion & Thorley, 2016; Meade, Perga, & Hart, in press; Rajaram, 2018, for reviews). In the current study, we focus on collaborative inhibition because we are interested in the effects of collaboration on individual memory (i.e., if collaboration has no impact on individual memory, collaborative group recall should equal pooled individual recall; see Dixon, 2013; Harris, Barnier, Sutton, Keil, & Dixon, 2017; Meade, Whillock, & Hart, 2019, for discussion of measurement issues).

The major theoretical explanation of collaborative inhibition is retrieval strategy disruption (Basden, Basden, Bryner, & Thomas, 1997), which proposes that each participant has a unique recall strategy that becomes disrupted when one's partner has a different strategy, resulting in fewer items remembered. Although much evidence supports retrieval strategy disruption, there is growing evidence that the processes underlying collaborative inhibition are more complex than can be ex-

This article was published Online First May 14, 2020.
Summer R. Whillock, Michelle L. Meade, Keith A. Hutchison, and Megan D. Tsosie, Department of Psychology, Montana State University.
We thank Ian Handley for helpful discussion and comments on earlier drafts and presentations. We thank Casey Kallem, Tiffany Ocampo, Abigeal Riddle, and Jamie Woolman for help collecting data. The data for this experiment are available at https://osf.io/cuq7v/. The recall and recognition data reported here were presented at the 2018 Annual Meeting of the Psychonomic Society. The collaborative process data were presented at the Annual Meeting of the Society for 2019 Social and Personality Psychology.
Correspondence concerning this article should be addressed to Michelle L. Meade, Department of Psychology, Montana State University, P.O. Box 173440, Bozeman, MT 59717. E-mail: mlmeade@montana.edu

plained by this singular mechanism (see Barber, Harris, & Rajaram, 2015; Rajaram, 2018; Rajaram & Pereira-Pasarin, 2010). Further work is necessary to more precisely determine the boundary conditions of retrieval strategy disruption, and to explore additional mechanisms that may influence and/or complement retrieval strategy disruption in young and older adults.

The present experiment sought to further test the retrieval strategy disruption theory by comparing collaborative inhibition in same-age and mixed-age dyads. Including mixed-age dyads allows us to determine if retrieval strategy disruption is an age-invariant process across different partners, or if there are age differences in the extent to which retrieval disruption is influenced by partner characteristics. Age is an especially salient partner characteristic (Meade et al., in press) because of the negative stereotypes associated with memory and aging (cf. Levy, 1996; Numbers, Barnier, Harris, & Meade, 2019). Especially when collaborating with unacquainted partners, individuals might rely on age-based assumptions because they have no preexisting knowledge of their partner's memory ability. Indeed, research in related paradigms demonstrates that individuals incorporate fewer suggestions from older adult partners than from young adult partners (Davis & Meade, 2013; Meade, McNabb, Lindeman, & Smith, 2017). Such discounting of another's responses could help protect one's retrieval strategy from disruption. Alternatively, older adults may be more likely to consider responses from young adults and so demonstrate increased disruption in mixed-age groups. Further, young and older adults may rely on different encoding strategies (Logan, Sanders, Snyder, Morris, & Buckner, 2002). Assuming encountering a different strategy than one's own causes disruption, this disruption should be greater in mixed-age dyads. Including mixed age dyads in the current experiment, then, allows us to examine how partner characteristics influence retrieval strategy disruption in same-age and mixed-age dyads.

The present study also sought to explore the role of collaborative process variables (i.e., the manner in which individuals converse and exchange information) as an additional mechanism underlying collaborative inhibition (Meade, 2013; Meade et al., 2018). The retrieval strategy disruption theory is somewhat circular, and collaborative processes offer a direct measure of mechanisms that can inform collaborative inhibition. Emerging evidence suggests collaborative process variables influence the magnitude of collaborative inhibition (e.g., Harris, Keil, Sutton, Barnier, & McIlwain, 2011), and further research is necessary to examine collaborative processes across a wider range of contexts. In the current experiment, we examine collaborative processes in mixed-age pairs because research in related paradigms has established that partners in mixed-age dyads communicate and exchange information differently than partners in same-age dyads (Siegel & Gregora, 1985). As such, including both same-age and mixed-age groups creates experimental contexts allowing for different collaborative processes to emerge. To the extent that collaborative inhibition is multiply determined (e.g., Rajaram, 2018), measuring if and how collaborative process variables complement the theoretical framework of retrieval strategy disruption will further our knowledge about the mechanisms underlying collaborative inhibition in young and older adults.

Age Differences in Collaborative Inhibition

Just five studies have examined age differences in the collaborative inhibition effect. Ross, Spencer, Blatz, and Restorick (2008) presented young adult couples (married 8 years) and older couples (married 51 years) with schematic images excluding key items so they could measure both correct and false recall. Henkel and Rajaram (2011) and Meade and Roediger (2009) both presented unacquainted young and older adults with categorized lists, again excluding key items to measure both correct and false recall. Finally, Blumen and Stern (2011) and Barber, Castrellon, Opitz, and Mather (2017) presented unacquainted young and older adults with unrelated word lists or emotional pictures, respectively. Across paradigms, all five studies demonstrated no age differences in the magnitude of collaborative inhibition for correct recall. Importantly, however, these studies only tested same-age partners. Same-age partners alone cannot determine if collaborative inhibition is age-invariant across partner age or if there are age differences in the extent to which age biases (cf. Davis & Meade, 2013) or encoding strategies (cf. Logan et al., 2002) influence retrieval disruption and/or collaborative processes.

In contrast to age-invariance in correct recall, collaboration effects on false recall are more complex. For instance, both Ross et al. (2008) and Henkel and Rajaram (2011) found that young and older adults were equally likely to benefit from collaboration by correcting each other's errors. However, Ross et al. demonstrated that older adults were more likely to inhibit incorrect answers during collaboration than young adults, as evident in the overall number of errors generated. Further, Meade and Roediger (2009) found that, when errors were not corrected during collaboration, older adults were more likely to falsely recognize them on a subsequent test. Therefore, it is still unclear how collaboration influences age differences in false recall. Again, the inclusion of only same-age dyads is limiting. Comparing same age-dyads to mixed-age dyads is necessary to determine if there are age differences in how likely individuals are to incorporate false suggestions from young and older adult partners (cf. Numbers et al., 2019), and/or if there are age differences in collaborative processes that influence false memory generation and/or error correction (cf. Ross et al., 2008; Siegel & Gregora, 1985; Thorley & Dewhurst, 2007).

Collaborative Process Variables

There is growing evidence that collaborative process variables influence collaborative inhibition effects (Meade, 2013; cf. Meade et al., 2018). For example, Meade, Nokes, and Morrow (2009) found that nonexpert pilots who used simple acknowledgments with no elaborations demonstrated collaborative inhibition. In contrast, expert pilots who acknowledged their partners' suggestions and elaborated on the content benefitted from collaboration (cf. Clark & Wilkes-Gibbs, 1986). Further, Meade and Gigone (2011) found larger collaborative inhibition effects for unshared information (presented to only a subset of the group) than for shared information because unshared information was less likely to be acknowledged and incorporated into the group recall (see Ekeocha & Brennan, 2008).

Research on age and collaborative process variables has focused exclusively on long-term married couples. Specifically, Harris et al. (2011) demonstrated that couples who failed to coordinate their recall strategies and/or failed to elaborate on each other's suggestions demonstrated collaborative inhibition, whereas couples who coordinated strategies showed a collaborative benefit. Likewise, Johansson, Andersson, and Rönnberg (2005) demonstrated that long-term couples who better coordinated and divided responsibility for their recall showed no collaborative inhibition effect. Finally, Ross et al. (2008) found that both long-term and newly married couples were equally likely to correct each other's errors during collaboration, but that older couples were more likely to inhibit erroneous responses.

Considered together, research on unacquainted young adults and long-term married couples suggests that collaborative process variables influence collaborative inhibition. However, existing research is limited by including only same-age partners and testing age differences only in married couples. The inclusion of mixed-age dyads in the current study creates an experimental context that allows room for collaborative processes to differ. Further, the comparison of unacquainted young and older adults in the current study allows an examination of age differences not confounded by years of practice remembering together.

Mixed-Age Dyads and Collaborative Memory

Although no studies have examined collaborative inhibition in mixed-age dyads, related literatures demonstrate that collaborating with a different-aged partner influences memory and/or collaborative process variables. Specifically, Davis and Meade (2013) asked participants to remember schematic images in collaboration with young or older adult confederates who suggested incorrect items had appeared in the images. On subsequent individual memory tests, both young and older adults were less likely to incorporate misleading suggestions by older adult confederates. Subsequent research demonstrated participants were especially likely to discount older adults' suggestions when age was salient (Meade et al., 2017) and when negative aspects of aging were emphasized (Numbers et al., 2019). Relatedly, Henkel and Rajaram (2011) found that young adults believe collaboration is less successful with older adult collaborators, whereas older adults believe collaborating with young and older adults is equally beneficial. Thus, if it is generally true that young adults believe collaboration with older adults is less beneficial, and they discount older adults' suggestions, then young adults in mixed-age groups should be less likely to consider their older adult partner's contributions than vice versa.

In another mixed-age study, Siegel and Gregora (1985) examined communication performance for same-age and mixed-age dyads in a problem-solving task. The mixed-age dyads spent the same amount of time completing the task, and had the same performance accuracy, as did the same-age dyads. However, the content of the conversations differed. Compared to same-age dyads, mixed-age dyads commented more about the task and strategies to perform it. Although these findings derive from outside of the collaborative inhibition paradigm, they nonetheless suggest that mixed-age groups may communicate and collaborate in distinct ways. Including mixed-age dyads in the current study, therefore, offers a means to examine possible boundary conditions of retrieval strategy disruption and any role of collaborative processes across different-aged partners.

Present Study

In the current study, we examined age differences in collaborative inhibition and collaborative process variables across same-age and mixed-age dyads. Consistent with previous research, we predicted equivalent collaborative inhibition in same-age dyads for correct recall (Barber et al., 2017; Blumen & Stern, 2011; Henkel & Rajaram, 2011; Meade & Roediger, 2009; Ross et al., 2008). More importantly, we compared same-age and mixed-aged dyads to test the possible influence of partner age on retrieval strategy disruption and the potential influence of collaborative process variables. If collaborative inhibition on correct recall is truly age-invariant, then the magnitude of collaborative inhibition should be equivalent in mixed-age and same-age dyads. However, if young and older adults rely on different encoding strategies (cf. Logan et al., 2002) and/or collaborative inhibition is influenced by collaborative process variables, then the magnitude of collaborative inhibition should be greater in mixed-age dyads compared to same-age dyads. Consistent with previous research demonstrating that mixed-age partners spend more time discussing the task rather than the content (Siegel & Gregora, 1985) and that collaborative process variables influence collaborative inhibition (e.g., Meade et al., 2009), the mixed-age dyads might negotiate and exchange information in a manner more disruptive to memory, and so demonstrate larger collaborative inhibition effects.

The current experiment also measured false recall and, specifically, the role of collaboration and collaborative process variables on false recall across same-age and mixed-age dyads. Although existing evidence on age differences in collaboration and false recall are mixed, the current experiment used the paradigm from Meade and Roediger (2006, 2009), and so we predicted that older adults should have more errors than young adults during collaboration and these increased errors should persist on subsequent individual tests. Again, however, the novel component is the mixed-age dyads. If retrieval strategy disruption is age-invariant regardless of one's partner, then false recall across same-age and mixed-age dyads should be equal. However, if young adults discount older adults' suggestions on memory tests (Davis & Meade, 2013; Meade et al., 2017; Numbers et al., 2019), then error rates should be lower in mixed-age dyads relative to same-age dyads because young adults might be less likely to incorporate older adults' suggestions.

Finally, the current experiment included an initial test, followed by individual recall and recognition tests. The initial test examined our primary measures of collaborative inhibition and collaborative process variables. The subsequent tests determined any post collaborative effects on individual memory. We predicted that collaborative inhibition should dissipate on subsequent tests, meaning collaborative and nominal groups should have similar correct recall and recognition. For false recall, we predicted that older adults' increased errors on Recall Test 1 would persist on subsequent individual recall tests, but not on recognition, because task demands of the recognition test encourage explicit considerations of the source for each item, and so should minimize false recognition across groups (cf. Multhaup, 1995).

Method

The research protocol was approved by the Institutional Review Board at Montana State University (SW090517-EX) and all participants were consented.

Participants

Seventy-two undergraduates (age range = 18–26 years old; $M = 19.2$; 33% male) from Montana State University participated for partial fulfillment of a course requirement. In addition, 72 older adults (age range = 65–93 years old; $M = 72.8$; 29% male) from the community participated for $10. This resulted in 24 dyads in each age group with 12 dyads assigned to each individual condition and 12 dyads assigned to each collaborative condition. The sample size was consistent with the range of sample sizes (10–17 dyads per condition) used in previous research on collaborative inhibition in unacquainted young and older adults (Blumen & Stern, 2011; Henkel & Rajaram, 2011; Meade & Roediger, 2009; Ross et al., 2008). The sample size was also sufficiently powered according to G*Power. Assuming the effect size of .56 (Marion & Thorley, 2016) and six groups, the total required sample size to achieve a power of .95 is 53 which, because we measured dyads (i.e., two people for each data point), translates to 106 total participants (our study included 144 total participants).

Gender distribution was similar across conditions (7–10 of the 24 individuals in each condition [29–42%] were male). Older adult participants had more education ($M = 3.89$ years post high school) than young adults ($M = 1.32$ years post high school), $t(142) = 10.78$, $SEM = .24$, $p < .01$. When gender and education were each entered separately as a covariate in ANCOVAs for Recall 1, Recall 2, and recognition, there were no significant main effects of gender, $Fs < 1.18$, $ps > .05$, or education, $Fs < 1.39$, $ps > .05$, and all other results remained unchanged.[1] Finally, older adults ($M = 35.3$) scored higher than younger adults ($M = 28.8$) on the Shipley vocabulary test (Shipley, 1946; $t(142) = 11.34$, $SEM = .57$, $p < .01$) and lower than younger adults on the Mini-Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975; $t(142) = 5.09$, $SEM = .19$, $p < .01$). Importantly, older adult scores on the MMSE ($M = 28.2$) and younger adult scores on the MMSE ($M = 29.1$) were in the normal/healthy range (24–30).

Design

The experiment consisted of a 2 × 3 between-subjects design. Collaboration (nominal vs. collaborative) and age group (young/young vs. young/old vs. old/old) were manipulated between subjects. The primary dependent variables were correct recall and recognition for the presented list items and false recall and recognition for the nonpresented, critical items. The secondary dependent variables were collaborative process variables.

Materials

Materials were selected from Meade and Roediger (2006, 2009) and included six categorized lists (kitchen utensils, occupations, sports, parts of a building, musical instruments, fish) constructed from Battig and Montague (1969). Each list contained 17 presented words and five critical items. Two versions of each list (List A & List B) were constructed to control for guessing of the most typical exemplars (see Meade & Roediger, 2009). Specifically, critical items were counterbalanced such that five of the top 10 exemplars were designated critical items for List A and the other five of the top 10 exemplars were designated critical items for List B. The recognition test was also selected from Meade and Roediger (2006, 2009) and contained 90 items: the 10 most typical exemplars from each category (five critical items and five studied) and 30 unrelated filler items.

Additional materials included a mathematical filler task, the Shipley vocabulary test (Shipley, 1946), the MMSE (Folstein et al., 1975), and locally developed demographics and metacognitive questionnaires. The metacognitive questionnaires asked participants to rate their own memory, their partner's memory, and how helpful it is to work with others on memory tasks. Rating scales on the metacognitive questionnaire ranged from 1 (*lowest or least favorable*) to 5 (*highest or most favorable*).

Procedure

Participants signed a consent form and were randomly assigned to complete the test individually (nominal condition) or in collaboration with a same-age partner (young/young; old/old) or a different-age partner (young/old).

Participants viewed 6 categorized word lists (17 items per list; 102 items total) on the computer screen. The lists were presented sequentially (one word at a time), with each word presented for 2 s with a 500-msec interstimulus interval. The experimenter verbally labeled the category name of each list as the first item in each list was presented. Participants viewed the lists individually on their own computers, and they were instructed to pay attention because their memory for the words would be tested later. After encoding all 102 items, participants completed a 2-min mathematical filler task.

Next, Recall Test 1 took place either individually, or with a same-age partner, or with a different-age partner. Participants had two minutes per list to recall as many of the studied items as possible. Participants were provided with the category name and recalled items from one category at a time (words recalled from a different category were still counted as correct). Participants completed the recall tests in the same order that the lists were presented during the study phase, but they could recall the words from each list in any order. Participants said the words out loud and wrote them down. In the individual condition, the participant recalled aloud and wrote their own items down. In the collaborative condition, one individual was randomly assigned to write down the words for both partners. Collaborative partners were given "free-for-all" instructions (i.e., they were not instructed to take turns, nor reach consensus). If participants asked the experimenter how to collaborate, they were told to recall however

[1] To control for gender, separate ANCOVAs were computed. For Recall 1, analysis was at the group level (nominal or collaborative recall) so gender was coded by group ($-1 = 2$ males; $0 = 1$ male, 1 female; $+1 = 2$ females). For Recall 2, analysis was at the individual level, so gender was coded by individual ($0 =$ male; $1 =$ female). To control for education differences, separate ANCOVAs were computed. For Recall 1, education was coded by group (years of education averaged across partners). For Recall 2, education was coded by individual (years of education for each participant). ANCOVAs were run post-hoc at the request of reviewers. Across ANCOVAs, the data remained unchanged. Thus, data reported in the Results section are from the original ANOVAs computed without education or gender as covariates.

they felt was best. Participants were instructed not to guess, and to only record words they were reasonably sure appeared on the lists. All participants were voice-recorded so that collaborative process variables could be examined.

After Recall Test 1, all participants completed Recall Test 2. The second recall test, and all subsequent tests, were completed individually and participants wrote their responses. Participants were again cued with the category name, and they again had two minutes per list to recall as many items as possible. As in Recall 1, category cues were presented in the same order in which the categories were studied.

Next, participants completed a source recognition test in which they indicated where, if anywhere, they had seen each word. Participants in the nominal groups (those who recalled individually on Recall Test 1) were asked to indicate if each word appeared in the study list (list) and/or if they themselves had recalled it earlier in the experiment (self). Finally, they had the option to indicate that the word had not appeared in the study list and they had not recalled it (neither). Participants in the collaborative groups (those who recalled with a partner on Recall Test 1) had these same options (list, self, neither) and, in addition, had the option to indicate that their partner had recalled the word earlier in the experiment (partner). There was no time limit for the recognition test.

Finally, participants completed a metacognitive questionnaire, a demographics questionnaire, the Shipley vocabulary test, and the MMSE.

Results

Statistical significance was set at $p \leq .05$. The default analytic design was a 2 (collaboration: collaborative or nominal) × 3 (age group: young/young, young/old, or old/old) between-subjects factorial analysis of variance (ANOVA). *Collaboration* (collaborative or nominal) refers to participants' experimental condition on Recall Test 1; on Recall 2 and recognition, the *collaboration factor* refers to prior collaboration or prior individual recall. Separate ANOVAs were computed for each dependent variable.

Recall Test 1

Table 1 presents the mean proportions of list items and critical items recalled on the initial recall test. Collaborative recall is the total output produced by participants working in dyads. Nominal recall is the nonredundant, pooled recall of participants working individually. Computing nominal recall is necessary to examine collaborative inhibition because it allows a comparison of the combined output of two individuals working alone (nominal recall) to the combined output of two individuals working together (collaborative recall).

Correct recall. There was a significant collaborative inhibition effect on correct recall, as measured by the main effect of collaboration, ($F(1, 66) = 9.44$, $MSE = .01$, $p = .003$, $d = .76$). Collaboration disrupted retrieval, such that participants in collaborative groups ($M = .53$) recalled significantly less than participants in nominal group ($M = .59$). Importantly, there was no interaction between age group and collaboration, $F < 1.0$, $p > .05$, $d = .17$, demonstrating that the magnitude of collaborative inhibition did not differ across age groups. This finding of age-invariant collaborative inhibition is consistent with previous research on same-age partners (Barber et al., 2017; Blumen & Stern, 2011; Henkel & Rajaram, 2011; Meade & Roediger, 2009; Ross et al., 2008) and demonstrates, for the first time, that collaborative inhibition is also age-invariant in mixed-age dyads.

The main effect of age group was not significant, $F < 1.0$, $p > .05$, $d = .31$, suggesting young and older adults recalled similar proportions of correct items. Likely, this is due to the strong retrieval support provided by the categorized list paradigm (Meade, Geraci, & Roediger, 2012; Meade & Roediger, 2006; cf. Craik & McDowd, 1987). Finding similar levels of correct recall across age groups is advantageous because initial age differences do not influence comparisons between individual and collaborative conditions or comparisons across repeated recall and recognition tests, (see Meade & Roediger, 2009).[2]

False recall. A separate ANOVA computed on the proportion of false items revealed a significant main effect of collaboration, or collaborative inhibition for errors, $F(1, 66) = 4.83$, $MSE = .01$, $p = .03$, $d = .54$. Consistent with previous literature demonstrating error correction in free-flowing collaborative groups (e.g., Henkel & Rajaram, 2011; Ross, Spencer, Linardatos, Lam, & Perunovic, 2004; Ross et al., 2008), collaborative groups ($M = .21$) recalled fewer false items than nominal groups ($M = .27$). Also consistent with previous research (e.g., Henkel & Rajaram, 2011; Meade & Roediger, 2009), older adults recalled the highest proportion of false items, $F(2, 66) = 4.64$, $MSE = .01$, $p = .01$, $d = .75$. The old/old dyads ($M = .30$) produced significantly more errors than young/young dyads ($M = .19$), $t(46) = 2.75$, $SEM = .04$, $p = .01$, $d = .79$, and numerically, but not significantly, more errors than the young/old dyads ($M = .23$), $t(46) = 1.78$, $SEM = .04$, $p = .08$, ($d = .52$). The young/young dyads and the young/old dyads did not differ from each other, $t = 1.1$, $p > .05$, $d = .33$. On categorized lists, in particular, older adults may be more susceptible to memory errors due to source monitoring confusion and/or guessing (cf. Huff, Meade, & Hutchison, 2011; Meade & Roediger, 2006).[3]

Table 1
Mean (SD) Proportion of Pooled Items Recalled as a Function of Age Group (Young/Young, Young/Old, or Old/Old) and Collaboration (Collaborative or Nominal Recall) on Recall Test 1 (N = 144)

Collaboration	Young young	Young old	Old old
Correct recall			
Pooled	.59 (.08)	.60 (.10)	.59 (.09)
Collaborative	.52 (.07)	.56 (.09)	.51 (.09)
False recall			
Pooled	.27 (.12)	.26 (.11)	.29 (.13)
Collaborative	.12 (.09)	.20 (.11)	.31 (.14)

[2] Individual (nonpooled) correct recall also did not vary across groups, as revealed by a separate one-way ANOVA, $F(2, 69) = .06$, $MSE = .01$, $p > .05$; $M = .38$ young/young dyads, $M = .38$ old/old dyads, and $M = .39$ young/old dyads).

[3] A separate one-way ANOVA computed on individual (nonpooled) false recall showed the same pattern, $F(2, 69) = 3.82$, $MSE = .01$. Individuals in old/old dyads ($M = .23$) had higher false recall than individuals in young/young dyads—$M = .15$, $t(46) = 2.36$, $SEM = .07$, $d = .68$—and young/old dyads—$M = .15$, $t(46) = 2.64$, $SEM = .08$, $d = .76$. Individuals in the young/young dyads and the mixed-age dyads did not differ, $t < 1.0$, $p > .05$, $d < .04$.

In addition, the interaction between collaboration and age group failed to reach significance, $F(2, 66) = 2.98$, $MSE = .01$, $p = .058$, $d = .60$. The patterns are relevant to the equivocal results across existing studies on age differences in collaboration and false memory, and so warrant further, albeit cautious, discussion. Follow-up tests demonstrate that only young/young dyads produced fewer errors in collaborative groups than in nominal groups, $t(22) = 3.46$, $SEM = .04$, $p = .002$, $d = 1.43$. The young/old dyads showed a numerical reduction ($M = .26$ pooled; $M = .20$ collaborative), but this difference failed to reach significance $t = 1.33$, $p > .05$, $d = .54$. The old/old dyads showed neither numerical, nor statistical, reduction in collaborative groups ($M = .29$ pooled; $M = .31$ collaborative, $t < 1.0$, $p > .05$, $d = .17$). Although these findings are inconsistent with previous research demonstrating that young and older adults are equally likely to error correct on collaborative tests (Henkel & Rajaram, 2011; Ross et al., 2008), they are consistent with Meade and Roediger's (2009) findings that errors produced during collaboration may be especially disadvantageous to older adults.

Recall Test 2

Data for Recall Test 2 are shown in Table 2. The primary interest in Recall Test 2 is to examine any lasting effects of prior collaboration on subsequent individual memory. Also important is whether or not any effects of prior collaboration vary across same-age and mixed-age dyads.

Correct recall. The ANOVA revealed no post collaborative costs on Recall 2, and in fact there was a numerical post collaborative benefit of prior collaboration that failed to reach significance, $F(1, 138) = 3.42$, $MSE = .01$, $p = .066$, $d = .31$. This finding is consistent with previous literature demonstrating that collaborative inhibition disappears on subsequent tests (e.g., Finlay, Hitch, & Meudell, 2000; Meade & Roediger, 2009) and/or benefits memory on subsequent tests (e.g., Basden, Basden, & Henry, 2000; Blumen & Rajaram, 2008). Also important is that any lasting effect of collaboration on subsequent recall was age-invariant; the main effect of age group was not significant, nor was the interaction between age group and collaboration, Fs < 1.0, ps $> .05$, ds $< .17$. The pattern of data is consistent with Henkel and Rajaram (2011) who found that young and older adults were equally likely to benefit from prior collaboration, although the benefit in the current study is only numerical and not statistically significant.

Table 2
Mean (SD) Proportion of Items Recalled as a Function of Age Group (Young/Young, Young/Old, or Old/Old) and Collaboration (Prior Collaborative or Prior Nominal Recall) on Subsequent Individual Recall Test 2 (N = 144)

Collaboration	Young young	Young old	Old old
Correct recall			
Prior nominal	.40 (.12)	.41 (.13)	.39 (.10)
Prior collaborative	.44 (.09)	.44 (.09)	.42 (.12)
False recall			
Prior nominal	.19 (.19)	.18 (.17)	.23 (.12)
Prior collaborative	.14 (.13)	.20 (.16)	.27 (.15)

False recall. A separate ANOVA computed on the proportion of false items recalled revealed only a significant main effect of age group, $F(2, 138) = 3.23$, $MSE = .02$, $p = .04$, $d = .43$. Old/old participants ($M = .25$) were more likely to recall false items than young/young participants ($M = .17$), $t(94) = 2.51$, $SEM = .03$, $p = .01$, $d = .51$, and marginally more likely to recall false items than young/old participants ($M = .19$), $t(94) = 1.89$, $SEM = .03$, $p = .063$, $d = .39$. Young/young and young/old participants did not differ from each other, $t < 1.0$, $p > .05$, $d < .13$. Thus, for old/old dyads, the elevated error rates from Recall 1 persisted into Recall 2. Importantly, there was no lasting effect of prior collaboration on false recall on Test 2, nor did collaboration interact with age group, Fs < 1.3, ps $> .05$, ds $< .28$. Note the pattern of data on Recall Test 2 is similar to Recall Test 1; however, the interaction failed to reach significance on Recall Test 2.

Recognition

Recognition was always completed individually and again the question of interest is any lasting effect of prior collaboration across same-age and mixed-age dyads. The recognition data in Tables 3 and 4 correspond to the response options on the recognition test. Correct recognition scores (see Table 3) represent the proportion of studied items the participants identified as having been present on the study list. This was computed as the sum of list responses and list-and-self responses, with any discrepancies due to rounding error. Because collaborative groups had the option to additionally select *list-and-other,* these responses were also included for collaborative groups. False recognition scores (see Table 4) represent the proportion of times participants identified critical items as having originated from the study lists. This is represented by the sum of list and list-and-self responses for critical, nonpresented items. List-and-other responses were also included for collaborative groups, with again any differences due to rounding error.

Correct recognition. An ANOVA computed on correct recognition scores revealed no significant main effects (Fs < 1.76, $p > .186$, ds $< .24$) and no significant interaction ($F < 1.0$, $p > .05$, $d = .00$). Prior collaboration had no lasting effect on correct recognition for same-age or mixed-age dyads.

False recognition. There was no significant influence of collaboration or age group on false recognition scores, nor any interaction (Fs < 1.78, ps $> .05$, ds $< .33$). Prior collaboration had no lasting impact on false recognition, and the age differences in false recall obtained on Recall 1 and 2 disappeared on the final recognition test, most likely because the test directed attention to the source of each item (cf. Davis & Meade, 2013; Multhaup, 1995).

Collaborative Process Variables

Secondary analyses were computed to examine collaborative process variables, or how young and older adults in same-age and mixed-age dyads talk to each other during collaborative recall. Collaborative process variables are measured in a variety of ways across the collaborative remembering literature (e.g., Gould, Kurzman, & Dixon, 1994; Harris et al., 2011; Van Bergen, Salmon, Dadds, & Allen, 2009; see Meade et al., 2018). In the current experiment, we measured the same collaborative process variables as Meade et al. (2009) because they have been shown to predict differences in collaborative inhibition.

Table 3
Mean (SD) Proportion of Correct Recognition as a Function of Age Group (Young/Young, Young/Old, or Old/Old) and Collaboration (Prior Collaborative or Prior Nominal Recall) on Subsequent Individual Recognition Test (N = 144)

Collaboration	Young young	Young old	Old old
	Prior individual		
List only	.29 (.18)	.29 (.15)	.32 (.20)
Both list and self	.58 (.22)	.58 (.16)	.53 (.20)
Total correct recognition	.87	.87	.85
Self	.03 (.09)	.01 (.03)	.01 (.04)
Neither	.10 (.06)	.12 (.07)	.14 (.13)
	Prior collaborative		
List only	.12 (.07)	.11 (.10)	.20 (.15)
Both list and self or other	.78 (.10)	.78 (.11)	.68 (.20)
Total correct recognition	.90	.89	.88
Self or other	.02 (.05)	.001 (.004)	.03 (.05)
Neither	.08 (.07)	.10 (.07)	.09 (.10)

For each word recalled on Test 1, we coded whether one's collaborator responded with silence, an acknowledgment, or a correction. Silence was coded as a lack of response (cf. Ekeocha & Brennan, 2008). Acknowledgments were split into simple acknowledgments (e.g., yeah, ok) and elaborative acknowledgments (e.g., "I remember that too," repeating the word, commenting, or adding additional details about the word; cf. Clark & Wilkes-Gibbs, 1986). Corrections were coded as error corrections (correcting one's partners' errors) or self-corrections (correcting oneself after suggesting an incorrect item; cf., Ross et al., 2008).

Two coders (Summer R. Whillock and a research assistant blind to the study) independently scored a subset of the protocols (25%), and their initial agreement was high (κ = .87). Disagreements were resolved via discussion and the coding scheme was updated to include "I'll write it down" as a separate category. We designated this its own category because there is no precedent in the literature and it was not clear if this was an acknowledgment the word had appeared or if participants wrote the word down because their partner suggested it, rather than because they too remembered it. The coders then rescored the original subset (to include the new "I'll write it down" category) and also scored the remaining protocols. Interrater reliability was high (κ = .90) and again disagreements were resolved via discussion.

Table 5 displays the average proportion of statements classified under each code, along with the effect size of the difference between mixed-age dyads and same-age dyads. Analyses of collaborative process variables are descriptive and are intended to illustrate the types of processes underlying collaboration in same-age and mixed-age dyads. Accordingly, we examined these data via effect sizes, rather than null hypothesis significance tests (see Meade et al., 2009; Nokes-Malach, Meade, & Morrow, 2012). Consistent with Cohen (1988), $d > .80$ is considered a large effect, $.80 > d < .20$ is considered a medium effect, and $d < .20$ is considered a small effect.

One interesting pattern to emerge from the collaborative process data is that participants in the young/old dyads were more likely to provide a simple acknowledgment, and less likely to be silent in response to their partner's suggestion. Specifically, the young/old dyads (M = .45) were less likely than the old/old dyads (M = .54, d = −.36), and the young/young dyads (M = .52, d = −.39) to remain silent after their partner recalled an item. Participants in the young/old dyads (M = .22) were also more likely to provide a simple acknowledgment than participants in the old/old dyads (M = .17, d = .38) and participants in the young/young dyads (M = .16, d = .44). Possibly, participants in mixed-age dyads were less comfortable or familiar and so felt the need to acknowledge their partner's contribution. This is consistent with previous research demonstrating that mixed-age dyads spend more time making support statements (e.g., Siegel & Gregora, 1985) and research demonstrating that silence can be a form of comfort or not needing to explain oneself (Fivush, 2010). More generally, these medium effect sizes support our hypothesis that mixed-age dyads interact differently than same-age dyads. Importantly, however, these differences in collaborative process styles did not seem to impact recall or the magnitude of collaborative inhibition on Recall Test 1, most likely because both simple acknowledgments and silence are relatively minimal and nonelaborative responses (cf. Clark &

Table 4
Mean (SD) Proportion of False Recognition as a Function of Age Group (Young/Young, Young/Old, or Old/Old) and Collaboration (Prior Collaborative or Prior Nominal Recall) on Subsequent Individual Recognition Test (N = 144)

Collaboration	Young young	Young old	Old old
	Prior individual		
List only	.35 (.19)	.38 (.18)	.33 (.20)
Both list and self	.17 (.16)	.16 (.13)	.21 (.14)
Total false recognition	.53	.54	.54
Self	.02 (.05)	.02 (.04)	.02 (.04)
Neither	.45 (.18)	.44 (.20)	.44 (.26)
	Prior collaborative		
List only	.30 (.24)	.28 (.19)	.23 (.21)
Both list and self or other	.17 (.11)	.28 (.18)	.40 (.19)
Total false recognition	.47	.56	.63
Self or other	.02 (.05)	.01 (.01)	.02 (.04)
Neither	.52 (.24)	.43 (.25)	.35 (.21)

Table 5
Mean (SD) Proportion of Responses Classified Under Each Collaborative Process Variable on Recall Test 1 (N = 144)

Variable	Old young	Old old	Young young
Silence	.452 (.204)	.538 (.272)	.524 (.167)
Effect size		−.36	−.39
Simple acknowledgment	.216 (.124)	.167 (.135)	.164 (.11)
Effect size		.38	.44
Elab acknowledgment	.204 (.132)	.197 (.161)	.175 (.129)
Effect size		.05	.22
Error correction	.095 (.07)	.067 (.089)	.119 (.089)
Effect size		.35	−.30
Self correction	.020 (.042)	.011 (.032)	.008 (.028)
Effect size		.24	.34
I'll write it down	.013 (.033)	.02 (.034)	.01 (.029)
Effect size		−.20	.01

Note. Effect size (Cohen's d) is based on a comparison between old/young dyads and old/old dyads; and old/young dyads and young/young dyads.

Wilkes-Gibbs, 1986). As demonstrated by Meade et al. (2009), simple acknowledgments are less predictive of collaborative inhibition than are elaborative acknowledgments. In the current study, elaborative acknowledgments were invariant across mixed-age and same-age dyads (M range = .18 - .20; ds < .22), consistent with finding no collaborative inhibition differences across age groups.

Looking next at corrections, young/old dyads (M = .10) were more likely than the old/old dyads (M = .07, d = .35), and less likely than young/young dyads (M = .12, d = −.30) to correct each other's errors. Further, young/young dyads (M = .12) were more likely than old/old dyads (M = .07, d = .58) to correct each other's errors, and a post hoc comparison revealed that this difference in error correction between young/young and old/old dyads was significant, $t(22) = 2.09$, SEM = .02, p = .048. This finding is inconsistent with previous research finding that young and older adults are equally likely to error correct each other on collaborative tests (Henkel & Rajaram, 2011; Ross et al., 2008) but consistent with other research demonstrating age differences in collaborative errors (Meade & Roediger, 2009; Ross et al., 2008).

Finally, the proportion of statements classified as self-corrections and "I'll write it down" did not exceed 2% of responses. These data are not discussed further because they are difficult to interpret due to floor effects.

Metacognitive Judgments

On the final questionnaires, participants rated their own memory, their partner's memory, and how helpful it is to work with others on memory tasks. Individuals generally view collaboration as beneficial to memory (e.g., Dixon, Gagnon, & Crow, 1998; Henkel & Rajaram, 2011), and yet there are interesting age differences in how strongly this belief correlates to performance (Henkel & Rajaram, 2011). Of interest to the current experiment is whether or not metacognitive beliefs vary across same-age and mixed-age partners.

For the self-rating data (see Table 6), a 2 (collaboration: prior collaborative or prior nominal) × 3 (age group: young/young, young/old, or old/old) between-subjects factorial ANOVA revealed only main effects of collaboration on ratings of one's own memory, $F(1, 111) = 18.77$, MSE = .84, p = .00, d = .85 and how helpful it is generally to remember with another person, $F(1, 111) = 4.63$, MSE = .91, p = .03, d = .33. Consistent with Henkel and Rajaram (2011), participants who had collaborated earlier in the experiment rated collaboration as more helpful (M = 4.2 prior collaboration; M = 3.8 prior individual) and also rated their own memories higher (M = 2.9 prior collaboration; M = 2.2 prior individual). No other main effects or interactions were significant, Fs < 1.16, ps > .05, ds < .21.

A separate one-way ANOVA with Age Group as a factor was computed on partner ratings (Collaboration was not a factor because only participants in the collaborative conditions answered questions about their partners; see Table 7). It revealed significant main effects of confidence in partner memory, $F(2, 69) = 3.97$, p = .02, partner memory accuracy, $F(2, 68) = 4.44$, p = .02, and partner memory ability, $F(2, 69) = 4.54$, p = .01. Follow up t tests confirmed that these findings were driven primarily by young/old dyads rating their partners' memories more favorably than old/old dyads. Specifically, young/old dyads (M = 3.8) were more confident in their partner's memory than old/old dyads (M = 3.2), $t(46) = 2.74$, SEM = .24, p = .01, d = .81. Young/old dyads (M = 3.8) rated their partners' memories as more accurate than old/old dyads (M = 3.1), $t(45) = 2.87$, SEM = .25, p = .01, d = .85. Finally, young/old dyads (M = 3.7) rated their partner's memory ability as higher than old/old dyads (M = 3.0) and marginally higher than young/young dyads—M = 3.3; $t(46) = 2.86$, SEM = .26, p = .01, d = .88 and $t(46) = 1.96$, SEM = .19, p = .057, d = .58, respectively. Interestingly, young and older adults in mixed-age dyads did not differ from each other on mean ratings (ts < 1.0, ps > .05), suggesting that both young and older adults in mixed-age dyads rated their partners similarly. This finding differs from Henkel and Rajaram's (2011), possibly because participants in the current study had recent direct experience collaborating with a different-aged partner and so were more likely to rely on partner ability, rather than age-based assumptions. Finally, young/young dyads and old/old dyads did not differ from each other, ts < 1.8, ps > .09, ds < .51, demonstrating that perceptions of partner memory ability and accuracy, as well as confidence in one's partner, differ across same-age and mixed-age dyads. No other main effects reached significance, Fs < 1.9, ps > .15.

Table 6
Mean Self-Memory Ratings as a Function of Age Group (Young/Young, Young/Old, or Old/Old) and Collaboration (Prior Collaborative or Nominal Recall; N = 144)

Collaboration	Young young	Young old	Old old
Memory ability			
Prior nominal	2.67 (.91)	2.74 (.81)	2.56 (.97)
Prior collaborative	2.88 (.89)	2.88 (1.03)	2.57 (1.08)
Memory confidence			
Prior nominal	3.28 (.96)	2.89 (.99)	3.00 (1.22)
Prior collaborative	3.25 (.93)	3.00 (1.35)	3.13 (1.06)
General memory			
Prior nominal	2.11 (1.02)	2.47 (.77)	1.94 (.83)
Prior collaborative	3.06 (.93)	2.96 (1.00)	2.74 (.92)
Memory accuracy			
Prior nominal	3.11 (.76)	3.26 (2.30)	3.15 (1.06)
Prior collaborative	3.38 (.72)	3.00 (1.18)	3.13 (1.06)
Anxiety			
Prior nominal	2.22 (1.31)	2.16 (1.34)	2.24 (1.15)
Prior collaborative	2.13 (1.15)	2.38 (1.38)	2.04 (1.26)
Helpful other (How helpful is it to remember with someone else?)			
Prior nominal	4.00 (1.08)	3.74 (1.15)	3.76 (.90)
Prior collaborative	4.38 (.81)	4.58 (.58)	3.70 (1.11)

Note. Rating scales ranged from 1 (*lowest or least variable*) to 5 (*highest or most favorable*).

Discussion

The current experiment is the first to examine collaborative inhibition in same-age and mixed-age partners. On an initial test, the magnitude of collaborative inhibition for veridical recall was the same for young/young, old/old, and young/old dyads. However, age differences emerged in false recall as older adults were less likely to correct each other's errors than young adults, and also demonstrated higher false recall overall. Importantly, on Recall Test 2 and recognition, any initial age differences in collaboration disappeared. Specifically, on Recall 2, there were no post collab-

Table 7
Mean Partner-Memory Ratings as a Function of Age Group (Young/Young, Young/Old, or Old/Old; N = 144)

Collaboration	Young young	Young old	Old old
Memory ability			
Prior collaborative	3.33 (.76)	3.71 (.55)	2.96 (1.16)
Memory confidence			
Prior collaborative	3.54 (.78)	3.83 (.64)	3.17 (1.01)
General memory			
Prior collaborative	3.29 (.91)	3.5 (.88)	3.13 (.90)
Memory accuracy			
Prior collaborative	3.54 (.78)	3.79 (.66)	3.09 (1.00)
Anxiety			
Prior collaborative	1.83 (.82)	1.75 (.90)	2.29 (1.33)
Helpful other			
Prior collaborative	3.67 (.92)	4.13 (.90)	3.67 (1.01)

Note. Rating scales ranged from 1 (*lowest or least variable*) to 5 (*highest or most favorable*).

orative costs for correct items. Older adults continued to show higher rates of false recall overall, but the effects of prior collaboration on false recall were age-invariant. Likewise, the effects of prior collaboration on both veridical and false recognition were age-invariant. The current experiment is also the first to examine collaborative process variables in same-age and mixed-age dyads. Relative to same-age dyads, participants in mixed-age dyads were more likely to provide a simple acknowledgment and less likely to be silent, suggesting that mixed-age dyads interact differently than same-age dyads. Nonetheless, these differences in collaborative process variables did not influence the magnitude of collaborative inhibition.

The current experiment demonstrated that collaborative inhibition for veridical recall is age-invariant across same-age and mixed-age partners, and that any lasting effects of collaboration on subsequent individual recall and recognition were also age-invariant. This finding replicates previous research in same-age dyads (Barber et al., 2017; Blumen & Stern, 2011; Henkel & Rajaram, 2011; Meade & Roediger, 2009; Ross et al., 2008) and extends previous research by demonstrating the same pattern in mixed-age dyads. Related work on mixed-age differences in other paradigms demonstrates that young adults actively discount older adults' suggestions on a memory task (Davis & Meade, 2013; Meade et al., 2017; Numbers et al., 2019) and mixed-age dyads communicate in distinct ways (Siegel & Gregora, 1985). Further, young adults generally view collaboration with older adult partners as relatively less beneficial (Henkel & Rajaram, 2011). Nonetheless, mixed-age dyads in the current experiment performed the same as same-age dyads. This is theoretically important because it demonstrates age-invariance of retrieval strategy disruption across partners and provides a first step to understanding how and when age-based biases influence collaborative inhibition in mixed-age dyads.

Regarding false recall, older adults had higher false recall overall on recall Test 1 and, importantly, they were less likely than young adults to reduce errors in collaborative groups. Such results are broadly consistent with previous research demonstrating that older adults are especially susceptible to false memories produced during collaboration (Meade & Roediger, 2009). However, the results are inconsistent with research demonstrating that young and older adults are equally likely to correct each other's errors (Henkel & Rajaram, 2011; Ross et al., 2008). Methodological differences likely explain the discrepancies. Specifically, both Henkel and Rajaram (2011) and Ross et al. (2008) included an initial test prior to the critical collaborative or individual recall test. The strengthened organization associated with taking an initial test(s; Blumen & Rajaram, 2008; Congleton & Rajaram, 2011; Congleton & Rajaram, 2012) likely influenced the pattern of collaborative inhibition for false items. Further, Henkel and Rajaram designated the top three categorical exemplars as critical lures, whereas we selected five of the top 10. Given that older adults are especially likely to guess on categorized lists (Huff et al., 2011), the greater taxonomic frequency of our critical lures likely influenced older adults' ability to detect and correct each other's errors. Notably, older adults continued to demonstrate elevated false recall, but did not have higher false alarms on the final recognition test, presumably because the task demands of recognition drew attention to source and so minimized errors across all groups (cf. Davis & Meade, 2013; Multhaup, 1995).

The data reported here are also relevant to larger theoretical questions about if and how retrieval strategy disruption is complemented by additional processes (cf. Barber et al., 2015; Rajaram, 2018), as this was the first study to examine how collaborative processes influence collaborative inhibition in unacquainted same-age and mixed-age dyads. Importantly, we found that mixed-age dyads were more likely to respond to partner suggestions with a simple acknowledgment than to remain silent. This finding is consistent with previous research suggesting that mixed-age dyads spend more time on metacomments about the task than same-age partners (Siegel & Gregora, 1985) and that choosing to be silent may indicate not needing to explain oneself (Fivush, 2010). Therefore, one speculative explanation for why mixed-age dyads were less silent is that the situation was relatively unusual, and they felt more need to explain themselves (cf. Fivush, 2010). Further, on the final metacognitive questionnaire, older adults in mixed-age dyads were more likely to rate their partners as more helpful and having a better memory. Thus, both the collaborative process data and the metacognitive data demonstrate that mixed-age dyads interact differently than same-age dyads on memory tests.

Importantly, differences in collaborative processes across same-age and mixed-age dyads did not correspond to differences in collaborative inhibition, demonstrating that not all collaborative process variables are equally relevant to the magnitude of the collaborative inhibition effect. In the current study, the mixed-age dyads differed from same-age dyads primarily in terms of simple acknowledgments and silence but did not differ from same-age dyads in terms of elaborative acknowledgments. This finding is consistent with research demonstrating that collaborative inhibition is most influenced by differences in elaborative acknowledgments (e.g., Meade et al., 2009), and that mixed-age partners can match the performance of same-age partners, despite interacting differently (Siegel & Gregora, 1985). Our finding that differences in simple acknowledgments and silence did not influence collaborative inhibition provides evidence that there are boundary conditions to the influence of collaborative process variables on collaborative inhibition.

Collaborative process variables remain an important consideration in understanding the mechanisms of collaborative inhibition. Although retrieval strategy disruption (Basden et al., 1997) is the primary theoretical explanation for collaborative inhibition, there is growing evidence that several mechanisms underlie the effect (Barber et al., 2015). Further, because the theory is somewhat circular, there is a need for more direct measures of mechanisms that underlie collaborative inhibition. In the current experiment, we examined collaborative processes as an exploratory mechanism complementary to retrieval strategy disruption. Additional research is necessary to more formally determine how collaborative processes complement and/or influence retrieval strategy disruption. Additional research is also necessary to more precisely determine when and how collaborative process variables influence collaborative inhibition, as the results presented here suggest possible boundary conditions. Although we acknowledge that the word lists recalled in the current study may not promote conversational remembering, we did find differences in collaborative process variables between mixed-age and same-age dyads when remembering word lists. Thus, the current results offer a first step to explore collaborative process variables across a wider range of contexts. For example, it is important to understand the relative influence of collaborative process variables across different types of materials and different relationship status between collaborators. Such research, along with continued efforts to examine retrieval strategy disruption, will lead to a more complete understanding of collaborative inhibition.

More generally, understanding collaborative inhibition informs the patterns of gains and losses associated with collaborative memory and aging. Specifically, finding collaborative inhibition for correct items on initial recall demonstrates that collaboration can be disruptive to both young and older adults' memories. However, collaboration disrupted false memories as well, which demonstrates that collaboration can also benefit young and older adults' memory. Importantly, this disruption was relatively transient and did not carry over on subsequent recall and recognition tests. Understanding the boundary conditions of when and how collaboration disrupts memory is necessary for predicting gains and losses associated with collaborative memory and aging.

References

Baltes, P. B., & Staudinger, U. M. (Eds.). (1996). *Life-span perspectives on the social foundation of cognition*. New York, NY: Cambridge University Press.

Barber, S. J., Castrellon, J. J., Opitz, P., & Mather, M. (2017). Younger and older adults' collaborative recall of shared and unshared emotional pictures. *Memory & Cognition, 45,* 716–730. http://dx.doi.org/10.3758/s13421-017-0694-3

Barber, S. J., Harris, C. B., & Rajaram, S. (2015). Why two heads apart are better than two heads together: Multiple mechanisms underlie the collaborative inhibition effect in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 41,* 559–566. http://dx.doi.org/10.1037/xlm0000037

Basden, B. H., Basden, D. R., Bryner, S., & Thomas, R. L., III. (1997). A comparison of group and individual remembering: Does collaboration disrupt retrieval strategies? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23,* 1176–1189. http://dx.doi.org/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. http://dx.doi.org/10.1002/1099-0720(200011/12)14:6<497::AID-ACP665>3.0.CO;2-4

Battig, W. F., & Montague, W. E. (1969). Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. *Journal of Experimental Psychology Monograph, 80,* 1–46. http://dx.doi.org/10.1037/h0027577

Blumen, H. M., & Rajaram, S. (2008). Influence of re-exposure and retrieval disruption during group collaboration on later individual recall. *Memory, 16,* 231–244. http://dx.doi.org/10.1080/09658210701804495

Blumen, H. M., Rajaram, S., & Henkel, L. (2013). The applied value of collaborative memory research in aging: Behavioral and neural considerations. *Journal of Applied Research in Memory & Cognition, 2,* 107–117. http://dx.doi.org/10.1016/j.jarmac.2013.03.003

Blumen, H. M., & Stern, Y. (2011). Short-term and long-term collaboration benefits on individual recall in younger and older adults. *Memory & Cognition, 39,* 147–154. http://dx.doi.org/10.3758/s13421-010-0023-6

Clark, H. H., & Wilkes-Gibbs, D. (1986). Referring as a collaborative process. *Cognition, 22,* 1–39. http://dx.doi.org/10.1016/0010-0277(86)90010-7

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Congleton, A. R., & Rajaram, S. (2011). The influence of learning methods on collaboration: Prior repeated retrieval enhances retrieval organization, abolishes collaborative inhibition, and promotes post-collaborative memory. *Journal of Experimental Psychology: General, 140,* 535–551. http://dx.doi.org/10.1037/a0024308

Congleton, A., & Rajaram, S. (2012). The origin of the interaction between learning method and delay in the testing effect: The roles of processing and conceptual retrieval organization. *Memory & Cognition, 40,* 528–539. http://dx.doi.org/10.3758/s13421-011-0168-y

Craik, F. I. M., & McDowd, J. M. (1987). Age differences in recall and recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 474–479. http://dx.doi.org/10.1037/0278-7393.13.3.474

Davis, S. D., & Meade, M. L. (2013). Both young and older adults discount suggestions from older adults on a social memory test. *Psychonomic Bulletin & Review, 20,* 760–765. http://dx.doi.org/10.3758/s13423-013-0392-5

Dixon, R. A. (1999). Exploring cognition in interactive situations: The aging ofN + 1 minds. In T. M. Hess & F. Blanchard-Fields (Eds.), *Social cognition and aging* (pp. 267–290). Cambridge, MA: Academic Press.

Dixon, R. A. (2013). Collaborative memory research in aging: Supplemental perspectiveson application. *Journal of Applied Research in Memory and Cognition, 2,* 128–130.

Dixon, R. A., Gagnon, L. M., & Crow, C. B. (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). Hillsdale, NJ: Erlbaum.

Ekeocha, J. O., & Brennan, S. E. (2008). Collaborative recall in face-to-face and electronic groups. *Memory, 16,* 245–261. http://dx.doi.org/10.1080/09658210701807480

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. http://dx.doi.org/10.1037/0278-7393.26.6.1556

Fivush, R. (2010). Speaking silence: The social construction of silence in autobiographical and cultural narratives. *Memory, 18,* 88–98. http://dx.doi.org/10.1080/09658210903029404

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state." A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12,* 189–198. http://dx.doi.org/10.1016/0022-3956(75)90026-6

Gould, O., Kurzman, D., & Dixon, R. A. (1994). Communication during prose recall conversations by young and old dyads. *Discourse Processes, 17,* 149–165. http://dx.doi.org/10.1080/01638539409544863

Harris, C. B., Barnier, A. J., Sutton, J., & Keil, P. (2014). Couples as socially distributed cognitive systems: Remembering in everyday social and material contexts. *Memory Studies, 7,* 285–297. http://dx.doi.org/10.1177/1750698014530619

Harris, C. B., Barnier, A. J., Sutton, J., Keil, P. G., & Dixon, R. A. (2017). "Going episodic": Collaborative inhibition and facilitation when long-married couples remember together. *Memory, 25,* 1148–1159. http://dx.doi.org/10.1080/09658211.2016.1274405

Harris, C. B., Keil, P. G., Sutton, J., Barnier, A. J., & McIlwain, D. J. F. (2011). We remember, we forget: Collaborative remembering in older couples. *Discourse Processes, 48,* 267–303. http://dx.doi.org/10.1080/0163853X.2010.541854

Henkel, L. A., & Rajaram, S. (2011). Collaborative remembering in older adults: Age-invariant outcomes in the context of episodic recall deficits. *Psychology and Aging, 26,* 532–545. http://dx.doi.org/10.1037/a0023106

Hess, T. M. (2005). Memory and aging in context. *Psychological Bulletin, 131,* 383–406. http://dx.doi.org/10.1037/0033-2909.131.3.383

Huff, M. J., Meade, M. L., & Hutchison, K. A. (2011). Age-related differences in guessing on free and forced recall tests. *Memory, 19,* 317–330. http://dx.doi.org/10.1080/09658211.2011.568494

Johansson, N. O., Andersson, J., & Rönnberg, J. (2005). Compensating strategies in collaborative remembering in very old couples. *Scandinavian Journal of Psychology, 46,* 349–359. http://dx.doi.org/10.1111/j.1467-9450.2005.00465.x

Levy, B. (1996). Improving memory in old age through implicit self-stereotyping. *Journal of Personality and Social Psychology, 71,* 1092–1107. http://dx.doi.org/10.1037/0022-3514.71.6.1092

Logan, J. M., Sanders, A. L., Snyder, A. Z., Morris, J. C., & Buckner, R. L. (2002). Under-recruitment and nonselective recruitment: Dissociable neural mechanisms associated with aging. *Neuron, 33,* 827–840. http://dx.doi.org/10.1016/S0896-6273(02)00612-8

Marion, S. B., & Thorley, C. (2016). A meta-analytic review of collaborative inhibition and postcollaborative memory: Testing the predictions of the retrieval strategy disruption hypothesis. *Psychological Bulletin, 142,* 1141–1164. http://dx.doi.org/10.1037/bul0000071

Meade, M. L. (2013). The importance of group process variables on collaborative memory. *Journal of Applied Research in Memory & Cognition, 2,* 120–121. http://dx.doi.org/10.1016/j.jarmac.2013.04.004

Meade, M. L., Geraci, L. D., & Roediger, H. L., III. (2012). Neuropsychological status in older adults influences susceptibility to false memories. *The American Journal of Psychology, 125,* 449–467. http://dx.doi.org/10.5406/amerjpsyc.125.4.0449

Meade, M. L., & Gigone, D. (2011). The effect of information distribution on collaborative inhibition. *Memory, 19,* 417–428. http://dx.doi.org/10.1080/09658211.2011.583928

Meade, M. L., Harris, C. B., Van Bergen, P., Sutton, J., & Barnier, A. J. (Eds.). (2018). *Collaborative remembering: Theories, research, and applications*. New York, NY: Oxford University Press. http://dx.doi.org/10.1093/oso/9780198737865.001.0001

Meade, M. L., McNabb, J. C., Lindeman, M. I. H., & Smith, J. L. (2017). Discounting input from older adults: The role of age salience on partner age effects in the social contagion of memory. *Memory, 25,* 704–716. http://dx.doi.org/10.1080/09658211.2016.1207783

Meade, M. L., Nokes, T. J., & Morrow, D. G. (2009). Expertise promotes facilitation on a collaborative memory task. *Memory, 17,* 39–48. http://dx.doi.org/10.1080/09658210802524240

Meade, M. L., Perga, V. A., & Hart, K. M. (in press). Memory and aging in social contexts. In A. K. Thomas & A. Gutchess (Eds.), *Handbook of cognitive aging: A life course perspective*. New York, NY: Cambridge University Press.

Meade, M. L., & Roediger, H. L., III. (2006). The effect of forced recall on illusory recollection in younger and older adults. *The American Journal of Psychology, 119,* 433–462. http://dx.doi.org/10.2307/20445352

Meade, M. L., & Roediger, H. L., III. (2009). Age differences in collaborative memory: The role of retrieval manipulations. *Memory & Cognition, 37,* 962–975. http://dx.doi.org/10.3758/MC.37.7.962

Meade, M. L., Whillock, S. R., & Hart, K. M. (2019). Methodological considerations in collaborative memory and aging research. In N. Jones, M. Platt, K. Mize, & J. Hardin (Eds.), *Conducting research in developmental psychology: A topical guide for research methods used across the lifespan* (pp. 200–209). London, UK: Routledge/Taylor-Francis Publishers. http://dx.doi.org/10.4324/9780429352065-15

Multhaup, K. S. (1995). Aging, source, and decision criteria: When false fame errors do and do not occur. *Psychology and Aging, 10,* 492–497. http://dx.doi.org/10.1037/0882-7974.10.3.492

Nokes-Malach, T. J., Meade, M. L., & Morrow, D. G. (2012). The effect of expertise on collaborative problem solving. *Thinking & Reasoning, 18,* 32–58. http://dx.doi.org/10.1080/13546783.2011.642206

Numbers, K. T., Barnier, A. J., Harris, C. B., & Meade, M. L. (2019). Ageing stereotypes influence the transmission of false memories in the social contagion paradigm. *Memory, 27,* 368–378. http://dx.doi.org/10.1080/09658211.2018.1511809

Park, D. C., Lautenschlager, G., Hedden, T., Davidson, N. S., Smith, A. D., & Smith, P. K. (2002). Models of visuospatial and verbal memory across the adult life span. *Psychology and Aging, 17,* 299–320. http://dx.doi.org/10.1037/0882-7974.17.2.299

Rajaram, S. (2018). Collaborative inhibition in group recall: Principles and implications. In M. L. Meade, C. B. Harris, P. Van Bergen, J. Sutton, & A. J. Barnier (Eds.), *Collaborative remembering: Theories, research, and applications* (pp. 55–75). New York, NY: Oxford University Press.

Rajaram, S., & Pereira-Pasarin, L. P. (2010). Collaborative memory: Research and theory. *Perspectives on Psychological Science, 5,* 649–663. http://dx.doi.org/10.1177/1745691610388763

Ross, M., Spencer, S. J., Blatz, C. W., & Restorick, E. (2008). Collaboration reduces the frequency of false memories in older and younger adults. *Psychology and Aging, 23,* 85–92. http://dx.doi.org/10.1037/0882-7974.23.1.85

Ross, M., Spencer, S. J., Linardatos, L., Lam, K. C. H., & Perunovic, M. (2004). Going shopping and identifying landmarks: Does collaboration improve older people's memory? *Applied Cognitive Psychology, 18,* 683–696. http://dx.doi.org/10.1002/acp.1023

Shipley, W. C. (1946). *Institute of Living Scale*. Los Angeles, CA: Western Psychological Services.

Siegel, G. M., & Gregora, A. W. (1985). Communication skills of elderly adults. *Journal of Communication Disorders, 18,* 485–494. http://dx.doi.org/10.1016/0021-9924(85)90035-8

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. http://dx.doi.org/10.1080/09541440600872068

Van Bergen, P., Salmon, K., Dadds, M., & Allen, J. (2009). Training mothers in emotion-rich elaborative reminiscing: Facilitating children's autobiographical memory and emotion knowledge. *Journal of Cognition and Development, 10,* 162–187. http://dx.doi.org/10.1080/15248370903155825

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. http://dx.doi.org/10.1037/0278-7393.23.5.1160

Received April 25, 2019
Revision received April 10, 2020
Accepted April 19, 2020 ■