Journal of Experimental Psychology: Learning, Memory, and Cognition

Does Collaboration Help or Hurt Recall? The Answer Depends on Working Memory Capacity

Audrey V. B. Hood, Summer R. Whillock, Michelle L. Meade, and Keith A. Hutchison

Online First Publication, August 25, 2022. http://dx.doi.org/10.1037/xlm0001155

AMERICAN PSYCHOLOGICAL ASSOCIATION

Journal of Experimental Psychology: Learning, Memory, and Cognition

ISSN: 0278-7393

https://doi.org/10.1037/xlm0001155

Does Collaboration Help or Hurt Recall? The Answer Depends on Working Memory Capacity

Audrey V. B. Hood, Summer R. Whillock, Michelle L. Meade, and Keith A. Hutchison
Department of Psychology, Montana State University

Collaborative inhibition (reduced recall in collaborative vs. nominal groups) is a robust phenomenon. However, it is possible that not everyone is as susceptible to collaborative inhibition, such as those higher in working memory capacity (WMC). In the current study, we examined the relationship between WMC and collaborative inhibition. Participants completed three shortened span tasks (automated operation span, automated reading span, symmetry span). They then viewed categorized word lists individually and then recalled the word lists alone or with a partner (Test 1), followed by an individual recall (Test 2). For correct recall, collaborative inhibition was greater among lower WMC individuals, and they showed no post collaborative benefits. Only higher WMC individuals benefited from prior collaboration. For false recall, higher WMC individuals had less false recall on Tests 1 and 2, and collaboration reduced errors on Test 1 for both lower- and higher WMC individuals. There were no lasting effects of collaboration on Test 2 errors. Furthermore, partner WMC appeared to influence recall, although this tentative finding is based on a smaller sample size. Specifically, on Test 2, participants had less false recall when their partner was higher in WMC and greater correct recall when both they and their partner were higher in WMC. We conclude that collaboration is relatively more harmful for lower WMC individuals and more beneficial for higher WMC individuals. These results inform theories of collaborative inhibition by identifying attentional control and WMC as mechanisms that moderate the magnitude of the effect.

Keywords: collaborative inhibition, working memory capacity, collaborative recall, social memory, attention control

Collaborative inhibition refers to the counterintuitive finding that people recalling in collaborating groups recall less than the pooled, nonredundant recall of the same number of people recalling separately. Collaborative inhibition is a robust phenomenon, occurring across a range of study materials and persisting across the life span (see Rajaram, 2018, for review). However, it is possible that not everyone may be as susceptible to collaborative inhibition—such as those higher in working memory capacity (WMC). Working memory capacity refers to the ability to maintain information in the face of distractions (e.g., Engle, 2002), and it may influence how individuals remember together because they may be more or less able to manage the attentional demands of collaboration. Thus, the current study takes initial steps toward examining if there is a relationship between individual differences in WMC and collaborative inhibition. Further, we believe individual differences in WMC may inform theories of collaborative inhibition by identifying mechanisms that moderate the magnitude of the effect. To motivate our investigation, we begin with an overview of collaborative inhibition and recent evidence suggesting there are multiple mechanisms contributing to the effect. We then provide an overview of WMC and why this is an important individual difference factor that may influence group recall.

Correspondence concerning this article should be addressed to Michelle L. Meade, Department of Psychology, Montana State University, P.O. Box 173440, Bozeman, MT 59717-3440, United States. Email: mlmeade@montana.edu

Collaborative Inhibition

Most studies examining collaborative inhibition follow a similar paradigm (see Meade et al., 2018, for a wider range of paradigms). First, participants study materials (e.g., word lists) alone, followed by a distractor period. Participants then work alone or together in small groups to complete a memory test, where they are instructed to recall the studied material. To examine collaborative inhibition, the collaborating groups are compared with nominal groups (groups of people working individually, whose nonredundant answers are combined). The outcome of these studies is somewhat contrary to what would be expected. Although the recall of collaborating groups is higher than a single individual's recall (e.g., Hinsz et al., 1997), individuals recalling in collaborating groups recall less than individuals in nominal groups (Weldon & Bellinger, 1997).

The leading explanation for collaborative inhibition is the retrieval strategy disruption theory (RSD; Basden et al., 1997). According to RSD, individuals have their own idiosyncratic strategy for encoding and recalling material, leading them to organize learned material (e.g., a word list) in their own particular way. If an individual can use this organizational structure during recall, it will help guide retrieval and thus lead to optimal performance. However, when working in groups, this is difficult to do as any one individual's organization and recall strategy may be interrupted by another individual's organization and recall strategy (as it is unlikely that any two people would use identical strategies). This disruption to each individual's strategy results in suboptimal performance (i.e., collaborative inhibition).

Many studies have supported RSD theory. For example, Basden et al. (1997) found that collaborative inhibition was greater for groups who studied large categories than for groups who studied small categories (see Marion & Thorley, 2016, for discussion). Although the number of items that each participant learned was held constant, there are seemingly more ways to organize items when presented in large categories, resulting in more conflicting organization strategies among group members. Retrieval strategy disruption has also been supported in studies demonstrating that collaborative inhibition increases as group size increases as having more group members leads to more disruptions during recall (Thorley & Dewhurst, 2007). Finally, a recent meta-analysis found that, in addition to group size, the magnitude of collaborative inhibition is larger when collaborating pairs are unacquainted, when using a turn-taking (compared to free-flowing) recall procedure, and when using uncategorized materials (Marion & Thorley, 2016).

Although much research has supported the RSD theory, there are several findings that run counter to it. For example, in the meta-analysis conducted by Marion and Thorley (2016), three factors hypothesized to influence collaborative inhibition (category size, number of study/test phases, and encoding task) failed to significantly moderate the effect. Additionally, Meade and Roediger (2009) found that the magnitude of collaborative inhibition was equal across different retrieval conditions (free-report cued recall, forced-report cued recall, or free recall). This is problematic for RSD theory, which predicts that providing more retrieval structure (e.g., by providing category name cues) should minimize collaborative inhibition. Furthermore, Meade and Gigone (2011) argued that RSD theory cannot easily account for the difference in collaborative inhibition between shared and unshared items. Specifically, they found that the effect was larger for items presented to only a subset of group members than for items presented to all group members. However, RSD theory predicts that collaborative inhibition should be larger for shared items because retrieval of a shared item by one's partner should disrupt one's own strategy for recalling that same item. Finally, RSD theory predicts that collaborative inhibition should be smaller if encoding strategies are aligned; however, this result is not consistently found. For example, Barber et al. (2010) found that shared encoding still resulted in collaborative inhibition, whereas Harris et al. (2013) found that shared encoding eliminated collaborative inhibition. Thus, despite evidence supporting RSD theory, there is accumulating evidence that RSD alone is insufficient to explain collaborative inhibition and that additional mechanisms may be necessary to explain deficits for collaborative groups.

There is growing evidence that collaborative inhibition is multiply determined, and researchers have identified several alternative mechanisms that may operate in addition to RSD. For example, Barber et al. (2015) determined that, in addition to retrieval disruption, retrieval inhibition influences collaborative inhibition. The concept of retrieval inhibition stems from research on part-set cuing and occurs when cued words are strengthened, leading to the inhibition of noncued words, making those words unavailable for retrieval (Barber et al., 2015). If collaborative inhibition stems from retrieval inhibition, the negative effects of collaboration should persist on subsequent individual recall and recognition tests because the unrecalled words should remain inhibited in memory. Consistent with this, Barber et al. (2015) found that collaborative inhibition persisted on subsequent recall and recognition tests, although the effect was dampened.

An additional mechanism suggested to influence collaborative inhibition is collaborative process variables (Harris et al., 2011; Meade et al., 2009; Whillock et al., 2020). Collaborative process variables represent the ways in which individuals communicate with each other and the factors underlying the exchange of information (Meade, 2013; Meade & Gigone, 2011). As a reminder, Meade and Gigone (2011) found that collaborative inhibition was larger for unshared items than for shared items. They suggested this is because participants are less likely to acknowledge each other's contributions for unshared items. Without an acknowledgment from their partner(s) that an item was studied, participants may be less likely to include that item in the group recall (see too Ekeocha & Brennan, 2008). Taken together, there is accumulating evidence that several mechanisms may operate in conjunction with, and/or may be complementary to, RSD in explaining collaborative inhibition.

Because there is growing evidence that RSD cannot account for the entirety of the findings in the collaborative inhibition literature, there is a pressing need to identify factors and mechanisms that explain the nuances of collaborative inhibition. Understanding the mechanisms of collaborative inhibition is important as collaborative remembering can lead to both positive and negative outcomes. Negative outcomes include socially induced false remembering and forgetting (Cuc et al., 2007; Meade & Roediger, 2002) and are especially important to consider in educational settings, where group learning activities (such as tutored and peer-mediated learning) often take place (Rajaram & Pereira-Pasarin, 2010). A positive outcome includes potentially better memory on subsequent individual free recall tests (for example, Barber & Rajaram, 2011; Basden et al., 2000; Blumen & Rajaram, 2008; Weldon & Bellinger, 1997; but see Barber et al., 2015; Finlay et al., 2000; Meade & Roediger, 2009; Whillock et al., 2020, for evidence against such improvement on a subsequent test). Post collaborative benefits suggest that collaboration might serve as a relearning opportunity through reexposure to previously studied material. Because of the potential benefits, it is important to understand when and how collaboration helps or hurts memory. Examining individual differences for whom collaboration helps or hurts memory can provide a better understanding of when and how collaboration influences recall.

One specific individual difference that has been minimally explored in collaborative inhibition, yet could be critically important, is WMC. It is possible that those higher or lower in WMC may be less susceptible to collaborative inhibition, which would help inform and constrain potential theories. Specifically, researchers have identified mechanisms associated with individual differences in WMC, such as attention control abilities and secondary memory processes, which may play important roles in collaborative recall.

Working Memory Capacity

Working memory is a dynamic system responsible for maintaining information in the face of distraction (Engle & Kane, 2004), as well as retrieving information when it cannot be maintained (Unsworth &

Engle, 2007). Thus, two important mechanisms that contribute to WMC are attention control abilities and secondary memory processes, both of which will be discussed below.

Attention control refers to the ability to organize thoughts and behavior in accordance with internal goals (Miller & Cohen, 2001) and is particularly important for blocking out potential distractions while trying to maintain important information in immediate (or primary) memory. These distractions can arise through internal sources (e.g., intruding thoughts) or through environmental stimuli (e.g., a partner interrupting one's recall). There is a great deal of evidence demonstrating that individuals higher in WMC outperform those lower in WMC on attention-based tasks, such as the Stroop task (Hutchison, 2011), dichotic listening task (Conway et al., 2001), antisaccade task (Kane et al., 2001), sustained attention to response task (McVay & Kane, 2009), and the AX continuous performance task (Redick, 2014). Each of these tasks require maintaining goal-relevant responses in the face of distractions or habitual tendencies (Engle, 2002; Hutchison, 2007; Kane et al., 2007). Thus, performance differences are thought to arise due to lower WMC individuals' poorer ability to actively maintain task goals in the face of distractions or habits and instead being more likely to have their attention captured by irrelevant stimuli (Engle & Kane, 2004). Attention control may be particularly important during collaborative recall as one must keep attention focused on the to-be-recalled study items while simultaneously being interrupted by a partner.

Secondary memory is engaged when information is no longer in primary memory and one must retrieve it from long-term memory (Unsworth & Engle, 2007). What is critical is the ability to use current retrieval cues to correctly discriminate between relevant and irrelevant information stored in memory (e.g., Shiffrin, 1970; Shiffrin & Atkinson, 1969; Unsworth & Engle, 2007). As with attention tasks, individuals higher in WMC also outperform lower WMC individuals on a number of memory tasks including free recall, cued recall, serial recall, and recognition (e.g., Unsworth, 2010, 2016; Unsworth, Brewer, & Spillers, 2009; also see Unsworth & Engle, 2007, for a review). Specifically, a number of studies have shown that lower WMC individuals produce more intrusions (items not presented on the list) in free recall (Unsworth, 2007; although see Wahlheim et al., 2019) and cued recall (Rosen & Engle, 1997), as well as produce critical nonpresented lures from Deese-Roediger-McDermott word lists following prior warnings (Watson et al., 2005). Further, source monitoring abilities have been shown to mediate the relation between WMC and intrusions in recall (Unsworth & Brewer, 2010). Performance differences on memory tasks are thought to arise at least partly due to lower WMC individuals' poorer discrimination between relevant and irrelevant information when retrieving information from secondary memory (Unsworth & Engle, 2007). Secondary memory processes are therefore also important during collaborative recall as one must be able to effectively discriminate between relevant and irrelevant recall items.

Thus, individual differences in WMC not only relate to behavior during tasks requiring mental control but also may extend to interactive group environments. For instance, Hansen and Goldinger (2009) examined the role of WMC in the collaborative game of "Taboo." They found that higher WMC individuals were better at eliciting answers from teammates, were less likely to make perseveration errors (repeating previous guesses or clues), and made fewer Taboo errors (saying at least part of the target word). These results demonstrate that, in addition to being able to maintain information in the face of distractions, higher WMC individuals are also better at searching memory, self-monitoring for errors, and suppressing irrelevant or no-longer-useful information. Further, they demonstrate that measuring WMC provides a useful experimental method of isolating and identifying individual cognitive mechanisms contributing to social interactions.

WMC in the Collaborative Inhibition Paradigm

To our knowledge, only a few studies have examined WMC in collaborative inhibition or related paradigms. Most relevant to the current study, Barber and Rajaram (2011, Experiment 2) examined WMC within the collaborative memory paradigm. However, they could not directly assess the role of WMC on collaborative inhibition because they did not separate each individual's recall within the collaborative groups. They did, however, demonstrate that individuals higher in WMC (as evidenced by the performance on the operation span task [OSPAN]; Turner & Engle, 1989; Unsworth et al., 2005) showed greater post collaborative benefits. They interpreted this finding as evidence that individuals higher in WMC were more likely to derive relearning or reexposure benefits from collaboration. They did not correlate OSPAN with performance in the nominal condition, so it remains unknown if any advantage on individual recall at Test 2 is selective to collaboration. Nonetheless, this study suggests that higher WMC individuals may be more likely to benefit from prior collaboration than lower WMC individuals.

Research in related paradigms is also relevant. For instance, Cokely et al. (2006) and Barber and Rajaram (2011, Experiment 1) examined WMC in part-set cuing, which refers to the counterintuitive finding that providing multiple cues leads to a decrease in memory performance. One explanation for the part-set cuing effect is similar to that of collaborative inhibition in that it is a disruption of retrieval strategies (Basden & Basden, 1995). Cokely et al. (2006) and Barber and Rajaram (2011) both found that individuals higher in WMC (as evidenced by OSPAN performance) showed increased part-set cuing interference. The explanation for these findings was that higher WMC individuals engaged in better and more elaborate encoding strategies, resulting in more interference from the cues. This was supported in Cokely et al.'s second experiment, where participants were instructed to link the to-be-remembered words in a story such that each word was related to the next. This manipulation of equating encoding strategies across participants eliminated the relationship between WMC and interference. Thus, individuals with higher WMC may use more elaborative encoding strategies, which are more susceptible to interference during collaboration.

In contrast to findings from the part-set cuing task, there is a good deal of evidence from the attentional control literature that individuals higher in WMC should demonstrate less interference during collaboration. First, higher WMC individuals are better able to maintain information in the face of distractions. This ability should be especially important during collaborative recall as one would be intermittently interrupted by a partner. Second, higher WMC individuals are also better able to properly discriminate between relevant and irrelevant information when searching and retrieving information from secondary memory (Unsworth & Engle, 2007). This ability is also important in collaborative recall, both during the initial group recall and later individual recall, as one must be able to properly discriminate between to-be-recalled studied words, related nonstudied items, extralist intrusions, and items already produced by one's partner.

Current Study

The purpose of the current study was to examine whether there is a relationship between WMC and the collaborative inhibition effect. Participants were randomly assigned to either a collaborative or a nominal retrieval condition. All participants first completed three shortened complex span tasks as a measure of WMC. They then viewed categorized word lists individually and then recalled the word lists based on condition. Specifically, at Recall Test 1, those in the collaborative condition engaged in category-cued recall with a partner, whereas those in the nominal condition recalled individually. Additionally, everyone, regardless of condition, completed a second, individual recall test.

We chose to use categorized word lists in order to minimize WMC differences in nominal recall because category cues can provide retrieval support for low and high performers (cf. Meade & Roediger, 2006). Minimizing individual differences in baseline nominal recall is important because it allows for a cleaner examination of differences in the magnitude of collaborative inhibition, uncontaminated by potential scaling artifacts (Whillock et al., 2020). Second, minimizing individual differences in nominal recall at Test 1 will allow us to more clearly determine the influence of WMC and collaboration on subsequent recall (see Meade & Roediger, 2009, for further discussion; Meade & Roediger, 2006). Thus, we acknowledge that by choosing categorized lists, we are potentially reducing WMC differences in recall performance. However, we did not expect to eliminate the relationship entirely (see Unsworth et al., 2012). Further, we believed that minimizing individual differences in baseline recall would allow for a cleaner examination of both collaborative inhibition and post collaborative effects on subsequent recall. In the current study, we chose to use dyads and categorized lists. Although dyads and categorized lists may reduce the magnitude of the collaborative inhibition effect (Marion & Thorley, 2016; see too Rajaram & Pereira-Pasarin, 2010), we expected to find collaborative inhibition because we used the same categorized list paradigm that has reliably produced collaborative inhibition in past studies (e.g., Meade & Gigone, 2011; Meade & Roediger, 2009; Whillock et al., 2020).

Because we had the additional individual difference factor of WMC for each participant, we recorded each individual's own recall during collaboration, which allowed us to examine both individual and pooled recall. Thus, in our analyses, we used individual WMC and collaboration condition to predict individual memory performance. This is critical for understanding how individual differences in WMC modulate the impact of collaboration on memory performance (cf. Barber & Rajaram, 2011). Specifically, doing so allowed us to examine whether collaborative recall differentially affects initial recall for higher- and lower WMC individuals, as well as how individual differences in WMC might relate to subsequent recall following collaboration. Furthermore, this procedure allowed us to disentangle how collaborative memory performance relates to an individuals' own WMC from that of one's recall partner.

Based on the working memory and collaborative inhibition literatures, we had three competing hypotheses, shown in Figure 1. Because numerous studies have found that individuals higher in WMC outperform those lower in WMC on memory tasks (e.g., Unsworth, 2010, 2016; Unsworth, Brewer, & Spillers, 2009; also see Unsworth & Engle, 2007, for a review), all three hypotheses predicted better nominal performance among individuals higher in WMC. However, because we were using categorized word lists, this difference between higher- and lower WMC individuals should be minimal. That being said, the differences between the three competing hypotheses focus solely on the predicted pattern for the collaborative condition.

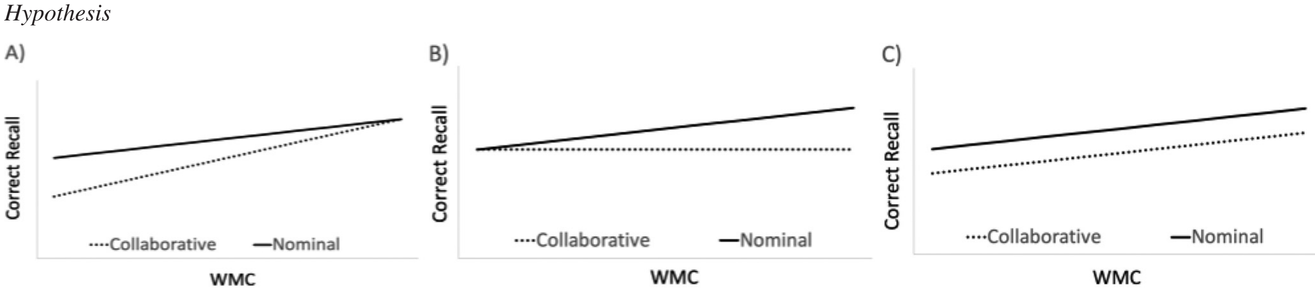
We note that these hypotheses are not contrary to RSD theory. Instead, our goal was to identify mechanisms that may further inform theories of collaborative inhibition. Also, the hypotheses in Figure 1 display our preregistered predictions. However, based on the obtained results and discussions with reviewers, we include a revised account of the attentional control hypothesis, which we reserve for the "Discussion" section.

Attentional Control Hypothesis

Individual differences in WMC exist due to differences in abilities to actively maintain information in the face of distractions, as well as retrieve task-relevant information when maintenance has been impeded (Engle, 2002; Engle & Kane, 2004; Shipstead et al., 2016). These abilities are especially important in collaborative recall as the task is to recall items while being interrupted by a partner's recall, requiring individuals to keep items accessible in

Figure 1

Anticipated Results in Support of the (A) Attentional Control Hypothesis, (B) Elaborate Encoding Hypothesis, and (C) Additive Hypothesis



Note. WMC = working memory capacity.

the face of this interruption and avoid recalling items their partner has already called. Therefore, successful task performance requires greater attentional control to help focus attention in the face of frequent distractions, as well as recover quickly from such distractions. If the magnitude of collaborative inhibition is related to the ability to maintain information in the face of distraction, individuals lower in WMC will demonstrate greater collaborative inhibition than individuals higher in WMC (Figure 1A).

Elaborate Encoding Hypothesis

In contrast, if the magnitude of collaborative inhibition is related to differences in elaborative encoding strategies, then higher WMC individuals will demonstrate greater collaborative inhibition than lower WMC individuals. The explanation is that higher WMC individuals are more likely to create and use elaborative encoding strategies, which puts them at greater risk of interference due to disruption of this strategy. Results supporting this hypothesis would be in line with results from Cokely et al. (2006) and Barber and Rajaram (2011, Experiment 1; Figure 1B).

Additive Hypothesis

Lastly, it is possible that the magnitude of collaborative inhibition is the same for higher- and lower WMC individuals (Figure 1C). Such a finding could be due to one of two alternative explanations. First, it could suggest that collaborative inhibition is not related to WMC processes (i.e., individual differences in attention control and elaborate encoding do not relate to collaborative inhibition). Alternatively, it is possible that processes consistent with both attention control and elaborate encoding occur simultaneously, causing the effects to cancel each other out and produce a null effect of WMC.

For the subsequent individual test, some studies have found that participants who were formerly part of a collaborative group perform better on subsequent individual free recall tests (e.g., Barber & Rajaram, 2011; Basden et al., 2000; Blumen & Rajaram, 2008; Weldon & Bellinger, 1997); however, post collaborative benefits are not always observed on subsequent tests (e.g., Finlay et al., 2000; Meade & Roediger, 2009; Whillock et al., 2020). These mixed results may be due, in part, to differences in experimental methodologies and study materials (e.g., an initial recall test prior to collaboration vs. no initial test, uncategorized vs. categorized word lists). Based on evidence demonstrating enhanced secondary memory retrieval among higher WMC individuals (Unsworth & Engle, 2007; Unsworth et al., 2014) and that greater executive control (measured with the automated operation span task) is associated with greater post collaborative benefits (Barber & Rajaram, 2011), we hypothesized that individuals higher in WMC would demonstrate greater post collaborative benefits at Test 2 than individuals lower in WMC. Note that this specific hypothesis was not included in our preregistration, which focused exclusively on Recall Test 1; however, we predicted this pattern of results based on previous studies (e.g., Barber & Rajaram, 2011).

Method

Participants

This study was preregistered and is publicly available at the following URL: https://aspredicted.org/f559x.pdf. We conducted an a priori power analysis using G-Power based on a previous experiment with similar measures (Marion & Thorley, 2016). In doing so, we were able to estimate a sample size of 36 participants to achieve power of .90 given our predicted effect size (Cohen's *d*) of .56 and interaction with a second variable. However, because our second variable was an individual difference factor (WMC), we planned to approximately double the suggested sample size to achieve sufficient variability in WMC within each group (approximately 64 per group). A total of 133 undergraduate students (female = 54.1%; M_{age} = 19.78, SD_{age} = 3.06) from Montana State University were recruited to take part in the study for partial course credit. All participants had normal or corrected-to-normal vision. The decision to remove or exclude data from any participant was based on notes made by research assistants during the data collection process. Thus, these data were never entered or analyzed. Data from one extra participant in the nominal condition were removed because there were no more nominal participants from which to pool the data. For the collaborative condition, when there were problems with at least one participant, data from both partners were removed. Data from 12 participants in the collaborative condition were removed for the following reasons: Two participants' data were collected during a training session, two participants had to leave midexperiment from being sick, two participants had to leave midexperiment claiming neurological issues, two participants clicked ahead and saw the word lists prior to the start of the experiment, and two participants claimed they already knew each other and had a "bad history" together. The final pair of collaborative participants' data were removed to equate the number of pairs in the nominal and collaborative conditions (final *N* = 120; female = 51.7%; M_{age} = 19.91, SD_{age} = 3.19; M_{years} post-high-school education = 1.31, SD_{years} post-high-school education = 1.11). The majority of the final sample was non-Hispanic or Latino (95.8%), native English speaking (97.5%), and White (88.3%; American Indian/Alaska Native = 1.7%, Asian = 3.3%, Black = .8%, Native Hawaiian/other Pacific Islander = .8%, bi/multiracial = 5%). The final sample consisted of 60 participants in the nominal condition and 60 participants in the collaborative condition, resulting in 30 dyads per condition. This study was approved by the Montana State University Institutional Review Board.

Materials

Working Memory Tasks

Working memory capacity was measured with the automated operation span task (AOSPAN; Unsworth et al., 2005), automated reading span task (RSPAN; Unsworth et al., 2005; see Daneman & Carpenter, 1980), and symmetry span task (SSPAN; Kane et al., 2004; Unsworth, Redick, et al., 2009). The shortened versions of these tasks were used as they take less time than the full-length versions but still produce valid estimates of WMC (Foster et al., 2015; Oswald et al., 2015). Having participants complete three complex-span tasks allowed us to create a composite score, which gives a reliable and valid estimate of WMC as a construct (Foster et al., 2015).

Each of these tasks required participants to engage in a processing task followed by the presentation of to-be-remembered items. During the AOSPAN, participants were asked to verify the accuracy of a solution to a math problem (e.g., (6/2) + 3 = ?; 7), whereas during the RSPAN, participants were asked to verify the meaningfulness of sentences (e.g., "The ship sailed across the dishwasher"). Following the verification of either a sentence or math operation, a capital letter (out of a list of 12 possible letters) appeared for 250 ms. This verification-letter sequence consisted of three to seven verification-letter pairs for the AOSPAN and between four and six verification-letter pairs for the RSPAN. Following the verification-letter sequence, a grid containing all 12 possible letters appeared on the screen. Participants were instructed to indicate all of the letters from that set in the order in which they were presented via a mouse click. During the SSPAN, participants were asked to verify whether a matrix was symmetrical along its vertical axis. Following the verification of the shape, a 4 × 4 grid appeared on the screen with one of the cells filled in red. Following a set of between three and seven verification-grid pairs, participants were asked to recall the sequence of red-square locations in the preceding displays in the order they appeared by clicking on the cells of an empty matrix.

All three span tasks were presented using E-Prime software. The AOSPAN and RSPAN were scored by summing the number of letters recalled in the correct serial position, as recommended by Conway and colleagues (Conway et al., 2005). The SSPAN was scored similarly, by summing the number of red-square locations recalled in the correct order.[1]

Memory Stimuli

Six categorized word lists were selected from Meade and Roediger (2006) and constructed from the Battig and Montague (1969) word norms. The top 22 exemplars were selected from six categories (i.e., birds, human body parts, vegetables, animals, articles of clothing, and flowers). From there, the top five most common exemplars from each category (e.g., "robin" in the bird list) were removed from the word lists to serve as the critical items to measure false recall for items that were not presented. The other 17 of the top 22 exemplars served as the presented items. Thus, each category contained 17 presented items and five nonpresented critical items. In total, participants were presented 17 items for each of the six categorized lists, resulting in 102 presented items. Consistent with the categorized list paradigm used in previous collaborative inhibition studies (e.g., Meade & Roediger, 2009; Whillock et al., 2020), the items were presented and blocked by category such that all items in one category were presented within the same list (e.g., all birds were presented in List 1). Recall was determined by having subjects produce the items on their own (nominal condition) or in collaboration with a fellow participant (collaborative condition).

Filler Task

The mathematical filler task consisted of simple arithmetic problems. Specifically, participants were handed a sheet of paper with 36 multiplication problems. They were asked to complete as many as they could in two minutes.

Post Experiment Questionnaires

Participants completed two brief post experiment questionnaires. The first was the metamemory questionnaire, which asked participants to rate their confidence and accuracy in their own performance, as well as their partner's (if applicable), and the helpfulness in working with a partner (if applicable). The second was the strategy questionnaire, which asked the participants to describe any particular strategies they adopted during recall of the word lists. Lastly, participants completed a brief demographics questionnaire regarding age, sex, education, and ethnicity.

Procedure

Procedures were based closely on the categorized list paradigm used in previous collaborative inhibition studies (e.g., Meade & Gigone, 2011; Meade & Roediger, 2009; Whillock et al., 2020). Participants were randomly assigned to either the collaborative or nominal condition. Participants in the nominal condition were always run individually, and participants in the collaborative condition were always run in pairs. Regardless of retrieval condition, participants first completed the three shortened working memory tasks (AOSPAN, RSPAN, and SSPAN) individually. After completing all three working memory tasks, participants were given instructions for viewing the word lists. Specifically, participants were told they would see a series of word lists presented on the computer screen. The encoding phase was always individual such that each participant viewed the word lists on their own computer. Participants were instructed to pay attention to each word because their memory for the words would be tested later. After receiving these instructions, participants were presented with six categorized word lists (i.e., birds, human body parts, vegetables, four-footed animals, articles of clothing, and flowers). Each list was presented sequentially, and the experimenter verbally labeled each upcoming list, instructing participants that "[list category] will be the next list, and you may press the enter key to begin." After viewing the final word list, participants completed a mathematical filler task in order to prohibit explicit rehearsal of the words. Participants were handed a sheet of paper with 36 multiplication problems and were instructed to complete as many problems as they could in 2 min.

After the 2-min filler task, participants began Recall Test 1. During Recall Test 1, participants recalled, out loud, as many items as they could remember from the six different word lists while the experimenter wrote down their recalled items on a piece of paper. Half of the participants recalled individually (nominal condition), and the other half recalled with a partner (collaborative condition). All participants recalled one list at a time, but words within each list could be recalled in any order. Participants were instructed to recall only those items they were reasonably sure appeared on the study lists. Participants had 2 min per word list, which was timed using a stopwatch by the experimenter. The experimenter kept track of the recalled items by writing them down on a sheet of paper with the participants' ID number listed on the top. Thus, even when participants worked together to recall in the collaborative condition, their individual recall was scored so that we could link their recall with their WMC. Participants in the collaborative condition recalled under "free-for-all" instructions, meaning that participants were not instructed to take turns or come to any consensus. If participants asked how they should collaborate, experimenters simply stated that the participants should recall however they thought was best. Recall was audio recorded for future potential investigation of collaborative processes variables or the interactional dynamics between collaborators (cf. Meade, 2013).

[1] We did not use any exclusion criteria for AOSPAN, RSPAN, or SSPAN performance. The positive relationship between processing accuracy and storage/recall suggests that using a processing score cutoff would remove data from more lower-span than higher-span individuals (see Richmond et al., 2021; Unsworth et al., 2009).

After recalling all six word lists in Recall Test 1, participants immediately moved to Test 2. During Recall Test 2, all participants recalled individually and were again given 2 min per list to recall as many items from the original word lists as they could. Participants recalled one list at a time, but within each list, they could recall the words in any order. Participants were reminded to only write down words they were reasonably sure appeared on the original word lists. Because Recall Test 2 was always completed individually in both the collaborative and nominal conditions, participants wrote down their own recall on a sheet of paper. This procedure is consistent with many collaborative inhibition studies that include an initial verbal recall followed by written recall (e.g., Meade & Roediger, 2009; see too Gardiner et al., 1977, for discussion of different response options on memory). After recalling all six word lists in Test 2, participants completed the metamemory questionnaire, strategy questionnaire, and demographics. Lastly, participants were thanked and debriefed.

Results

Working Memory Capacity

To create the WMC composite, participants' AOSPAN, RSPAN, and SSPAN scores were converted to z scores, and their z scores were averaged across the three tasks. We then conducted an independent-samples t test on collaborative versus nominal to ensure the WMC composite scores did not differ between our two retrieval conditions. This t test was nonsignificant, $t(118) = .750$, $p = .455$, indicating no significant difference in WMC across the two conditions.

Collaborative Inhibition

We ran independent-groups t tests to examine collaborative inhibition and post collaborative recall comparing the pooled recall of participants in the nominal and collaborative conditions at Test 1 and, separately, comparing their individual recall at Test 2 (see Table 1 for means). There was a significant effect of Retrieval Condition on correct recall at Test 1 such that participants in the nominal condition recalled significantly more correct items than participants in the collaborative condition, $t(58) = -3.02$, $p = .004$. Thus, we replicated collaborative inhibition in our current sample (Weldon & Bellinger, 1997). There was no effect of Retrieval Condition on correct recall at Test 2, $t(118) = .839$, $p = .403$, demonstrating no differences in post collaborative recall (Finlay et al., 2000; Meade & Roediger, 2009). There was a significant difference in false recall at Test 1 such that participants in the nominal condition recalled significantly more false items than participants in the collaborative condition, $t(58) = -2.41$, $p = .019$, replicating error correction in collaborative groups (Harris et al., 2012; Ross et al., 2008). There were no significant differences for false recall at Test 2, $t(118) = .716$, $p = .475$ (Meade & Roediger, 2009; Whillock et al., 2020).

Table 1
Mean Proportion (Standard Deviation) of Recalled Items as a Function of Retrieval Condition (Collaborative or Nominal) at Recall Test 1 and Test 2

Retrieval Condition	Recall Test 1	Recall Test 2
Correct recall		
Nominal	.602 (.109)	.421 (.115)
Collaborative	.519 (.104)	.438 (.116)
False recall		
Nominal	.347 (.180)	.241 (.190)
Collaborative	.238 (.170)	.265 (.176)

Working Memory Capacity as a Predictor of Collaborative Memory

For analyses involving WMC, we supplemented our frequentist analyses with Bayesian analyses (JASP Team, 2019) to test for possible concerns over power for detecting individual differences. Thus, we report Bayesian evidence for the interactions involving WMC. For each analysis, we compared the model containing the interaction involving WMC to the null model that is missing the interaction. The resulting Bayes factor (BF_{10}) shows the ratio of how much better the model with the interaction predicts the data over the null model missing that interaction. For instance, a BF_{10} of 3 indicates the model containing the effect is 3 times more likely than the null model missing that component, and a BF_{10} of .33 means the null model is 3 times more likely than the model containing the effect. According to the classification scheme from Lee and Wagenmakers (2013; adjusted from Jeffreys, 1961), a BF_{10} of 10–30 = strong evidence, 3–10 = moderate evidence, 1–3 = anecdotal (weak) evidence, and 1 = no evidence. (Note that values < 1 equal evidence for the null such that .33 and .10 equal moderate and strong evidence for the null hypothesis, respectively.)[2]

Typically, in the collaborative inhibition paradigm, the recall for individuals who work together in the collaborative condition is combined and then compared to the pooled, nonredundant recall of individuals working in the nominal condition. However, because we have the individual difference factor of WMC for each participant, we used each individual's own recall during collaboration (instead of the pooled recall). This creates an important caveat for Recall Test 1 that we want to bring to the reader's attention.

Because we were examining individual recall within a collaborative paradigm, individuals in the collaborative condition were likely going to produce less recall than individuals recalling alone because they can only produce items not already recalled by their partner. Therefore, in the regression analyses examining recall at Test 1, we included Retrieval Condition as a factor, but we are not discussing the main effect of Retrieval Condition (these data are, however, provided in Table 2) as the main effect of collaborative inhibition was already tested in the more appropriate t test comparison described above. The multiple regression analyses were conducted to test whether collaborative inhibition interacts with WMC. We note that this caveat only applies to Recall Test 1 as everyone recalled individually at Recall Test 2. Therefore, for Recall Test 2, we also report the main effects of Retrieval Condition.

Correct Recall

Recall Test 1. We first examined correct recall between the collaborative and nominal conditions as a function of WMC, beginning with Recall Test 1 (see Figure 2). As a reminder, because we had the additional individual difference factor of WMC for each participant,

[2] It is important to note that although these labels help facilitate scientific communication, they approximate standards of evidence (e.g., Rosnow & Rosenthal, 1989; Wagenmakers et al., 2018).

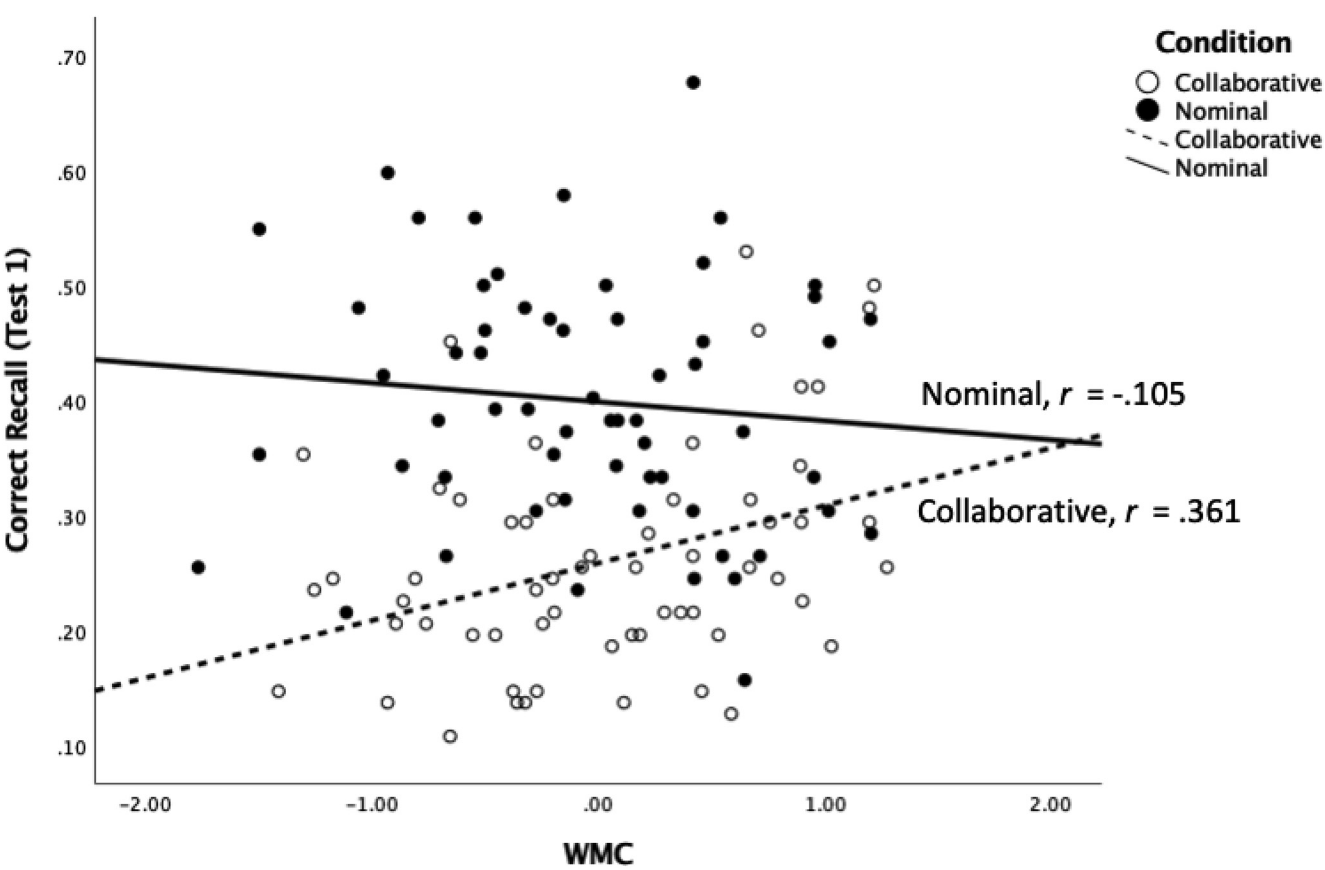
Table 2
Results of Regression Analyses (Correct Recall)

Regression analysis	*B*	*SE*	β	*t*	*F*	Adjusted R^2
Recall Test 1						
Step 1						
Retrieval Condition	−.070	.009	−.567	−7.44***	27.99***	.312
WMC	.017	.014	.098	1.29		
Step 2						
Retrieval Condition × WMC	.033	.013	.186	2.51***	21.59***	.342
Recall Test 2						
Step 1						
Retrieval Condition	.007	.010	.065	.716	2.15	.019
WMC	.028	.015	.172	1.89		
Step 2						
Retrieval Condition × WMC	.038	.015	.231	2.61*	3.77*	.065

Note. WMC = working memory capacity; composite score of shortened AOSPAN, RSPAN, and SSPAN.
* $p < .05$. *** $p < .001$.

we used each individual's own recall during collaboration (instead of the pooled recall). In this first analysis, we regressed individual correct recall during Test 1 on Retrieval Condition (collaborative or nominal) and WMC (*z*-scored composite) in Step 1 to examine the main effects and entered the Retrieval Condition × WMC interaction in Step 2. These regression results are shown at the top of Table 2. (As discussed above, the main effect of Retrieval Condition in Recall 1 was already discussed above using the more appropriate pooled group data and will not be discussed here.) There was a significant WMC × Retrieval Condition interaction (β = .186, t = 2.51, p = .014, BF_{10} =

Figure 2
Correct Recall at Test 1 as a Function of Working Memory Capacity (WMC)



Note. The solid line (filled circles) represents individual participants' correct recall within the nominal condition, and the dotted line (open circles) represents individual participants' correct recall within the collaborative condition. This figure exaggerates the effects of collaboration as individuals in the collaborative condition only recalled items not already recalled by their partner.

3.44) such that collaborative inhibition was greater among those lower in WMC. As shown in Figure 2, this interaction is due to collaboration being especially disruptive among lower WMC individuals. Although the regression analysis included the full range of WMC, we next examined just the upper and lower quartile of WMC to illustrate this interaction. For those in the lower quartile of WMC, an independent-samples t test revealed that those in the nominal condition recalled significantly more correct items (M = .413, SD = .120) compared to those in the collaborative condition (M = .242, SD = .092), $t(27) = -4.26$, $p < .001$. In contrast, for those in the upper quartile of WMC, there were no significant differences in correct recall between those in the nominal condition (M = .361, SD = .122) and those in the collaborative condition (M = .331, SD = .116), $t(28) = -.689$, $p = .496$. Thus, collaborative inhibition occurred among the individuals in our sample that were lower in WMC, whereas it did not occur among those higher in WMC. One can also examine this interaction using the full range of WMC by examining the differential relation between WMC and recall for collaborative and nominal groups. In this case, WMC differences only existed in the collaborative condition as the correlation of WMC and correct recall is significant for those in the collaborative condition (r = .361, p = .005) but not those in the nominal condition ($r = -.105$, $p = .423$). Note that this null effect of WMC for nominal recall is counter to all three hypotheses and yet is not surprising given our use of categorized lists.

Recall Test 2. The relation between WMC, Retrieval Condition, and correct recall at Test 2 (which always took place individually) is shown in Figure 3, with the regression results shown at the bottom of Table 2. There was no main effect of Retrieval Condition (β = .065, t = .716, p = .476) or WMC (β = .172, t = 1.89, p = .061). There was a significant WMC × Retrieval Condition interaction (β = .231, t = 2.61, p = .010, BF_{10} = 5.92) with effects of collaboration again differing as a function of WMC. To explore this interaction further, we again examined the upper and lower quartile of WMC. For those in the lower quartile of WMC, an independent-samples t test revealed that there were no significant differences in correct recall between participants who had previously recalled by themselves (nominal condition; M = .424, SD = .111) or with a partner (collaborative condition; M = .386, SD = .094), $t(27) = -.745$, $p = .463$. In contrast, those in the upper quartile of WMC showed post collaborative benefits such that those who had previously recalled with a partner (collaborative condition) recalled significantly more correct items (M = .528, SD = .133) than those who previously recalled by themselves (nominal condition; M = .382, SD = .140), $t(28) = 2.91$, $p = .007$. As was the case for Recall Test 1, the relation between WMC and correct recall was significant among those in the collaborative condition (r = .402, p = .002) but not among those in the nominal condition ($r = -.064$, p = .624). These results demonstrate a post collaborative benefit on correct recall, but only for individuals higher in WMC.

To examine changes in individual recall performance from Test 1 to Test 2, we included individual recall at Test 1 in our multiple regression analysis.[3] Specifically, we ran a multiple regression predicting individual recall at Test 2 from individual recall at Test 1, Retrieval Condition, WMC, and Retrieval Condition × WMC interaction. Not surprisingly, individual recall at Test 2 was predicted by individual recall at Test 1 (β = .950, t = 18.023, $p < .001$). However, the only other significant predictor was Retrieval Condition ($\beta = -.148$, $t = -11.567$, $p < .001$). There was no main effect of WMC (β = .012, t = 1.539, p = .127) or Retrieval Condition × WMC interaction (β = .007, t = .867, p = .388). This demonstrates that the relation between WMC and correct recall performance did not change from Test 1 to Test 2. One can see this by comparing Figure 2 to Figure 3. Specifically, although those in the collaborative condition recalled about 15% more items at Test 2 than at Test 1 (because they can recall all words at Test 2, rather than just those their partner has not recalled), this boost from Test 1 to Test 2 was similar across levels of WMC. If there was a differential benefit for higher- versus lower WMC individuals, we would have seen a change in the slope from Test 1 to Test 2. Note, also, that this boost from Test 1 to Test 2 is different from a post collaborative benefit, which does not consider individual recall performance on Test 1. Instead, a post collaborative benefit focuses only on Test 2 and compares the prior collaborative group to the prior nominal group.

False Recall

Recall Test 1. We next examined false recall between the collaborative and nominal conditions as a function of WMC in the same manner as we examined correct recall. These regression results are shown at the top of Table 3, and the data are shown in Figure 4. Like correct recall, the main effect of Retrieval Condition for false recall at Test 1 was already discussed using the more appropriate pooled group data and will not be discussed here (these data are, however, displayed in Table 3). There was a main effect of WMC such that false recall decreased among those higher in WMC, $\beta = -.266$, $t = -3.11$, p = .002. There was no significant interaction, suggesting that the effects of collaboration on false recall are independent of individual differences in WMC. The BF_{10} for the interaction was .28 (showing moderate evidence in favor of the null). Thus, both higher- and lower WMC individuals benefited from error correction in collaborative groups.

Recall Test 2. The relation between WMC, Retrieval Condition, and false recall at Test 2 (again, which always took place individually) is shown in Figure 5, with the regression results shown at the bottom of Table 3. There was a main effect of WMC, with reduced false recall among those higher in WMC, $\beta = -.206$, $t = -2.28$, p = .024. There was no main effect of Retrieval Condition (β = .080, t = .884, p = .379) or WMC × Retrieval Condition interaction ($\beta = -.035$, $t = -.386$, p = .701, BF_{10} = .34), suggesting that any collaborative advantage in reducing errors at Test 1 does not persist to Test 2. This is the case regardless of one's WMC.

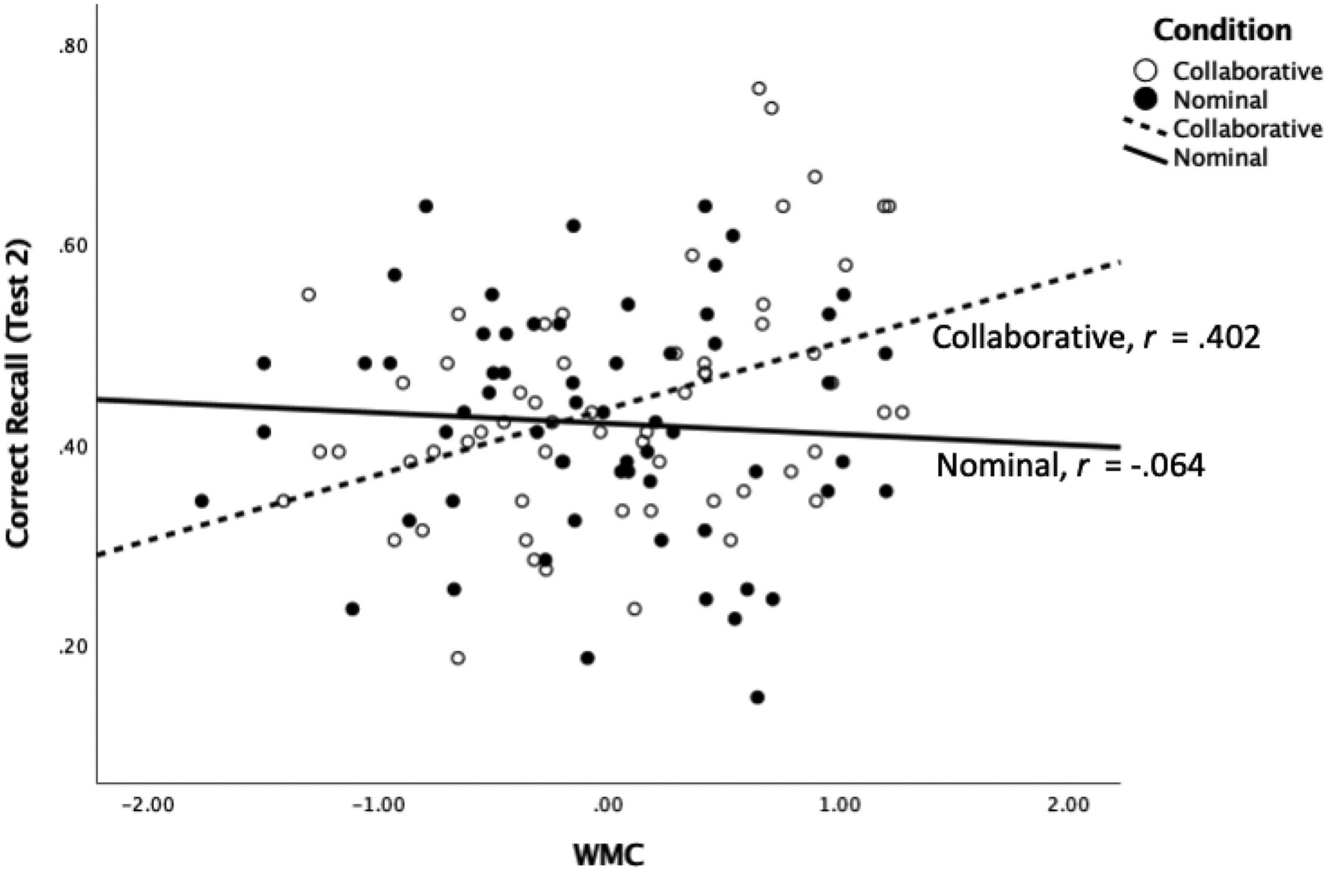
We again examined changes in individual recall performance from Test 1 to Test 2 for false recall. To do so, we included individual recall at Test 1 in our multiple regression analysis. Specifically, we ran a multiple regression predicting individual false recall at Test 2 from individual false recall at Test 1, Retrieval Condition, WMC, and Retrieval Condition × WMC interaction. Not surprisingly, individual false recall at Test 2 was predicted by individual false recall at Test 1 (β = 1.042, t = 16.532, $p < .001$). However, like correct recall, the only other significant predictor was Retrieval Condition ($\beta = -.116$, $t = -6.163$, $p <$ .001). There was no main effect of WMC (β = .008, t =, 585, p = .560) or Retrieval Condition × WMC interaction ($\beta = -.002$, $t = -.116$, p = .908). This again demonstrates that WMC did not affect changes in false recall performance from Test 1 to Test 2.

Extralist Intrusions

An extralist intrusion (ELI) is any item that participants recall on the memory test that was not presented to participants (i.e., correct

[3] We thank an anonymous reviewer for this suggestion.

Figure 3
Correct Recall at Test 2 as a Function of Working Memory Capacity (WMC)



Note. The solid line (filled circles) represents individual participants' correct recall within the nominal condition, and the dotted line (open circles) represents individual participants' correct recall within the collaborative condition. All participants recalled alone for Test 2.

recall) or one of the critical lures (i.e., false recall). Although ELIs were very low in the current data (less than one per word list) and this was not our primary dependent variable, we examined the relationship between WMC, Retrieval Condition, and ELIs as further evidence of group and WMC differences in false recall.

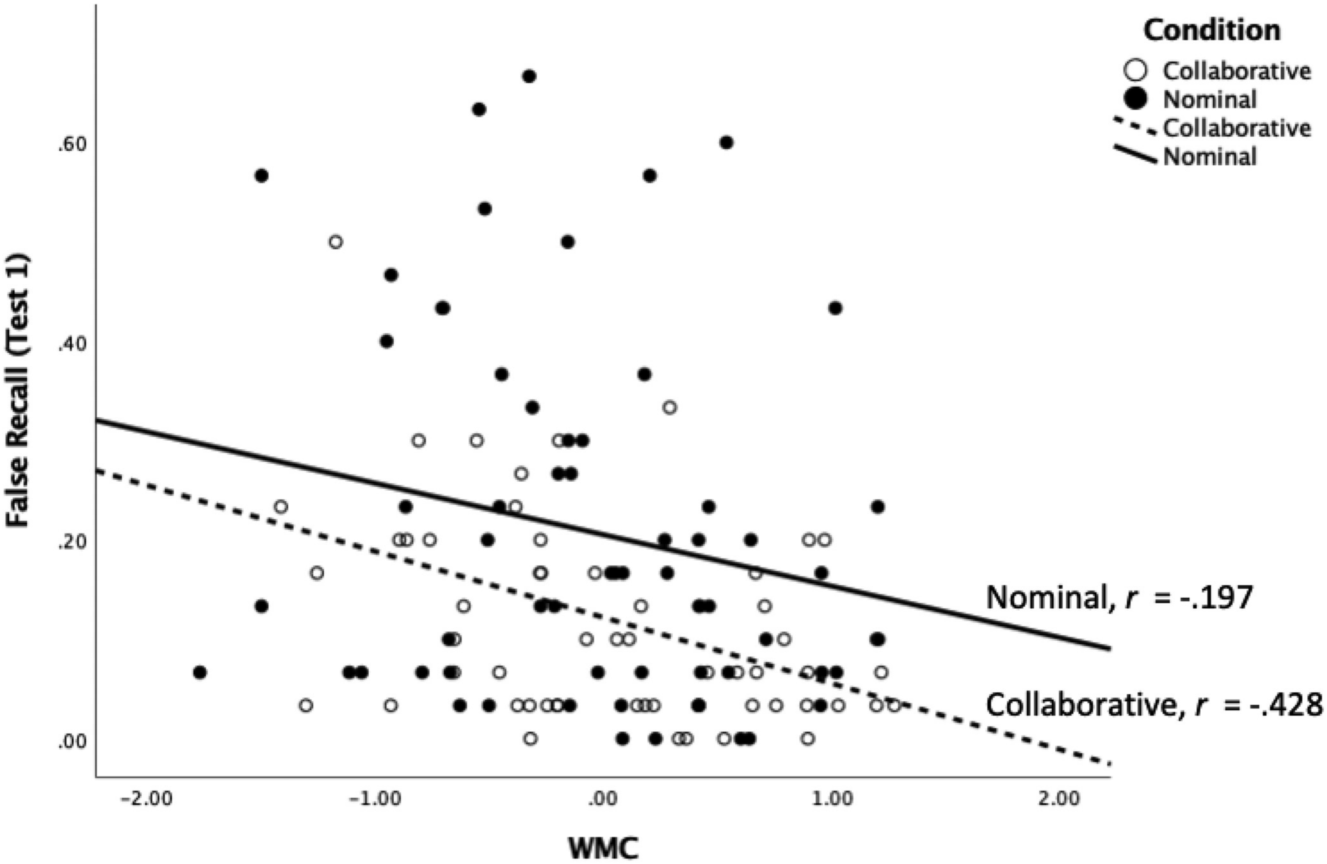
As in the analyses examining correct and false recall at Test 1, because we were examining individual recall within a collaborative paradigm, when examining ELIs between the nominal and collaborative condition at Test 1, we used the more appropriate *t* test. There was a significant effect of ELIs at Test 1, $t(118) = -2.528$, $p =$

Table 3
Results of Regression Analyses (False Recall)

Regression analysis	*B*	*SE*	β	*t*	*F*	Adjusted R^2
Recall Test 1						
Step 1						
Retrieval Condition	−.042	.013	−.268	−3.14**	10.51***	.138
WMC	−.059	.019	−.266	−3.11**		
Step 2						
Retrieval Condition × WMC	−.007	.019	−.033	−.384	7.00***	.131
Recall Test 2						
Step 1						
Retrieval Condition	.015	.016	.080	.884	2.86	.030
WMC	−.054	.024	−.206	−2.28*		
Step 2						
Retrieval Condition × WMC	.009	.024	−.035	−.386	1.94	.023

Note. WMC = working memory capacity; composite score of shortened AOSPAN, RSPAN, and SSPAN.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 4
False Recall at Test 1 as a Function of Working Memory Capacity (WMC)



Note. The solid line (filled circles) represents individual participants' false recall within the nominal condition, and the dotted line (open circles) represents individual participants' false recall within the collaborative condition. This figure exaggerates the effects of collaboration as individuals in the collaborative condition only recalled items not already recalled by their partner.

.013, such that participants in the nominal condition (M = .653, SD = 1.07) produced significantly more ELIs than participants in the collaborative condition (M = .286, SD = .355). Although we did not make a prediction a priori, this finding does align with the pattern of results we reported for false recall in Test 1, where we found that participants in the nominal condition recalled significantly more false items than participants in the collaborative condition, replicating error correction in collaborative groups (Harris et al., 2012; Ross et al., 2008).

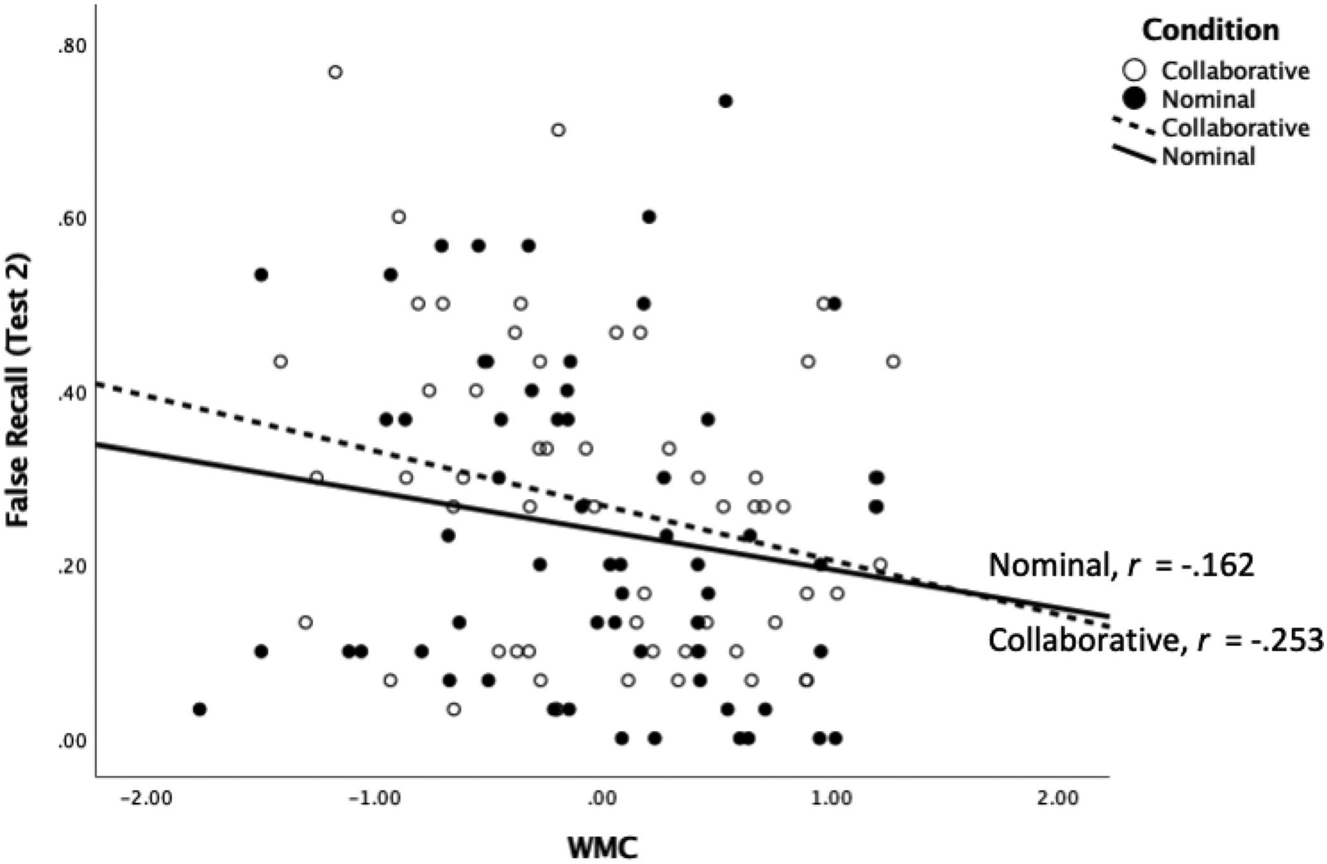
We next conducted a multiple regression analysis predicting ELIs by Retrieval Condition, WMC, and Retrieval Condition × WMC. (Again, although we included Retrieval Condition as a factor, we are not discussing the main effect of Retrieval Condition from this analysis as the main effect of ELIs was already tested in the more appropriate comparison described above.) At Test 1, ELIs were predicted by WMC ($\beta = -.300$, $t = -2.961$, $p = .004$). Specifically, higher WMC was negatively related to ELIs such that the higher one's WMC, the fewer extralist intrusions they recalled ($r = -.269$, $p = .003$). These results are in line with the Test 1 false recall data, where we found that false recall decreased among those higher in WMC. Last, at Test 1, there was no Retrieval Condition × WMC interaction ($\beta = .134$, $t = 1.320$, $p = .189$). At Test 2, ELIs were predicted by WMC ($\beta = .338$, $t = 2.406$, $p = .018$) such that those higher in WMC had lower levels of extralist intrusions ($r = -.249$, $p = .006$). This mirrors the false recall results at Test 2, where we found reduced false recall among those higher in WMC. There was no Retrieval Condition × WMC interaction.

Together, these results demonstrate that collaborating with a partner can reduce the production of incorrect items. Additionally, they provide further evidence that individuals higher in WMC are more accurate than those lower in WMC such that they are less likely to include extralist items during recall (e.g., Unsworth & Engle, 2007).

Effects of Partner's Working Memory Capacity (Collaborative Group Only)

We were also interested in examining how participants' performance might be related to their partner's WMC and potential interactions between an individual's own WMC and partner WMC in producing correct and false recall. The following analyses therefore only included participants who worked collaboratively during Test 1. To anticipate, several of the null interactions in this last section

Figure 5
False Recall at Test 2 as a Function of Working Memory Capacity (WMC)



Note. The solid line (filled circles) represents individual participants' false recall within the nominal condition, and the dotted line (open circles) represents individual participants' false recall within the collaborative condition. All participants recalled alone for Test 2.

had only weak Bayesian evidence in support of the null. Because this analysis only included half of the sample (participants in the collaborative condition only), it is possible that these analyses are underpowered, and therefore future research should aim to replicate these effects.

Correct Recall

Recall Test 1. We regressed individual correct recall during collaboration on own WMC and partner WMC in Step 1 to examine the main effects and entered the Own WMC × Partner WMC interaction in Step 2. These regression results are shown at the top of Table 4. There was a main effect of own WMC (β = .366, t = 2.95, p = .005) such that recall increased among those with higher WMC. There was no significant main effect of partner WMC (β = −.046, t = −.372, p = .711) and no Own WMC × Partner WMC interaction (β = .110, t = .886, p = .380, BF_{10} = .52). However, the evidence against this interaction was weak.

Recall Test 2. Examining correct recall at Test 2, there was again a main effect of own WMC (β = .393, t = 3.23, p = .002) such that recall increased along with increasing WMC. There was no main effect of partner WMC (β = .081, t = .664, p = .509). Of interest, there was a significant Own WMC × Partner WMC interaction (β = .328, t = 2.86, p = .006, BF_{10} = 9.09) that is shown in Figure 6. To explore this interaction further, we performed a quartile split on own WMC and examined the relation between partner WMC and performance separately for those lower and higher in WMC. For lower own WMC individuals (dotted line in Figure 6), the correlation between partner WMC and correct recall was not significant (r = −.307, p = .266). However, for higher own WMC individuals (solid line in Figure 6), the correlation between partner WMC and correct recall was significant (r = .702, p = .002), with better recall when one's partner had a higher WMC. Given that partners higher in WMC produced more correct responses during Test 1, this interaction suggests that only higher WMC individuals incorporate such partner-recalled items into their individual recall at Test 2.

False Recall

Recall Test 1. These regression results are shown at the top of Table 5. For false recall at Test 1, there was a main effect of own WMC (β = −.428, t = −3.55, p = .001) such that false recall decreased among higher WMC individuals. There was no significant main effect of partner WMC (β = .007, t = .056, p = .955) or Own WMC × Partner WMC interaction, although the evidence for this null interaction is weak (β = −.025, t = −.202, p = .841, BF_{10} = .35).

Table 4
Results of Regression Analyses (Collaborative Condition Only: Correct Recall)

Regression analysis	*B*	*SE*	β	*t*	*F*	Adjusted R^2
Recall Test 1						
Step 1						
Own WMC	.051	.017	.366	2.95**	4.34*	.102
Partner WMC	−.006	.017	−.046	−.372		
Step 2						
Own WMC × Partner WMC	.021	.024	.110	.886	3.14*	.098
Recall Test 2						
Step 1						
Retrieval Condition	.064	.020	.393	3.23**	5.77**	.139
WMC	.013	.020	.081	.664		
Step 2						
Retrieval Condition × WMC	.075	.026	.328	2.86**	7.05***	.235

Note. Own WMC = an individual's working memory capacity (WMC) composite score, composed of shortened AOSPAN, RSPAN, and SSPAN; partner WMC = the WMC composite score of an individual's partner.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Recall Test 2. For false recall at Test 2, there was a main effect of partner WMC (β = −.256, $t = -2.05$, $p = .045$) such that false recall decreased with increasing partner WMC (see Figure 7). Because partners higher in WMC produced fewer errors at Test 1, this result is presumably due to less opportunity for contagion when an individual worked with a higher WMC partner. There was no significant main effect of own WMC (β = −.224, $t = -1.80$, $p = .078$) and no Own WMC × Partner WMC interaction, although again the evidence for this null interaction was weak (β = −.054, $t = -.433$, $p = .667$, $BF_{10} = .41$) for false recall at Test 2.

Post Experiment Questionnaires

Metamemory Questionnaire

At the completion of the study, participants completed two post experiment questionnaires for exploratory purposes. The first questionnaire asked about self-reported memory performance. Specifically, participants were asked to rate their self-reported confidence and accuracy in their own ability to remember word lists and in their partner's ability to remember word lists (for those in the collaborative condition), as well as self-reported helpfulness of working with a partner (for those in the collaborative condition). Each question was rated on a scale of 1 (*not confident/accurate/helpful*) to 5 (*very confident/accurate/helpful*). We examined responses in relation to an individual's own WMC and their partner's WMC. The only significant result was a relationship between self-reported confidence in an individual's own ability to remember the word lists and their partner's WMC ($r = -.347$, $p = .007$) such that self-reported confidence in people's own ability to remember word lists decreased as their partner's WMC increased.

Strategy Questionnaire

We were also interested in examining the types of strategies reported by participants during recall. Although exploratory, participants' self-reported strategies may inform the extent to which collaborators relied on similar strategies (a key component of RSD) and if there are WMC-related differences in strategy use. Specifically, we asked participants to report whether they used any sort of strategy and, if so, what the strategy was, if their chosen strategy helped or did not help, and if they would use the same or different strategy if they were to take the recall tests again. All four authors worked together to create a coding scheme for the open responses, which was then coded independently by the first and second authors. There was a 93.9% agreement between the two coders, who then met to discuss and reconcile any discrepancies within their coding. The coders were able to reconcile 100% of their original discrepancies.

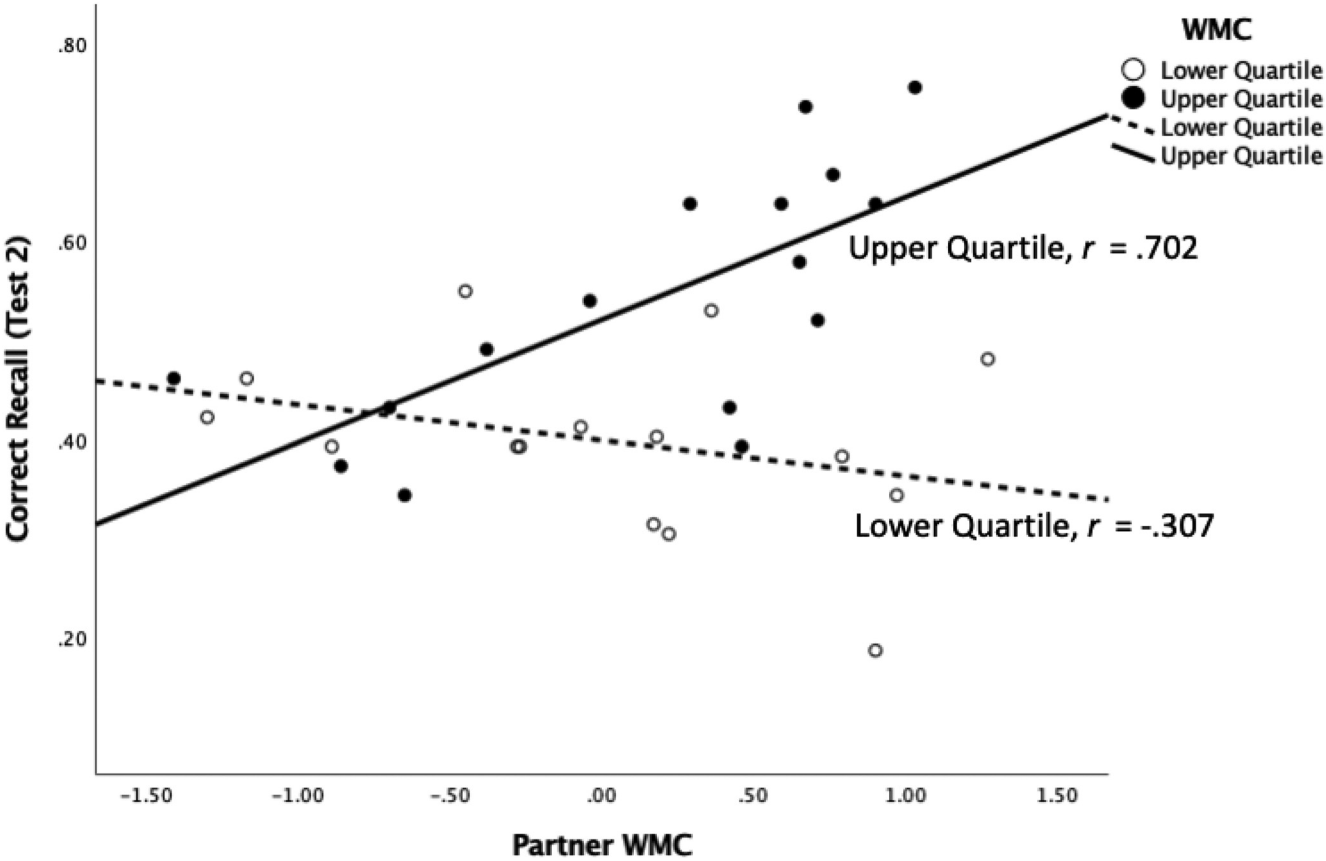
A majority of participants (80.83%) indicated that they used a strategy. The type of strategy used varied (see Figure 8). The highest reported response was to use multiple strategies (24.2%), followed by reciting (23.3%) and linking/making associations (13.3%). Of those who used a strategy during recall, 42.5% felt their strategy helped. Participants were split on using the same or different strategy if they were to do the recall again (45% said different, 40.8% said same), with the new strategy most often being other (26.7%; e.g., focusing on fewer items), linking (12.5%), or using multiple strategies (9.2%).

We were also interested in exploring the types of strategies used between higher- and lower WMC individuals.[4] Figure 8 shows the average WMC among individuals choosing each strategy type. A one-way analysis of variance indicated that there was a significant difference in the type of strategy used as a function of WMC, $F(6, 100) = 2.22$, $p < .05$. A Tukey post hoc test revealed that there was a significant difference in WMC between those using reciting/repetition and those using multiple strategies such that lower WMC individuals were more likely to use reciting/repetition, whereas higher WMC individuals were more likely to use multiple strategies. However, with nine options of strategies, there are 36 possible comparisons, which greatly inflates the Type I error rate. It is also likely these specific comparisons were significant because of the larger N associated with each. Therefore, this result should be interpreted with caution.

[4] We were also interested in examining collaborative inhibition as a function of matched versus mismatched strategy use and whether the "match" effect was simply an artifact of people with differential WMC choosing different strategies. However, only four partners matched on strategy type used during recall, and therefore we were unable to conduct this analysis.

Figure 6

Correct Recall at Test 2 as a Function of Partner Working Memory Capacity (WMC; Collaborative Condition Only)



Note. The solid line (filled circles) represents individual participants' correct recall within the upper quartile of WMC, and the dotted line (open circles) represents individual participants' correct recall within the lower quartile of WMC.

Discussion

In the current study, we examined how WMC interacts with collaborative recall in the collaborative inhibition paradigm. Overall, we replicated collaborative inhibition such that there was greater correct recall in the nominal compared to the collaborative condition (Weldon & Bellinger, 1997). Further, this effect was greater among those lower in WMC. Specifically, collaborative inhibition decreased with increasing WMC, and an extreme groups' analysis confirmed that, among the lower WMC individuals in our sample, those recalling collaboratively were disrupted relative to those recalling individually.

Table 5

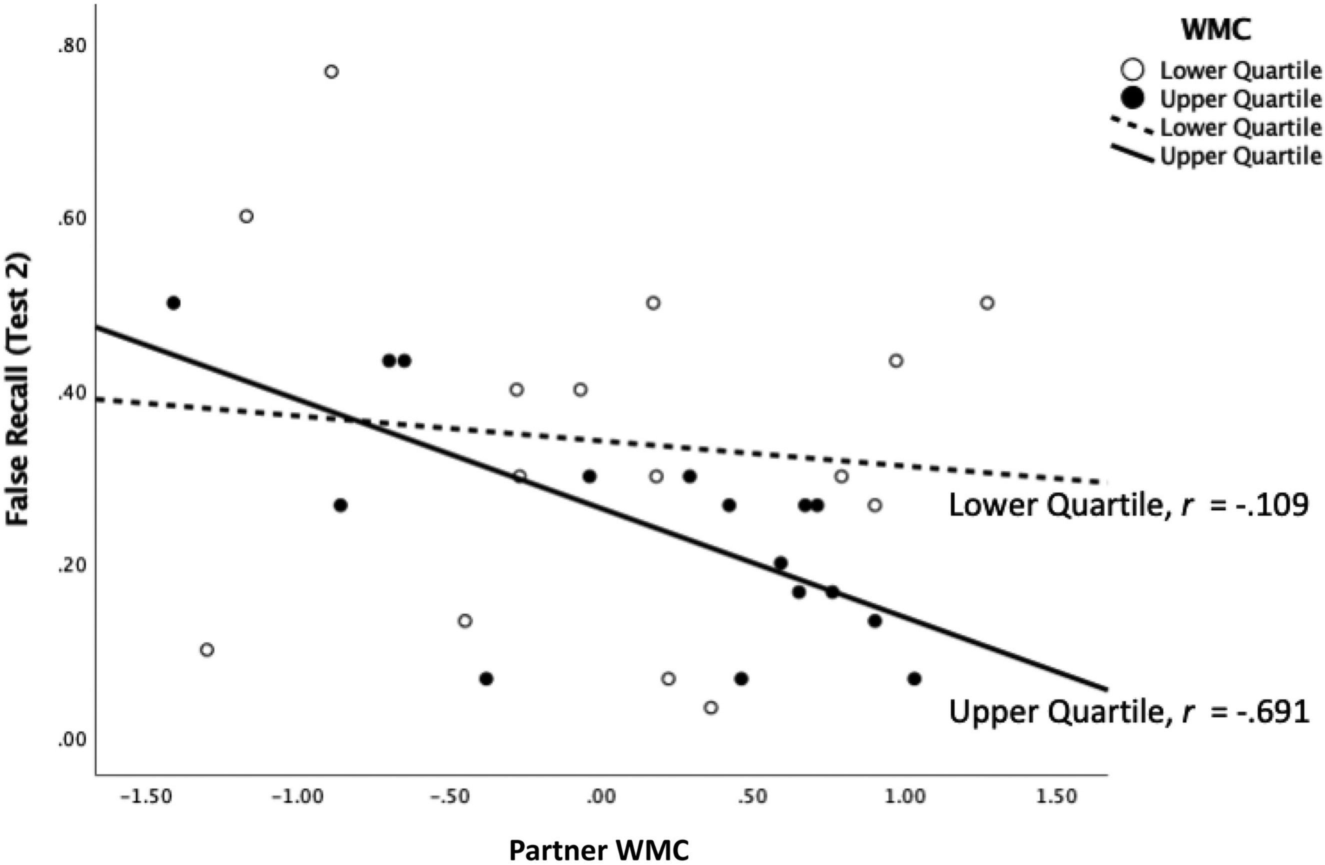
Results of Regression Analyses (Collaborative Condition Only: False Recall)

Regression analysis	*B*	*SE*	β	*t*	*F*	Adjusted R^2
Recall Test 1						
Step 1						
Own WMC	−.067	.019	−.428	−3.55**	6.28**	.154
Partner WMC	.001	.019	.007	.056		
Step 2						
Own WMC × Partner WMC	−.005	.027	−.025	−.202	4.20*	.140
Recall Test 2						
Step 1						
Retrieval Condition	−.056	.031	−.224	−1.80	4.20*	.098
WMC	−.064	.031	−.256	−2.05*		
Step 2						
Retrieval Condition × WMC	−.019	.044	−.054	−.433	2.82*	.085

Note. Own WMC = an individual's WMC composite score, composed of shortened AOSPAN, RSPAN, and SSPAN; partner WMC = the WMC composite score of an individual's partner.

* $p < .05$. ** $p < .01$.

Figure 7
False Recall at Test 2 as a Function of Partner Working Memory Capacity (WMC; Collaborative Condition Only)



Note. The solid line (filled circles) represents individual participants' false recall within the upper quartile of WMC, and the dotted line (open circles) represents individual participants' false recall within the lower quartile of WMC.

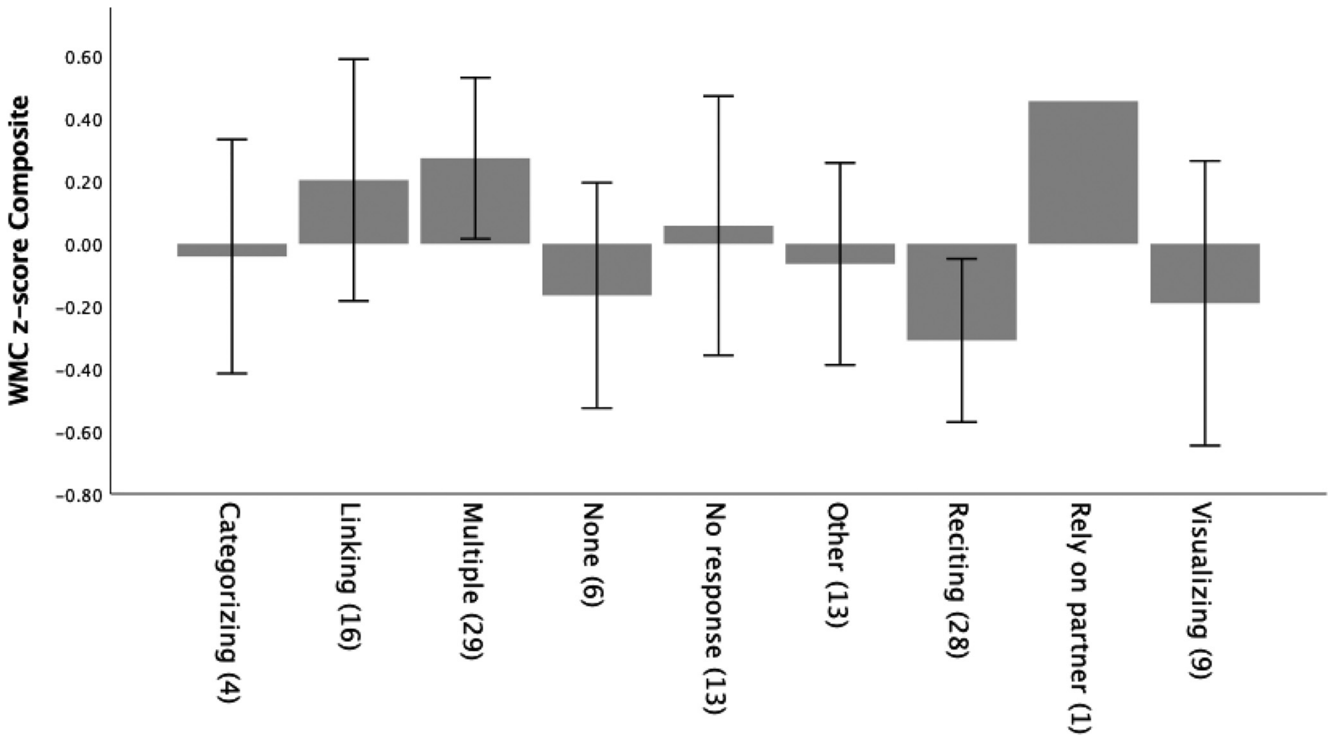
Recall that we had three competing hypotheses regarding collaborative inhibition—the attentional control, elaborative encoding, and additive hypotheses (see Figure 1). Our result of greater collaborative inhibition among those lower in WMC supports the attentional control hypothesis. According to Engle and colleagues, individuals higher in WMC are better able to maintain information in the face of distraction, as well as retrieve task-relevant information when maintenance has been impeded (Engle, 2002; Engle & Kane, 2004; Shipstead et al., 2016). Consistent with this, in the current study, individuals higher in WMC were better able to recall items while being interrupted by a partner's recall, avoiding the potentially detrimental effects of collaboration.

Our other two competing hypotheses cannot explain this finding. For instance, if collaborative inhibition is related to WMC-related differences in elaborative encoding strategies, we should have found the opposite pattern. Specifically, because higher WMC individuals should be more likely to use elaborative strategies, strategy disruption should have been more harmful to their recall than that of lower WMC individuals, who are less likely to develop such strategies (Cokely et al., 2006). Results from our strategy questionnaire data demonstrated that, indeed, higher WMC individuals reported using multiple strategies (which may be more elaborative), whereas lower WMC individuals reported using simple repetition/reciting. Despite this difference in reported strategy use, higher WMC individuals did not show problems with collaborative recall.

Further, if collaborative inhibition is not related to WMC processes or by counteracting attention control and elaborate encoding abilities, we would have found similar magnitudes of collaborative inhibition for higher- and lower WMC individuals. Our finding of greater collaborative inhibition among lower WMC individuals disconfirms these alternative explanations.

It is important to note that this result is inconsistent with findings by Cokely et al. (2006) and Barber and Rajaram (2011, Experiment 1). In their experiments, individuals higher in WMC demonstrated greater interference, which was attributed to their propensity to engage in elaborate encoding strategies (i.e., the current elaborate encoding hypothesis). However, Cokely et al. (2006) and Barber and Rajaram (2011) used part-set cuing and not collaborative inhibition. Although similar, these paradigms differ in two fundamental ways. First, in part-set cuing, recall is performed individually, whereas in collaborative inhibition, recall is performed in a group. Second, in part-set cuing, participants are given all of the retrieval cues before completing the memory task, whereas in collaborative inhibition, the cues are presented

Figure 8
Average WMC Composite Scores Among Individuals Reporting Use of Each Strategy Type



Note. The number of responses for each strategy type reported is listed in parentheses beside each option. Error bars = 95% confidence interval.

intermittently from the other participant/s in the group (Garrido et al., 2012). Recalling with a partner who intermittently interrupts one's recall likely places a larger burden on WMC as, here, one must be able to (a) effectively maintain information in the face of distraction and (b) properly discriminate between relevant and irrelevant information. This may explain why the results from our collaborative inhibition paradigm are more consistent with predictions based on attentional control.

Each of our hypotheses also predicted a small advantage in nominal performance for individuals higher in WMC, based on previous individual difference studies indicating greater recall among higher WMC individuals (e.g., Unsworth, 2010, 2016; Unsworth, Brewer, & Spillers, 2009; also see Unsworth & Engle, 2007, for a review). However, examining correct recall at Test 1, we did not find this. It is possible that the way in which the categorized word lists were presented (i.e., one category at a time, not intermixed) and the way in which participants recalled the categories (i.e., category cued, one list at a time) provided support for both higher- and lower WMC individuals, resulting in minimized differences in nominal performance regardless of WMC. Consistent with this possibility, Huff et al. (2011) found a young adult advantage in recall for uncategorized lists but not for categorized lists (see also Balota et al., 2000).

Also important is that at Test 1, there was no collaborative inhibition among the higher WMC individuals in our sample. This finding demonstrates that not everyone is equally susceptible to collaborative inhibition, and it highlights a relatively rare occurrence when collaborative inhibition is eliminated. However, a caveat is that some of the procedures used in this study (i.e., dyads instead of groups, blocked category presentation rather than mixed, and category cued recall rather than free recall) have been shown to reduce the magnitude of collaborative inhibition (cf. Marion & Thorley, 2016). It is possible that the specific materials and procedures used in the current study lessened the overall rate of collaborative inhibition, which reduced our ability to detect any collaborative inhibition for those higher in WMC. Future studies could replicate our design using uncategorized lists and a wider range of stimuli, groups, and procedures to determine how study materials and procedures influence the relationship between WMC and collaboration. However, as noted previously, doing so will likely lead to large differences in nominal performance, potentially making disruption due to collaboration difficult to interpret.

Examining correct recall at Test 2, we found a post collaborative benefit (i.e., higher recall for those who previously recalled collaboratively than those who previously recalled individually). However, this benefit only occurred among those individuals higher in WMC. In addition, we examined changes in individual recall performance from Test 1 to Test 2 by including individual recall at Test 1 in our multiple regression analysis. Not surprisingly, individual recall at Test 2 was predicted by individual recall at Test 1. However, the only other significant predictor was Retrieval Condition, representing a boost in recall for the collaborative group only, which is not surprising given that people can recall all words at Test 2 (and not just those their partner has not already recalled). There was no main effect of WMC or Retrieval Condition $\times$ WMC interaction, demonstrating that WMC was independent from changes in correct recall performance from Test 1 to Test 2. Thus, the post collaborative benefit for higher WMC individuals is likely a result of no impairment during initial collaboration combined with the boost of being able to recall individually at Test 2. In contrast, the lack of a post collaborative benefit among lower WMC individuals is likely a result of their initial recall impairment during collaboration combined with an equal boost in recall at Test 2.

The finding that only higher WMC individuals show a post collaborative benefit replicates Barber and Rajaram (2011). However, their interpretation was that higher WMC individuals may be better able to take advantage of reexposure and cross-cuing at Test 2 compared to individuals lower in WMC. Although this interpretation follows past research demonstrating that higher WMC individuals are better at discriminating between correct and incorrect items (Unsworth & Engle, 2007), our data demonstrates that everyone had an equal boost in correct recall at Test 2. Nonetheless, better discrimination could still explain why higher WMC individuals were not initially impaired during Test 1. As we will discuss below, future research should tease apart whether it is attention control, secondary memory, or combination of both of these processes that could explain this finding.

Regarding false recall, we replicated the typical finding that there was less false recall in the collaborative compared to the nominal condition at Test 1 (e.g., Harris et al., 2012; Ross et al., 2008), and we found no difference in false recall at Test 2 (Meade & Roediger, 2009; Whillock et al., 2020). When examining individual differences in false recall (Tests 1 and 2), individuals higher in WMC recalled fewer false items compared to those lower in WMC during both Test 1 and Test 2. In both cases, this is consistent with higher WMC individuals' having better source monitoring ability, helping to discriminate actual studied material from highly familiar or strongly activated lures (Unsworth & Engle, 2007; Watson et al., 2005).

We were also interested in examining how participants' performance might be influenced by their partner's WMC and potential interactions between an individual's own WMC and partner WMC in producing correct and false recall. We found that, for correct recall at Test 2, there was an interaction between an individual's own WMC and their partner's WMC. Specifically, for lower WMC individuals, the correlation between partner WMC and correct recall was not significant. However, for higher WMC individuals, the correlation between partner WMC and correct recall was significant, with better recall when one's partner also had a higher WMC. This is likely due to a combination of (a) partners with higher WMC producing more items during collaboration and (b) higher WMC individuals being better at remembering those additional items produced during the initial collaborative recall. At Test 2, false recall decreased with increasing partner WMC. Because higher WMC individuals produced fewer errors at Test 1, this result is presumably due to less opportunity for contagion when an individual worked with a partner higher in WMC (cf. Roediger et al., 2001).

Post Experiment Questionnaires

At the completion of the study, participants completed two questionnaires examining how they felt about their own memory performance and their self-reported use of strategies during the recall portions of the experiment. Although exploratory, there were some interesting findings. First, self-reported confidence in people's own ability to remember word lists decreased as their partner's WMC increased. This suggests the possibility that recalling with a partner higher in WMC hurts confidence in an individual's own memory performance, potentially as a result of noticing differences in recall ability (cf. Hart & Meade, 2021). Second, the results from the strategy questionnaire revealed that higher WMC individuals used a combination of strategies, whereas lower WMC individuals relied on the less optimal strategy of reciting/repetition. Thus, it is possible that part of lower WMC individual's poor recall reflects poor strategy use. However, it is important to note that this strategy use alone cannot explain the WMC differences in recall as there were no WMC differences in the nominal condition. Future studies should further investigate these preliminary findings.

These results provide insights into the mechanisms underlying collaborative inhibition and, specifically, factors that relate to being more or less susceptible to collaborative inhibition as well as to the positive and negative effects of collaboration. Specifically, higher WMC individuals showed no collaborative inhibition combined with a significant post collaborative benefit. In contrast, lower WMC individuals showed significant collaborative inhibition and no post collaborative benefit. Identifying mechanisms that relate to the magnitude of collaborative inhibition and post collaborative benefits informs how and when collaboration influences memory.

Our results also add to the increasing evidence that collaborative inhibition is multiply determined. Past research has demonstrated that, in addition to retrieval strategy disruption, retrieval inhibition influences the effects of collaboration by inhibiting unrecalled words so that they cannot be retrieved on subsequent individual tests (Barber et al., 2015). Collaborative process variables, or the ways in which individuals communicate and exchange information with each other, are another mechanism that influence collaborative inhibition (Harris et al., 2011; Meade et al., 2009; Ross et al., 2008). The present study expands upon past work by identifying WMC as another mechanism underlying collaborative inhibition. Future research can examine how attentional control and/or secondary memory mechanisms relate to, or complement, other existing mechanisms. For example, it is possible that those with better attentional control are better able to regulate the ways in which they exchange information with their partner during collaboration and/or they are better able to inhibit unrecalled words. Taken together, our results suggest that WMC is an important mechanism to consider when examining collaborative memory.

Limitations, Alternative Explanations, Implications, and Future Directions

This experiment was designed to take initial steps toward examining WMC within the collaborative inhibition paradigm. The main goal was to examine whether there was a relationship between individual differences in WMC and collaborative recall. Although the current findings provide insight into how individual differences in WMC relate to collaborative memory, there are important limitations to address. Additionally, although the current findings support the attentional control hypothesis, we note there are other possible alternative explanations for the results. Below, we discuss these limitations and alternative explanations, as well as areas of focus for future studies that could help address these concerns.

One potential limitation is that our sample size was small, raising a concern over whether we had enough power for the interactions involving individual differences in WMC. Because these were the analyses of most interest, we chose to approximately double the suggested sample size of 36 recommended from our a priori power analysis, as well as report Bayesian evidence for or against the interactions involving WMC. Importantly, the results of the Bayesian analyses showed moderate evidence for all three of the significant WMC interactions. However, within the subsection on own versus partner WMC, there were several null interactions that only contained weak evidence for the null. Given that this analysis only included half the sample (participants in the collaborative condition only), it is likely that this specific analysis was indeed underpowered. Therefore, future research should aim to replicate these effects.

Another potential limitation is the use of categorized lists. As mentioned above, the use of categorized lists potentially minimized recall differences between higher- and lower WMC individuals because the list structure helps to scaffold recall for those lower in WMC. In addition, one downside of using categorized lists is that we potentially handicapped RSD theory as doing so provided support for individuals lower in WMC. This may have resulted in them putting less effort into clustering and organizing the items as the use of categorized lists provided this structure for them (both at encoding and retrieval), leaving less to be disrupted. Again, we chose to rely on categorized lists to minimize scaling effects and to increase the interpretability of carryover effects on recall at Test 2. However, future research should determine the generalizability of these results across a wider range of materials and collaborative inhibition procedures.

It is also possible the free-for-all recall procedure mitigated collaborative inhibition effects if, for instance, higher WMC individuals recalled prior to getting disrupted. However, the free-for-all recall procedure was important to (a) make connections to the existing literature and (b) test WMC differences in recall performance. A turn-taking recall procedure could potentially constrain WMC differences in recall performance. Thus, we feel the free-for-all was the most appropriate recall procedure for the purposes of the current study as it allowed us to examine how individual differences in WMC naturally relate to recall. Nonetheless, future research could use different types of recall procedures to test how they interact with WMC.

Although the current findings fit well within the current attentional control hypothesis (Figure 1A) such that individuals higher in WMC demonstrated less collaborative inhibition, presumably due to their ability to maintain information in the face of distractions (e.g., their partner), it is also plausible that secondary memory processes could explain these findings. For instance, it is possible that higher- and lower WMC individuals are equally distracted during collaboration, but only individuals higher in WMC are able to keep the to-be-recalled memory set separate from the already-recalled items, avoiding perseveration or interference in memory search (similar to Hansen and Goldinger's, 2009, finding that higher WMC individuals were less likely to make perseveration errors in the collaborative game of Taboo). Hence, it may be secondary memory processes, and not attentional control per se, that are responsible for these WMC-related differences in the susceptibility to collaborative inhibition. It is also possible that both processes are occurring simultaneously as attention control and secondary memory correlate at the latent level (Shipstead et al., 2014; Unsworth et al., 2014). An important next step for future research is to tease apart the mechanisms contributing to WMC-related differences in collaborative inhibition. Specifically, research could focus on examining whether this relationship is driven by attention control abilities or secondary memory processes. One potential method of doing this could be a large-scale study using structural equation modeling to examine these relationships at the latent level.

Another alternative explanation worth discussing is a criterion shift. For instance, one could explain collaborative inhibition as people having a higher criterion for outputting an item when they are recalling with another individual compared to when they are recalling individually. However, previous research using forced recall has argued against criterion shifts as an explanation for collaborative inhibition because the effect is evident even when recall criteria and output bias are controlled via forced recall (see Meade & Roediger, 2009; Weldon et al., 2000). Further, a criterion shift explanation could not explain our interaction of collaborative inhibition with WMC unless one claimed that only lower WMC individuals shift their criterion when recalling with a partner. There are two arguments against this. First, we found an interaction between WMC and Retrieval Condition in correct, but not false, recall. Any account stating that only lower WMC individuals lower their criterion when collaborating would have predicted an interaction in false recall. Second, although ELIs were very low in the current data (less than one per word list), there was no interaction with WMC.

Last, it is also possible that motivational factors, such as social loafing, may contribute to the current results. In regard to collaborative inhibition, Weldon et al. (2000) manipulated motivation across five experiments and found that, although increasing motivation sometimes increased overall recall, it failed to eliminate collaborative inhibition. Further, there is evidence to suggest that individual differences in WMC are not due to higher WMC individuals exerting more mental effort. Instead, research suggests individuals lower in WMC exert more effort compared to individuals higher in WMC (Heitz et al., 2008), whereas those higher in WMC are more efficient in when they exert effortful control (Hood et al., 2022).

Conclusion

The current study was the first to examine WMC on the magnitude of the collaborative inhibition effect. There are several novel findings to highlight. First, collaborative inhibition was greater among lower WMC individuals, and they derived no post collaborative benefits, whereas higher WMC individuals did not show collaborative inhibition, and they derived significant post collaborative benefits. Second, performance depended not only on participants' own WMC but on their partner's as well. On a second individual recall test, participants produced less false recall when their partner was higher in WMC and greater correct recall when both they and their partner were higher in WMC. Overall, these results demonstrate that collaboration is relatively more harmful for lower WMC individuals and relatively more beneficial for higher WMC individuals. Further, these results add to the increasing evidence that collaborative inhibition is multiply determined and demonstrate the important role that WMC, and attention control in particular, may play in collaborative recall. Examining the individual cognitive mechanisms that contribute to collaborative memory is critical in order to help provide a more complete understanding of human memory.

References

Balota, D. A., Dolan, P. O., & Duchek, J. M. (2000). Memory changes in healthy older adults. In E. Tulving & F. I. M. Craik (Eds.), *The Oxford handbook of memory* (pp. 395–409). Oxford University Press.

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*(2), 559–566. https://doi.org/10.1037/xlm0000037

Barber, S. J., & Rajaram, S. (2011). Collaborative memory and part-set cueing impairments: The role of executive depletion in modulating retrieval disruption. *Memory*, *19*(4), 378–397. https://doi.org/10.1080/09658211.2011.575787

Barber, S. J., Rajaram, S., & Aron, A. (2010). When two is too many: Collaborative encoding impairs memory. *Memory & Cognition*, *38*(3), 255–264. https://doi.org/10.3758/MC.38.3.255

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*(5), 1176–1189. https://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*(6), 497–507. https://doi.org/10.1002/1099-0720(200011/12)14:6<497::AID-ACP665>3.0.CO;2-4

Basden, D. R., & Basden, B. H. (1995). Some tests of the strategy disruption interpretation of part-list cuing inhibition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 1656–1669. https://doi.org/10.1037/0278-7393.21.6.1656

Battig, W. F., & Montague, W. E. (1969). Category norms of verbal items in 56 categories A replication and extension of the Connecticut category norms. *Journal of Experimental Psychology*, *80*, 1–46. https://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*(3), 231–244. https://doi.org/10.1080/09658210701804495

Cokely, E. T., Kelley, C. M., & Gilchrist, A. L. (2006). Sources of individual differences in working memory: Contributions of strategy to capacity. *Psychonomic Bulletin & Review*, *13*(6), 991–997. https://doi.org/10.3758/BF03213914

Conway, A. R., Cowan, N., & Bunting, M. F. (2001). The cocktail party phenomenon revisited: The importance of working memory capacity. *Psychonomic Bulletin & Review*, *8*(2), 331–335. https://doi.org/10.3758/BF03196169

Conway, A. R. A., Kane, M. J., Bunting, M. F., Hambrick, D. Z., Wilhelm, O., & Engle, R. W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic Bulletin & Review*, *12*(5), 769–786. https://doi.org/10.3758/BF03196772

Cuc, A., Koppel, J., & Hirst, W. (2007). Silence is not golden: A case for socially shared retrieval-induced forgetting. *Psychological Science*, *18*(8), 727–733. https://doi.org/10.1111/j.1467-9280.2007.01967.x

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning & Verbal Behavior*, *19*(4), 450–466. https://doi.org/10.1016/S0022-5371(80)90312-6

Ekeocha, J. O., & Brennan, S. E. (2008). Collaborative recall in face-to-face and electronic groups. *Memory*, *16*(3), 245–261. https://doi.org/10.1080/09658210701807480

Engle, R. W. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science*, *11*(1), 19–23. https://doi.org/10.1111/1467-8721.00160

Engle, R. W., & Kane, M. J. (2004). Executive attention, working capacity, and a two-factor theory of cognitive control. *Psychology of Learning and Motivation*, *44*, 145–199. https://doi.org/10.1016/S0079-7421(03)44005-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*(6), 1556–1567. https://doi.org/10.1037/0278-7393.26.6.1556

Foster, J. L., Shipstead, Z., Harrison, T. L., Hicks, K. L., Redick, T. S., & Engle, R. W. (2015). Shortened complex span tasks can reliably measure working memory capacity. *Memory & Cognition*, *43*(2), 226–236. https://doi.org/10.3758/s13421-014-0461-7

Gardiner, J. M., Passmore, C., Herriot, P., & Klee, H. (1977). Memory for remembered events: Effects of response mode and response-produced feedback. *Journal of Verbal Learning & Verbal Behavior*, *16*(1), 45–54. https://doi.org/10.1016/S0022-5371(77)80006-6

Garrido, M. V., Garcia-Marques, L., & Hamilton, D. L. (2012). Enhancing the comparability between partlist cueing and collaborative recall. *Experimental Psychology*, *59*, 199–205.

Hansen, W. A., & Goldinger, S. D. (2009). Taboo: Working memory and mental control in an interactive task. *The American Journal of Psychology*, *122*, 283–291.

Harris, C. B., Barnier, A. J., & Sutton, J. (2012). Consensus collaboration enhances group and individual recall accuracy. *The Quarterly Journal of Experimental Psychology*, *65*, 179–194. https://doi.org/10.1080/17470218.2011.608590

Harris, C. B., Barnier, A. J., & Sutton, J. (2013). Shared encoding and the costs and benefits of collaborative recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *39*(1), 183–195. https://doi.org/10.1037/a0028906

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*(4), 267–303. https://doi.org/10.1080/0163853X.2010.541854

Hart, K. M., & Meade, M. L. (2021). Social contagion of memory and the role of self-initiated relative judgments. *Acta Psychologica*, *212*, 103189.

Heitz, R. P., Schrock, J. C., Payne, T. W., & Engle, R. W. (2008). Effects of incentive on working memory capacity: Behavioral and pupillometric data. *Psychophysiology*, *45*(1), 119–129.

Hinsz, V. B., Tindale, R. S., & Vollrath, D. A. (1997). The emerging conceptualization of groups as information processors. *Psychological Bulletin*, *121*(1), 43–64. https://doi.org/10.1037/0033-2909.121.1.43

Hood, A. V. B., Hart, K. M., Marchak, F. M., & Hutchison, K. A. (2022). Patience is a virtue: Individual differences in cue-evoked pupil responses under temporal certainty. *Attention, Perception, & Psychophysics*. Advance online publication. https://doi.org/10.3758/s13414-022-02482-7

Huff, M. J., Meade, M. L., & Hutchison, K. A. (2011). Age-related differences in guessing on free and forced recall tests. *Memory*, *19*(4), 317–330. https://doi.org/10.1080/09658211.2011.568494

Hutchison, K. A. (2007). Attentional control and the relatedness proportion effect in semantic priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*(4), 645–662. https://doi.org/10.1037/0278-7393.33.4.645

Hutchison, K. A. (2011). The interactive effects of listwide control, item-based control, and working memory capacity on Stroop performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *37*(4), 851–860. https://doi.org/10.1037/a0023437

JASP Team. (2019). JASP (Version 0.11.1) [Computer software]. https://jasp-stats.org/

Jeffreys, H. (1961). *Theory of probability* (3rd ed.). Oxford University Press.

Kane, M. J., Bleckley, M. K., Conway, A. R. A., & Engle, R. W. (2001). A controlled-attention view of working-memory capacity. *Journal of Experimental Psychology: General*, *130*(2), 169–183. https://doi.org/10.1037/0096-3445.130.2.169

Kane, M. J., Brown, L. H., McVay, J. C., Silvia, P. J., Myin-Germeys, I., & Kwapil, T. R. (2007). For whom the mind wanders, and when: An experience-sampling study of working memory and executive control in daily life. *Psychological Science*, *18*(7), 614–621. https://doi.org/10.1111/j.1467-9280.2007.01948.x

Kane, M. J., Hambrick, D. Z., Tuholski, S. W., Wilhelm, O., Payne, T. W., & Engle, R. W. (2004). The generality of working memory capacity: A latent-variable approach to verbal and visuospatial memory span and reasoning. *Journal of Experimental Psychology: General*, *133*(2), 189–217. https://doi.org/10.1037/0096-3445.133.2.189

Lee, M. D., & Wagenmakers, E.-J. (2013). *Bayesian cognitive modeling: A practical course*. Cambridge University Press.

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*(11), 1141–1164. https://doi.org/10.1037/bul0000071

McVay, J. C., & Kane, M. J. (2009). Conducting the train of thought: Working memory capacity, goal neglect, and mind wandering in an executive-control task. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *35*, 196–204. https://doi.org/10.1037/a0014104

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

Meade, M. L., & Gigone, D. (2011). The effect of information distribution on collaborative inhibition. *Memory*, *19*(5), 417–428. https://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*. Oxford University Press. https://doi.org/10.1093/oso/9780198737865.001.0001

Meade, M. L., Nokes, T. J., & Morrow, D. G. (2009). Expertise promotes facilitation on a collaborative memory task. *Memory*, *17*(1), 39–48. https://doi.org/10.1080/09658210802524240

Meade, M. L., & Roediger, H. L., III. (2002). Explorations in the social contagion of memory. *Memory & Cognition*, *30*(7), 995–1009. https://doi.org/10.3758/BF03194318

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*(3), 433–462. https://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*(7), 962–975. https://doi.org/10.3758/MC.37.7.962

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, *24*, 167–202.

Oswald, F. L., McAbee, S. T., Redick, T. S., & Hambrick, D. Z. (2015). The development of a short domain-general measure of working memory capacity. *Behavior Research Methods*, *47*(4), 1343–1355. https://doi.org/10.3758/s13428-014-0543-2

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). Oxford University Press.

Rajaram, S., & Pereira-Pasarin, L. P. (2010). Collaborative memory: Cognitive research and theory. *Perspectives on Psychological Science*, *5*(6), 649–663. https://doi.org/10.1177/1745691610388763

Redick, T. S. (2014). Cognitive control in context: Working memory capacity and proactive control. *Acta Psychologica*, *145*, 1–9. https://doi.org/10.1016/j.actpsy.2013.10.010

Richmond, L. L., Burnett, L. K., Morrison, A. B., & Ball, H. (2021). Performance on the processing portion of complex working memory span tasks is related to working memory capacity estimates. *Behavior Research Methods*. Advance online publication. https://doi.org/10.3758/s13428-021-01645-y

Roediger, H. L., III, Meade, M. L., & Bergman, E. T. (2001). Social contagion of memory. *Psychonomic Bulletin & Review*, *8*(2), 365–371. https://doi.org/10.3758/BF03196174

Rosen, V. M., & Engle, R. W. (1997). The role of working memory capacity in retrieval. *Journal of Experimental Psychology: General*, *126*(3), 211–227. https://doi.org/10.1037/0096-3445.126.3.211

Rosnow, R. L., & Rosenthal, R. (1989). Statistical procedures and the justification of knowledge in psychological science. *American Psychologist*, *44*, 1276–1284.

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*(1), 85–92. https://doi.org/10.1037/0882-7974.23.1.85

Shiffrin, R. M. (1970). Memory search. In D. A. Norman (Ed.), *Models of human memory* (pp. 375–447). Academic Press. https://doi.org/10.1016/B978-0-12-521350-9.50017-6

Shiffrin, R. M., & Atkinson, R. C. (1969). Storage and retrieval processes in long-term memory. *Psychological Review*, *76*(2), 179–193. https://doi.org/10.1037/h0027277

Shipstead, Z., Harrison, T. L., & Engle, R. W. (2016). Working memory capacity and fluid intelligence: Maintenance and disengagement. *Perspectives on Psychological Science*, *11*(6), 771–799. https://doi.org/10.1177/1745691616650647

Shipstead, Z., Lindsey, D. R. B., Marshall, R. L., & Engle, R. W. (2014). The mechanisms of working memory capacity: Primary memory, secondary memory, and attention control. *Journal of Memory and Language*, *72*, 116–141. https://doi.org/10.1016/j.jml.2014.01.004

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*(6), 867–881. https://doi.org/10.1080/09541440600872068

Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language*, *28*(2), 127–154. https://doi.org/10.1016/0749-596X(89)90040-5

Unsworth, N. (2007). Individual differences in working memory capacity and episodic retrieval: Examining the dynamics of delayed and continuous distractor free recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*(6), 1020–1034. https://doi.org/10.1037/0278-7393.33.6.1020

Unsworth, N. (2010). On the division of working memory and long-term memory and their relation to intelligence: A latent variable approach. *Acta Psychologica*, *134*(1), 16–28. https://doi.org/10.1016/j.actpsy.2009.11.010

Unsworth, N. (2016). Working memory capacity and recall from long-term memory: Examining the influences of encoding strategies, study time allocation, search efficiency, and monitoring abilities. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *42*(1), 50–61. https://doi.org/10.1037/xlm0000148

Unsworth, N., & Brewer, G. A. (2010). Individual differences in false recall: A latent variable analysis. *Journal of Memory and Language*, *62*(1), 19–34. https://doi.org/10.1016/j.jml.2009.08.002

Unsworth, N., Brewer, G. A., & Spillers, G. J. (2009). There's more to the working memory capacity-fluid intelligence relationship than just secondary memory. *Psychonomic Bulletin & Review*, *16*(5), 931–937. https://doi.org/10.3758/PBR.16.5.931

Unsworth, N., & Engle, R. W. (2007). The nature of individual differences in working memory capacity: Active maintenance in primary memory and controlled search from secondary memory. *Psychological Review*, *114*(1), 104–132. https://doi.org/10.1037/0033-295X.114.1.104

Unsworth, N., Fukuda, K., Awh, E., & Vogel, E. K. (2014). Working memory and fluid intelligence: Capacity, attention control, and secondary memory retrieval. *Cognitive Psychology*, *71*, 1–26. https://doi.org/10.1016/j.cogpsych.2014.01.003

Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005). An automated version of the operation span task. *Behavior Research Methods*, *37*(3), 498–505. https://doi.org/10.3758/BF03192720

Unsworth, N., Redick, T. S., Heitz, R. P., Broadway, J. M., & Engle, R. W. (2009). Complex working memory span tasks and higher-order cognition: A latent-variable analysis of the relationship between processing and storage. *Memory*, *17*(6), 635–654. https://doi.org/10.1080/09658210902998047

Unsworth, N., Spillers, G. J., & Brewer, G. A. (2012). Working memory capacity and retrieval limitations from long-term memory: An examination of differences in accessibility. *The Quarterly Journal of Experimental Psychology*, *65*, 2397–2410.

Wagenmakers, E. J., Marsman, M., Jamil, T., Ly, A., Verhagen, J., Love, J., Selker, R., Gronau, Q. F., Šmíra, M., Epskamp, S., Matzke, D., Rouder, J. N., & Morey, R. D. (2018). Bayesian inference for psychology. Part I: Theoretical advantages and practical ramifications. *Psychonomic Bulletin & Review*, *25*, 35–57.

Wahlheim, C. N., Alexander, T. R., & Kane, M. J. (2019). Interpolated retrieval effects on list isolation: Individual differences in workingmemory capacity. *Memory & Cognition*, *47*, 619–642.

Watson, J. M., Bunting, M. F., Poole, B. J., & Conway, A. R. A. (2005). Individual differences in susceptibility to false memory in the Deese-Roediger-McDermott paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *31*(1), 76–85. https://doi.org/10.1037/0278-7393.31.1.76

Weldon, M. S., & Bellinger, K. D. (1997). Collective memory: Collaborative and individual processes in remembering. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *23*(5), 1160–1175. https://doi.org/10.1037/0278-7393.23.5.1160

Weldon, M. S., Blair, C., & Huebsch, P. D. (2000). Group remembering: Does social loafing underlie collaborative inhibition? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*(6), 1568–1577. https://doi.org/10.1037/0278-7393.26.6.1568

Whillock, S. R., Meade, M. L., Hutchison, K. A., & Tsosie, M. D. (2020). Collaborative inhibition in same-age and mixed-age dyads. *Psychology and Aging*, *35*(7), 963–973. https://doi.org/10.1037/pag0000490

Received November 24, 2020
Revision received April 8, 2022
Accepted April 14, 2022 ■