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Exploring the relationship between retrieval disruption from collaboration and recall

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When people recall together in a collaborative group they recall less than their potential. This phenomenon of *collaborative inhibition* is explained in terms of retrieval disruption. However, collaborative recall also re-exposes individuals to items recalled by others that they themselves might otherwise have forgotten. This re-exposure produces post-collaborative benefits in individual recall. The current study examined whether reduced retrieval disruption during group recall is related not only to less collaborative inhibition, but also to greater post-collaborative recall benefits. To test this we devised a paradigm to calculate the extent to which each individual experienced retrieval disruption during group recall. We also included two types of collaborative groups, one of which was expected to experience greater retrieval disruption than the other. Results suggest that the relationship between retrieval disruption and recall performance depends on the level at which retrieval disruption is measured. When retrieval disruption was assessed at the individual level, then minimising retrieval disruption was associated with higher recall (i.e., less collaborative inhibition and greater post-collaborative individual recall). However, when retrieval disruption was assessed at the group level there was no relationship with recall. Furthermore, the findings from this design suggest a role of cross-cueing in modulating group recall levels.

Keywords: Collaborative inhibition; Retrieval disruption; Clustering; Cross-cueing; Human memory.

The information-processing approach, likening an individual's mind to a computer, has been highly influential in the study of memory. According to this view information can come in, be processed, stored, and retrieved. Problematically, metaphors such as these constrain the way researchers conceptualise variables (see Roediger, 1980). For example, the computer analogy tends to treat social factors as inputs to the system rather than as integral components. In other words, these factors are often treated as confounding variables, rather than systematically examined as a part of the incoming information stream (see Weldon,

2001). It is only recently that researchers have begun to systematically examine how social factors affect memory.

One social factor that influences memory is collaboration. At the retrieval stage, when individuals work together as a collaborative group they recall more than any one individual. However, collaborative groups recall *less* than their potential. That is, they recall less than the pooled, non-redundant answers of the same number of individuals working alone (a *nominal group*). This is known as *collaborative inhibition* (Weldon & Bellinger, 1997). The most widely cited

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explanation of collaborative inhibition is the *retrieval disruption hypothesis* (Basden, Basden, Bryner, & Thomas, 1997). Put simply, during encoding individuals develop their own idiosyncratic organisation of information. Later, at retrieval, when information is provided in a different order (as part of someone else's recall) it disrupts the individual's organisational structure and lowers the individual's recall performance. This in turn lowers group performance and hence less information is recalled in a group, compared to individual, setting.

The retrieval disruption hypothesis has received considerable experimental support. For example, in one study participants learned either 15 instances of 6 categories (large categories) or 6 instances of 15 categories (small categories). Although all participants learned the same number of items, there are presumably more ways to organise items in the large, compared to small, categories. Thus group members likely had more divergent organisational strategies, and were more likely to experience retrieval disruption, after studying the large categories. Consistent with this hypothesis, collaborative inhibition was greater for groups who studied the large, compared to small, categories (Basden et al., 1997; Experiment 1).

Additional support for the retrieval disruption hypothesis comes from studies showing that collaborative inhibition is only obtained when the retrieval task is guided by an individual's subjective organisation. For example, collaborative inhibition is not present when the memory test has a set organisational framework such as a cued-recall (Finlay, Hitch, & Meudell, 2000), or recognition test (Clark, Hori, Putnam, & Martin, 2000). In these situations the set organisational scheme of the test disrupts both the collaborative and the nominal groups, thereby eliminating collaborative inhibition. In summary, prior studies converge on the conclusion that retrieval disruption leads to collaborative inhibition.

Although collaboration is harmful to group memory, it almost always has a positive effect on later individual recall (e.g., Basden, Basden, & Henry, 2000; Blumen & Rajaram 2008; Weldon & Bellinger, 1997). When comparing participants who first perform a collaborative memory test followed by an individual memory test (CI) to participants who complete two individual memory tests (II), higher recall on the second test is observed in the CI condition compared to the II condition. This is thought to be due to *re-exposure*

benefits. During a collaborative recall test an individual is exposed to items she herself had forgotten, but that a group member recalled. Thus collaborative recall can serve as a second study opportunity and improve subsequent memory.

While these downstream benefits of collaboration have now been well documented, no research has yet examined whether these post-collaboration benefits are related to the extent to which an individual experiences retrieval disruption during collaboration. In other words, is the extent of retrieval disruption during group recall related to post-collaborative individual memory? Given that it is easier to incorporate information into memory when there is an established organisational scheme (e.g., von Hippel, Jonides, Hilton, & Narayan, 1993) we expected a negative relationship between retrieval disruption during group recall and post-collaborative individual recall. That is, to the extent that an individual can minimise retrieval disruption during group recall, and thereby maintain his own organisational structure, we expected to see higher post-collaborative individual recall.

To test this question it is necessary to quantify the extent of retrieval disruption experienced during group recall. Some research has done this by creating a comparison between two collaborative conditions, one of which is expected to create more retrieval disruption than the other. For example, in the study previously described by Basden and colleagues (1997), greater retrieval disruption was expected for participants who studied large, compared to small, categories. Other research has quantified retrieval disruption more specifically by calculating the adjusted ratio of clustering, or ARC, scores (Roemaker, Thompson, & Brown, 1971). ARC scores reflect the degree to which recalled items are clustered according to a category structure. It is assumed that when retrieval disruption increases, groups are less likely to recall items according to categorical structures and more likely to switch between categories (Basden et al., 1997). Some results are in line with this prediction (e.g., Finlay et al., 2000; but see Basden et al., 1997). For example, as group size increases collaborative inhibition increases (Thorley & Dewhurst, 2007) and clustering decreases (Basden et al., 2000). Although this method quantifies the amount of retrieval disruption experienced between groups, it should be noted that it calculates a single score for each group. Thus it does not allow for an assessment of the extent to

which each *individual* within the group experienced retrieval disruption. This measure at the individual level is needed to calculate the relationship between the extent of retrieval disruption that a group member experiences during collaboration and the extent to which this group member shows benefits of this collaboration on later individual recall.

In the current study we developed a paradigm that enabled us to examine these within-group, individual differences in retrieval disruption. We created three lists of ad-hoc categories. Although the same items appeared within each list, across lists the items were arranged into different category structures. For example, across the lists the word *blender* appeared in the categories *Things that can be electrical*, *Things to sell at a yard sale*, and *Things that may be made of metal*. At encoding, participants individually studied one of the lists. Later, at retrieval, some participants worked alone to recall the items (their recall was later combined to assess nominal group performance). Other participants worked in collaborative groups. In some groups all individuals had seen the same list (*identical organisational structure*). In other groups each individual had seen a different list (*divergent organisational structure*).

These latter groups, those in the collaborative divergent organisational structure condition, were the key focus of the current study. As each group member studied a different category structure we could calculate the degree to which the group recall was aligned with each participant's studied category structure. This provided a measure of the retrieval disruption suffered by each individual participant, and we examined whether this was related to subsequent individual memory. We expected lower retrieval disruption during group recall to be related to higher post-collaborative memory performance.

We also examined how retrieval disruption is related to group, rather than post-collaborative, recall. Within the collaborative divergent organisational structure condition, we predicted that lower disruption across all individuals within the group should be related to higher group recall. Using the just-described method of quantifying retrieval disruption using ARC scores for each individual, this assessment provides a further test of the claim that retrieval disruption is critical in producing collaborative inhibition.

Finally we also included a typical comparison used in previous studies. That is, we included two collaborative conditions, one of which was ex-

pected to create greater retrieval disruption than the other. For participants in the *divergent organisational structure* condition the same items were in different categories for each participant. In contrast, participants in the *identical organisational structure* condition studied the items in the same categories. To the extent greater retrieval disruption is expected to occur within the divergent, rather than identical, organisational structure condition, we expected the former condition to produce greater collaborative inhibition.

In summary, we developed a paradigm that allowed us to quantify the amount of retrieval disruption experienced by each individual during collaborative recall. We tested the prediction that lower retrieval disruption during collaboration would lead to increases in both group recall and post-collaborative individual recall.

METHOD

Participants and design

A total of 300 Stony Brook undergraduates participated for course credit. The experiment had a 2 (Retrieval Group: *Collaborative* or *Nominal*) \times 2 (Encoding Structure: *Identical* or *Divergent Organisational Structure*) between-participants design, with 25 triads per condition (always strangers).

Materials

We created three lists, each containing nine ad-hoc categories with four exemplars per category. The same 36 items were used in each list such that items never appeared in the same category across the three lists. For example, across the lists *stapler* appeared in the categories *Things that may be made of metal*, *Things you may find in an office*, and *Things that are man-made*. Items that appeared together within a category in one list never appeared together within a category in another list. For example, in List 1 the category *Things that may be made of metal* contained the items *stapler*, *fan*, *coins*, and *tools*. These items were then separated into different categories in Lists 2 and 3 (e.g., *coins* and *tools* were never again in the same category). Items were concrete nouns and were selected with the requirement that each item would make a reasonable exemplar of three different categories (see Appendix).

Procedure

Encoding. Participants were exposed to items from one of the lists, and rated how well the items matched their categories (see Appendix for average ratings). Each item was displayed for 5 seconds, and items were blocked by category. The blocked presentation and the rating manipulation were chosen to ensure that participants created organisational structures based on the categories.

Participants performed the study task individually. Within the *identical organisational structure* groups (nominal or collaborative) all group members saw the same list (List 1, 2, or 3) during encoding. In contrast, in the *divergent organisational structure* groups (nominal or collaborative) each group member saw a different list.

Delay. Participants individually completed puzzles for 45-minutes.

Group memory test. Participants completed a free recall test either individually (to form nominal triads) or in collaborative triads for 7 minutes. Participants were instructed to recall as many items as possible from the rating task and to write down only the items, not the categories. Collaborative groups were allowed to talk freely, and resolve disputes, among themselves. Furthermore, collaborative groups were instructed that while they all saw the same items, they might not have thought about them in the same way.

Final individual memory test. Immediately after completing the first memory test, all participants individually completed a second free recall test for 7 minutes. Participants were again instructed to write down only the items, not the categories.

RESULTS

Nominal group scoring

Nominal group recall was computed by non-redundantly combining the recall of three individuals working alone. Two types of nominal groups were created based on the encoded lists. In the nominal divergent organisational structure groups each group member encoded a different list. In the nominal identical organisational structure groups each group member encoded the same list (either List 1, 2, or 3).

Retrieval disruption scoring

We operationalised the amount of retrieval disruption experienced in three ways. First, during group recall we assumed that the collaborative divergent organisational groups would experience greater retrieval disruption (and thus greater collaborative inhibition) than the collaborative identical organisational groups. This group differences approach has been used in previous studies (e.g., Basden et al., 1997).

We also assessed the extent of retrieval disruption experienced by groups using adjusted ratio of clustering (ARC) scores (Roemaker et al., 1971). ARC scores can fall between -1 and 1 ; zero indicates chance clustering and higher scores indicate greater than chance clustering. Within the collaborative divergent organisational structure groups we calculated ARC scores three times, once for each list structure (since one participant had seen each of the three list structures). As expected, group recall did not systematically conform to any one of the three lists. The mean ARC score of the group recall was $.06$, $.01$, and $-.01$, according to the List 1, 2, and 3 structures, respectively. To determine the average amount of disruption experienced by all individuals within a given group, we averaged across these scores.¹ This resulted in a mean average ARC score of $.02$ (range of $-.09$ to $.15$), which was significantly lower than that of the collaborative identical organisational structure groups ($M = .39$; range of $.05$ to $.84$), $t(48) = -10.10$, $SE = .04$, $p = .001$. Thus, as assumed by the group differences approach above, retrieval disruption was greater in the collaborative divergent,

¹Within the collaborative divergent organisational structure groups there is some interdependence between the ARC scores of the three group members. If the group recall product highly conforms to one group member's organisational structure it cannot highly conform to either of the other two group members' organisational structures. However, it is important to note that not all groups systematically conformed to one particular organisational structure. When comparing groups we see that the same average ARC score (e.g., $.02$) could either reflect minimal disruption for one individual accompanied by greater disruption for the other group members (e.g., ARC scores of $.40$, $-.07$, and $-.27$) or moderate disruption for all group members (e.g., ARC scores of $.04$, $.03$, and $-.02$). In both of these cases the average ARC score (e.g., $.02$) should be predictive of group recall. This is because group recall also reflects the average contributions from each group member. In some cases there may be a dominant contributor and in other cases the contributions may be more equally distributed.

compared to identical, organisational structure groups. In subsequent analyses we examine the extent to which these average ARC scores were related to group recall.

Within the collaborative divergent organisational structure groups, a distinction can be made between the average amount of retrieval disruption experienced by all group members and the amount experienced by each individual. As our final measure of retrieval disruption we calculated the extent to which *each individual* experienced retrieval disruption. We operationalised this as the extent to which the group recall was clustered according to the organisational structure the individual encoded. These ARC scores ranged from $-.30$ to $.61$. Interestingly, this range overlaps with the range of ARC scores observed in the collaborative identical organisational structure groups (range of $.05$ to $.84$) suggesting that some individuals within the collaborative divergent organisational structure groups experienced *less* retrieval disruption than some individuals in the collaborative identical organisational structure groups. In subsequent analyses we examine the relationship between the amount of disruption experienced by each individual and post-collaborative individual recall.

Group recall and its relationship to retrieval disruption

We first examined the relationship between retrieval disruption and group recall by determining whether the magnitude of the collaborative inhibition effect varied as a function of encoding structure. As mentioned above, average ARC scores were lower, indicating greater retrieval disruption, in the collaborative divergent, compared to identical, organisational structure condition. However, this did not translate into increased collaborative inhibition. Although a 2 (Retrieval Group: Collaborative or Nominal) \times 2 (Encoding Structure: Identical or Divergent Organisational Structure) ANOVA revealed a significant difference in group recall across the conditions, $F(3, 96) = 3.67$, $MSE = .01$, $p = .02$, $\eta_p^2 = .10$, this was due entirely to a main effect of retrieval group type. Collaborative groups (divergent organisational structure: $M = .68$; identical organisational structure: $M = .67$) recalled significantly less than nominal groups (divergent organisational structure: $M = .73$; identical organisational structure:

$M = .74$), $F(1, 96) = 10.70$, $MSE = .01$, $p = .001$, $\eta_p^2 = .10$. However, there was neither a main effect of encoding structure, $F(1, 96) < 1$, nor an interaction between encoding structure and retrieval group type, $F(1, 96) < 1$. That is, we replicated the standard finding of collaborative inhibition in group recall and discovered that collaborative inhibition was surprisingly no greater in the divergent, compared to identical, organisational structure groups. This is in contrast to previous research demonstrating greater collaborative inhibition for conditions presumed to be associated with greater retrieval disruption (e.g., Basden et al., 1997; Thorley & Dewhurst, 2007). We will return to this unexpected finding in the discussion section.

We further examined the relationship between retrieval disruption and collaborative inhibition within the collaborative divergent organisational structure groups using ARC scores. As mentioned previously, to do this we calculated the average amount of disruption experienced across the group members (i.e., the average ARC score according to the three list structures). We expected greater retrieval disruption to be associated with lower group recall. Consistent with this prediction, groups with less retrieval disruption (i.e., higher average ARC scores) had marginally greater recall, $r(25) = .39$, $p = .06$. Thus the group's ability to minimise disruption across all group members was associated with increases in group recall.

Post-collaborative individual recall and its relationship to prior retrieval disruption

A 2 (Retrieval Group: Collaborative or Nominal) \times 2 (Encoding Structure: Identical or Divergent Organisational Structure) ANOVA revealed a significant difference in final individual recall across the conditions, $F(3, 296) = 31.40$, $MSE = .02$, $p < .001$, $\eta_p^2 = .24$. This was due to a main effect of retrieval group condition. Individuals who previously participated in collaborative groups (divergent organisational structure: $M = .52$; identical organisational structure: $M = .54$) recalled significantly more than individuals who previously recalled alone (i.e., nominal groups members – divergent organisational structure: $M = .37$; identical organisational structure: $M = .39$), $F(1, 296) = 92.08$, $MSE = .02$, $p < .001$,

$\eta_p^2 = .24$. However, there was no main effect of encoding structure, $F(1, 296) = 2.07$, $MSE = .02$, $p = .15$, $\eta_p^2 = .007$, nor an interaction between retrieval group type and encoding structure, $F < 1$. Thus simply being in a group setting in which retrieval disruption was minimised (the collaborative identical organisational structure condition) did not confer additional downstream benefits compared to being in a collaborative group that experienced more retrieval disruption (the collaborative divergent organisational structure condition).

Finally, we examined the relationship between retrieval disruption, as assessed via ARC scores for each individual, and subsequent individual memory performance. As mentioned above, within the collaborative divergent organisational structure groups we calculated ARC scores three times, once for each individual's organisational structure. As predicted, the more an individual was able to minimise retrieval disruption during group recall (i.e., the more the group recall was clustered according to the individual's encoded list structure), the higher his or her post-collaborative individual recall performance, $r(75) = .30$, $p = .01$ (see Figure 1). Thus the more the group recall was aligned with the individual's organisational structure, the greater his or her subsequent recall.

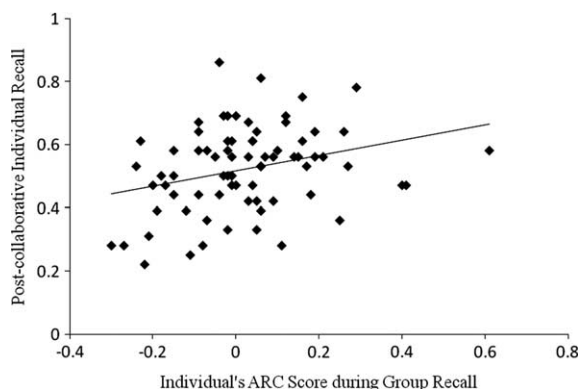


Figure 1. Within the collaborative divergent organisational structure groups, the relationship between the amount of retrieval disruption experienced by an individual during group recall (i.e., the ARC score of the group recall according to the individual's organisational structure from encoding) and his or her post-collaborative individual recall. Note that higher ARC scores indicate *less* retrieval disruption.

DISCUSSION

This study examined the relationship between retrieval disruption on the one hand, and both collaborative and post-collaborative individual recall on the other. Looking first at group recall, results revealed mixed support for the relationship between retrieval disruption and collaborative inhibition. Within the collaborative divergent organisational structure condition, groups that were able to minimise retrieval disruption across all individuals had marginally higher recall. This is in line with previous findings that retrieval disruption is an important factor affecting group recall. However, although retrieval disruption was on average greater in the collaborative divergent, compared to identical, organisational structure groups recall did not differ between these groups.

Why was the increased retrieval disruption in the collaborative divergent, compared to identical, organisational structure groups not related to increased collaborative inhibition unequivocally? It is likely that collaborative recall is affected by factors other than retrieval disruption. One such factor is *cross-cueing*, the notion that one person's recollections can serve as facilitatory cues and aid the recollection of others. In past work cross-cueing has been difficult to detect (e.g., Meudell, Hitch, & Boyle, 1995) although recent studies report some evidence for its operation (Congleton & Rajaram, in press; Takahashi & Saito, 2004). We examined whether collaborative divergent organisational structure groups would exhibit greater cross-cueing, as evidenced by higher category recall, than collaborative identical organisational structure groups. To assess this, within the collaborative divergent organisational structure groups, we calculated category recall three times using each of the participant's list structures. Of the nine categories the mean number represented in the group recall was 8.96, 8.88, and 8.96 according to the List 1, 2, and 3 structures, respectively. In all three cases, Mann-Whitney U tests showed this was significantly greater than the number recalled ($M = 8.48$) in the collaborative identical organisational structure groups ($z = -3.06$, $p = .002$; $z = -2.33$, $p = .02$; and $z = -3.06$, $p = .002$, respectively). Thus both the decrements from retrieval disruption and the benefits from category cross-cueing were greater in the

collaborative divergent, compared to identical, organisational structure groups. These findings suggest that the opposing forces of increased retrieval disruption and increased cross-cueing in the divergent organisation condition resulted in no significant difference in group recall between the two collaborative groups.

Future research is needed to examine more fully the preliminary cross-cueing benefits seen here. As we noted earlier, cross-cueing benefits have been difficult to capture experimentally (e.g., Meudell et al., 1995). In the rare instances where cross-cueing has been reported, the paradigm has required comparisons of gains across multiple group memory tests (Congleton & Rajaram, 2011; Takahashi & Saito, 2004). The current study design, which involves only one group recall session, thus opens up new avenues for examining cross-cueing benefits in collaborative retrieval.

To address the main novel purpose of the current study we also examined the relationship between retrieval disruption during group recall and subsequent post-collaborative individual recall. When we examined this question broadly at the group level, results showed that final individual recall was no greater for individuals who previously recalled in a collaborative identical, compared to divergent, organisational group even though the former condition on average yielded less retrieval disruption. However, a different pattern of results emerged when examining the relationship between the amount of retrieval disruption experienced by *each individual*. These results indicated that the less a given individual experienced disruption during the group recall, the better his or her post-collaborative recall. Thus, retrieval disruption may be important in predicting the downstream benefits an individual receives from collaborative recall.

In the current study we investigated the role of retrieval disruption on both group and individual memory performance using the novel method of directly assessing the extent of disruption experienced by individuals during collaborative recall. Taken together, results indicate that the relationship between retrieval disruption and recall are dependent on how one operationalises retrieval disruption (i.e., whether retrieval disruption is assessed at the individual or group level), and that retrieval disruption may play an important, but not solitary, role in predicting group recall. Furthermore, post-collaborative individual mem-

ory may be higher when the retrieval disruption previously experienced by a given individual was low.

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APPENDIX

Stimuli used in the current experiment

	<i>List 1</i>		<i>List 2</i>		<i>List 3</i>	
	n = 66		n = 53		n = 61	
Things that can be electrical	blender	4.60	chainsaw	3.88	radio	4.47
	clock	3.89	hairdryer	4.54	stove	3.78
	iron	4.14	shaver	3.78	television	4.63
	typewriter	3.40	vacuum	4.28	toaster	4.33
Things to sell at a yard sale	book	4.51	blender	3.55	iron	3.37
	camera	3.85	gloves	3.14	sweater	4.03
	chainsaw	2.71	radio	4.12	toys	4.75
	toaster	3.92	tools	4.10	vacuum	3.65
Things that may be made of metal	coins	4.73	iron	4.60	blender	3.80
	fan	4.08	lamp	3.16	jewelry	4.35
	stapler	4.37	lighter	3.33	scissors	4.50
	tools	4.64	stove	4.32	trumpet	4.68
Things you may find in an office	computer	4.94	calendar	4.92	book	4.73
	pen	4.95	scissors	4.57	candy	3.80
	radio	4.00	stapler	4.90	fan	4.22
	tissues	4.23	wallet	3.48	lamp	4.63
Things that are man made	lamp	3.97	cigarettes	3.98	comb	3.88
	lipstick	3.85	sweater	4.35	hairdryer	3.95
	jewelry	4.17	television	4.37	stapler	3.98
	vacuum	4.11	tissues	3.76	typewriter	4.10
Things that start with a certain letter	scissors	4.97	toaster	4.98	chainsaw	4.85
	shaver	4.92	toys	5.00	cigarettes	4.88
	stove	4.98	trumpet	5.00	clock	4.98
	sunglasses	5.00	typewriter	4.98	coins	4.78
Things people keep in their pockets/purses	cigarettes	4.39	candy	3.76	calendar	2.69
	comb	4.08	coins	4.80	lighter	4.30
	gloves	3.78	lipstick	4.49	sunglasses	4.32
	wallet	4.85	pen	4.35	tissues	4.43
Things to give as a gift	calendar	3.03	book	4.02	camera	4.82
	candy	3.86	clock	3.08	pen	3.12
	television	3.52	computer	3.90	tools	3.97
	toys	4.86	jewellery	4.84	wallet	4.05
Things that fit in the trunk of a car	hairdryer	4.21	camera	4.06	computer	4.12
	lighter	4.14	comb	3.92	gloves	4.31
	sweater	4.50	fan	3.45	lipstick	3.70
	trumpet	4.14	sunglasses	3.67	shaver	3.95

During encoding, participants rated how well each item matched the ad hoc category on a scale from 1 (“Does not match the category at all”) to 5 (“Matches the category extremely well”). Average ratings are provided. Although 100 participants studied each of the three lists, data were lost from one of the computers. Thus the average ratings provided are based on a subset of the participants.