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## Collaboration enhances later individual memory for emotional material

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### ABSTRACT

Research on collaborative remembering suggests that collaboration hampers group memory (i.e., collaborative inhibition), yet enhances later individual memory. Studies examining collaborative effects on memory for emotional stimuli are scarce, especially concerning later individual memory. In the present study, female undergraduates watched an emotional movie and recalled it either collaboratively ( $n=60$ ) or individually ( $n=60$ ), followed by an individual free recall test and a recognition test. We replicated the standard collaborative inhibition effect. Further, in line with the literature, the collaborative condition displayed better post-collaborative individual memory. More importantly, in post-collaborative free recall, the centrality of the information to the movie plot did not play an important role. Recognition rendered slightly different results. Although collaboration rendered more correct recognition for more central details, it did not enhance recognition of background details. Secondly, the collaborative and individual conditions did not differ with respect to overlap of unique correct items in free recall. Yet, during recognition former collaborators more unanimously endorsed correct answers, as well as errors. Finally, extraversion, neuroticism, social anxiety, and depressive symptoms did not moderate the influence of collaboration on memory. Implications for the fields of forensic and clinical psychology are discussed.

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Remembering is a constructive process that is vulnerable to external influences, including social interactions (Conway, 2012). Previous research has focused on what happens when several people collaborate and create a single memory report afterwards (Rajaram & Pereira-Pasarin, 2010). The typical collaborative memory experiment (Weldon & Bellinger, 1997) consists of several phases. First, participants engage in an individual study phase. During a first recall phase following encoding, participants are then allocated to one of the two recall conditions. In the collaborative condition, small groups of participants work together to construct a single memory report. In the individual condition, participants are instructed to recall the studied material on their own. After a distracter period to prevent rehearsal, one or more subsequent individual recall phases may follow during which all participants are asked to produce their own memory report (Rajaram & Pereira-Pasarin, 2010).

The literature indicates that collaborative remembering bears advantages as well as disadvantages (Rajaram & Pereira-Pasarin, 2010). One outcome is that groups of participants usually recall more than separate individuals (Ross, Spencer, Blatz, & Restorick, 2008). More strikingly, however, the group output contains fewer items if it is compared to the *combined* recall of participants in the individual condition. This phenomenon is referred to as

collaborative inhibition (Weldon & Bellinger, 1997). Critical for observing collaborative inhibition is that the recall performance of collaborative groups is compared with that of nominal groups. That is, if a collaborative group consists of three members, total unique details recalled by this small group should be compared with the total number of unique details reported by three single individuals asked to remember only by themselves (i.e., a nominal comparison group).

Collaborative inhibition has been observed for a range of stimuli, including simple word-lists (Basden, Basden, & Henry, 2000; Blumen & Rajaram, 2008) and more complex materials such as stories (Takahashi & Saito, 2004), short film clips (Andersson & Rönnerberg, 1996; Wessel, Zandstra, Hengeveld, & Moulds, 2015), and staged (Vredeveldt, Hildebrandt, & Van Koppen, 2015) as well as real-life events (Yaron-Antar & Nachson, 2006). Among several possible explanations for collaborative inhibition, the retrieval strategy disruption hypothesis (Basden, Basden, Bryner, & Thomas, 1997) has received the most support (see Harris, Barnier, & Sutton, 2012; Rajaram & Pereira-Pasarin, 2010). According to this account, people's idiosyncratic retrieval strategies are disturbed by exposure to the recall of others following different strategies. Thus, due to interference, people cannot use their own recall strategy optimally. Interestingly, recent research suggests that in

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addition to retrieval disruption, retrieval inhibition (i.e., the inhibition of non-cued items through suppression of their memory representation) might also be responsible for collaborative inhibition (see Barber, Harris, & Rajaram, 2015).

Apart from its cost (i.e., collaborative inhibition), collaboration can be beneficial in several ways. To begin with, collaboration exposes people to information brought up by group members, possibly complementing their own individual memory of the studied material (i.e., re-exposure). Indeed, engaging in individual recall after a collaborative recall phase results in recalling more correct items than not collaborating before (Blumen & Rajaram, 2008, 2009; Congleton & Rajaram, 2011; Weldon & Bellinger, 1997). Furthermore, individual recognition is enhanced by prior collaborative remembering (Basden, Reysen, & Basden, 2002; Peker & Tekcan, 2009; Rajaram & Pereira-Pasarin, 2007). Thus, the positive effect of re-exposure during collaboration on later individual memory does not seem to be specific to the type of memory task.

The second beneficial effect of collaboration is error pruning. By jointly recalling and receiving feedback, group members have the opportunity to correct each other's recall errors. Accordingly, collaborative groups tend to make fewer recall errors than nominal groups (Ross et al., 2008; Ross, Spencer, Linardatos, Lam, & Perunovic, 2004; Vredeveldt et al., 2015). These error-correcting properties of collaborating groups even extend to stimuli that are known to enhance recognition errors (e.g., DRM lists; Takahashi, 2007, Experiments 2 & 3; Thorley & Dewhurst, 2009; but see Basden, Basden, Thomas, & Souphasith, 1998).

Taken together, the costs of collaboration (i.e., collaborative inhibition) are evident at the level of group recall. In contrast, the benefits of collaboration (i.e., re-exposure and error pruning) are more versatile. During the collaborative phase, collaborative groups make fewer errors in recall and recognition than nominal groups. On subsequent individual memory tests, former collaborators recall and recognise more correct items and make fewer errors than participants who previously provided individual reports. Interestingly, it has been suggested that the individual memories of former collaborators become more alike. That is, even though collaboration enhances later individual recall, it appears to reduce the number of *unique* elements in individual memories (Harris et al., 2012).

Whereas a plethora of studies have investigated the effects of collaboration on memory, there are only a few studies that have incorporated emotional material. More research on collaborative memory for emotional material is warranted as it could bear implications for the fields of clinical and forensic psychology (see also, Wessel & Moulds, 2008; Wessel et al., 2015). People are likely to share memories of emotional events in various contexts in real-life, for example with a therapist or with other survivors of an accident. To the best of our knowledge, only three collaborative memory studies employed emotional material. Vredeveldt et al. (2015) interviewed eyewitnesses

(couples) about an emotional scene in a theatre play. Yaron-Antar and Nachson (2006) compared collaborative and individual recall of a real-life emotional event (i.e., the assassination of Israel's Prime Minister Rabin). Wessel et al. (2015) used an emotional film depicting a fatal accident as stimulus material. In line with research using neutral stimuli, the latter two studies found evidence for collaborative inhibition. In contrast, Vredeveldt et al. did not find evidence of collaborative inhibition but did find an error pruning effect. Yet, only Yaron-Antar and Nachson (2006) studied the effect of collaboration on post-collaborative individual memory. They found a beneficial effect of collaboration on the *rate* (i.e., the percentage correct of the total detail count) but not the *total number* of accurate details (Yaron-Antar & Nachson, 2006). Thus, the knowledge about the effects of collaboration on later individual recall of emotional material is limited at best.

Investigating the effect of collaboration on memory for emotional material is relevant since the literature on emotional memory suggests that recall of the information related to the source of emotion (i.e., central details) is enhanced, whereas memory for more peripheral aspects is relatively poor (Burke, Heuer, & Reisberg, 1992; Kensinger, 2009). Presumably this is due to directing attention to the most distinctive or threatening features of an emotional situation, at the expense of attention to peripheral detail (i.e., attentional narrowing, e.g., Chipchase & Chapman, 2013; Christianson, 1992). Although Wessel et al. (2015) failed to find a differential pattern in collaborative recall of correct details, it is unknown whether collaboration affects the details in later individual memory differentially. Another paucity in the literature concerns the role of individual differences. It is conceivable that personality traits such as neuroticism and extraversion influence social interactions during recall, and that this, in turn, would affect collaborative memory. Extraversion is related to dominant behaviour (Trapnell & Wiggins, 1990). Further, some evidence suggests that extraverts introduce more contradictions and counterexamples in small group discussions (Nussbaum, 2002). Neuroticism, on the other hand, has been found to be related to submissive behaviour (Côté & Moskowitz, 1998). Relatedly, social anxiety might influence collaborative remembering. It has been found that the memory of socially anxious individuals is more susceptible to social influences (Wright, London, & Waechter, 2010).

The main goal of the present study was to extend previous findings on collaborative memory of an emotional film (Wessel et al., 2015) in three ways. First, we investigated the impact of collaboration on different types of detail in subsequent individual memory (i.e., after the collaborative inhibition phase). Specifically, the details were categorised according to their relevance to the plot of the movie. Because peripheral details should be relatively poorly encoded, subsequent individual memory for these details may especially profit from their introduction in a

group discussion. Furthermore, because collaborative recall may create greater overlap in individual memories, these memories should contain fewer *unique* details in former collaborators (see also Harris et al., 2012). The second issue that was addressed in the present study concerns the type of memory measure used to assess post-collaborative individual memory. Recognition tests have been employed previously, especially in studies using simple stimuli (e.g., words, objects; e.g., Rajaram & Pereira-Pasarin, 2007). The impact of collaboration on later individual recognition for relatively complex stimuli is largely unknown. Recognition depends on retrieval strategies to a lesser extent than free recall and as such, may be more susceptible to circumstances tied to encoding. Because the group discussion provides an encoding phase in itself, it may be that recognition is especially sensitive to detecting overlap in individual memories. The third issue that was explored in the present study pertained to the question of whether individual differences in social anxiety, extraversion, and neuroticism would be associated with the effect of collaboration on later individual recall and recognition. Finally, with regard to the first collaborative recall phase, we expected to replicate the classic collaborative inhibition effect in that collaborative groups would report fewer correct details (i.e., the standard collaborative inhibition effect) and fewer errors than nominal groups.

## Method

### Participants

One-hundred and twenty female first-year psychology students of the University of Groningen participated in exchange for course credit. Their average age was 20.2 years ( $SD = 1.55$ , range 17–28 years). All were native German speakers.<sup>1</sup> They were randomly assigned to one of the two conditions, collaborative recall ( $n = 60$ ) or individual recall ( $n = 60$ ). The study was approved by the ethical committee of the Department of Psychology at the University of Groningen.

### Material

#### Emotional movie clip

A Northern Irish commercial warning against drunk driving (“Shame”, aired from 2001 to 2005, Department of Environment (DOE), <http://www.youtube.com/watch?v=xtJqw-DGI8>) served as emotional movie-clip. The clip shows how the lives of a happy family and a young man collide in an alcohol-induced accident during which a young boy is killed. The clip lasted 1:01 minutes and was presented on a 21-inch LCD screen attached to a desktop computer. Sound was delivered through headphones.

#### Questions about the movie

As a manipulation check, participants completed two 11-point Likert Scales, asking for the perceived emotionality

of the movie (anchors: 0 = *not emotional at all* and 10 = *extremely emotional*) and the participant’s disengagement during watching (i.e., the extent to which they looked away during movie presentation; 0 = 0% to 10 = 100%).

### Memory measures

In order to assess *free recall* participants were asked to imagine that they were eyewitnesses and to recall as detailed and as objectively as possible everything that happened during the movie. They wrote down their recall report in a Microsoft Word document.

The *recognition questionnaire* consisted of 45 4-alternative multiple choice questions about the movie (e.g., *What colour was the shirt of the child?* with answer options *Green, Yellow, Blue, and Red*). The total score consisted of the number of correctly answered items (range 0–45).

### Individual differences measures

The neuroticism and extraversion subscales of the *Eysenck Personality Questionnaire* (EPQ; Eysenck & Eysenck, 1975) were administered. The EPQ items are answered with either “yes” or “no”. The relevant subscales consist of 22 items for Neuroticism (EPQ-N; range 0–22) and 19 items for Extraversion (EPQ-E; range 0–19). The subscales demonstrated acceptable to good reliability in the current sample ( $\alpha = 0.81$  and 0.65 for EPQ-N and EPQ-E, respectively).

The *Brief Fear of Negative Evaluation Scale* (BFNE; Leary, 1983; German translation, Vormbrock & Neuser, 1983; Wieser, Pauli, Weyers, Alpers, & Mühlberger, 2009) assesses apprehension about being evaluated by others. It consists of 12 questions that are rated on a 5-point Likert Scale (anchors: 0 = *agree very little* to 4 = *agree very much*). The total score ranges from 0 to 48. The BFNE showed excellent reliability in the current sample ( $\alpha = 0.94$ ).

The *Beck Depression Inventory, second edition* (BDI-II; Beck, Steer, Ball, & Ranieri, 1996) is a 21-item, self-report measure for assessing depressive symptoms in the past two weeks. Each item represents a symptom of depression and is scored on a 4-point scale representing increasing intensity (0–3; range total scores: 0–63). The BDI-II was used as a screening tool for high depressive symptoms which have the potential to negatively influence memory specificity (Van Vreeswijk & de Wilde, 2004). The internal consistency in the current sample was good ( $\alpha = 0.85$ ).

### Procedure

Three unacquainted participants were tested simultaneously.<sup>2</sup> Upon arrival in the laboratory, participants were seated at individual desks with computers. They were told that the experiment would investigate the influence of an emotional movie on group behaviour. After signing informed consent, participants watched the emotional movie clip on their individual computers. Immediately afterwards they provided the emotionality and disengagement ratings. A distracter period of 5 minutes followed during which the triads worked together

to solve a logic grid puzzle. They were informed that they would not have enough time to finish it, but that they should try to get as far as possible.

Next, participants engaged in a first free recall phase. Participants in the *collaborative condition* were instructed to work together on a single memory report, providing as much detail of the movie as possible. They were instructed to report all information that they agreed on in their texts (i.e., consensus instructions, see also Harris et al., 2012). Then they were to enter their report in one text document on a single computer, with one person in charge of typing. They were instructed that when none of the members of the group could come up with new information for the duration of one minute, they could discontinue their recall efforts. Participants in the *individual condition* were asked to enter everything they could remember of the movie on their own individual computer. Recall duration was timed using a stopwatch. All participants were informed that they had plenty of time for recall. After 25 minutes they were told that they had five minutes left. We based the 30 minutes recall window on our previous study (Wessel et al., 2015) in which none of the participants needed more than 23 minutes. The collaborative groups spent significantly more time on recall ( $m = 20:41$  minutes,  $SD = 6:04$ , 95% CI [19:07, 22:16]) than individually working participants ( $m = 16:20$ ,  $SD = 5:05$ , 95% CI [15:01, 17:39], *Cohen's d* = 1.1, 95% CI<sub>d</sub> [0.57, 1.62]).

Following this initial recall phase, participants in both conditions worked individually for the remainder of the experiment. First, they completed another distracter task, consisting of a 10 minutes attention engaging task<sup>3</sup> on their computers. Then they engaged in a second recall phase and provided individual free recall reports. Again, recall duration was timed. After 10 minutes participants were informed that they had five more minutes but were allowed more time if needed. Three participants took 20 minutes. Participants who had previously collaborated took significantly longer ( $M = 14:04$ ,  $SD = 3:20$ ) than participants who had worked individually during the initial recall phase ( $M = 11:15$ ,  $SD = 2:58$ ;  $t(118) = -4.88$ ,  $p < .001$ ,  $d = 0.9$ , 95% CI<sub>d</sub> [0.52, 1.27]). Subsequently, participants completed the recognition questionnaire without any time limit and completed the BFNE, the BDI-II, and the EPQ subscales. Before they were debriefed, participants watched a positive video in order to neutralise any negative mood that might have been induced by the movie. In total, the session took approximately 90 minutes.

### Data coding

The details in the free recall reports were coded according to the protocol developed by Wessel et al. (2015). Each correct detail was awarded one point. There were four detail categories differing in their degree of centrality to the movie plot (see also Burke et al., 1992). The most central category was *Actions*, referring to behaviours of the four main characters in the movie (e.g., "The boy was

playing soccer", one point). *Action Details* were considered as less central and represented objects that were handled by the main characters or aspects that were descriptive of an action (e.g., "He was drinking beer out of a glass"; two points). A more peripheral category was *Person Details*, reflecting the appearance (e.g., gender, clothes, hairstyle) of four main characters in the movie (e.g., "A little boy in a yellow t-shirt played soccer" was awarded three points). *Background Details* constituted the most peripheral category and contained details that were irrelevant to the movie plot (e.g., locations, objects that were not part of an action, persons in the background, surroundings; e.g., "The garden was surrounded by a wooden fence"; three points). Nonspecific information (e.g., "a light-coloured shirt" instead of a light-blue shirt) received half a point rather than one point. In addition, distortions (e.g., "The girl was playing soccer" rather than the boy) and confabulations ("The mother was in the garden" whereas there was no mother in the movie) were coded as errors in their respective categories. The points awarded for correct details as well as errors were summed for every detail category. Because there was no present total number of details, these sum scores served as dependent variables.

In order to check coding consistency, two independent raters (GB and CK) who were blind to condition scored 21 (11%) of the recall reports. For every detail category intra-class correlation coefficients (ICC) were calculated using a two-way random model with absolute agreement (Shrout & Fleiss, 1979). ICCs for the correct details were excellent (ranging from .84 for Background Details to .91 for Person Details). The reliabilities for the errors can be considered fair to good (ranging from .54 for Actions to .83 for Person Details; Fleiss, 1986).

Originally, the recognition test was not designed to reflect the detail categories. Yet, inspection of the items light of the free recall coding protocol revealed that the items were distributed over four detail categories reasonably well (i.e., Actions, 13 items; Action Details, 11 items; Person Details, 13 items; and Background Details, 7 items). One item referred to a written message on the screen ("Don't drink and drive") and was not included in any category. The number of items endorsed in each detail category were summed and transformed into proportions.

### Pooling of free recall reports

The free recall reports of three individual members of a triad were pooled such that all *unique* correct details were counted. That is, if an item was mentioned by two or more members of the triad, it was counted only once. For example, if participant A mentioned a teddy bear and a soccer ball, and participant B reported the swing and the soccer ball, the pooled report would contain the teddy bear, the swing, and the soccer ball. If participant A provided more specific information (e.g., teddy bear) than participant B (e.g., stuffed animal), the specific details were counted for the pooled report. Errors were

pooled in a similar fashion, that is, if two or more participants reported the same detail incorrectly, it was scored as one error. However, details were only counted as errors if they had not already been counted as correct. Thus, if participant A correctly described the little boy's shirt as yellow but participant B reported it being blue, one correct detail but no error was scored. Because the purpose of pooling was to create an index of the potential recall of three individuals, allowing correct information to prevail over incorrect information yields an appropriate comparison for collaborative reports constructed under consensus instructions (see also Wessel et al., 2015).

### Statistical analysis

*First phase collaborative and pooled recall.* In order to see whether the present data replicated the standard collaborative inhibition effect, the data obtained for the collaborative and nominal conditions in the first recall phase were subjected to independent *t*-tests. Where the normality assumption was violated, we used Mann-Whitney *U* tests (Mann & Whitney, 1947) with *r* as effect size for nonparametric tests (Fritz, Morris, & Richler, 2012).

*Second phase individual recall and recognition.* Because the participants had been tested in triads during the first recall phase, the individual data from the second recall phase suffered from violation of the independence assumption that generally applies to techniques for simple between-group comparisons. To account for the nested structure of these data, we analysed them using hierarchical linear modelling (HLM; Snijders & Bosker, 2012). Specifically, each recall condition contained two levels (i.e., individuals within triads). Our main interest was to evaluate differences in memory between the conditions. Therefore, we entered a dummy variable representing recall condition as a fixed effect at the level of the triads. This rendered regression coefficients with accompanying *t*-values (i.e., the coefficient divided by its standard error). For sake of simplicity, we restrict our report of the HLM analyses to these *t*-values.

To see whether the conditions displayed different recognition patterns across detail categories, the HLM analyses included dummy variables for condition and detail category and their interaction. Again, we report the *t*-value for the recall condition dummy. Since the detail categories were coded as three dummy variables and accordingly there were three interaction terms, we report Chi-squared-statistics indicating whether the interaction as a whole was significant and *t*-values for the differences between the conditions per category. All multilevel analyses were performed using MLwiN 2.3 (Rasbash, Charlton, Browne, Healy, & Cameron, 2014) and all other analyses with SPSS 22.0.

In addition, *t*-tests and Mann-Whitney *U* tests were employed for group comparisons involving pooled data. Pooled correct recognition and recognition errors were subjected to a 2 (condition) × 4 (detail category) Analysis

of Variance (ANOVA) with repeated measures on the last factor.

## Results

### Ratings and individual differences

Overall, participants evaluated the movie clip as quite emotional ( $M = 6.98$ ,  $SD = 1.7$ ) and reported that they hardly looked away during watching ( $M = 0.04$ ,  $SD = 0.16$ ).<sup>4</sup> Table 1 lists the ratings and individual differences scores for the individual and collaborative conditions. The conditions did not differ on either of these variables.

### Collaborative inhibition<sup>5</sup>

Table 2 lists the correct scores and errors of the initial free recall tests for the nominal and collaborative conditions. Group comparisons showed that the mean total correct score was significantly higher for the nominal groups,  $t(38) = 8.06$ ,  $p < .001$ ,  $d = 2.55$ , 95%  $CI_d$  [1.7, 3.38]. Similar group differences were observed for the correct scores across all detail categories for actions,  $t(38) = 6.18$ ,  $p < .001$ ,  $d = 1.96$ , 95%  $CI_d$  [1.19, 2.7], action details,  $t(38) = 5.19$ ,  $p < .001$ ,  $d = 1.64$ , 95%  $CI_d$  [0.91, 2.35], person details,  $t(38) = 4.38$ ,  $p < .001$ ,  $d = 1.39$ , 95%  $CI_d$  [0.68, 2.07], and background details  $t(38) = 6.18$ ,  $p < .001$ ,  $d = 1.95$ , 95%  $CI_d$  [1.19, 2.7].

A Mann-Whitney *U* test showed that overall, participants in the nominal groups reported significantly more erroneous details than those in the collaborative condition,  $U = 65.5$ ,  $z = -3.67$ ,  $p < .001$ ,  $r = -0.58$ ,  $CI_r$  [-0.75, -0.33]. Regarding the separate detail categories, the nominal groups reported significantly more false person details,  $U = 102.5$ ,  $z = -2.71$ ,  $p = .007$ ,  $r = -0.43$ , 95%  $CI_r$  [-0.65, -0.14], and background details,  $U = 123.0$ ,  $z = -2.14$ ,  $p = .038$ ,  $r = -0.34$ ,  $CI_r$  [-0.59, -0.03], than the collaborative condition. Other group differences with regard to errors were in the same direction but were not significant, i.e., actions,  $U = 141$ ,  $z = -1.65$ ,  $p = .114$ ,  $r = -0.26$ ,  $CI_r$  [-0.53, 0.06], and action details,  $U = 138.5$ ,  $z = -1.72$ ,  $p = .096$ ,  $r = -0.27$ ,  $CI_r$  [-0.54, -0.05].

### Second phase individual recall<sup>6</sup> and recognition

Table 3 shows the recall and recognition performance of the individual participants ( $N = 120$ ) during the second phase. The HLM analysis showed that overall, participants in the collaborative condition recalled significantly more details than participants in the individual condition,  $t(38) = 4.77$ ,  $p < .001$ ,  $d = 0.87$ , 95%  $CI_d$  [0.46, 1.27]. Although the difference between the conditions for recalling person details failed to reach significance,  $t(38) = 1.66$ ,  $p = .053$ ,  $d = 0.30$ , 95%  $CI_d$  [-0.63, 0.67], significant differences were observed for all remaining detail categories, i.e., actions,  $t(38) = 3.79$ ,  $p < .001$ ,  $d = 0.69$ , 95%  $CI_d$  [0.30, 1.08], action details,  $t(38) = 4.61$ ,  $p$

**Table 1.** Means (*SD*) and *t*-tests of the Emotionality and Disengagement Ratings and Individual Differences Measures Scores per Condition.

	Individual ( <i>n</i> = 60)	Collaborative ( <i>n</i> = 60)	<i>t</i> (118)	<i>p</i>	<i>Cohen's d</i>
Emotionality	7.17 (1.79)	6.80 (1.61)	1.18	.240	0.22
Disengagement	0.01 (0.04)	0.06 (0.22)	-1.74	.087	0.32
BDI-II	8.35 (6.55)	8.15 (5.95)	0.18	.861	0.03
BFNE	24.65 (10.31)	22.90 (9.15)	0.98	.327	0.18
EPQ-E	20.65 (1.89)	20.32 (1.69)	1.02	.311	0.19
EPQ-N	8.85 (4.46)	9.15 (4.62)	-0.36	.718	0.07

Note: BDI-II, *Beck Depression Inventory, second edition*; BFNE, *Brief Fear of Negative Evaluation Scale*; EPQ-E, *Eysenck Personality Questionnaire, Extraversion subscale*; EPQ-N, *Eysenck Personality Questionnaire, Neuroticism subscale*.

**Table 2.** Mean (*SD*) Number of Correct and False Details in Immediate Recall for the Nominal and Collaborative Groups.

	Immediate recall	
	Nominal <sup>a</sup> groups ( <i>n</i> = 20)	Collaborative groups ( <i>n</i> = 20)
Correct details		
Total	94.45 (11.97)	65.10 (11.03)
Actions	30.75 (4.42)	22.85 (3.62)
Action details	22.05 (3.78)	15.83 (3.81)
Person details	21.78 (4.64)	15.53 (4.37)
Background details	19.88 (4.27)	10.90 (4.90)
Errors		
Total	9.15 (3.42)	4.75 (2.55)
Actions	1.85 (1.46)	1.15 (1.35)
Action details	1.95 (1.36)	1.20 (1.11)
Person details	2.90 (2.08)	1.30 (1.08)
Background details	2.45 (2.24)	1.10 (1.29)

<sup>a</sup>Nominal groups = three participants in the individual condition whose recall reports were pooled.

< .001,  $d = 0.84$ , 95%  $CI_d$  [0.43, 1.24], and background details,  $t(38) = 2.57$ ,  $p = .007$ ,  $d = 0.47$ , 95%  $CI_d$  [0.09, 0.84]. In contrast, the total number of errors did not differ significantly between the collaborative and individual conditions,  $t(38) = 0.45$ ,  $p = .328$ ,  $d = 0.08$ , 95%  $CI_d$  [-0.28, 0.44]. None of the detail categories showed significant differences in errors between the conditions, all  $t$ 's < 1.44, all  $d$ 's < 0.30). Thus, during subsequent individual testing, participants who had collaborated recalled more correct details but made the same number of errors compared to participants who had worked separately.

Similarly, a 2 (Condition)  $\times$  4 (Detail Category) repeated measures HLM analysis revealed that there was no significant difference in overall recognition between participants in the collaborative and those in the individual condition,  $t(38) = 0.75$ ,  $p = .23$ ,  $d = 0.14$ , 95%  $CI_d$  [-0.22, 0.5]. However, both the overall effect of detail category,  $\chi^2(4) = 81.76$ ,  $p < .001$ , and the interaction of condition with detail category,  $\chi^2(4) = 11.46$ ,  $p < .05$ , were significant. More specifically, the interaction revealed that compared to the individual condition, participants in the collaborative condition recognised significantly more actions,  $t(31) = 2.34$ ,  $p < .05$ ,  $d = 0.74$ , 95%  $CI_d$  [0.09, 1.38], action details,  $t(31) = 2.82$ ,  $p < .01$ ,  $d = 0.89$ , 95%  $CI_d$  [0.23, 1.54], and person details,  $t(31) = 2.97$ ,  $p < .01$ ,  $d = 0.94$ , 95%  $CI_d$  [0.27, 1.60]. There was no significant difference in correct recognition of background details between the conditions,  $t(31) = 0.00$ ,  $p = .5$ ,  $d = 0.0$ .

**Table 3.** Mean number of correct and false details in individual protocols and proportion correct recognition for the individual and collaborative conditions at second recall.

	Condition	
	Individual ( <i>n</i> = 60)	Collaborative ( <i>n</i> = 60)
Correct details		
Total	53.15 (12.58)	66.41 (13.12)
Actions	18.28 (4.87)	22.68 (4.83)
Action details	12.16 (3.73)	16.63 (4.83)
Person details	13.33 (4.58)	15.02 (4.23)
Background details	9.38 (4.36)	12.08 (5.09)
Errors		
Total	5.95 (3.44)	6.28 (3.69)
Actions	1.00 (1.24)	1.40 (1.44)
Action details	1.52 (1.07)	1.55 (1.36)
Person details	1.98 (1.64)	2.03 (2.00)
Background details	1.45 (1.85)	1.30 (1.28)
Recognition		
Total correct <sup>a</sup>	.51 (.10)	.56 (.08)
Actions	.44 (.15)	.50 (.11)
Action details	.57 (.18)	.64 (.12)
Person details	.55 (.13)	.62 (.14)
Background details	.50 (.15)	.49 (.16)

Note: Standard deviations are in parentheses.

<sup>a</sup>The mean proportions for the total correct recognition scores and total false alarm deviate slightly from the mean of the four detail categories because the questionnaire contained one item that did not fit with any of the detail categories.

## Second phase pooled recall and recognition

### Free recall

To check whether collaboration resulted in more similar individual recall at subsequent testing the pooled reports of the collaborative and individual conditions were compared ( $n = 20$  triads per condition, see Table 4). The conditions did not significantly differ regarding the total number of unique correct details  $t(38) = -0.45$ ,  $p = .66$ ,  $d = 0.14$ , 95%  $CI_d$  [-0.48, 0.76]) or either one of the detail categories, all  $t$ 's(38) < .98, all  $p$ 's > .33, all  $d$ 's < 0.32. However, overall, the collaborative condition made significantly fewer unique errors than the individual condition,  $t(38) = 2.20$ ,  $p = .03$ ,  $d = 0.70$ , 95%  $CI_d$  [0.52, 1.33]. Yet, for none of the separate detail categories the difference between conditions reached significance, all  $t$ 's (38) < 1.96, all  $p$ 's > .06, all  $d$ 's < 0.62. Thus, relative to participants who worked alone, the individual free recall reports of people who previously constructed a memory together were not more alike with respect to correct details. However, their memories did become more similar regarding the erroneous details.



**Table 4.** Mean number of correct and false details in pooled protocols and proportions unanimous correct recognition and false alarms for the individual and collaborative conditions at second recall.

	Condition	
	Individual ( <i>n</i> = 20)	Collaborative ( <i>n</i> = 20)
<b>Correct details</b>		
Total	93.78 (11.15)	95.78 (16.57)
Actions	28.95 (4.47)	30.30 (5.94)
Action details	23.38 (4.07)	24.75 (6.14)
Person details	21.68 (4.15)	20.33 (4.54)
Background details	19.78 (4.71)	20.40 (7.48)
<b>Errors</b>		
Total	11.75 (5.10)	8.70 (3.51)
Actions	2.25 (1.41)	1.95 (1.61)
Action details	2.25 (1.52)	1.95 (1.36)
Person details	4.00 (2.41)	2.65 (1.93)
Background details	3.25 (2.92)	2.15 (1.84)
<b>Correct recognition<sup>a</sup></b>		
Total	.21 (.08)	.33 (.11)
Actions	.15 (.13)	.27 (.12)
Action details	.22 (.13)	.39 (.12)
Person details	.26 (.09)	.40 (.19)
Background details	.24 (.12)	.26 (.18)
<b>False alarms<sup>1</sup></b>		
Total	.06 (.03)	.11 (.06)
Actions	.12 (.08)	.13 (.09)
Action details	.03 (.04)	.09 (.10)
Person details	.03 (.04)	.09 (.10)
Background details	.10 (.09)	.15 (.13)

Note: Standard deviations are in parentheses.

<sup>a</sup>Proportions unanimous agreement in triads. The mean proportions for the total correct recognition scores and total false alarm deviate slightly from the mean of the four detail categories because the questionnaire contained 1 item that did not fit with any of the detail categories.

### Recognition

For pooling of the recognition data, we counted the number of items for which all three members of a triad were unanimous in their answer. These numbers were transformed into proportions (see Table 4). Thus, whereas in free recall, lower numbers are indicative of more similarity, for recognition, higher proportions reflect more similarity. The 2 (condition)  $\times$  4 (detail category) repeated measures ANOVA yielded significant main effects of condition  $F(1, 38) = 12.18, p < .001, \eta_p^2 = .24, CI \eta_p^2 [0.04, 0.44]$ , and detail category,  $F(3, 114) = 9.12, p < .001, \eta_p^2 = .19, CI \eta_p^2 [0.07, 0.3]$ . Moreover, the condition by detail category interaction was significant,  $F(3, 114) = 3.53, p < .05, \eta_p^2 = .09, CI \eta_p^2 [0.00, 0.18]$ . Follow-up *t*-tests showed that the collaborative condition was more unanimous than the individual condition with respect to actions, action details and person details, all  $t(38) > 2.99$ , all  $p$ 's  $< .01$ , all  $d$ 's  $> 0.94$ . The conditions did not significantly differ on background detail,  $t(38) = 0.45, p = .66, d = 0.14, 95\% CI_d [-0.48, 0.76]$ .

The ANOVA regarding the proportion of items for which all members of a triad agreed on the same wrong alternative did not reveal a significant condition by detail category interaction,  $F(3, 114) = 1.06, p = .37, \eta_p^2 = .03, CI \eta_p^2 [0.00, 0.09]$ . However, there was a significant main effect of condition  $F(1, 38) = 8.53, p < .01, \eta_p^2 = .18, CI \eta_p^2 [0.02, 0.38]$ , indicating that overall, recognition errors were more similar in members of previously collaborating triads than in participants who had engaged in the initial recall test

separately. In addition, the main effect of detail category was significant,  $F(3, 114) = 9.05, p < .001, \eta_p^2 = .19, CI \eta_p^2 [0.07, 0.3]$ . Follow-up pairwise comparisons showed that participants agreed on significantly more erroneous alternatives in actions and background details than action details and person details, all  $t$ 's (38)  $> 3.52$ , all  $p$ 's  $< .01$ , all  $d$ 's  $> 1.11$ .

### Individual differences and individual memory performance

Table 5 shows the correlations between the individual differences variables and memory performance for the individual and collaborative conditions separately. As can be seen in this table, neither condition showed significant associations between correct recall, recall errors and recognition on the one hand, and depressive symptoms, extraversion, neuroticism and fear of negative evaluation on the other hand.

### Discussion

The results of the initial collaborative recall phase replicated the standard collaborative inhibition effect (Rajaram & Pereira-Pasarin, 2010) and are in line with the notion that collaborative inhibition generalises to the recall of emotional material (Wessel et al., 2015; Yaron-Antar & Nachson, 2006; but see Vredeveldt et al., 2015). Moreover, the present study confirms the beneficial effect of collaboration for subsequent individual recall and recognition of emotional material (see Yaron-Antar & Nachson, 2006). Thus, both the costs and benefits of collaboration that have been documented for neutral material (see Rajaram & Pereira-Pasarin, 2010) seem to emerge when rather complex emotional material is involved.

Apart from replicating the standard effects of collaboration, the present study speaks to three specific issues. The first pertains to the question of whether collaboration affects individual memory depending on the centrality of the details to the theme of the emotional information. The results show that for free recall, centrality did not play an important role. Similar recall patterns were observed across detail categories, for both correct details and errors, in individual as well as pooled reports. The only exception was the lack of a significant difference between the conditions for correct recall of person details in the individual reports. However, the importance of this null-finding is unclear, as numerically the collaborative condition did recall more person details than the individual condition. This difference was of a small to medium effect size (ES; Cohen, 1977). Thus, we cannot firmly conclude that person details are immune to the benefits of prior collaborative recall. In contrast, the results with respect to recognition seem to be more consistent. The individual as well as pooled results showed that prior collaboration was beneficial for all detail categories, except background details.

**Table 5.** Pearson correlations between memory indices at second recall and individual differences per condition. The lower triangle contains correlations for the individual condition ( $n = 60$ ), the upper triangle contains correlations for the collaborative condition ( $n = 60$ ).

	Total correct R2	Total errors R2	Recognition	BDI	BFNE	EPQ-E	EPQ-N
Total correct R2	–	.417**	.313*	–.044	.153	.219	–.029
Total errors R2	–.089	–	.072	–.068	.157	–.053	.043
Recognition	.599**	–.218	–	.115	.161	.070	–.022
BDI	.306	–.032	.194	–	.194	–.277*	.504**
BFNE	.214	–.008	.066	.405**	–	–.025	.440**
EPQ-E	.012	.065	.099	–.105	.043	–	–.169
EPQ-N	–.017	–.149	.023	.590**	.609**	–.091	–

Note: R2, Recall 2; BDI-II, Beck Depression Inventory, second edition; BFNE, Brief Fear of Negative Evaluation Scale; EPQ-E, Eysenck Personality Questionnaire, Extraversion Subscale; EPQ-N, Eysenck Personality Questionnaire, Neuroticism Subscale.

\*Correlation is significant at the .05 level (2-tailed).

\*\*Correlation is significant at the .01 level (2-tailed).

Secondly, the results are consistent with the idea that recognition tests might be sensitive for picking up overlap in the individual memory of former collaborative group members. Whereas the collaborative and individual conditions did not differ with respect to the numbers of unique correct items in free recall, the recognition data showed that former collaborators more unanimously endorsed correct answers. Future studies should confirm whether recognition is indeed a more sensitive measure for detecting overlap in post-collaborative individual memory than free recall.

Finally, we explored whether individual differences are associated with the number of correct details and errors in post-collaborative memory. Overall, extraversion, neuroticism, social anxiety, and depressive symptoms did not moderate the influence of collaboration on memory. This is in contrast with the finding that higher fear of negative evaluation (i.e., social anxiety) is associated with more memory conformity (Wright et al., 2010). Whereas Wright and colleagues found an association between social anxiety and memory *during* collaboration, we were interested in the relationship between social anxiety and memory *after* collaboration. Hence, the studies are not directly comparable and differences in design might explain that there was no significant effect of social anxiety.

On a more theoretical level, the findings regarding individual memory fit with the notion that a group discussion about a to-be-constructed memory report acts as an additional encoding phase in which group members provide additional information complementing single participants' idiosyncratic memory representations. Whether a detail surfaces in the discussion would depend on idiosyncratic retrieval, which may suffer from interference by different strategies adopted by other group members (i.e., retrieval disruption, Basden et al., 1997). However, initial encoding processes may also play a role. If indeed, the emotional nature of the film in the present study-induced attentional narrowing (Christianson, 1992), memory representations of peripheral details would have been relatively poor. One could speculate that the more peripheral a detail is, the lower the probability of being attended to in initial encoding, decreasing the probability of being mentioned in the discussion. This might explain the lack of significant difference between the conditions in the

recognition of unimportant background details. To the extent that (peripheral) detail was mentioned in the discussion, additional encoding would account for the finding that more correct items were unanimously endorsed (i.e., by all members of the triad) in the collaborative condition during recognition. The observation that the collaborative condition made fewer unique errors and had more unanimous false alarms at recognition suggests that such an extra encoding opportunity may also strengthen memory for erroneous detail once it is accepted by the group. Although it has been shown that collaborative groups engage in error pruning (Harris et al., 2012; Ross et al., 2008), presumably not all false detail is weeded out of group discussions.

On a related note, the present finding that the collaborative reports at initial recall contained fewer errors is consistent with the notion of error pruning. The lack of significant group difference in the numbers of errors in subsequent individual recall suggest that the effects of error pruning can be short-lived. This is at odds with previous findings (e.g., Thorley & Dewhurst, 2009). However, the nature of the stimulus material may be important. The majority of studies investigating post-collaborative individual memory used word-lists as stimuli (Blumen & Rajaram, 2008; Harris et al., 2012; Ross et al., 2008; Ross et al., 2004; Thorley & Dewhurst, 2007). Previous work employing stimuli containing a narrative structure (such as stories, real-life events) did not specifically examine errors (Cuc, Ozuru, Manier, & Hirst, 2006; Weldon & Bellinger, 1997; Yaron-Antar & Nachson, 2006). Thus, as far as story-like stimuli are concerned, the extant literature seems to lack clear evidence that earlier collaboration decreases errors in individual memory. It is plausible to assume that the retrieval of stimuli containing a narrative structure relies more on schematic knowledge than that of wordlists. Retrieval processes that are guided by schemas easily invite erroneous detail (cf. Bartlett, 1932) and perhaps such detail is resistant to the earlier discarding in a group discussion. Of course, this is a speculative account. Future research might shed light on this issue.

As for practical implications, the current findings may be relevant to the fields of forensic and clinical psychology. With regard to the forensic field, the results suggest that having eyewitnesses collaborate on constructing one

single memory report might be beneficial (cf. Vredeveldt et al., 2015). Even though such a group report would contain fewer correct details than the members potentially can retrieve, the error-pruning process would result in fewer mistakes. In addition, collaboration would strengthen members' individual memories. A potential caveat of such a method is that errors in memory also become more alike, and unanimous false recognition by several people may create the impression that a particular detail must be true. This would be an important caveat that potentially hampers legal investigation and awaits further investigation. If confirmed, this might imply that in case of real-life eyewitness testimony where avoiding false positives is of utmost importance, collaboration might not be advisable after all. Additionally, future applied studies may examine whether the current results generalise to different modalities. For example, written reports may be less detailed overall and even less accurate with regard to perpetrator information than oral reports provided by eyewitnesses (see Sauerland & Sporer, 2011). As for implications for clinical psychology, the results more generally contribute to the idea that groups of people who experienced the same traumatic event (e.g., a motor vehicle accident) might benefit from collaboratively remembering what happened to them (Wessel & Moulds, 2008). Memories in trauma survivors may contain unrealistic distortions that contribute to symptom maintenance (Conway, 2005; Ehlers, Hackmann, & Michael, 2004). Addressing these distortions has therapeutic benefits (e.g., Ehlers, Clark, Hackmann, McManus, & Fennell, 2005). As historical truth is less important in psychotherapy than in legal psychology, collaborative remembering might add to the therapeutic toolbox provided that clients are not involved in legal proceedings associated with their trauma.

Several aspects of the current study leave room for improvement. To begin with, it may be argued that limiting the time for recall may have affected the amount of detail recalled. As for initial collaborative recall, three groups reached the time limit of 30 minutes. Additional analyses showed that excluding these groups from the analyses did not change the pattern of results, lending confidence to the conclusion that the results reflect a replication of the well-established collaborative inhibition effect (see Rajaram & Pereira-Pasarin, 2010). As for subsequent individual recall, participants in the collaborative condition more often exceeded the time-limit of 15 minutes. After 10 minutes recall, participants were encouraged to complete the recall test within the subsequent 5 minutes and it could be argued that this was detrimental to recall performance. However, it is unclear how the time-limit can explain the finding that the collaborative condition outperformed the individual condition. Granting unlimited time would have rendered more details in the collaborative condition. Thus, if anything, limiting the time for the second recall phase would have resulted in an underestimation of the effect. A second methodological consideration is that even though the sample size provided sufficient

power on an individual level ( $n = 120$ ), the comparisons of the pooled data ( $n = 20$  vs.  $n = 20$ ) had less power to detect medium effect sizes. Future research could increase the sample size to achieve more powerful group comparisons. Relatedly, the results concerning the individual recall of errors might have suffered from the small variance in recall errors. Employing a design that produces more errors to study the influence of collaboration more reliably would solve this problem in further studies. Additionally, although the trauma-film paradigm is thought to be a useful tool for studying mechanisms involved in memories for emotional events (Holmes & Bourne, 2008), real-life traumatic situations would be much more complex and emotionally intense. The external validity of the current study is limited further by the homogeneity of the sample (university students) and the use of a single movie as a substitute for an emotional event. Specifically, we used the same movie as Wessel et al. (2015) and it is unknown whether the findings would generalise emotional material in general. Future studies might explore other emotional stimuli (see Wells & Windschitl, 1999, for a discussion on stimulus sampling). Furthermore, it should be acknowledged that the items in the recognition questionnaire were allocated to the detail categories in a post-hoc fashion. Although 44 out of 45 items fit unequivocally within one of those categories, future studies may fine-tune recognition measures to further examine their ability to pick up subtle effects of centrality. Finally, it should be noted that there was a rather short delay of 10 minutes between the first and second recall. Thus, the findings cannot provide insights about the effects of collaboration on individual recall attempts after a long delay. A logical next step would be to extend the period between collaboration and individual recall to investigate whether the effects of collaboration on later individual memory of emotional material are persistent over time.

Overall, the present study demonstrated that the beneficial effect of collaboration on later individual memory also extends to complex emotional material. The results suggest that the centrality of detail to the emotional theme of information does not play a major role in individual free recall. Yet, the benefits of collaboration may be less pronounced for recognition of peripheral background detail. Errors may be pruned during a group discussion, but that does not necessarily result in fewer errors in post-collaborative individual memories. Yet, the recognition data suggest that those errors that do survive in individual memory are more likely to be agreed on by all group members, especially in recognition. Furthermore, individual differences in extraversion, neuroticism, social anxiety, and depressive symptoms did not moderate the impact of collaboration on individual memory. Our findings contribute to and extend the few existing studies on collaborative memory for emotional material (Vredeveldt et al., 2015; Wessel et al., 2015; Yaron-Antar & Nachson, 2006). While it can be concluded that social factors affect memory, the

current findings also give rise to the speculation that the nature of complex emotional stimulus material might yield slightly different results than word stimuli, especially with regard to errors. Further research may shed light on this issue.

## Notes

1. Participants were undergraduates of the University of Groningen International Bachelor of Psychology program. This program is taught in English, yet the majority of undergraduates is German. In order to promote group discussions and fluency during recall, the experiment was mainly conducted in the participants' native tongue. Questionnaires that were not available in German were administered in the English language. Entering the International Bachelor program requires proof of English proficiency (a minimum of A1 on the Cambridge English: Advanced examination or equivalent). This should suffice for understanding and adequately responding to the items in the questionnaires.
2. Participants were invited to come to the laboratory in groups of three. In four instances, one of the group-members did not show up and the resulting two-member groups were assigned to the individual condition. For purpose of data-analysis, six participants from these two-member groups were randomly selected to constitute two triads. The data of the two remaining participants were dropped from all analyses.
3. This was an adapted version of the Attentional Network Task (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002), that was shortened to serve as a filler task. Because there is no information on the validity of this adaptation, we did not analyse the data.
4. Three participants (all in the collaborative condition but in different triads) indicated that they looked away for 100% of the time. Nevertheless, these participants produced recall accounts. They did not differ considerably from other participants on any of the relevant variables. Thus, we assumed that these participants misread the question asking about the time they did *not* look at the movie and included them in the analyses. These three participants would also explain the non-significant trend towards a difference between the conditions on disengagement (see Table 1).
5. Three collaborative groups reached the time-limit of 30 minutes. To see whether this may have artificially inflated the collaborative inhibition effect, we ran the analyses without these groups. The same pattern of results (i.e., more detailed recall for the nominal compared to the collaborative groups) emerged as in the analyses based on the entire sample.
6. We ran analyses excluding the participants taking 15 minutes or more ( $n = 25$  and  $n = 6$  in the collaborative and individual conditions, respectively) for the second recall phase to see whether the instruction affected the number of details reported. The same pattern of results emerged as in the analyses based on the entire sample.

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