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When discussion between eyewitnesses helps memory

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Purpose. Police interviewers are typically instructed to prevent eyewitnesses from talking to each other, because witnesses can contaminate each other's memory. Previous research has not fully examined, however, how discussion between witnesses affects correct and incorrect recall of witnessed events. We conducted quantitative and qualitative analyses to explore the influence of co-witness discussion in more detail.

Methods. Witnesses were interviewed individually or in pairs about a videotaped violent event. We conducted individual interviews prior to collaboration (to obtain an independent record of what individuals remembered) and after collaboration (to assess whether collaboration subsequently triggered new memories).

Results. Pairs that were interviewed together (collaborative pairs) remembered just as much correct information overall as pairs interviewed individually (nominal pairs), but collaborative pairs made significantly fewer errors. We found evidence of retrieval disruption during the discussion (i.e., collaborative pairs omitted significantly more old information during the second interview than nominal pairs) but also of a delayed cross-cuing effect (i.e., collaborative pairs reported significantly more new information in the final interview than nominal pairs). Pairs who used more content-focused retrieval strategies during the discussion (acknowledgements, repetitions, restatements, and elaborations) reported significantly more information.

Conclusions. The current findings suggest that, under certain conditions, discussion between eyewitnesses can help rather than hurt memory. Theoretical and practical implications will be discussed.

Memories can be influenced by many factors, particularly by other people. Through social influence, individuals can incorporate errors into their memories, or even come to remember whole events that never happened (Loftus & Pickrell, 1995; Porter, Yuille, & Lehman, 1999; Shaw & Porter, 2015). Legal psychologists have long warned police and legal professionals about memory conformity (Wright, Self, & Justice, 2000) and social contagion (Roediger, Meade, & Bergman, 2001), which is particularly important in light of findings that a witness typically observes an event together with at least one other person

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(Paterson & Kemp, 2006; Skagerberg & Wright, 2008). In contrast, whether discussion about events can also *benefit* eyewitness memory has remained relatively unexamined. In most previous research on co-witness discussion, participants talked either with a confederate who intentionally introduced false information (e.g., Meade & Roediger, 2002; Roediger *et al.*, 2001; Shaw, Garven, & Wood, 1997) or with a co-participant who had seen a different version of the event (e.g., French, Garry, & Mori, 2008; Gabbert, Memon, & Allan, 2003; Gabbert, Memon, & Wright, 2006; Kanematsu, Mori, & Mori, 2003; Wright *et al.*, 2000). Further, researchers typically examined only a subset of the data (e.g., ignoring what was said during the discussion itself). Unlike previous studies, we analysed correct and incorrect recall of a videotaped violent event before, during, and after an uncontrived oral discussion between witnesses, to fully examine potential advantages and disadvantages of collaborative remembering in event recall.

Remembering together

Collaborative remembering has been studied primarily for recall of simple stimuli, such as word lists. Initially, researchers expected to observe *cross-cuing* (Meudell, Hitch, & Boyle, 1995; Meudell, Hitch, & Kirby, 1992); that is, one person's utterance (e.g., 'apple') should cue another person's memory, leading him to remember new, emergent information that he would not have remembered on his own (e.g., 'banana'). The cross-cuing hypothesis was not supported – on the contrary, research has consistently shown that individuals working together (i.e., collaborative groups) produced significantly fewer words than the same number of individuals working alone (i.e., nominal groups), an effect termed *collaborative inhibition* (Weldon & Bellinger, 1997). The main mechanism underlying collaborative inhibition seems to be a disruption in individual retrieval strategies (Barber, Harris, & Rajaram, 2015; Basden, Basden, Bryner, & Thomas, 1997; Weldon & Bellinger, 1997). For example, one person may organize his recall of a list of words alphabetically, whereas another may organize his recall of the words by category. These individuals have dissimilar idiosyncratic retrieval strategies and when they collaborate, their contributions will likely disrupt each other's retrieval processes.

There are at least two reasons to expect different findings for collaborative recall of events as opposed to lists of simple stimuli. First, collaborative inhibition may be reduced for recall of events because individual strategies are less likely to be idiosyncratic: People typically recall events chronologically (see also Schank & Abelson, 1977). Second, cross-cuing may be facilitated for recall of events because event memories involve a more complex and connected cognitive network than lists of simple stimuli (see also Anderson, 1983). Thus, whereas hearing the word 'apple' may not cue a memory of the word 'banana', the mention of a car will likely cue retrieval of the car's properties (e.g., that it had a broken mirror).

Collaborative recall of emotional events, as opposed to simple stimuli, is a relatively understudied topic to date. Two studies have examined the recall of events seen on video, specifically, footage of the assassination of Israel's Prime Minister Rabin (Yaron-Antar & Nachson, 2006), and a video clip in which a boy gets killed by a drunk driver (Wessel, Zandstra, Hengeveld, & Moulds, 2015). In these studies, participants wrote down their recall of the event, either individually or with two strangers. Both studies found collaborative inhibition. That may, however, have been due to the fact that collaborative groups had to (1) write down their responses and (2) agree on a response before writing it down. Even when working alone, witnesses tend to report less when they have to write rather than speak (Bekerian & Dennett, 1990; Sauerland & Sporer, 2011; but see

Sauerland, Krix, Kan, Glunz, & Sak, 2014). When witnesses have to agree on a response with two others, one might expect that even less information ends up in the written report. In serious criminal cases, witnesses normally participate in an oral interview rather than write a report (see, e.g., Sauerland & Sporer, 2011). A recent meta-analysis showed that collaborative inhibition tends to be reduced in free-flowing conversation (Marion & Thorley, 2016). Therefore, the findings of these studies may not generalize to eyewitness interviews in the real world.

One study to date has examined collaborative recall in the form of a joint eyewitness interview (Vredeveldt, Hildebrandt, & Van Koppen, 2016). That experimental procedure was both more realistic and less likely to result in collaborative inhibition than the procedure used in previous research (Wessel *et al.*, 2015; Yaron-Antar & Nachson, 2006). Witnesses were jointly interviewed about a rape–murder scene from a live theatre play. They collaborated with only one partner, whom they had known for 31 years on average. When participants collaborate in pairs rather than triads and with someone they know rather than a stranger, collaborative inhibition is reduced (Marion & Thorley, 2016). Indeed, Vredeveldt *et al.* found no difference in the total amount of correct information reported by collaborative and nominal pairs. Because their study involved only eight nominal pairs, however, no firm conclusions could be drawn based on their data. The present study included 20 pairs in each condition, thus providing a more powerful test of the effect of collaboration during joint eyewitness interviews about a violent event.

Post-collaborative benefits

The aforementioned studies on recall of simple stimuli show that, although collaboration typically inhibits recall *during* collaboration, it also consistently improves individual recall output *after* collaboration (e.g., Basden, Basden, & Henry, 2000; Blumen & Rajaram, 2008; Choi, Blumen, Congleton, & Rajaram, 2014). In other words, individuals who have previously collaborated remember more than individuals who have not collaborated. These post-collaborative benefits are likely due to a combination of re-exposure and cross-cuing (Blumen, Young, & Rajaram, 2014). During the collaboration, individuals are re-exposed to information that they had themselves forgotten. When individuals repeat that information after the collaboration, it often triggers new memories (i.e., a delayed cross-cuing effect; see also Congleton & Rajaram, 2011). It is therefore important to provide witnesses with a final individual recall opportunity. To our knowledge, only one study to date has examined post-collaborative recall of an emotional event (Yaron-Antar & Nachson, 2006). Their data suggest that there may have been post-collaborative benefits, but we cannot draw reliable conclusions because the relevant condition in their study contained only five triads. In the present study, we explored post-collaborative effects for recall of a violent event. We hypothesized that witnesses who had previously collaborated would report more new, emergent information than witnesses who had not collaborated.

Memory errors

In the context of eyewitness memory, we are not only concerned with how many correct details a witness remembers, but also with how many errors the witness makes. After all, eyewitness errors can have serious consequences (see, e.g., Gross & Shaffer, 2012; Scheck, Neufield, & Dywer, 2003). A consistent finding in the collaborative-recall literature is that collaborative groups make substantially fewer errors than nominal groups, both for recall of simple stimuli (e.g., Harris, Barnier, & Sutton, 2012, 2013;

Weigold, Russell, & Natera, 2014) and more complex information (Ross, Spencer, Linardatos, Lam, & Perunovic, 2004; Vredeveldt *et al.*, 2016; Wessel *et al.*, 2015; Yaron-Antar & Nachson, 2006). We expected to observe the same pattern in our data. Moreover, we tracked the path of errors that had been introduced or corrected during the discussion to the subsequent individual interview. We adapted this error-tracking approach from a study that examined how conferring between 4 to 6 police officers affected their subsequent written statements (Hope, Gabbert, & Fraser, 2013). In that study, 48% of the errors introduced by one group member during the discussion were subsequently reported by at least one other group member in the individual statement (i.e., memory contamination). We hypothesized that we would find similar instances of memory contamination, but we also expected to observe instances of error pruning (see Rajaram & Pereira-Pasarin, 2010).

Retrieval strategies

We examined not only the number of correct and incorrect details recalled but also the strategies used during the collaboration to retrieve the information from memory. Autobiographical memory researchers have highlighted the importance of looking beyond averages when studying the effects of collaboration during recall (e.g., Harris, Keil, Sutton, Barnier, & McIlwain, 2011; Morris, Barnier, & Harris, 2015). Although collaboration is disruptive for some groups, it can be beneficial for other groups (i.e., collaborative facilitation). Research on collective remembering of personal events (Harris, Barnier, Sutton, & Keil, 2014; Sutton, Harris, Keil, & Barnier, 2010; Wegner, 1987, 1995) and public events (see Hirst, Coman, & Coman, 2013, for an overview) suggests that collaboration can facilitate recall, provided that certain conditions are met. Transactive memory theory postulates that groups are 'capable of memory feats far beyond those that might be accomplished by any individual' (Wegner, 1995, p. 336), but only if group members (1) have information that the other members do not have (differentiation), and (2) are able to share that information through an integrated group memory structure (integration). We provide insight into these collaborative processes by analysing the discussion between partners.

The few previous studies that have analysed the use of retrieval strategies during collaborative recall have consistently shown that partners who actively listen to and elaborate upon each other's contributions remember more. For example, when recalling flight scenarios, pairs of novice pilots and non-pilots showed collaborative inhibition, whereas pairs of expert pilots showed collaborative facilitation (Meade, Nokes, & Morrow, 2009). Specifically, expert pilots who collaborated recalled a higher proportion of the studied flight scenario than expert pilots who worked alone. An analysis of the expert pilots' discussions showed that they (1) possessed more domain knowledge than novices and non-pilots and (2) communicated their knowledge more effectively (by repeating, restating, and elaborating upon each other's contributions) – two key elements of successful transactive memory systems. Research with older married couples similarly showed collaborative inhibition in autobiographical remembering for some couples, but collaborative facilitation for others (Barnier *et al.*, 2014; Harris *et al.*, 2011). Partners who cued each other and repeated and elaborated upon each other's contributions remembered more together than apart. Finally, the aforementioned research with eyewitnesses also found that partners who acknowledged, repeated, restated, and elaborated upon each other's contributions remembered significantly more about a witnessed event (Vredeveldt *et al.*, 2016). Because those retrieval strategies concern the content of the partner's statements, Vredeveldt *et al.* conceptualized them as 'content-

focused' retrieval strategies. Based on the findings from these three studies, we predicted that pairs in our study who used more content-focused collaborative retrieval strategies would remember more about the event.

In contrast, various other retrieval strategies either do not predict the amount of information recalled, or are associated with reduced output. In the research on flight scenarios (Meade *et al.*, 2009), non-pilots and novice pilots were more likely than expert pilots to use simple acknowledgments and not follow up with elaborations. In the research on autobiographical events (Harris *et al.*, 2011), 'group-diminishing' strategies – nomination of an expert, disagreement about strategies, corrections and the failure to provide unsuccessful cues – were negatively related to the amount recalled. Similarly, 'gap-filling' strategies – simple acknowledgements and providing task-irrelevant information – negatively predicted the amount recalled. In the research on eyewitness recall (Vredeveldt *et al.*, 2016), strategies focused on the process of remembering rather than the content of the memories – explanations, corrections, cuing attempts, expressions of renewed remembering, and positive remarks about the relationship – were unrelated to the amount recalled. Based on those findings, we expected that process-focused strategies in our study would not be significantly associated with the amount of information recalled by eyewitnesses.

The effect of retrieval strategies on the accuracy of the reported information was either not examined in previous research (Harris *et al.*, 2011; Meade *et al.*, 2009) or found to be non-significant (Vredeveldt *et al.*, 2016). We therefore predicted no significant effect on the accuracy of witness reports.

Present study

In the present study, 40 pairs of witnesses were interviewed about a videotaped violent event. All participants took part in three interviews. For 20 collaborative pairs, we first obtained an independent record of what each participant remembered (Interview 1), then asked participants to collaborate with a partner (Interview 2), and then conducted another individual interview to assess whether participants remembered any additional information after the collaboration (Interview 3). For 20 nominal pairs, who served as a control condition, all three interviews were conducted individually. Because our experimental procedure involved various conditions that reduce the retrieval disruption typically caused by collaboration (i.e., acquainted pairs recalling story-like material using free-flowing conversation; see Marion & Thorley, 2016), we did not expect to observe collaborative inhibition. We hypothesized that collaborative pairs would benefit from delayed cross-cuing in the final individual interview (as has been observed for recall of simple stimuli; Congleton & Rajaram, 2011). We also expected that collaborative pairs would make fewer errors than nominal pairs (see e.g., Wessel *et al.*, 2015). Finally, we predicted that pairs who acknowledged, repeated, restated, and elaborated upon each other's contributions would remember more (Vredeveldt *et al.*, 2016).

Method

Participants

Power calculations based on previous findings (Harris *et al.*, 2011; Vredeveldt *et al.*, 2016) indicated that data from 20 pairs (i.e., 40 participants) per experimental condition would achieve power of .80 at $\alpha = .05$. Participants were students at an undergraduate

college in the Netherlands, recruited through snowball sampling. Data for six participants were excluded due to failed recordings. Our final sample consisted of 80 participants (20 male), with a mean age of 20.68 (*SD* = 1.57; range: 18–26). Participants could sign up for a time slot individually (in which case they were randomly paired with another student) or with a fellow student. Twenty pairs were randomly assigned to the nominal condition and 20 to the collaborative condition. Pairs in the collaborative condition had known each other for 14.73 months on average (*SD* = 11.67; range 0–36). Four pairs indicated that they did not know each other before the study, seven pairs were acquainted or vaguely acquainted, and nine pairs were friends or good friends.[1]

Materials

Participants watched an 8-min violent video clip taken from a TV drama (see Vredeveldt, Hitch, & Baddeley, 2011, for more information). The clip shows survivors of a plane crash who discover a house on an island. The man who lives in the house shoots one of the survivors in the arm with a rifle, then reconciles with them, and stitches up the wound, after which a physical fight breaks out between the man and the survivors.

Procedure

Participants were recruited via advertisements calling for participation in a study 'investigating how people respond to violent TV'. Participants could win a €50 voucher for their participation. Two participants per session arrived at the laboratory, signed an informed consent form, and watched the video together. Next, all participants took part in three interviews about the video, each preceded by a 5-min distractor task (a word finder). Pairs in the nominal condition participated in three individual interviews (in separate rooms with different interviewers). For pairs in the collaborative condition, the first and third interviews were conducted individually, but the second interview was collaborative.

All interviews followed an identical structure. Participants were instructed to report as much as possible about the video from start to finish, but not to guess. For the collaborative interview, participants were instructed to 'work together to remember as much as possible'. Interview questions were asked in three consecutive phases: (1) free recall, in which participants were asked to describe the events in the video in detail, without interruption; (2) approximately five open-ended follow-up questions, tailored to what the participant had said during the free recall phase (e.g., 'You mentioned a weapon, can you tell me more about that?'); (3) 20 predetermined questions about the video (e.g., 'Where on his body does the man get shot?'; see Vredeveldt *et al.*, 2011). All interviews were audio-recorded.

At the end of the session, participants provided demographic information and, in the collaborative condition, information about their relationship with the other pair member (e.g., how long they had known each other). Finally, participants were debriefed and thanked for their participation. Each session took approximately one and a half hour.

[1] *Preliminary analyses showed that neither relationship duration nor relationship quality (as measured on an 11-item questionnaire) correlated with correct or incorrect recall, so these variables will not be discussed further.*

Data coding

Content coding

A detailed coding scheme was constructed based on the video, and additional items mentioned by participants that were not in the original coding scheme were added progressively. Each item in the coding scheme represented a single information unit. For example, the statement 'was shot', 'in his arm', 'with a rifle' was coded as three information units. The final coding scheme contained 306 items. One coder scored all interviews based on the audio-recordings. For each item, the coder scored whether the participant described the item correctly, incorrectly, or not at all. A second coder, blind to the first coder's scores, independently coded 13% of the interviews (i.e., 31 interviews, 9,517 data points). Inter-rater agreement was substantial (percentage agreement = 91%; $\kappa = .79$, $p < .001$; κ maximum = .98). The scores of the first coder were retained for the main analysis.

Retrieval strategy coding

All collaborative interviews were transcribed and the transcripts were coded for statements about collaborative retrieval strategies. An overview of all coding categories with descriptions, examples, and frequencies is provided in Table 1. These strategies correspond to the strategies recorded by Vredeveldt *et al.* (2016), except that we eliminated their final three categories due to floor effects in their study (relationship positive, relationship negative, and role division). In their research, acknowledgements, repetitions, restatements, and elaborations frequently occurred together and were conceptualized as a content-focused interaction style, while explanations, corrections, successful and failed cuing attempts, and expressions of renewed remembering were conceptualized as a process-focused interaction style.

For the retrieval strategy coding, coders did not score every detail (as they did for the content coding), but rather selected only those statements from the transcripts that indicated some sort of collaborative retrieval strategy. Two coders independently counted how often each type of strategy occurred in each collaborative interview. Inter-rater reliability for recorded frequencies in each coding category ranged from $r_s(20) = .79$, $p < .001$ (for restatements) to $r_s(20) = .96$, $p < .001$ (for repetitions), with very high overall inter-rater reliability, $r_s(180) = .99$, $p < .001$. Prior to the main analysis, disagreements between coders were resolved by discussion.

Data analysis

All analyses reported in the article reflect pair performance (i.e., the number of non-redundant details obtained per witness pair). If a particular item had been described correctly by one pair member but incorrectly by the other, it counted towards the number of correct details as well as the number of incorrect details. Prior to all analyses reported in this article, relevant assumptions were checked. For incorrect recall, one outlier was replaced with the mean plus two standard deviations (this did not affect the results). For correct recall, data transformations could not attenuate problems with heterogeneity of variance.[2] Therefore, we checked all results with nonparametric tests, which confirmed

[2] *Specifically, the data for nominal pairs showed greater variability than the data for collaborative pairs. The best-performing nominal pairs recalled just as much as the best-performing collaborative pairs, but the worst-performing nominal pairs recalled less than the worst-performing collaborative pairs.*

Table 1. Retrieval strategy coding categories and means (*M*) and standard deviations (*SD*) for the frequency of occurrence per collaborative interview (adapted from Vredeveldt *et al.*, 2016)

Strategy	Description and examples	*M*	*SD*
Successful cue	Cuing attempt (e.g., 'What was her name again?') that is followed by retrieval of information by the partner (e.g., 'It was Kate' or 'Something starting with a K')	4.15	2.87
Failed cue	Cuing attempt (e.g., 'What was her name again?') that is not followed by retrieval of information by the partner (e.g., 'I don't remember')	1.75	2.20
Acknowledgement/ confirmation	Indicating support for a partner's statement, such as 'Yes', 'Yeah', 'Hm hm', or 'That's right'	75.35	33.26
Correction/ disagreement	Correcting a partner's statement (e.g., 'No, it was Jen'), or questioning its accuracy (e.g., 'I remember it differently')	11.75	9.51
Elaboration	Building on a partner's statement by providing additional information, either countable (i.e., a new detail as classified in the content coding scheme) or non-countable (e.g., 'she looked creepy')	37.10	15.68
Explanation	Explaining one's own statement to the partner (e.g., 'I remember her name because it's my sister's name')	7.45	5.46
Repetition	Repeating a partner's statement verbatim	12.25	6.52
Restatement	Reformulating a partner's statement without changing the content (e.g., rephrasing 'he did not participate' to 'he did not get involved')	7.20	4.29
Renewed remembering	Indicating that a partner's statement triggers a memory (e.g., 'Now I remember it again' or 'I had forgotten about that!')	2.35	2.03

all parametric findings. To enable comparisons with other dependent variables, we provide parametric test statistics in the text. All reported statistical tests and associated *p*-values are two-tailed. We provide effect sizes η^2 for ANOVA results and Cohen's *d* for simple contrasts.

Results

Correct recall

From an applied perspective, one of the most important questions addressed in this research is: how much accurate information can we obtain when we have access to a pair of witnesses? To answer this question, we first assessed the total number of correct details reported across all interviews (i.e., cumulative recall). There was no significant difference in the number of correct details reported by collaborative pairs ($M = 161.90$, $SD = 17.91$) and nominal pairs ($M = 151.30$, $SD = 29.38$), $t(38) = 1.38$, $p = .176$, $d = 0.44$, 95% CI (−0.20, 1.06). In other words, we did not find the collaborative inhibition effect that is so typical for recall of simple stimuli.

In addition to the overall number of correct details reported, we were also interested in the development of witness reports from one interview to the next. Pair performance before, during, and after collaboration was examined using a 2 (Condition: nominal, collaborative) × 3 (Interview: 1, 2, 3) mixed ANOVA on the number of correct details. There was no significant effect of Condition, $F(1, 38) = 0.14$, $p = .712$, $\eta^2 = .00$, but a significant effect of Interview, $F(2, 76) = 8.37$, $p < .001$, $\eta^2 = .18$, and a significant

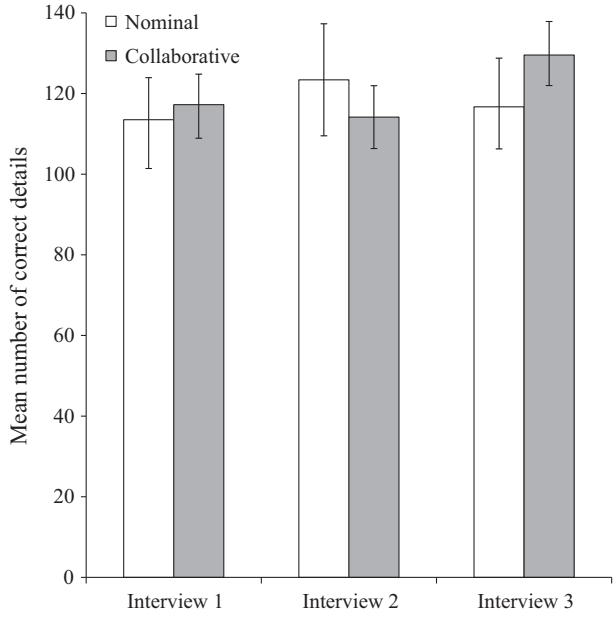

Figure 1. Mean number of correct details mentioned by pairs in the nominal (n = 20) and collaborative (n = 20) condition during the first, second, and third interviews. Error bars represent 95% confidence intervals.

interaction between Condition and Interview, $F(2, 76) = 17.11, p < .001, \eta^2 = .31$. The interaction pattern shown in Figure 1 suggests that collaborative pairs provided fewer details than nominal pairs during collaboration and more details after collaboration, but none of the simple effects was significant, Interview 1: $F(1, 38) = 0.37$, $p = .546$, $d = 0.19$, 95% CI (−0.43, 0.81); Interview 2: $F(1, 38) = 1.48, p = .232, d = -0.38$, 95% CI (−1.01, 0.24); Interview 3: $F(1, 38) = 3.36, p = .075, d = 0.58$, 95% CI (−0.06, 1.21).

To assess the development of witness reports in more detail, we assessed what percentage of the correct details mentioned in an earlier interview was omitted during a subsequent interview.[3] During the second interview, collaborative pairs omitted 26% of the correct details they had reported in the first interview (SD = 7%; 30.85 out of 117.25 details), whereas nominal pairs omitted only 15% (SD = 4%; 16.60 out of 113.50 details), $t(31.28) = 6.23, p < .001, d = 1.98$, 95% CI (1.21, 2.73). Thus, collaborative pairs were less likely to repeat old information in Interview 2. Prior collaboration had no effect on omissions in the third interview: Collaborative pairs omitted 21% of the details they had reported during the first or second interview (SD = 5%; 30.70 out of 146.20 details), compared to 23% for nominal pairs (SD = 7%; 32.55 out of 141.50 details), $t(38) = -1.14$, $p = .262$, $d = -0.34$, 95% CI (−0.97, 0.28).

We also assessed correct details that were newly added during the second or third interview. For collaborative pairs, 24% (SD = 5%) of the correct details provided in the second interview were new (i.e., not reported in a previous interview), compared to 22% (SD = 6%) for nominal pairs. This difference was not significant, $t(38) = 1.31, p = .199$,

[3] *All analyses of omissions and new details are presented as percentages to take into account differences in base rates (which were not significant for correct details but were significant for errors).*

d = 0.40, 95% CI (−0.23, 1.03). During the third interview, however, pairs who had previously collaborated provided significantly more new correct information (M = 11%, SD = 4%) than pairs who had not collaborated (M = 8%, SD = 4%), $t(38) = 2.58$, $p = .014$, d = 0.81, 95% CI (0.16, 1.45). Thus, collaboration inspired subsequent remembering of new details (i.e., delayed cross-cuing).

In sum, collaboration did not significantly affect the overall amount of correct information recalled, but it did affect the mix of old and new information in repeated interviews. Collaborative pairs reported less old information during the discussion and more new information after the discussion than nominal pairs.

Incorrect recall

Next, we examined how collaboration affected the number of incorrect details (errors) in witness reports. To assess how many errors pairs of witnesses made overall, we assessed the total number of incorrect details reported across all interviews. Overall, errors were relatively infrequent: On average, only 23 out of the 179 details reported per pair were incorrect. Crucially, collaborative pairs' cumulative recall contained significantly fewer errors (M = 19.95, SD = 5.47) than nominal pairs' cumulative recall (M = 25.20, SD = 7.44), $t(38) = -2.54$, $p = .015$, $d = -0.80$, 95% CI (−1.45, −0.15).

To assess the number of errors per interview, we conducted a 2 (Condition: nominal, collaborative) × 3 (Interview: 1, 2, 3) mixed ANOVA. The analysis revealed a significant effect of Condition, $F(1, 38) = 12.70$, $p = .001$, $\eta^2 = .25$, but no significant effect of Interview, $F(2, 76) = 1.34$, $p = .268$, $\eta^2 = .03$, and no significant interaction between Condition and Interview, $F(2, 76) = 2.09$, $p = .131$, $\eta^2 = .05$. Because the interaction was not significant, one would normally not follow it up with simple effects analyses. To enable comparisons with the correct-recall data, however, in this case we do provide the statistics for each interview. These should be interpreted with the appropriate caution. There was no significant baseline difference between conditions (Interview 1), $F(1, 38) = 2.53$, $p = .120$, $d = -0.50$, 95% CI (−1.13, 0.13), but collaborative pairs made significantly fewer errors than nominal pairs during the collaboration (Interview 2), $F(1, 38) = 14.02$, $p < .001$, $d = -1.18$, 95% CI (−1.85, −0.50), and after the collaboration (Interview 3), $F(1, 38) = 6.10$, $p = .018$, $d = -0.78$, 95% CI (−1.42, −0.13).

To assess the pattern of errors from one interview to the next, we examined how many of the errors made in an earlier interview were omitted during a subsequent interview. During the second interview, collaborative pairs omitted 32% of the errors that they had reported in the first interview (SD = 11%; 3.85 out of 11.40 errors), whereas nominal pairs omitted only 24% (SD = 12%; 3.25 out of 13.45 errors). The difference was marginally significant, $t(38) = 2.02$, $p = .05$, d = 0.64, 95% CI (0.00, 1.23). This suggests that error pruning in collaborative recall may not always take the form of explicit corrections; rather, partners may simply be less likely to mention a previously reported error when another witness is present during the interview. In contrast, during the third interview, collaborative pairs omitted only 26% of the errors that they had reported in a previous interview (SD = 13%; 4.60 out of 16.30 errors), whereas nominal pairs omitted 34% (SD = 10%; 7.30 out of 21.15 errors). This difference was also marginally significant, $t(38) = -2.03$, $p = .05$, $d = -0.63$, 95% CI (−1.26, 0.01). Thus, collaborative pairs tended to repeat relatively more errors in their final interview than nominal pairs.

We also examined how many errors were first introduced during the second or third interview. There were no significant differences between conditions in the percentage of errors that were new in the second interview (collaborative: M = 27%, SD = 16%;

nominal: M = 31%, SD = 12%), $t(38) = -1.09$, $p = .284$, $d = -0.29$, 95% CI (−0.92, 0.33), or in the third interview (collaborative: M = 14%, SD = 8%; nominal: M = 14%, SD = 10%), $t(34.72) = 0.15$, $p = .881$, $d = 0.06$, 95% CI (−0.56, 0.68).

Error tracking

We investigated how often errors that were introduced or corrected during the discussion ended up in the final individual recall. For this purpose, we defined *memory contamination* as an error made by one participant during the second interview that was subsequently included in their partner's final individual recall (provided that that partner had not independently made the same error during his first individual recall). In the collaborative condition, 13% of the errors verbalized by one witness during the second interview (M = 8.00, SD = 4.00) contaminated the partner's subsequent individual testimony. Even without collaboration, however, 6% of the errors verbalized by one participant in the second interview (M = 13.40, SD = 4.50) subsequently appeared in the partner's final recall.[4] In other words, 'contamination' occurred in the nominal condition despite the fact that partners never heard each other's recall.

We defined *error pruning* as an item mentioned incorrectly by participant A during the first or second interview, which was mentioned correctly by participant B during the second interview and omitted from participant A's testimony in the third interview.[5] In the collaborative condition, 24% of the errors verbalized during the first or second interview (M = 16.45, SD = 4.96) met the definition of error pruning. In the nominal condition, 17% of the errors verbalized during the first or second interview (M = 21.30, SD = 7.11) were classified as a pruned error.[6] Thus, like memory contamination, error pruning occurred even when partners did not hear each other's testimony. This suggests that findings of memory contamination and error pruning in collaborative recall reflect, at least in part, coincidental memory patterns rather than social influence. This finding will be addressed in the Discussion.

Are collaborating witnesses more likely to contaminate each other's memory or prune each other's errors? For witnesses in the collaborative condition, memory contamination (13%) was considerably less frequent than error pruning (24%), $t(19) = 3.75$, $p = .001$, $d = 0.95$, 95% CI (0.38, 1.59).[7] In light of these findings, it seems that the emphasis in the literature on the potential contaminating effects of co-witness discussion is somewhat unwarranted.

Retrieval strategies

We examined whether certain collaborative retrieval strategies were associated with the amount (i.e., total number of details across all interviews) or accuracy (i.e., proportion of reported details that were correct) of witness reports (see also Vredeveldt *et al.*, 2016). Table 1 shows how often each retrieval strategy occurred during the collaborative

[4] *For memory contamination, the difference between the collaborative condition (13%) and the nominal condition (6%) was not significant,* $t(38) = 1.95$, $p = .058$, $d = 0.61$, *95% CI (−0.02, 1.25).*

[5] *Note that requiring the partner to provide the correct detail during Interview 2 is a relatively strict definition of error pruning, since one can also correct an error without providing the correct answer (e.g., 'I don't know his name but it was definitely not David'). Dropping this requirement, however, would make the definition too lenient, as it would include items that were mentioned incorrectly once and then simply never mentioned again.*

[6] *For error pruning, the difference between the collaborative condition (24%) and the nominal condition (17%) was significant,* $t(38) = 2.12$, $p = .040$, $d = 0.64$, *95% CI (0.01, 1.29).*

[7] *In the nominal condition, memory contamination (6%) was also significantly less frequent than error pruning (17%),* $t(19) = 4.01$, $p < .001$, $d = 1.14$, *95% CI (0.49, 1.86).*

interviews. Prior to analysis, retrieval strategy frequencies were square-root-transformed to reduce positive skew and the accuracy variable was inverted and square-root-transformed to counter negative skew. Vredeveldt *et al.* identified four strategies associated with content-focused interaction: acknowledgements, repetitions, restatements, and elaborations. In the present study, these four strategies were again closely related ($\alpha = .79$). The remaining strategies (successful and failed cuing attempts, explanations, corrections, and expressions of renewed remembering), which were all part of Vredeveldt *et al.*'s process-focused interaction component, were somewhat less closely related ($\alpha = .68$).

We conducted linear regressions for amount and accuracy, respectively. We first entered the strategies associated with content-focused interaction (predicted to have an effect on amount) and then those associated with process-focused interaction (predicted to have no effect). The model with content-focused strategies explained a significant portion of the variance in the amount of information reported, $R^2 = .54$, $F(4, 15) = 4.37$, $p = .015$. The number of elaborations in the discussion was a significant positive predictor of amount reported, $\beta = .65$, $t(19) = 2.66$, $p = .018$, but the other content-focused strategies were not significant predictors (all ps $> .30$). Adding process-focused strategies to the model did not significantly increase the portion of variance explained, $R^2 = .18$, $F(5, 10) = 1.25$, $p = .356$.

For the accuracy of reported information, the model with content-focused strategies did not explain a significant portion of the variance, $R^2 = .13$, $F(4, 15) = 0.58$, $p = .681$, and adding the process-focused strategies did not result in a significant change either, $R^2 = .43$, $F(5, 10) = 2.02$, $p = .162$. Thus, as in previous research, retrieval strategies did not predict accuracy. Note, however, that there was relatively little variance to explain in our study, given that errors were quite infrequent.

As predicted, we found that content-focused interaction strategies (particularly elaborations) were associated with an increased amount of information reported. To illustrate the relationship between the content-focused interaction style and the amount of information reported, consider the following qualitative example.

A: The younger man had dark curly hair.
B: Really dark, down to the shoulders.
A: About shoulder length, yeah.
B: And shiny.
A: Yeah, and he had a very neat beard.

In this example, witness B repeats and elaborates on her partner's statement about hair colour ('*really* dark') and continues to elaborate with a statement about hair length. Witness A rephrases and acknowledges that statement ('about shoulder length, yeah'). Witness B elaborates with another hair feature ('shiny') and Witness A acknowledges that statement and elaborates by describing the man's beard. This example illustrates that actively listening to and elaborating upon each other's statements can increase the amount of information recalled about a witnessed event (for more examples, see Vredeveldt *et al.*, 2016).

Discussion

We examined effects of collaboration during eyewitness interviews about a violent event. Overall, collaboration did not harm correct recall of the witnessed event – if anything, the

trend was in the opposite direction, with collaborative pairs recalling non-significantly more correct details overall than nominal pairs. Collaborative pairs were less likely than nominal pairs to repeat previously reported information in Interview 2, but more likely to report new, emergent information in Interview 3. Moreover, collaborative pairs made significantly fewer errors overall than nominal pairs, pointing to important error pruning benefits of co-witness discussion. Indeed, error pruning was significantly more frequent than memory contamination. Finally, content-focused retrieval strategies (particularly elaborations) predicted an increased amount of information reported.

There was no significant difference between collaborative and nominal pairs in the total number of correct details reported, but there was a significant interaction between condition and interview. The interaction revealed a pattern of reduced correct recall during collaboration and increased correct recall after collaboration, but neither of these simple effects was statistically significant. Thus, we found no clear evidence of collaborative inhibition during the discussion, unlike previous studies on recall of simple stimuli (e.g., Basden *et al.*, 1997, 2000; Finlay, Hitch, & Meudell, 2000; Weldon & Bellinger, 1997). The difference could be explained by the nature of the to-be-remembered material (see also Marion & Thorley, 2016). People tend to recall events using a similar strategy (Schank & Abelson, 1977): They typically recount episodes in chronological order and describe objects and persons together with their properties (e.g., the mention of a car is usually accompanied by a description of the car). In our study, chronological retrieval strategies were further promoted by the instruction to recall the video from start to finish. Because collaborative inhibition for recall of simple stimuli is caused in large part by a disruption in idiosyncratic individual retrieval strategies (Barber *et al.*, 2015; Basden *et al.*, 1997), it should be reduced when individual retrieval strategies align, as was the case in our study.

Our findings are also at odds with two recent findings of collaborative inhibition for recall of emotional events (Wessel *et al.*, 2015; Yaron-Antar & Nachson, 2006), but there were important methodological differences between those studies and the current research. Participants in those two studies provided a consensus-based written recall of an event in groups of three individuals who did not know each other. In our study, recall took the form of an oral interview, witnesses collaborated with only one partner, and most witnesses knew their partner prior to participation. All of these factors have been associated with reduced collaborative inhibition (Marion & Thorley, 2016). Our findings are in line with exploratory findings reported by Vredeveldt *et al.* (2016), who studied an emotional event under similar conditions (i.e., oral interviews with acquainted pairs). It should be noted that our findings may not generalize to other situations, such as when witnesses collaborate with strangers or in larger groups.[8] Future research should examine the role of prior acquaintance and group size in collaborative remembering of witnessed events.

Unlike previous research, witnesses in our study participated in individual interviews both before and after collaborating. An individual recall opportunity *before* collaboration can help to strengthen witnesses' individual retrieval strategies, which should protect against retrieval disruption during the subsequent discussion and allow witnesses to listen to their partner without forgetting their own contributions (Blumen & Rajaram, 2008; Congleton & Rajaram, 2011). The initial interview in the present study, however, did not

[8] *Unfortunately, neither of the surveys on the prevalence of co-witnesses (Paterson & Kemp, 2006; Skagerberg & Wright, 2008) examined whether the witness knew their co-witness prior to the event, so we do not have access to statistics on the prevalence of prior acquaintance amongst co-witnesses.*

fully prevent the forgetting of old information during the discussion, since collaborative pairs omitted more old information in Interview 2 than nominal pairs. Nevertheless, including an initial individual interview is also important from a practical perspective, because it provides an independent record of what the witnesses remembered prior to collaboration. In a legal investigation, it is crucial to know the original source of the information.

Adding an individual interview *after* collaboration can provide witnesses with an opportunity to benefit from their partner's earlier contributions without being interrupted. Indeed, we found that prior collaboration significantly increased the percentage of new, emergent information reported in the final interview. Thus, individuals did not simply rehash what their partner had said in the previous interview, but actually came up with new details that had not been reported yet by either of the pair members. This finding reflects a delayed cross-cuing effect (see also Blumen *et al.*, 2014; Congleton & Rajaram, 2011; Takahashi & Saito, 2004).

Collaboration resulted in a large and reliable reduction in the number of errors reported, consistent with previous findings in the collaborative-recall literature (Rajaram & Pereira-Pasarin, 2010). The finding that witnesses prune each other's errors, challenges popular beliefs in the literature on eyewitness memory, which is rife with warnings that witnesses will contaminate each other's memory and conform to each other's errors (e.g., Gabbert *et al.*, 2006; Meade & Roediger, 2002; Paterson, Kemp, & Forgas, 2009). This apparent contradiction can again be explained by differences in methodology. In most co-witness studies, participants are faced with collaborators who are more likely to introduce errors than correct errors, either because they have seen a different version of the event (e.g., Gabbert *et al.*, 2006), or because they are confederates instructed to introduce false information (e.g., Meade & Roediger, 2002). Thus, participants are typically not given a chance to benefit from each other's knowledge. In contrast, witnesses in the present study had seen the same event and discussed it together in a structured collaborative interview without external manipulation. In this more realistic situation, witnesses benefitted from each other's knowledge by pruning and correcting each other's errors.

Following Hope *et al.*'s (2013) work, we tracked the path of errors across interviews to assess whether collaborating witnesses were more likely to contaminate each other's memory or correct each other's errors. The analysis revealed that memory contamination (13%) was less frequent than error pruning (24%). Importantly, however, even in the absence of any communication between pair members, 6% of the errors from one witness's recall subsequently appeared in the nominal partner's recall and 17% of the errors made by one witness were pruned in that witness's final interview after the nominal partner had mentioned the item correctly in Interview 2. This means that memory contamination and error pruning are at least in part due to simple coincidence rather than social influence. Thus, what looks like social influence (a witness adopting their partner's error or omitting an error after their partner has corrected it) may not in fact be caused by collaboration at all. Because Hope and colleagues did not have a nominal group condition, it is unclear to what extent the memory contaminations found in their study reflected social influence as opposed to coincidental overlap in memory patterns.

Whether collaboration is beneficial or harmful is largely dependent on the collaborative retrieval strategies that partners use. We found that content-focused retrieval strategies (acknowledgements, repetitions, restatements, elaborations) explained a significant portion of the variance in the amount reported. This was driven by elaborations: Pairs that elaborated on each other's statements remembered significantly more event details. The role of collaborative retrieval strategies has now been studied in

drastically different contexts: pilots' recall of flight scenarios (Meade *et al.*, 2009), elderly couples' recall of long-ago autobiographical events (Harris *et al.*, 2011), middle-aged couples' recall of a scene in a theatre play (Vredeveldt *et al.*, 2016), and students' recall of a videotaped violent event (current study). Although there are some minor differences in findings, the similarities are striking. The consistent picture emerging from all of these studies is that partners who actively listen to and elaborate upon each other's statements remember substantially more information. This picture is also congruent with developmental research showing that children remember more about a witnessed event if their mother has an elaborative conversation style (e.g., Leichtman, Pillemer, Wang, Koreishi, & Han, 2000; Reese, Haden, & Fivush, 1993; Reese & Newcombe, 2007). A next step for future research could be to examine whether a pre-collaboration instruction to use these effective retrieval strategies will help witnesses to remember more together. Alternatively, it is possible that such memory benefits only occur for pairs who use these strategies spontaneously.

Unlike content-focused strategies, retrieval strategies focusing on the process of remembering together (successful and failed cuing attempts, explanations, corrections, renewed remembering) did not predict the amount of reported information (see also Vredeveldt *et al.*, 2016). It should be noted that the lack of an association between explicit cuing attempts and recall output does not disprove the idea that (delayed) cross-cuing occurs in collaborative event recall. For example, the mention of a get-away car by one witness can jog the partner's memory of the car and its properties, which would constitute cross-cuing without an explicit attempt to cue.

Around the world, police officers are instructed to prevent discussion between witnesses, because witnesses may adopt each other's errors. In contrast, we found that collaboration between witnesses significantly reduced errors, without reducing correct recall. Based on these findings, we would certainly not advocate that witnesses should always be allowed to talk to each other, since the circumstances in the present study were optimal for collaborative benefits to emerge. We do call into question, however, the sweeping statement that witnesses should never be allowed to discuss the event. Instead, we propose that researchers start investigating under what conditions co-witness discussion hurts memory and under what conditions it helps. This would be a crucial step in formulating tailored recommendations for policymakers and police practitioners that specify when to separate witnesses and when to allow co-witness discussion. When it comes to memory for events, two heads together may not know more than two heads apart, but they do sometimes know better.

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