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The collaborative encoding deficit is attenuated with specific warnings

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Individuals learning together do so less effectively than individuals learning alone, an effect known as the *collaborative encoding deficit*. In the present studies we examined whether providing participants with a warning about the collaborative encoding deficit would increase their encoding task performance, and reduce subsequent memory deficits. Across two experiments, specific warnings were beneficial for memory. Collaborating participants who were told about the collaborative encoding deficit, and who received suggestions for how to complete the encoding task, had superior memory than participants who received no warning. This benefit was not due to qualitative changes in encoding task performance, was unrelated to the type of collaboration utilised, was absent when a more general warning was utilised, and was unrelated to self-reported task motivation. Rather, specific warnings appear to protect against the collaborative encoding deficit by increasing time spent on, and attention directed to, the encoding task.

Keywords: Collaboration; Collaborative encoding deficit; Warnings; Human memory; Motivation.

We humans are social beings. We come into the world as the result of others' actions. We survive here in dependence on others. Whether we like it or not, there is hardly a moment of our lives when we do not benefit from others' activities. (His Holiness, the 14th Dalai Lama of Tibet, 1999, p. 62)

Given that humans are social beings it is difficult, if not impossible, to separate cognitive from social tasks. When people complete cognitive tasks alone they are affected by their social and cultural environments. Furthermore, people frequently complete cognitive tasks, such as learning and remembering, in interactive, collaborative, groups. For example, friends often reminisce with one another about past shared experiences,

families develop a lifetime of shared memories together, jury members collaboratively discuss trials, and students learn information in study groups. Despite the frequency of collaborative learning and remembering in everyday settings, cognitive research has only begun to systematically examine how collaboration affects the processes of learning and remembering (for reviews, see Harris, Paterson, & Kemp, 2008; Hirst & Manier, 2008; Rajaram, 2011; Rajaram & Pereira-Pasarin, 2010; Weldon, 2001).

Looking first at collaborative remembering, research suggests that its efficacy depends upon whether the comparison is between the group and a single individual, or between the group and its potential. Groups, not surprisingly, recall more information than any one individual (e.g., Weldon

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& Bellinger, 1997; Yuker, 1955). However, groups recall less than their potential. The comparison here is between the recall of a collaborative group and the recall of a *nominal* group of equal size. Nominal groups are groups in name only and their recall consists of the pooled, nonredundant items recalled by individuals working alone. This nominal group product is then compared to the number of items recalled by the same number of individuals working together. In this comparison, nominal groups typically outperform collaborative groups. This outcome is known as *collaborative inhibition* (Weldon & Bellinger, 1997), and is thought to arise in large part from a mechanism known as retrieval disruption (Basden, Basden, Bryner, & Thomas, 1997; see also Barber & Rajaram, 2011; Finlay, Hitch, & Meudell, 2000). Specifically, during encoding individuals develop their own idiosyncratic methods of organising information in memory. Later, during retrieval, if items are presented in a different order (as part of a group member's recall) it disrupts the individual's own organisation of the materials and lowers recall.

Although ample evidence shows that collaboration during *retrieval* negatively affects recall, less is known about its role at *encoding*. In a recent study, we focused on how individual encoding differs from collaborative encoding. To examine this, we used an encoding task that required construction of meaningful sentences, and manipulated whether participants performed this task individually or collaboratively. We also manipulated whether participants worked individually or collaboratively at retrieval to evaluate the role of study–test match on recall (Barber, Rajaram, & Aron, 2010, Exp. 1). We describe this study in some detail as its findings motivated the key questions in the present research. During encoding, participants were shown unrelated word pairs (see Graf & Schacter, 1985) and were asked to create, either individually or with a stranger, a single sentence that linked the words (e.g., *citizen*—*trail*: “*The citizen walked the winding trail*”). In the dyadic encoding conditions, participants were asked to equally contribute to the creation of the sentences. Here, one participant began each sentence using the first word (e.g., *citizen*: “*The citizen walked*”), and the other participant finished the sentence using the second word (e.g., *trail*: “*the winding trail*”), a procedure we termed as *turn-taking dyadic encoding*. Later, all participants completed a cued-recall test in which they were given the first word from each

pair (e.g., *citizen*—) and were asked to recall the word that was paired with it at encoding (e.g., *trail*). This was again done either individually or collaboratively. In the cases where participants both encoded and recalled collaboratively, the partner was equally often the same individual at both time points, as different individuals at encoding and retrieval.

We tested two hypotheses about how individual encoding would compare to collaborative encoding. The first hypothesis was drawn from work on the role of *cue uniqueness*. According to this literature, individually generated items are more idiosyncratically meaningful and are therefore better cues at retrieval (for the individual who generated them) than collaboratively generated items (Andersson & Ronnberg, 1997; Mäntylä & Nilsson, 1983). Thus, individual encoding should lead to higher recall than collaborative encoding regardless of the retrieval conditions. A second hypothesis was drawn from a large body of research on the *encoding-specificity* effect that posits that recall should be better when there is a match between study and test conditions than when there is a mismatch (Tulving, 1983; Tulving & Osler, 1968). Thus, after individual encoding participants should recall more when working individually than when working with a partner. Similarly, after collaborative encoding one should recall more when working with the same partner from encoding than when working individually or with a new partner.

Our results were in line with the cue uniqueness hypothesis. Participants who encoded information collaboratively recalled less information than participants who encoded information individually (see also Barber, Rajaram, & Fox, 2012). This was true regardless of whether participants completed the cued-recall task individually, with a new partner, and, strikingly, even when the partner at recall was the same as the one at encoding. Furthermore, our results suggested that this *collaborative encoding deficit* may in part be due to a reduction in the efficacy of cues available at retrieval following collaborative encoding; collaborative dyads tended to generate less cohesive sentences (i.e., sentences without well-integrated ideas and clauses) than individuals. This in turn likely reduced the effectiveness of the cue words in bringing to mind the target words at retrieval. For example, the cue word *citizen* would presumably be more effective in bringing to mind the target word *trail* if the sentence created at encoding was cohesive, such as “*The New York citizen walked a*

trail in Central Park”, compared to if the sentence created was relatively uncohesive, such as “*I am a citizen of the United States and I like to eat trail mix*”. In brief, collaborative encoding reduced sentence cohesiveness at encoding, and was also associated with poorer subsequent recall.

In a second experiment (Barber et al., 2010, Exp. 2), we tested whether the collaborative encoding deficit arose because of the turn-taking procedure for creating sentences, and could be eliminated by using a more natural, free-flowing method of collaborative encoding. As in Experiment 1, some participants collaboratively created sentences from pairs of words through turn taking such that they equally contributed to each sentence. In contrast, other participants were asked to work together to create sentences from the word pairs, but no restrictions were imposed about how to collaborate. We termed this *free-for-all dyadic encoding*. Replicating Experiment 1 results, compared to individual encoding, the turn-taking dyadic encoding participants created uncohesive sentences and recalled less information. However, a different pattern emerged for the free-for-all dyadic encoding participants. These participants created sentences that were as cohesive as those created by the individual encoding participants. This improvement reduced the collaborative encoding deficit in later recall but, importantly, the collaborative encoding deficit nonetheless persisted. In other words, increasing sentence cohesiveness in the free-for-all dyadic encoding condition resulted in an attenuation of, but not an elimination of, the collaborative encoding deficit. Thus, the collaborative encoding deficit cannot be fully explained by a lack of sentence cohesiveness at encoding. This outcome suggests that cues generated by others, even when qualitatively good, are less effective at guiding retrieval than cues generated by the self.

To summarise, our previous results suggest that collaboration can impair encoding (Barber et al., 2010, 2012). In some cases (i.e., turn-taking dyadic encoding), this is because collaboration leads to the creation of qualitatively poor retrieval cues. However, the collaborative encoding deficit persists even when collaboration is associated with qualitatively good cues (i.e., free-for-all dyadic encoding). Thus, qualitatively poor cues cannot be the sole mechanism underlying the collaborative encoding deficit.

Although our previous results suggest that differences in cue quality cannot be the sole mechanism underlying the collaborative encoding

deficit, an open question is whether it plays any causal role. That is, our previous results suggest that the free-for-all dyadic encoding condition was associated with both increases in sentence cohesiveness and increases in cued-recall compared to the turn-taking dyadic encoding condition. However, it is unclear whether the increases in sentence cohesiveness *caused* the increases in cued-recall or whether both are simply associated with the more naturalistic form of free-for-all dyadic encoding. As a first step in addressing this, in the current study we examined whether awareness of the relationship between collaboration and cue quality would modulate the collaborative encoding deficit. To do this, we provided some collaborating dyads with a warning about how collaboration impaired encoding performance in previous studies, and specifically instructed participants to avoid these decrements. We expected that this warning would improve sentence creation task performance, and we tested whether this in turn would improve subsequent cued-recall.

We also examined whether the warning would improve performance equally across the two forms of collaborative encoding. As mentioned earlier, in our previous research (Barber et al., 2010), participants in a turn-taking dyadic condition had both poorer sentence cohesiveness and poorer cued-recall performance than participants in the individual encoding condition. In contrast, participants in a free-for-all dyadic encoding condition were able to create cohesive sentences (i.e., their sentences were as cohesive as those from participants in the individual encoding condition) but still had poorer cued-recall performance than participants in the individual encoding condition. Given that we expected the warning to improve sentence cohesiveness (and were interested in whether this in turn benefits memory performance), it is possible that only participants in the turn-taking condition will benefit from the warning since only they show a deficit in creating cohesive sentences. However, it is also possible that the warning may induce participants to be more motivated to attempt creating “good”, cohesive, sentences and thus improve performance for both forms of collaborative encoding. A third possibility is that the warning will have no effect in either group. This last possibility would be similar to previous research showing no effect on collaborative recall when motivation was manipulated at retrieval (Weldon, Blair, & Huesch, 2000).

EXPERIMENT 1

Method

Participants and design

A total of 120 undergraduates at Stony Brook University participated for partial-course credit, with 24 participants (12 pairs of strangers) assigned to each condition: (1) individual encoding, (2) free-for-all dyadic encoding, (3) free-for-all dyadic encoding with a warning, (4) turn-taking dyadic encoding, and (5) turn-taking dyadic encoding with a warning.

Materials

We generated 128 unrelated nouns from the MRC Psycholinguistic database (Wilson, 1988) that were four to seven letters in length, 10–100 per million in word frequency, and 450–700 in concreteness. Words were combined into 64 unrelated word pairs.

Procedure

Encoding. Participants created a single sentence out of each word pair such that the first word of the pair came earlier in the sentence than the second word of the pair. For example, given the word pair: “*lady—journal*”, a potential sentence is: “*The lady kept a secret journal*”. In the individual encoding condition participants worked alone on this task. In the two free-for-all dyadic encoding conditions participants worked with a partner (always a stranger) to create a single sentence linking the words. No specific instructions were provided about how to collaborate. Finally, in the two turn-taking dyadic encoding conditions participants worked with a partner (always a stranger) to equally contribute towards the creation of each sentence such that for each word pair one participant began the sentence with the first word, and the other participant finished the sentence with the second word. Participants alternated who started and completed the sentences. No mention was made of the subsequent memory test.

In the collaborative encoding conditions that included warning, participants received additional task instructions that emphasised three facts: (1) Dyads in the past have done poorly on this sentence-creation task; (2) this was because they often created sentences that were not cohesive; and (3) in the following task participants should

strive to create cohesive sentences. Examples were provided of both cohesive and uncohesive sentences. For the full text of the warning, see Appendix A. Finally, we note that all instructions were read aloud by the experimenter to ensure that all participants within the warning conditions actually received the warning. Furthermore, we did not provide any participants in the individual encoding condition with a warning. This is because the warning focused on improving collaborative task performance, and therefore was not applicable to these participants.

Filled delay. Participants individually completed 45 min of puzzles.

Retrieval. Participants individually completed an unexpected cued-recall test in which they saw the first word of each pair (*lady—*) in a different order from encoding and attempted to recall the corresponding target (*journal*).

Results

Because all conditions entailed recalling alone, individual recall data is reported. This decision is supported by the facts that (1) nominal group scores yielded a similar pattern of results for all measures, and (2) a pairwise intraclass correlation analysis (see Gonzalez & Griffin, 1999) suggests independence between the two individual recall scores within dyads, $r = -.10$, $z = -0.69$, $p = .25$.¹

Correct recall. There were significant differences in correct cued-recall among the five conditions, $F(4, 115) = 6.57$, $MSE = 0.04$, $p < .001$, $\eta_p^2 = .19$ (see Figure 1), and follow-up comparisons replicated the collaborative encoding deficit. Parti-

¹Pairwise intraclass correlations were also calculated separately for each of the dyadic conditions. Here, results again suggested independence of data points within the free-for-all condition, $r = -.38$, $z = -1.32$, $p = .09$, turn taking with a warning condition, $r = .23$, $z = 0.78$, $p = .22$, and free-for-all with a warning condition, $r = .14$, $z = 0.48$, $p = .32$. In contrast, interdependence was observed in the turn-taking condition, $r = -.67$, $z = -0.23$, $p = .01$. However, we note that the interdependence observed was such that high scores by one dyad member corresponded to low scores by the other dyad member. Negative correlations such as these actually have the result of reducing the number of Type 1 errors observed in between-dyads designs (Kenny, Kashy, & Cook, 2006). Thus, we remain confident that any significant effects observed as a function of condition in subsequent analyses are not due to confounds associated with interdependence of the data.

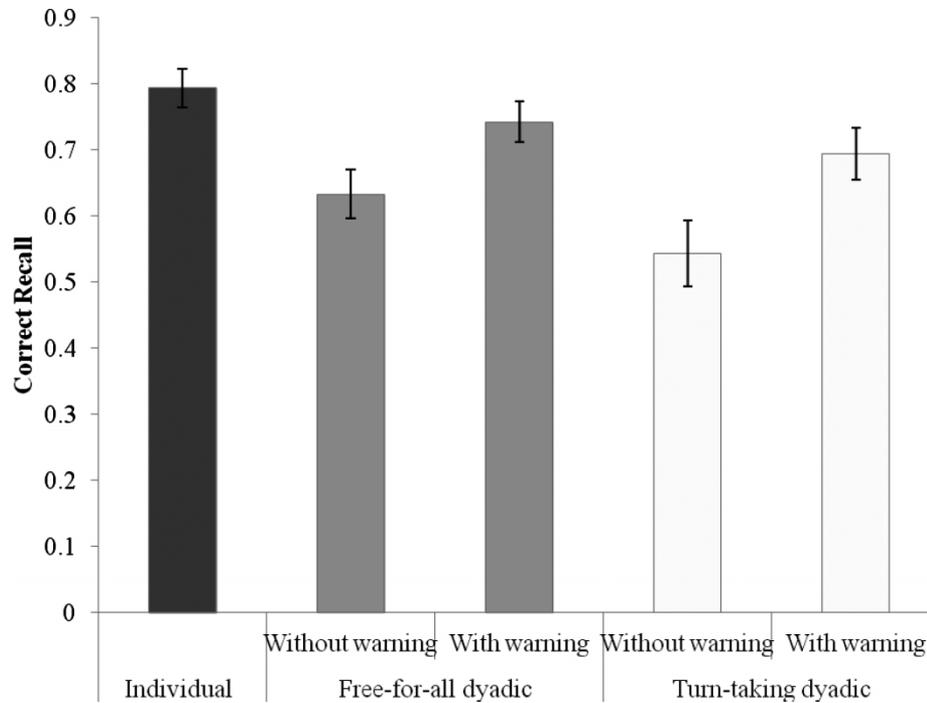


Figure 1. Mean proportion of items correctly recalled by individuals as a function of encoding conditions in Experiment 1. Error bars are $\pm 1 SE$.

participants in the individual encoding condition ($M = 0.79$) recalled significantly more than participants in both the turn-taking dyadic encoding (no-warning) condition ($M = 0.54$), $t(115) = 4.66$, $SE = 0.05$, $p < .001$, $d = 1.29$, and in the free-for-all dyadic encoding (no-warning) condition ($M = 0.63$), $t(115) = 2.99$, $SE = 0.05$, $p = .003$, $d = 1.00$. Thus, as in previous research, collaboration impaired encoding compared to individual encoding (Barber et al., 2010, Exp. 2; see also Barber et al., 2012). Furthermore, as in past research, participants in the turn-taking dyadic encoding (no-warning) condition recalled fewer items than participants in the free-for-all dyadic encoding (no-warning) condition, although this difference was only marginally significant (but of a moderate effect size), $t(115) = -1.67$, $SE = 0.05$, $p = .097$, $d = 0.43$.

We next examined whether the warning improved recall and whether this depended upon the form of collaboration utilised at encoding (i.e., turn taking vs. free-for-all). Results indicated that the warning at encoding improved subsequent cued-recall performance, and that this was true for both turn taking and free-for-all encoding methods. Participants in the turn-taking dyadic encoding conditions recalled significantly more items when provided with a warning at encoding ($M = 0.69$) than when simply given the turn-

taking instructions ($M = 0.54$), $t(115) = 2.81$, $SE = 0.05$, $p = .006$, $d = 0.70$. Similarly, participants in the free-for-all dyadic encoding conditions recalled significantly more items when provided with a warning at encoding ($M = 0.74$) than when simply given the free-for-all instructions ($M = 0.63$), $t(115) = 2.04$, $SE = 0.05$, $p = .04$, $d = 0.66$. A 2 (type of collaboration: turn taking vs. free-for-all) \times 2 (warning condition: no warning vs. warning) ANOVA revealed no significant interaction between the type of collaborative encoding and warning condition, $F(1, 92) = 0.27$, $MSE = 0.04$, $p = .60$.

Furthermore, the warning attenuated the collaborative encoding deficit. Although participants in the turn-taking dyadic encoding with a warning condition ($M = 0.69$) and in the free-for-all dyadic encoding with a warning condition ($M = 0.74$) continued to recall numerically less than participants in the individual encoding condition ($M = 0.79$), these differences were no longer statistically significant, $t(115) = 1.85$, $SE = 0.05$, $p = .07$, $d = 0.60$, and $t(115) = 0.96$, $SE = 0.05$, $p = .34$, respectively. Of note, this is the first instance where we have observed an elimination of the collaborative encoding deficit (particularly in the latter condition) (see Barber et al., 2010, 2012).

Sentence cohesiveness and encoding time. Thus far we have demonstrated that providing participants with a warning eliminated the collaborative encoding deficit. We next examined whether these beneficial effects were due to improvements in the quality of the sentences produced at encoding. Two raters, blind to condition, independently rated each sentence for cohesiveness on a 4-point scale. Sentences considered “completely cohesive” (rated 4) had well-integrated ideas and clauses (e.g., *fruit—oxygen*: “Two things plants can do are bear *fruit* and produce *oxygen*”). Sentences considered “completely uncohesive” (rated 1) were typically two sentences with little link between them (e.g., “She had *fruit* salad for dessert even though there was a lack of *oxygen* in the room”). The raters showed excellent agreement on the 4608 sentences (complete agreement on 71.3% and only one-point difference on an additional 20.9%). Disagreements that were greater than one-point difference were resolved by discussion between the two raters. For disagreements of only one-point the average of the two ratings was used in the following analyses.

There were significant differences in sentence cohesiveness among the five conditions, $F(4, 67) = 14.53$, $MSE = 0.04$, $p < .001$, $\eta_p^2 = .47$. Replicating prior findings (Barber et al., 2010, Exp. 2), both participants in the individual encoding condition ($M = 3.82$) and in free-for-all dyadic encoding (no-warning) condition ($M = 3.80$) produced more cohesive sentences than participants in the turn-taking dyadic encoding (no warning) condition ($M = 3.48$), $t(67) = 4.77$, $SE = 0.07$, $p < .001$, $d = 1.95$, and $t(67) = 3.89$, $SE = 0.08$, $p < .001$, $d = 1.65$, respectively. Furthermore, as in past research cohesiveness did not differ between the individual encoding condition and the free-for-all dyadic encoding (no-warning) condition, $t(67) = 0.28$, $SE = 0.07$, $p = .78$ (although this was again subject to ceiling effects).

Was the benefit of the warning on cued-recall performance due to changes in the quality of cues produced by participants? To answer this, we examined whether the warning affected the quality of the sentences produced during encoding. Interestingly, results revealed that it did not. Participants in the turn-taking dyadic encoding conditions did not produce significantly more cohesive sentences when provided with a warning at encoding ($M = 3.39$) than when given standard instructions ($M = 3.48$), $t(67) = -1.07$, $SE = 0.08$, $p = .29$. Similarly, participants in the free-for-all dyadic encoding conditions did not produce

significantly more cohesive sentences when provided with a warning at encoding ($M = 3.83$) than when given standard instructions ($M = 3.80$), $t(67) = 0.29$, $SE = 0.08$, $p = .77$. Although the results from the free-for-all dyadic encoding conditions (both with and without warning) must be interpreted cautiously due to ceiling effects, together with the turn-taking dyadic encoding results (which did not exhibit a ceiling effect), this pattern suggests that the warning did *not* increase subsequent recall by improving the quality of the sentences produced at encoding. This outcome is similar to past research showing that collaborative encoding deficit in later recall is not fully explained by the sentence quality at encoding (Barber et al., 2010, Exp. 2).

Rather, it appears that the warning benefited performance, at least in part, because it increased the length of time participants spent on the encoding task. Within a 2 (type of collaboration: turn taking versus free-for-all) \times 2 (warning condition: no warning vs. warning) ANOVA on time spent on the encoding task, there was a significant effect of warning condition, $F(1, 44) = 5.72$, $MSE = 77.61$, $p = .02$, $\eta_p^2 = .12$. Collaborating participants spent longer on the encoding task after receiving a warning ($M = 36.17$ min) compared to when they received no warning ($M = 30.08$ min). This increase in encoding time as a function of the warning did not interact with collaboration type, $F(1, 44) = 0.13$, $MSE = 77.61$, $p = .72$, $\eta_p^2 = .003$.²

² We also examined whether participants in the individual encoding condition differed from participants in the collaborative (with and without warnings) encoding conditions in terms of the amount of time spent at encoding. Results revealed that there were marginally significant differences in encoding time among the five conditions, $F(4, 67) = 2.41$, $MSE = 70.71$, $p = .058$, $\eta_p^2 = .13$. Consistent with previous results (Barber et al., 2010), follow-up contrasts showed that participants in the individual encoding condition ($M = 29.75$ min) were numerically faster at completing the sentence task than participants in the four dyadic encoding conditions, $t(67) = -1.61$, $SE = 8.41$, $p = .11$. Although this contrast did not reach statistical significance, this numerical pattern suggests that the recall benefit of individual encoding cannot be explained by an increase in time spent on the task. This is in contrast to the pattern observed for the collaborative dyads, where the warning increased both recall and time spent on the task. Thus, although increased encoding time cannot explain why individual encoding is superior to collaborative encoding, it may in part explain why collaborative encoding with a warning is superior to collaborative encoding without a warning.

Discussion

Replicating past research, collaboration at encoding impaired subsequent cued recall performance. This was true both when the form of collaboration allowed for free-flowing discussion and when it was constrained to a turn-taking procedure (see also Barber et al., 2010). The novel finding in the context of this replication was that these deficits were attenuated, and, in the case of free-for-all dyadic encoding, eliminated when a specific warning was provided about the collaboration's deleterious effects on the encoding task. In contrast to our predictions, while the warning benefited subsequent recall, this was in the absence of any improvement in sentence cohesiveness at encoding. This outcome suggests that qualitative differences in cues are *not* a key factor contributing to the collaborative encoding deficit. Rather, results suggest that participants in the warning conditions spent longer on the encoding task than participants in the no-warning conditions. Thus, increased knowledge about the nature of the collaborative encoding deficit may direct participants to devote extra time towards the task, thus enhancing its mnemonic value.

This pattern of results opens the question of whether the attenuated collaborative encoding deficit in Experiment 1 was due to increases in general motivation or to increases in attention spent on the encoding task. On the one hand, the fact that the warning increased time spent on the encoding task may be an indication that it increased participants' motivation to do well on the encoding task. On the other hand, it could reflect increased attention to the encoding task without reflecting increases in achievement-related motivation. To examine these two possibilities, in Experiment 2 all participants completed the encoding phase using the free-for-all dyadic procedure. A free-for-all method of collaborative encoding was used because the specific warning similarly affected performance in both the turn-taking and free-for-all dyadic encoding conditions in Experiment 1 and the latter is a more naturalistic way to collaborate. Some participants received the specific warning used in Experiment 1, others received a general warning designed to increase motivation but without mention of sentence cohesiveness, and a third group received no warning. Furthermore, at the end of the experiment we asked participants to indicate how they had been affected by the warnings. Responses

were analysed to determine whether the warnings increased task motivation, increased attention to the encoding task, and furthermore, how this related to subsequent memory performance. We also assessed whether the warning increased time spent on the encoding task, and whether this varied across the two types of warnings.

EXPERIMENT 2

Method

Participants and design

A new sample of 88 undergraduates (44 pairs of strangers) at Stony Brook University participated for partial-course credit. Two participants were subsequently removed from both warning conditions due to low recall performance (more than 2 *SD* below the mean), an additional one was removed for high error rates (greater than 3 *SD* above the mean), and a final one was removed for falling asleep during the experiment. This left 28 participants assigned to each condition: (1) free-for-all dyadic encoding, (2) free-for-all dyadic encoding with the specific warning used in Experiment 1 (see Appendix A), and (3) free-for-all dyadic encoding with a nonspecific warning (see Appendix B).

Materials

The same materials from Experiment 1 were used.

Procedure

Encoding. The encoding phase was similar to that of Experiment 1. Participants created a single sentence out of each word pair such that the first word of the pair came earlier in the sentence than the second word of the pair. All participants completed this task with a partner using the free-for-all dyadic encoding method. Two groups of participants received warnings prior to beginning the encoding phase, which were read aloud by the experimenter. For participants in the specific warning condition, the warning was identical to Experiment 1 (see Appendix A). In the nonspecific, general warning condition no mention was made of sentence cohesiveness. Rather, participants were simply told that people tend to do poorly when collaborating on the sentence-creation task and that they should "try not to

let this happen” to them. For the full-text of this nonspecific warning, see Appendix B.

Filled delay. Participants individually completed 45-min of puzzles.

Retrieval. Participants individually completed a surprise cued-recall test in which they saw the first word of each pair in a different order from encoding and attempted to recall the corresponding target.

Final questionnaire. At the end of the experiment, participants in the warning conditions were reminded of the warning they had received. They then indicated (1) whether they remembered receiving this warning earlier in the experiment, (2) whether they kept the warning in mind while completing the encoding task, and (3) how the warning impacted their encoding performance. Responses to these open-ended questions were analysed to determine whether the warnings increased task motivation and attention to the encoding task.

Results

Since all conditions entailed recalling alone, we again report individual recall data. As in Experiment 1, we note that (1) nominal group scores yielded a similar pattern of results for all measures, and (2) a pairwise intraclass correlation analysis (see Gonzalez & Griffin, 1999) suggests independence between the two individual recall scores within dyads, $r = .06$, $z = 0.37$, $p = .36$.³

Correct recall. There were significant differences in correct cued-recall among the three conditions, $F(2, 81) = 7.62$, $MSE = 0.03$, $p = .001$, $\eta_p^2 = .16$ (see Figure 2). As in Experiment 1, the specific warning was effective at improving recall. Participants who completed the free-for-all dyadic encoding with a specific warning ($M = 0.79$) subsequently had higher cued-recall than participants who received no warning ($M = 0.69$), $t(81) = 2.18$,

$SE = 0.05$, $p = .03$, $d = 0.61$. Novel to this experiment, this benefit was *not* present for participants who received the nonspecific, general, warning ($M = 0.61$). In contrast to predictions, these participants actually recalled marginally *less* than participants who received no warning ($M = 0.69$), $t(81) = -1.71$, $SE = 0.05$, $p = .09$, $d = 0.42$, and significantly less than participants who received the specific warning ($M = 0.79$), $t(81) = 3.89$, $SE = 0.04$, $p < .001$, $d = -1.12$.

Assessment of warning instructions. We next assessed participants’ self-reports of how the warnings affected their encoding performance. Responses indicated that 40.7% ($n = 8$ from the specific warning condition and $n = 14$ from the general warning condition) of participants ignored the warning, forgot the warning, or stated that the warning did not influence their performance.⁴ An additional 40.7% ($n = 10$ from the specific warning condition and $n = 12$ from the general warning condition) indicated that the warning improved their task motivation or made them “try harder” while performing the task. The final 18.5% ($n = 10$, all from the specific warning condition) indicated that the warning made them focus their attention specifically on creating “good” or cohesive/coherent sentences. Recall differed among these three groups of participants, $F(2, 51) = 3.16$, $MSE = 0.03$, $p = .05$, $\eta_p^2 = .11$.⁵ Participants who focused attention on increasing the quality of their sentences had statistically higher recall ($M = 0.82$) than participants who ignored or forgot the warning ($M = 0.65$), $t(51) = 2.51$, $SE = 0.07$, $p = .02$, $d = 0.88$, and marginally higher recall than participants who felt generally motivated or “tried hard” ($M = 0.69$), $t(51) = 1.84$, $SE = 0.07$, $p = .07$, $d = 0.88$. Furthermore, increased motivation did not exert such strong effects. Although participants who felt generally motivated or “tried hard” ($M = 0.69$) recalled numerically more than participants who ignored or forgot the warning ($M = 0.65$), this difference was not statistically significant, $t(51) = -0.84$, $SE = 0.05$, $p = .40$. Thus, it seems that the benefit of receiving a specific warning is not due to increases in motivation. Rather, it appears to

³As noted earlier, two participants were removed from each of the warning conditions. In calculating pairwise intraclass correlations, we also excluded data from their partners. We also calculated pairwise intraclass correlations separately for each condition. Results again suggested independence of data points within the no-warning condition, $r = -.26$, $z = -0.97$, $p = .17$, specific warning condition, $r = -.15$, $z = -0.52$, $p = .30$, and general warning condition, $r = .02$, $z = 0.06$, $p = .48$.

⁴“Forgetting” the warning was uncommon, and only reported by two participants.

⁵Two participants were not included in this analysis. One participant failed to provide an answer to this question. The other participant stated that the warning made him feel nervous and impaired his performance.

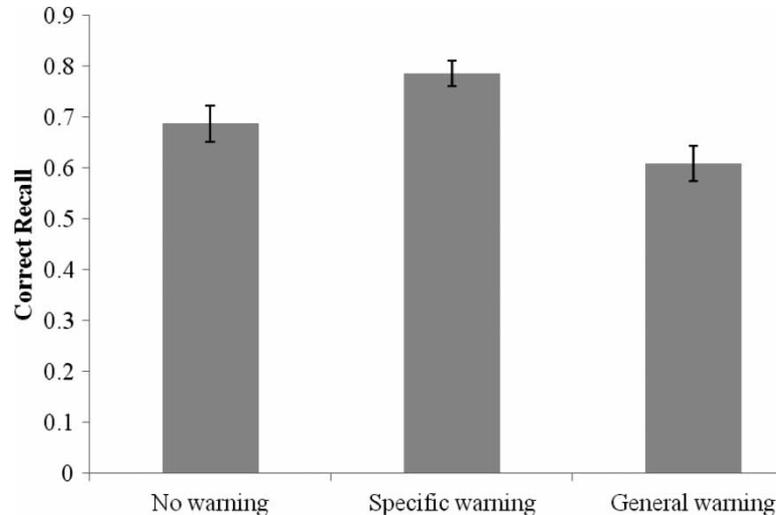


Figure 2. Mean proportion of items correctly recalled by individuals as a function of encoding conditions in Experiment 2. Error bars are $\pm 1 SE$.

be driven by increased attention to the encoding task.

This conclusion was further supported by the numerical pattern of the encoding times. In contrast to Experiment 1, overall there was no difference between the conditions in time spent on the encoding task, $F(2, 41) = 1.59$, $MSE = 52.25$, $p = .22$. However, replicating the results from Experiment 1, participants who received the specific warning spent marginally longer on the encoding task ($M = 28.27$ min) than participants who did not receive the warning ($M = 23.86$ min), $t(27) = 1.96$, $SE = 2.25$, $p = .06$, $d = 0.73$. Although a similar numeric pattern was present for the general warning, the difference here was much smaller and the pattern did not approach statistical significance. Participants who received the general warning ($M = 24.53$ min) did not significantly differ in time spent at encoding from those who received no warning, $t(27) = 0.24$, $SE = 2.85$, $p = .81$.

Discussion

Replicating Experiment 1, providing participants with a specific warning about how to complete the encoding task improved subsequent memory performance in Experiment 2. Novel to this experiment, this improvement was absent (and numerically reversed) after providing participants with a general warning. Subsequent analyses suggest that this pattern is driven by how participants interpreted the warning they had

received. Participants who self-reported that the warning made them focus their attention at encoding on achieving “good” sentences had subsequently higher recall than individuals who did not receive the warning. In contrast, participants who self-reported that the warning increased their motivation at encoding did not show this benefit. Thus, the means by which the warning improved performance seems to be by focusing further attentional resources towards the encoding task. This conclusion is further supported by the numerical pattern of the encoding times. Although these results should be interpreted cautiously (due to the lack of consistency in reaching statistical significance in every comparison), warnings appear to have increased time spent on the encoding task, especially for participants who received the specific warning.

GENERAL DISCUSSION

Collaboration can impair encoding. In general, participants who encoded information with a partner created less cohesive sentences at encoding and subsequently had poorer recall than participants who encoded information individually. Past evidence has shown that, although this deficit can be partially overcome when the quality of sentence construction improves, it nonetheless persists. The present research further examined the relationship between sentence construction quality and the collaborative encoding deficit by examining whether warning participants about

this deficit during encoding would improve both sentence quality and subsequent recall. Interestingly, our results suggest that the collaborative encoding deficit can be eliminated when participants are specifically warned about the perils of collaborative encoding. However, counter to our predictions, while the specific warning improved memory performance it did not affect the quality of sentences created at encoding (Experiment 1), indicating the role of multiple factors in producing the collaborative encoding deficit in recall. Specifically, this dissociation suggests that while qualitative differences in cue quality can improve later recall to some extent, this is not a key factor in producing the collaborative encoding deficit. Further, as we discuss later, no single explanation accounts for why the collaborative encoding deficit occurs and why it is ameliorated.

Although the specific warning's benefit in Experiment 1 was not due to changes in encoding task performance, it may have been in part due to changes in time spent on the encoding task. Participants who received the specific warning spent longer on the encoding task than participants who did not receive the warning. Furthermore, results from Experiment 2 suggest that the benefits of the specific warning are not because of a general increase in motivation, but rather because of the benefit of having specific task-relevant instructions. Within Experiment 2, participants who self-reported that the warning caused them to pay additional attention to the sentence-creation task showed the best recall performance whereas participants who reported that the warning caused them to "try harder" did significantly worse. Thus, the benefit of the specific warning appears to be that it encourages greater attention to, and perhaps deeper processing of, the stimuli that were subsequently tested. This could suggest that collaboration at encoding impairs performance, at least in part, by dividing attention away from the encoding task, and perhaps towards aspects of the social interaction.

We also examined the possibility that collaboration impairs performance because people do not devote enough attention towards the contributions of their partners, but the findings do not provide decisive answers in support of this possibility. In our previous research using dyadic free-for-all encoding, we observed a numeric pattern such that participants tended to recall more targets from the sentences created entirely by themselves compared to those created entirely by their partner (Barber et al., 2010, Exp. 2). In

the current Experiment 1, we again observed this pattern. Of the participants in the free-for-all dyadic encoding (no warning) condition who created at least some sentences using an alternating strategy, there was a tendency for these participants to recall more of the sentences created entirely by themselves, $t(17) = 1.78$, $SE = .04$, $p = .09$, $d = .32$. Interestingly, this benefit of individual generation was absent when participants were provided with a warning. Here, participants recalled no more of the sentences created by themselves ($M = 0.72$) compared to those created by their partner ($M = 0.75$), $t(21) = -0.34$, $SE = .02$, $p = .73$. Furthermore, a 2 (condition: free-for-all dyadic encoding with vs. without a warning) $\times 2$ (sentence generator: self vs. partner) revealed a marginal interaction between these factors, $F(1, 38) = 3.25$, $MSE = .01$, $p = .08$, $\eta_p^2 = .08$. Although the warning increased recall of both the self- and partner-generated sentences, it had a greater increase in recall of the partner-generated sentences. However, we do note that this effect did not replicate in Experiment 2. Here, recall was no better for self- over other-generated sentences in any of the conditions: free-for-all dyadic encoding (no warning), $t(21) = -0.72$, $SE = 0.02$, $p = .48$; free-for-all dyadic encoding with specific warning, $t(25) = -0.68$, $SE = 0.02$, $p = .50$; and free-for-all dyadic encoding with general warning, $t(23) = 0.37$, $SE = 0.03$, $p = .71$.

Nonetheless, the possibility that collaborative encoding directs attention away from the encoding task, and particularly from the partner's contributions, will need to be addressed more specifically in future research. For example, based upon the current results, the collaborative encoding deficit may be attenuated when deep encoding instructions are utilised (e.g., intentional encoding) compared to relatively shallower encoding instructions (e.g., incidental encoding). This is because the deeper encoding instructions focus additional attention to, and processing of, the encoded materials. Deeper encoding may also attenuate the collaborative encoding deficit by increasing participants' attention to their partners' contributions. For example, under intentional encoding conditions participants may increase attention to the partners' contributions because they know that information will be tested later on.

There are also some limitations to the current study that will need to be addressed in future research. First, in Experiment 1 we did not

provide participants in the individual encoding condition with a warning. This was because the warning that we used in Experiment 1 focused specifically on performance by collaborative dyads and was therefore not applicable to participants in the individual encoding condition. Furthermore, we were primarily interested in whether the warning would increase performance within the collaborative encoding conditions to be equivalent to what naturally occurs during individual encoding. However, without inclusion of this condition, the warning conditions and learning conditions of Experiment 1 are confounded with one another, and it is unclear whether warnings specifically benefit collaborating dyads or whether they would also benefit participants who encoded individually. To address this issue, we recruited a new set of 24 participants (drawn from the same pool of subjects as in Experiment 1), and asked them to complete the encoding task individually, but after receiving a modification of the specific warning used in Experiment 1, which stated that “participants”, rather than “collaborative groups”, had done poorly on the sentence creation task in previous experiments. We then combined these data with those from Experiment 1, and conducted a 2 (encoding condition: individual vs. collaborative [either free-for-all or turn taking]) \times 2 (warning condition: warning vs. no warning) ANOVA on the proportion of items recalled. Because the primary question here is whether the warnings’ benefits were specific to collaborating dyads, in this analysis we collapsed across form of collaborative encoding. Results showed a marginal interaction between the encoding and warning conditions, $F(1, 140) = 2.69$, $MSE = 0.03$, $p = .10$, $\eta_p^2 = .02$. A follow-up analysis showed that, in contrast to the collaborative encoding conditions, participants in the individual encoding with a warning condition ($M = 0.82$) did not recall significantly more than those who received no-warning ($M = 0.79$), $t(46) = 0.65$, $SE = 0.04$, $p = .52$. Although this result should be interpreted with caution (as it is both based upon a null result and because participants in this new condition were from the same pool of subjects as those in Experiment 1, but were not randomly assigned to conditions), it does suggest that the benefits of the warning are stronger during collaborative encoding. However, this speculation will need to be examined more specifically in future research.

A second limitation to the current study is that our primary results from Experiment 2 are based

upon participants’ self-reports. Although some participants reported that the warning made them “try harder”, we did not include measures of whether these participants actually tried harder, or valued the task more. We also did not assess motivational strength within the participants who receive no warning. Furthermore, we were unable to examine whether self-reported increases in attention to the encoding task related to cohesiveness in Experiment 2. This is because sentence cohesiveness within the free-for-all collaborative encoding conditions is universally high, even when participants receive no warning. Thus, due to ceiling effects, it is unclear whether participants who self-reported that the warnings caused them to focus additional attention to the sentence creation task created qualitatively different sentences than participants who self-reported that they ignored the warnings. This limitation is mitigated in part due to the fact that previous results show no mediating role of cohesiveness in predicting recall levels (Barber et al., 2010, Exp. 2) as well as by Experiment 1 results demonstrating no relationship between the specific warning and cohesiveness levels within either the free-for-all or turn-taking collaborative encoding conditions (the latter of which was not affected by ceiling effects).

Despite these limitations, results from studies such as this have important implications for educational practices. Within the education literature, support for collaborative encoding has been mixed (Kester & Paas, 2005), likely due to the myriad of definitions and approaches used in the study of “collaborative learning” (for a review, see Dillenbourg, 1999). However, one variable that has been identified as key in predicting the efficacy of collaborative learning is the degree to which the learning environment provides instructional support or constraints (Kirschner, Paas, & Kirschner, 2009). Without guidance, groups often collaborate ineffectively and thus, show benefits when they are provided with *learning scripts* (e.g., Weinberger, Ertl, Fischer, & Mandl, 2004). Even though learning scripts vary across paradigms, they usually provide the learner with instructions about which activities will be beneficial or detrimental to learning and with strategies for working on the assigned tasks (see Kollar, Fischer, & Hesse, 2006). Thus, providing a script ensures that the learners are aware of not only what they are supposed to do, but also how they are supposed to do it. Our results fit in well with these conclusions.

In the current research, one could conceptualise the specific warning as similar to a learning script in that it provided information about what should be done (i.e., create cohesive sentences) as well as with information about how to do this (i.e., the examples that were provided). In contrast, the nonspecific warning that simply emphasised that participants should “try hard” did not provide the same benefits.

Other types of task instructions may also be beneficial in improving collaborative encoding and are worth exploring in future research. Drawing again from the education literature, a distinction has been made between epistemic scripts, which provide information about the task and strategies for completing the task, and social scripts, which provide instructions about how to work together. Some research has actually shown social scripts to be more beneficial than epistemic scripts (e.g., Weinberger et al., 2004). This is in line with research showing that group coordination is positively correlated with collaborative encoding efficacy (Michinov & Michinov, 2009). Thus, providing information about how to effectively coordinate the collaboration itself may also improve subsequent memory in our paradigm, and perhaps even to a greater extent than the warnings used here. This possibility is consistent with our finding that when participants used a free-for-all method of collaboration (that effectively allows the dyad to coordinate their work as it best suits their mutual preference) and used specific warnings, the collaborative encoding deficits was entirely eliminated.

In summary, the current study examined how various warnings affect the collaborative encoding deficit. Across two experiments, the collaborative encoding deficit in cued recall was eliminated when participants were provided with detailed task instructions in the form of a specific warning. In contrast, neither a general warning nor self-reported increased task motivation were associated with improvements in recall performance. Thus, increased motivation does not attenuate collaborative deficits in recall at either encoding (Experiment 2) or at retrieval (Weldon et al., 2000). However, our results do suggest a potential role for attention in modulating the collaborative encoding deficit. In Experiment 2, participants who self-reported that the warning caused them to pay additional attention to the sentence-creation task had the best memory performance. While it is almost certain that

collaborative memory outcomes would be modified by a myriad of other factors, the current results suggest that collaborative groups can encode information as effectively (although not more effectively) as individuals when they are provided with additional task-relevant information and are allowed to collaborate in a free-flowing manner. This presumably occurs because such conditions allow them to pay a greater amount of attention to the encoding task.

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APPENDIX A: THE WARNING USED IN EXPERIMENT 1 AS WELL AS IN THE SPECIFIC WARNING CONDITION OF EXPERIMENT 2

Before we get started I have one final warning for you. In previous experiments, we have found that when people collaborate on a task like this they tend to do very poorly. In particular, people tend to make up less cohesive sentences when working with a partner than they do when working individually. That is, the sentences simply do not flow well or convey a clear meaning. For example, in a previous experiment when given the word pair “citizen” and “trail” one dyad created the sentence “I am a citizen of the United States; he followed a dirt trail”. Another created sentence was: “I am a citizen of America and like to eat trail mix”. In these examples, you will notice that there is no consistency in either theme or subject across the sentence. Better sentences would be something like “A New York citizen walked on a trail in Central Park” or “The citizen walked the winding trail”. In order to do this task well please try to make your sentences as cohesive as possible. Do you have any questions?

APPENDIX B: THE NONSPECIFIC WARNING USED IN EXPERIMENT 2

Before we get started I have one final warning for you. In previous experiments, we have found that when people collaborate on a task like this they tend to do very poorly. In particular, people tend to do less well on this task when working with a partner than they do when working individually. Please try to make sure this doesn’t happen to you and your partner. Do you have any questions?