

Study repetition and divided attention: Effects of encoding manipulations on collaborative inhibition in group recall

Luciane P. Pereira-Pasarin · Suparna Rajaram

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Abstract Two experiments tested the effects of encoding manipulations on group recall and on the magnitude of collaborative inhibition. *Collaborative inhibition* refers to the phenomenon where by a collaborative group recalls less than do the same number of individuals who work alone and then have their nonredundant responses pooled. Participants studied categorized word lists once or three times (Experiment 1) or under conditions of full versus divided attention (Experiment 2). Study repetition both improved retrieval organization in recall and attenuated collaborative inhibition, and divided attention encoding both reduced retrieval organization in recall and eliminated collaborative inhibition. These experiments are the first to focus on encoding variables and to show that collaborative inhibition can vary as a function of encoding manipulations.

Keywords Collaborative inhibition · Collaborative recall · Divided attention · Study repetition

When family members get together, they may engage in discussions of a trip they took together. In doing so, these individuals attempt to retrieve information while being exposed to the recall product of others who are contributing to the discussion. Contrary to intuition, such collaboration does not enhance each individual's ability to recall more.

While the magnitude of recall by group predictably exceeds that of a single individual (Yuker, 1955), a growing body of research on collaborative memory shows that exposure to the recall product of group members during discussion reduces total group recall relative to its optimal level. This counter intuitive phenomenon is named *collaborative inhibition* (Weldon & Bellinger, 1997), and it refers to the finding that the recall of a collaborative group is worse than it potentially could be. This outcome is observed when a collaborative group is compared with a nominal group—that is, a group in name only—where the recall of the same number of individuals working alone is pooled in a nonredundant fashion to arrive at the group's potential. For example, if participant 1 recalls three items (e.g., *stove*, *elevator*, and *river*), participant 2 recalls three items (e.g., *trophy*, *river*, and *school*), and participant 3 recalls four items (e.g., *stove*, *elevator*, *ostrich*, and *chisel*), the nonredundant group output consists of seven items (e.g., *stove*, *elevator*, *river*, *trophy*, *school*, *ostrich*, and *chisel*) (Basden, Basden, Bryner, & Thomas, 1997; Weldon & Bellinger, 1997).

As we elaborate later, recent studies have shown that several variables manipulated during an experiment can reduce the magnitude of collaborative inhibition. However, published studies typically have manipulated these variables, such as study–test delay or changes in the retrieval tasks or retrieval instructions, during post encoding stages, leaving open the question of whether manipulations at encoding can also reduce the magnitude of collaborative inhibition during group recall. The present study was designed to address this critical gap in our understanding of the factors that can modulate collaborative inhibition in recall.

In selecting the encoding variables that are most likely to reduce collaborative inhibition, we turned to a candidate

L. P. Pereira-Pasarin (✉)
Department of Psychology, Caldwell College,
120 Bloomfield Avenue,
Caldwell, NJ 07006, USA
e-mail: Lpereirapasarin@caldwell.edu

S. Rajaram
Psychology Department,
Stony Brook University,
Stony Brook, NY, USA

theoretical mechanism that has been proposed to account for this phenomenon. Basden, Basden, and colleagues have proposed that the same cognitive mechanism that produces part-list cuing inhibition in individual recall—namely, retrieval disruption—is also responsible for collaborative inhibition in group recall. In part-list cuing studies, participants are given either a part-list cued recall test or a free recall test (Basden & Basden, 1995; Basden, Basden, & Galloway, 1977; Basden & Draper, 1973). In a part-list cued recall test, participants are given a test booklet that already contains, for example, 6 of the 12 studied items per word list and are instructed to recall the *remaining* 6 studied items for each study list. In a free recall test, participants are given a blank sheet of paper and are asked to recall as many items as they can from the study phase of the experiment. Results indicate that participants in the free recall test condition outperform participants in the part-list cued recall test condition in the recall of the *remaining* 6 studied items of each study list. This phenomenon is referred to as *part-list cuing inhibition*. Individuals' retrieval strategies are presumed less effective when part-list cues are present, as compared with when part-list cues are absent. The rationale for this phenomenon is that part-list cues introduce a retrieval order that is inconsistent with the idiosyncratic organization participants develop while encoding the study items.

Consistent with the implications of part-list cues, the negative effects of collaboration on group memory are typically attributed to the cognitive mechanism of retrieval disruption. According to this proposal, exposure to the recall product of group members during collaboration introduces a retrieval order that is inconsistent with the idiosyncratic sequences individuals might otherwise use, thereby reducing individual output (Basden et al., 1997). That is, while certain types of organization (e.g., by category) may have commonalities across participants, unique preexisting knowledge and past experiences can impose variations and idiosyncrasies in the way each individual organizes these clusters of information and the order of these clusters in recall. Consequently, participants in the collaborative condition perform worse than those in the nominal condition because the latter are not exposed to others' recall product during retrieval and do not experience retrieval disruption.

Collaborative inhibition in group recall is a robust phenomenon. It occurs for a variety of study materials, such as unrelated word lists (Andersson, Hitch, & Meudell, 2006; Andersson & Rönnerberg, 1997; Weldon & Bellinger, 1997, Experiment 1; Wright & Klumpp, 2004), story recall (Takahashi & Saito, 2004; Weldon & Bellinger, 1997, Experiment 2), categorized lists (Basden et al., 1997; Basden, Basden, & Henry, 2000), word pairs (Finlay, Hitch, & Meudell, 2000, Experiments 2 and 3), associatively related

items (Basden, Basden, Thomas, & Souphasith, 1998; Basden, Reysen, & Basden, 2002), semantic versus episodic tasks (Andersson & Rönnerberg, 1996), and emotionally laden events (Yaron-Antar & Nachson, 2006).

The collaborative inhibition deficit in group recall has been shown to attenuate or disappear only under some conditions. Among these are retrieval conditions where the retrieval task precludes retrieval disruption, as in the case of a recognition task in which all studied items are presented (Clark, Abbe, & Larson, 2006; Clark, Hori, Putnam, & Martin, 2000; Meade & Roediger, 2009) and in the case of a cued recall task in which the retrieval order is preset by the presentation order of the recall cues (Barber, Rajaram, & Aron, 2010; Finlay et al., 2000) and, therefore, retrieval disruption occurs to the same extent for both collaborative and nominal groups. Similarly, collaborative inhibition is also eliminated when participants are prevented from switching categories by requiring them to recall items from a given category contiguously before moving on to recalling items from another category (Basden et al., 1997, Experiment 4), once again aligning the same retrieval strategy for all participants.

Collaborative inhibition also dissipates under conditions that presumably weaken individual retrieval strategies and, thereby, create a situation where there is less organization to disrupt. This was demonstrated in a study that explored the effects of delay on collaborative inhibition (Takahashi & Saito, 2004). On the basis of the findings that delay reduces part-list cuing inhibition (Raaijmakers & Phaf, 1999), the experimenters reasoned that after a 1-week delay, participants would not be able to effectively use their idiosyncratic organization and retrieval strategies established at encoding. Under these conditions, while overall levels of recall would decline with delay for both nominal and collaborative group participants, the state of weakened retrieval organization would mean that participants in the collaborative group would suffer less disruption (because there is less organization to disrupt) and, therefore, would be in a position to contribute what they did remember. The findings supported these expectations. Participants read a story and performed an immediate free recall memory test (Experiment 1) or a delayed free recall test after a week (Experiment 2), either individually or in dyads. Collaborative inhibition was observed in immediate recall. After a 1-week delay, memory performance predictably declined, but participants in the collaborative recall condition forgot fewer items than did those in the nominal condition, resulting in the disappearance of collaborative inhibition.

In brief, past research has shown that when collaborative recall conditions reduce retrieval disruption suffered by the collaborating members—by imposing similar retrieval strategies either through retrieval tasks or retrieval instructions or through weakened retrieval organization—collaborative

inhibition diminishes in group recall. Interestingly, these findings on the nature of collaborative inhibition in group memory has come from studies that typically have manipulated variables at the post-encoding stages. In contrast, the present study addressed how changes at *encoding* might affect collaborative inhibition in later group recall.

Past research on collaborative recall where encoding variables were manipulated is scarce, and, critical for present purposes, even the scarce evidence that does exist does not speak to the role of encoding manipulations in changing the size of the collaborative inhibition effect. In one study, two encoding variables were manipulated for a list of unrelated items (Weldon & Bellinger, 1997, Experiment 1). Participants studied items in either picture or word format (the picture–word manipulation; Nelson & McEvoy, 1979; Paivio, 1971) and by processing the items for either meaning or surface-level information (the levels-of-processing manipulation; Craik & Lockhart, 1972; Craik & Tulving, 1975). The authors' goal was to determine whether the robust phenomena of the picture superiority effect (where pictures are remembered better than words) and the levels-of-processing effect (where information studied at a deep level is remembered better than information studied at a shallow level) that are routinely observed in individual recall would also generalize to collaborative recall. The outcomes confirmed this to be the case. However, the impact of these encoding variables on the size of collaborative inhibition was neither an aim of the study nor evaluated. Interestingly, an inspection of the descriptive data in their Table 1 and Fig. 1 shows that while pictures and words produced different levels of recall, both types of items revealed equivalent collaborative inhibition. But the levels-of processing manipulation showed a different pattern; the collaborative inhibition effect was substantial for items that were rated for pleasantness of meaning, but was considerably reduced for items rated for surface-level information. The unrelated nature of the stimuli precluded an assessment of the possible bases for the presence or reduction of collaborative inhibition across different types of encoding. In brief, while there are some hints that encoding variables may be important, past studies have not addressed the role of encoding variables in shaping the magnitude of collaborative inhibition. This gap in the literature motivates a targeted test in the present study of the ways in which encoding variables can affect collaborative inhibition in group recall.

Specifically, we sought to determine the effects of collaboration on group recall as a function of two encoding variables by taking into account the manner in which particular forms of encoding would affect the extent of retrieval disruption during collaborative recall. In Experiment 1, we manipulated the number of presentations for a given study word (one vs. three times). In Experiment 2, we

manipulated attention (full vs. divided) at study. We selected these two independent variables (number of presentations and divided attention) because past research on individual memory has shown these variables to influence the extent of retrieval organization that participants display in individual recall. Thus, these encoding variables are well suited for testing the extent to which they can shape the magnitude of collaborative inhibition in group recall.

Number of presentations at study

Past research has shown that repetition at study changes the organization of information in later recall. Support for the benefits of repeated study for organization has come from a classic study by Rundus (1971) that evaluated overt rehearsal protocols at study, as well as recall performance (Rundus, 1971, Experiment 3). Words that were repeated at study received more rehearsal during study, and spaced repetitions increased rehearsal (Rundus, 1971, Experiment 2). Consequently, memory performance was better for repeated items (especially those that received spaced repetitions) than for items presented once. In addition, when rehearsal protocols and recall were assessed for a list of items that included both categorized words (such as those used in the present experiments) and noncategorized (unrelated) words, rehearsal protocols and recall performance showed four characteristics that are important for understanding the effects of study repetition, organization, and recall (Rundus, 1971, Experiment 4). One, participants clustered items into categories (thus, organized the items) during rehearsal, and this clustering was stronger for categorized than for noncategorized words; two, the probability of recall increased as the amount of rehearsal increased; three, the probability of recall was higher for categorized lists (that were clustered more during rehearsal) than for noncategorized lists; and four, clustering of items according to category was evident during both rehearsal and recall. Taken together, findings from this study suggest that repeated study of categorized words would increase the organization of these studied items. Because strengthened organization is presumed to decrease retrieval disruption during collaboration (Basden et al., 1997, Experiment 1), presenting items three times should reduce the size of the collaborative inhibition effect, as compared with presenting items only once.

Some evidence from a collaborative memory study has provided preliminary support for this prediction (Basden et al., 2000, Experiment 2). Participants viewed a categorized word list and then performed an individual recall or a group recall test. After the first study–recall cycle, participants repeated the same procedure for a total of three consecutive study–recall cycles.

Collaborative inhibition was reported in the first study–recall cycle but disappeared in the second and third study–recall cycles. These findings suggest that the magnitude of the collaborative inhibition effect can be reduced if group members are given additional opportunities to encode information. However, the manipulation of repeated encoding in the Basden et al. (2000) study was interwoven with repeated testing, making it difficult to isolate the independent effects of study repetition on individual memory and collaborative inhibition. Experiment 1 in the present study was designed to test this novel question. We isolated the number of presentations (one vs. three) at study and investigated whether this variable by itself can protect group memory from collaborative inhibition.

Divided attention at study

An extensive body of research has shown that divided attention at encoding reduces subsequent memory for studied words, relative to full attention encoding. In such studies, participants typically have studied a list of words either without any distraction (the full attention condition) or while performing another task, such as monitoring digits or tones (the divided attention condition). This deleterious effect of divided attention encoding has been shown on a variety of memory tasks, such as free recall (Baddeley, Lewis, Eldridge, & Thomson, 1984; Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; Craik & Kester, 2000), cued recall (Craik & Kester, 2000; Naveh-Benjamin, Craik, Guez, & Kreuger, 2005), and recognition (Craik & Kester, 2000; Craik & McDowd, 1998). Furthermore, studies have also shown that when participants study a list of categorized words under conditions of full versus divided attention at encoding, later individual recall shows a significant reduction not only in the magnitude of recall, but also in clustering according to category (i.e., retrieval organization; Craik & Kester, 2000; Park, Smith, Dudley, & Lafronza, 1989). These findings converge on the prediction that if divided attention encoding reduces the extent to which participants can organize study information, participants will bring fewer idiosyncratic retrieval strategies to the recall situation that can be disrupted during collaboration. Since individual output suffers less disruption during collaboration, individuals can contribute more of what they learned, even though the overall level of recall in the divided attention condition is expected to be lower, as compared with the full attention condition. This process would lead to the novel finding that group recall would suffer less collaborative inhibition following poor individual encoding, as compared with standard (full attention) conditions of encoding.

In summary, evidence from the literature on the effects of study repetition and divided attention study on individual memory suggests that these encoding variables create conditions where retrieval disruption is less likely to operate (albeit for opposite reasons), as compared with the default method of single presentation with full attention that has been used in past studies on collaborative memory. Specifically, past studies have shown that encoding conditions where study items are presented once and require full attention—typically with intentional study instructions, deep processing (e.g., rate pleasantness of meaning), and moderate study–test delay (e.g., a few minutes or less than 1 h)—routinely lead to collaborative inhibition in group recall. Furthermore, as was described earlier, manipulations of multiple study–test cycles (Basden et al., 2000) and study–test delay (Takahashi & Saito, 2004) reduce or eliminate collaborative inhibition—presumably, because of reduced retrieval disruption. Taken together, these findings support the prediction that collaborative inhibition will be replicated in the default encoding conditions of single presentation and full attention, and that the magnitude of collaborative inhibition will attenuate when items are presented three times and in the divided attention condition. The following experiments tested these predictions.

Experiment 1

Method

Participants Ninety-six Stony Brook University undergraduates participated in this experiment. Forty-eight participants were tested in triads in each recall condition (collaborative/nominal).

Materials Twenty categories were selected (Battig & Montague, 1969). Eight critical categories with five exemplars in each category served as critical items. Eight categories with one exemplar in each category served as buffers. Four categories with ten exemplars in each category served as fillers. The critical exemplars, buffers, and fillers were equated on word length of five to nine letters, $F < 1$, $M = 6.80$, and low taxonomic frequency, $F < 1$, $M = 26.22$.

Design Collaboration (collaborative/nominal) was manipulated between-subjects, and the number of presentations at study (one or three) was manipulated within-subjects. Participants were randomly assigned to the collaborative or the nominal condition. The eight critical categories were divided into two sets of four categories. One set (i.e., 20 items) was presented once, and the other set (i.e., 20 items) was presented three times. The two sets of critical

categories were counter balanced for number of presentation across participants, resulting in two study lists. Each study list consisted of 128 items: 20 critical items presented once, 20 critical items presented three times, 40 fillers, and four primacy and four recency buffers. With the exception of buffers, all the exemplars were randomized in the study lists such that no two exemplars from the same category appeared consecutively. Furthermore, items were intermixed with respect to one/three-presentation status. Repeated items were presented with a lag of 3 or 4 intervening items between presentations.

Procedure Each of the 128 study items was presented on a computer monitor for 5 s in lowercase letters, using an Arial 60-point-size font. An asterisk was used as a placeholder during the interstimulus interval of 1 s. Participants in the collaborative and nominal conditions were instructed to read each item silently and to rate each item for pleasantness of meaning on a scale from 1 (*very unpleasant*) to 5 (*very pleasant*).¹ Participants were also informed that some words would be repeated in the study list and that they would complete a later (unspecified) memory test.

After a 5-min distractor task that required production of the names of presidents of the United States, participants performed a free recall task in groups of 3 (collaborative condition) or individually (nominal condition). Participants in the collaborative condition were given one blank sheet of paper. A free-for-all collaborative memory procedure commonly used in past studies (see Rajaram & Pereira-Pasarin, 2010) was used, and the group designated one of its members as the scribe (see Blumen & Rajaram, 2008). Participants were instructed to recall as many items as they could from the study phase of the experiment. Participants were asked to resolve disagreements, if any, on their own and were asked to provide one final group answer. The groups' recall, as well as that of the individuals (in the nominal condition), was self-paced and lasted approximately 10 min. Participants in the nominal condition performed the recall memory test individually and were also instructed to recall as many items as they could from the study phase. The nominal group output was calculated by using the standard procedure in collaborative memory studies. Briefly, the nonredundant output of 3 participants who worked individually at test was pooled to form one nominal group score.

Results and discussion

The alpha level was set at .05 (in both experiments), unless otherwise noted. A 2×2 mixed analysis of variance

(ANOVA) for collaboration and number of study presentations on the mean proportions of correct recall revealed a replication of the repetition advantage, such that recall was significantly better when items were presented three times ($M = .81$), as opposed to once ($M = .56$), $F(1, 30) = 98.05$, $MSE = .01$. A main effect of collaboration revealed that the collaborative inhibition effect was replicated, such that recall was better in the nominal condition ($M = .74$) than in the collaborative condition ($M = .63$), $F(1, 30) = 9.57$, $MSE = .02$. Importantly, the main effect of collaboration was qualified by a significant interaction between number of presentations and collaboration, $F(1, 30) = 4.93$, $MSE = .01$. Replicating past research, collaborative inhibition was present when items were presented once (nominal recall, $M = .64$; collaborative recall, $M = .48$), $t(30) = 3.00$, $SE = .05$. However, this effect was significantly attenuated and was only marginal when items were presented three times (nominal recall, $M = .83$; collaborative recall, $M = .79$), $t(30) = 1.78$, $SE = .03$, $p = .09$ (see Fig. 1). This novel finding shows that presenting items three times reduces collaborative inhibition, presumably because it makes individual retrieval less susceptible to disruption during collaboration.

While assessment of retrieval organization was not a central aim here, findings from the analysis on the adjusted ratio of clustering (ARC; Roenker, Thompson, & Brown, 1971) performed on the recall protocols were consistent with the role of repetition noted in past research in improving retrieval organization (Basden et al., 2000; Rundus, 1971). ARC scores have been used in both individual memory studies (Craik & Kester, 2000; Roenker et al., 1971) and collaborative memory studies (Basden et al., 1997; Basden et al., 2000; Basden et al., 1998) to measure the ratio of clustering, the order in which participants recall items from categorized lists, and the extent to which they organize information into clusters. We selected ARC as our measurement of organization for the following reasons. First, substantial evidence indicates that ARC is a valid measurement of clustering and organization in recall. Second, ARC scores have been used in both individual memory and collaborative memory studies to

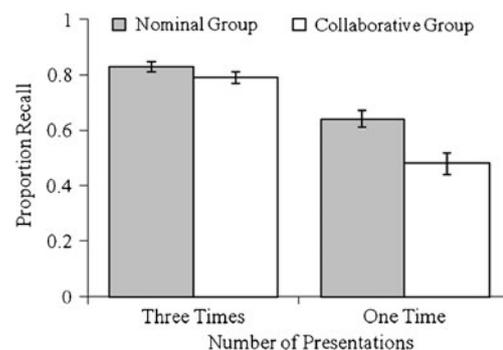


Fig. 1 Mean proportions of recall as a function of collaboration and number of presentations. The error bars indicate standard errors

¹ We used a deep level of encoding because, in past research, such processing has produced substantial collaborative inhibition with a single study presentation (Weldon & Bellinger, 1997, Experiment 1).

measure the ratio of clustering. Third, ARC is a very inclusive measure that takes into account the number of categories recalled and the number of items recalled in each category. Fourth, ARC as a measure of organization is not sensitive to the level of recall, and this feature of the measure was especially useful in that we predicted differential levels of recall as a function of our manipulations across Experiments 1 and 2. ARC scores range from negative one to positive one, where a score of zero represents chance, negative scores reflect below chance performance, and a positive score of one reflects perfect clustering. A 2×2 mixed ANOVA on the ARC scores for collaboration and number of presentations showed a significant main effect of number of presentations, such that organization was better when items were presented three times ($M = .28$), as compared with only once ($M = .18$), $F(1, 30) = 4.08$, $MSE = .04$. Further analyses of the ARC scores were not informative, because of the design structure of this experiment. That is, with respect to the effects of collaboration on organization, ARC scores did not differ between collaborative and nominal groups in the three presentation condition, because study repetition presumably reduced disruption for participants in both conditions. When items were presented once, although better organization in the nominal group than in the collaborative group might be expected (Basden et al., 1997), assessment of recall clusters was rendered uninformative, because repetition was manipulated within subjects and participants' recall protocol included items from both conditions.

Finally, turning to recall intrusions, these scores were very low and also supported previous findings that collaboration prunes the report of intrusions when free-flowing, naturalistic methods of collaboration are used (Rajaram & Pereira-Pasarin, 2007, 2010; Ross, Spencer, Blatz, & Restorick, 2008; Ross, Spencer, Linardatos, Lam, & Perunovic, 2004). That is, collaborative groups ($M = .01$) reported significantly fewer intrusions than did nominal groups ($M = .05$), $t(30) = 3.80$, $SE = .01$.

In brief, the key finding to emerge from this experiment was that presenting items three times, as compared with presenting them once, at encoding *decreased* the magnitude of collaboration inhibition.

Experiment 2

We now turn to an encoding manipulation that has been shown to reduce organization in individual memory and test whether this manipulation—namely, dividing attention at study—can attenuate collaborative inhibition. As was described earlier, considerable evidence has shown that divided attention at study impairs performance on explicit memory tasks, such as free recall, cued recall, and recognition (Baddeley et al., 1984), and that it also reduces organization of study items and

lowers an individual's performance on later memory tasks (Craig & Kester, 2000; Park et al., 1989). Together, these findings suggest that participants in the divided attention condition will be left with fewer idiosyncratic retrieval strategies that can be disrupted during later collaboration. Thus, even though the overall level of recall in the divided attention condition is expected to be lower, as compared with the full attention condition, since this lowered individual output will suffer less disruption during collaboration, individuals can contribute more of what they do remember. As a result, group recall is less likely to suffer from collaborative inhibition following divided attention encoding, as compared with the full attention encoding condition.

Method

Participants One hundred ninety-two Caldwell College undergraduate students were tested in this experiment. Forty-eight students were tested in triads in each condition of collaboration and attention.

Materials Five categories with 12 low-frequency target exemplars were selected from published norms (Battig & Montague, 1969). Six categories with one exemplar served as buffers. The target and buffer exemplars were equated on word length of five to nine letters ($F < 1$, $M = 6.71$) and low taxonomic frequency ($F < 1$, $M = 27.83$). A tone-monitoring task was used to divide attention.

Design Collaboration (collaborative/nominal) and attention (full/divided) were manipulated between-subjects.² Participants were randomly assigned to each condition of collaboration and attention. One study list of 60 target exemplars (five categories with 12 target exemplars) was used for each condition of collaboration and attention. With the exception of the buffer items, the exemplars from the target categories were intermixed such that no 2 exemplars from the same category appeared consecutively.

² In a prior experiment, we manipulated the effects of attention as a within-subjects variable by testing a different group of 96 participants. We replicated the main effects of collaboration and attention. Furthermore, we also observed the novel finding that the collaborative inhibition effect was present in the full attention condition, such that collaborative group recall ($M = .44$) was significantly lower than nominal group recall ($M = .56$), $t(30) = 3.11$, $SE = .04$, but was attenuated in the divided attention condition, where collaborative group recall ($M = .09$) was more comparable to nominal group recall ($M = .14$), $t(30) = 2.21$, $SE = .02$, producing a significant interaction, $F(1, 30) = 4.07$, $MSE = .01$. Since this effect was accompanied by recall levels in the divided attention condition that were on the low end of the range, thereby raising potential concerns about floor effects, we replicated these findings under conditions that increased recall levels by manipulating attention as a between-subjects variable in Experiment 2.

Procedure Each of the 66 study items was presented on a screen via a projector for 5 s in lowercase letters, using an Arial 60-point-size font. An asterisk was used as a placeholder during the interstimulus interval of 1 s. Participants studied 60 target exemplars along with three primacy and three recency buffers under full attention or divided attention encoding instructions. In the full attention condition, participants read each word silently for a later (unspecified) memory test. In the divided attention condition, participants additionally completed a tone-monitoring task in which they were required to indicate on a separate sheet of paper whether the tone presented was a low (125 Hz), medium (250 Hz), or high (500 Hz) tone. Each tone was presented for the duration of 0.5 s every 2 s. The retention interval task and test phase were identical to those in Experiment 1.

Results and discussion

A 2×2 completely randomized ANOVA for collaboration and attention on the mean proportions of correct recall replicated a main effect of attention, such that recall was better in the full attention condition ($M = .53$) than in the divided attention condition ($M = .26$), $F(1, 60) = 109.40$, $MSE = .01$, and a main effect of collaboration, such that recall was better in the nominal condition ($M = .44$) than in the collaborative condition ($M = .35$), $F(1, 60) = 11.19$, $MSE = .01$. Importantly, a significant interaction between collaboration and attention was observed, $F(1, 60) = 10.86$, $MSE = .01$. Follow-up comparisons showed that the collaborative inhibition effect was present in the full attention condition (nominal recall, $M = .61$; collaborative recall, $M = .44$), $t(30) = 4.35$, $SE = .04$, but disappeared in the divided attention condition, (nominal recall, $M = .26$; collaborative recall, $M = .26$), $t(30) < 1$ (see Fig. 2). It is worth noting that while divided attention study lowered performance, recall levels were nonetheless well above floor (in both the collaborative [$M = .26$] and nominal [$M = .26$] group recall conditions), mitigating possible concerns that the absence of collaborative inhibition was affected by low recall levels (see note 2). Together, these results show that divided attention encoding makes group recall less susceptible to disruption during collaboration.

Once again, while our focus was mainly on the relationship between the encoding variables and their effects on the magnitude of collaborative recall, we conducted secondary analyses related to ARC score patterns. A 2×2 completely randomized ANOVA for collaboration and attention for ARC scores showed a significant main effect of attention, such that organization was higher in the full attention condition ($M = .28$) than in the divided attention condition ($M = .13$), $F(1, 60) = 16.20$, $MSE = .02$. These results nicely replicate previous findings

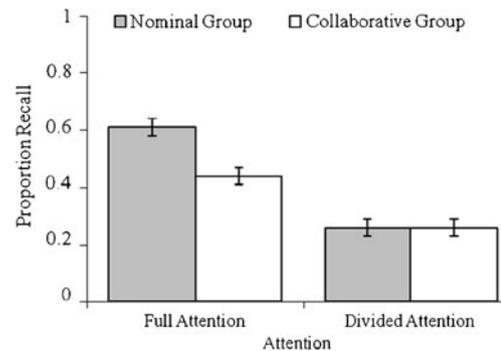


Fig. 2 Mean proportions of recall for the nominal and collaborative conditions as a function of attention. The error bars indicate standard errors

in the literature showing that divided attention reduces organization of information (Craik & Kester, 2000; Park et al., 1989).

The ARC analyses on collaboration and attention showed a replication of the main effect of collaboration, such that organization was higher in the nominal condition ($M = .26$) than in the collaborative condition ($M = .15$), $F(1, 60) = 7.68$, $MSE = .02$. Furthermore, a significant interaction between collaboration and attention, $F(1, 60) = 4.88$, $MSE = .02$, revealed that the reduction of organization as a result of collaboration was present in the full attention condition, (nominal, $M = .38$; collaborative, $M = .19$), $t(30) = 3.57$, $SE = .06$, but disappeared in the divided attention condition, (nominal, $M = .14$; collaborative, $M = .11$), $t(30) < 1$. This interaction should be interpreted with caution, because of low ARC scores in the divided attention condition, but are, nonetheless, consistent with the expectations.

Turning to intrusions, once again we replicated the pattern observed in the previous experiment and in the literature (Rajaram & Pereira-Pasarin, 2007, 2010; Ross et al., 2008; Ross et al., 2004). That is, collaborative groups ($M = .03$) reported significantly fewer intrusions than did nominal groups ($M = .08$), $t(62) = 4.89$, $SE = .01$, suggesting that collaboration can help prune individual memory errors under certain conditions. Intrusion rates did not differ as a function of full attention ($M = .05$) or divided attention ($M = .06$) encoding, $t < 1$.

In brief, these results clearly reveal that despite the robustness of the collaborative inhibition effect, the negative effects of collaboration on group recall are not ubiquitous and can disappear when attention is divided at encoding.

General discussion

The experiments reported in this article were designed to test the role of encoding factors in shaping the magnitude of

collaborative inhibition in group recall. While numerous studies in the literature have thus far focused on the roles of various post encoding factors in modulating retrieval organization and the magnitude of group recall that is affected by the collaborative processes, the present study makes novel contributions in that it focused on two theoretically motivated *encoding* factors.

On the one hand, we tested the idea that groups will experience less collaborative inhibition when contributing members can strengthen their individual retrieval strategies by studying items three times, as compared with studying once. For example, past research has shown that people show greater benefits of collaboration in their post-collaborative recall if they are able to individually recall studied information in a pre-collaborative phase before discussing the material in groups. This is because the first individual recall can help strengthen their individual retrieval strategies prior to experiencing disruption during collaboration and, thereby, help them augment their own recall with additional nonredundant information that other group members recall (Blumen & Rajaram, 2008). Furthermore, as was described in the introduction, evidence shows that repeated study increases retrieval organization by providing additional opportunities for individuals to engage in rehearsal (Rundus, 1971). Finally, as was shown in a previous study on collaborative recall, repeated study–test cycles can reduce the magnitude of collaborative inhibition with each study–test cycle (Basden et al., 2000, Experiment 2). However, because the selective contribution of repeated encoding could not be isolated in that study, we tested and confirmed the predictions arising from past research in Experiment 1, where the presentation of items three times, as compared with once, at encoding attenuated collaborative inhibition in group recall.

On the other hand, we predicted that groups would also experience less collaborative inhibition in a converse situation where the contributing members possessed weak retrieval organization. This prediction was tested by using an encoding factor that has been shown to reduce retrieval organization—namely, the level of attention with which participants encode events. This outcome was expected to occur because past research that has manipulated a *post* encoding variable, such as study–test delay period (Takahashi & Saito, 2004), suggested that when the retrieval organization is weaker, as compared with the default levels (single study, full attention condition used in past studies), there is less to disrupt, and consequently, group members can report what little they do remember. Consistent with this reasoning, the findings from Experiment 2 showed that collaborative inhibition disappeared under divided attention encoding.

It is worth noting in this context that recall levels (higher for repeated study and lower for divided attention) by

themselves might not necessarily affect collaborative inhibition. Past research has shown that collaborative inhibition sometimes does not occur despite reasonably high recall (about 55%) (shallow processing of a list of unrelated pictures; Weldon & Bellinger, 1997, Experiment 1), and collaborative inhibition can be substantial when high levels of recall (about 63%–78%) are associated with encoding that encourages attention to meaning and, presumably, organization (deep processing of a list of unrelated pictures; Weldon & Bellinger, 1997, Experiment 1). While this issue bears further scrutiny in future research, findings reported in the present study show that encoding variables known to affect retrieval strategies in past research on individual memory can produce systematic changes in collaborative inhibition.

In conclusion, this series of experiments shows that even though collaborative inhibition in recall is a robust effect, encoding factors can shape collaborative inhibition, thereby advancing our understanding beyond past research that has focused mainly on post encoding factors in exploring the nature of group recall.

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