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Production of false memories in collaborative memory tasks using the DRM paradigm

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Studies on collaborative memory have revealed an interesting phenomenon called collaborative inhibition (CI) (i.e., nominal groups recall more information than collaborative groups). However, the results of studies on false memories in collaborative memory tasks are controversial. This study aimed to understand the production of false memories in collaborative memory tasks by applying the *turn-taking* method to the DRM paradigm. Experiment 1 aimed to analyse the production of false memories in collaborative memory tasks by controlling for the backward associative strength (BAS) of the presented word lists. In Experiment 2, we intended to define the limits of the collaborative inhibition effect when the nominal recall task followed the *turn-taking* method. The results of both experiments revealed that, in addition to the existence of the collaborative inhibition effect, collaborative recall produced significantly fewer false memories than nominal recall. However, collaborative inhibition was not affected by the *turn-taking* method of retrieval.

Remembering events or general information with friends or relatives is a daily task. After decades of research on individual memory, it was only in the 1990s that several studies began to investigate the functioning of memory in groups, usually called collaborative memory (e.g., Barnier, Sutton, Harris, & Wilson, 2008; Basden, Basden, Bryner, & Thomas, 1997;

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Meade, Nokes, & Morrow, 2009; Rajaram & Pereira-Pasarin, 2010). Collaborative memory can be defined as the act of remembering within a group an event or information that has been experienced by all elements of this group (e.g., Meade et al., 2009; Meade & Roediger, 2009).

In the study of collaborative memory, the main objective is to understand if a group (i.e., collaborative group) retrieves more information than an individual alone and to evaluate the accuracy of that retrieval. In this sense, the performance of the collaborative group (i.e., two or more people recalling the same information together) is compared to the individual performance. The results of studies on collaborative memory revealed that collaborative groups recall significantly more information than an individual alone (e.g., Basden, Basden, Thomas, & Souphasith, 1998; Maki, Weigold, & Arellano, 2008; Weldon & Bellinger, 1997). There are two methods to recall information in groups: the turn-taking method or the free-for-all method. In the turn-taking method, participants are asked to recall the information in turns. That is, the participant usually has 10 s to recall one unit of information (e.g., word, event detail). Then, the turn to recall passes to another member of the group, who again has 10 s to recall another unit, and so forth. When a participant needs less than 10 s to recall one unit of information, the turn passes immediately to another group member. The task ends when, after three attempts, none of the participants recall any new information. Participants are also instructed not to repeat words that have already been recalled by themselves or another group member, and they are unable to talk to each other during the recall task. In the free-for-all method, a member of the group is responsible for writing down the retrieved information, and the group is free to choose the recall strategy. There is no time constraint or defined order in recalling the information. The task ends when the participants cannot remember more information. Studies have revealed that the recall method, i.e., turn-taking or free-for-all, has no effect on the amount of information correctly recalled (e.g., Thorley & Dewhurst, 2007).

However, it is not fair to compare the amount of recall of two or more persons with the recall of only one individual. In this sense, in collaborative memory studies, the performance of collaborative groups is compared with nominal groups. Nominal groups represent the sum of the information recalled individually by the same number of participants that constitute the collaborative group. In this sum, all redundant units of information are removed. This group represents the maximum potential recall of the elements of the group without the influence of collaboration. Studies have concluded that nominal groups remember significantly more information than collaborative groups (e.g., Andersson, 2001; Barber, Rajaram, & Aron,

2010; Choi, Blumen, Congleton, & Rajaram, 2014; Rajaram & Pereira-Pasarin, 2007; Ross, Spencer, Blatz, & Restorick, 2008; Weldon & Bellinger, 1997). This effect is called collaborative inhibition (e.g., Weldon & Bellinger, 1997). There are some explanations for the occurrence of the collaborative inhibition effect such as production blocking (Diehl & Stroebe, 1987) and social loafing (Latané, Williams, & Harkins, 1979). However, the most common explanation for the occurrence of this effect is the disruption of retrieval strategies hypothesis proposed by Basden and colleagues (1997). According to this hypothesis, each individual has his/her own organization and retrieval strategies, which can differ from other members of the group. At the time of recall, each individual uses these strategies to retrieve the encoded information. During collaborative recall, the retrieval strategies of the members of the group are different, i.e., do not follow the same retrieval organization. This difference makes the strategies of each participant less effective, resulting in decreased performance of the collaborative group, i.e., collaborative inhibition effect.

In addition to the collaborative inhibition effect, the production of false memories has also been a target of interest in some studies on collaborative memory. However, there are few studies on this topic, especially when we refer to studies applying the DRM paradigm (Deese, 1959; Roediger & McDermott, 1995) on this type of task (Basden et al., 1998; Maki et al., 2008; Takahashi, 2007; Thorley & Dewhurst, 2007; Weigold, Russel, & Natera, 2014). Despite the small number of studies, the results have been controversial and sometimes contradictory, and our goal is to contribute by shedding some light on the topic.

First, it is important to clarify what the DRM paradigm is and how it works. The DRM paradigm consists of the presentation of lists of words (e.g., butter, food, eat, sandwich) that are associated with non-studied critical lures (e.g., bread). Subsequently, participants complete a free recall and/or recognition test. Relative to recall tasks, the aim is to study the retrieval of non-studied critical lures or false recall. The typical findings are that false recall rates are relatively high and similar to hit rates (Roediger & McDermott, 1995). As mentioned, there are few studies on the production of false memories in collaborative memory tasks, and the results are controversial. The first study on this topic was carried out by Basden et al. (1998, Exp. 1). Their aim was to compare the performance of the nominal group with that of the collaborative group on a recall task (DRM lists) using the turn-taking method. The results replicated the collaborative inhibition effect. However, with respect to the production of false memories, the nominal and collaborative groups did not differ. The authors concluded that listening to the other group members recalling words that were previously

presented and associated with a critical non-presented word (i.e., critical lure) did not increase the production of false memories when compared with the production of false memories during the individual task (i.e., nominal group). In this study, adjusted ratio of clustering (ARC - Roenker, Thompson, & Brown, 1971) scores was analysed. The main goal of the ARC is to understand whether recall is clustered by the categories or lists presented. An ARC value close to 1 reveals that recall follows the organization by lists, whereas an ARC value of 0 indicates a random pattern of recall. Comparing collaborative and nominal recall, this value is considered an indirect measure of the degree of disruption of the retrieval strategies (Basden et al., 1998). The results revealed that the ARC score in the nominal group was higher than the collaborative group. This higher ARC score meant that the nominal group recalled the information list by list. However, the collaborative group did not follow such organization during recall.

In another study, Thorley and Dewhurst (2007) used both types of collaborative recall methods – free-for-all and turn-taking – with pairs, trios and quartets with the DRM paradigm. The results showed that the production of false memories increased with group size. However, the most interesting result was the fact that the collaborative group produced more false memories when the recall task followed a turn-taking method. Conversely, when the recall task involved a free-for-all method, false memories produced by the nominal group and the collaborative group were scarce. This result emphasized that some methods, such as the turn-taking method, induced a pressure to respond, leading to more errors or intrusions that are the basis of the production of false memories (Thorley & Dewhurst, 2007).

Finally, Maki et al. (2008) used ten DRM lists and the free-for-all method of recall. They replicated the collaborative inhibition effect for the presented words. With regard to false memories, the results revealed that the collaborative group produced significantly fewer false memories than the nominal group. Authors such as Pritchard and Keenan (2002) have argued that the low recall of false memories by the collaborative group occurs because during recall, participants can talk to each other and reach agreement about the words that are actually presented, more accurately rejecting words that were not presented (false memories). More recently, using a procedure similar to Maki et al. (2008), Weigold et al. (2014) obtained the same pattern of results regarding correct and false recall.

Given the mixed findings mentioned, this study aimed to contribute to the understanding of the production of false memories in collaborative

memory tasks using the DRM paradigm. The previously reported disparate results may have been due to characteristics of the DRM lists (e.g., associative strength between the words of the lists and the critical lures) or procedural specificities (e.g., method of recall).

There are two types of associative strength lists: forward associative strength (FAS) and backward associative strength (BAS). The FAS corresponds to the probability that the critical lure has to generate a word (e.g., bed and night (CL) has an FAS of .56). To create these lists, the critical lure is presented, and participants are asked to recall the first word that comes to mind. The words that are more frequently produced are considered to be most strongly associated with the critical lure presented. However, according to Deese (1959), the variable that most influences the production of false memories is the backward associative strength (BAS). The BAS corresponds to the probability that the critical lure has to be generated with the presentation of each word in the list. For this, the probability that each word in the list (e.g., rock) has of eliciting the recall of the critical lure (e.g., music) is calculated. Studies suggest that BAS is the best predictor of the production of false memories since lists with high BAS produce significantly more false memories than lists with low BAS (e.g., Deese, 1959; Roediger & McDermot, 1995; Roediger, Watson, McDermott, & Gallo, 2001). For this reason, in our study, the variable BAS was controlled.

Moreover, the differences in the results of studies on the production of false memories in collaborative memory tasks can also be due to the collaborative recall method. As previously mentioned, participants produce more false memories when the turn-taking method is used.

In this sense, our objectives were (1) to replicate the collaborative inhibition effect, (2) to understand the production of false memories in a collaborative recall task with the DRM paradigm controlling for BAS[1], and (3) to analyse the effect of the turn-taking method. In the present study, we decided to use the turn-taking method to clarify the contradictory results found by Basden et al. (1998) and Thorley and Dewhurst (2007) using this method. Moreover, both the free-for-all method and the turn-taking method have reliable evidence in collaborative memory studies (see Wright & Klumpp, 2004).

[1] Our goal was not to study the production of false memories in collaborative memory tasks using the DRM paradigm in relation to the BAS variable but to control this variable so that the results were not influenced by it.

This study thus contributed to a better understanding of the production of false memories in collaborative memory tasks.

EXPERIMENT 1

The purpose of Experiment 1 was to understand the production of false memories using the DRM paradigm (Roediger & McDermott, 1995) in a collaborative memory task applying the turn-taking method. To fulfil this objective, the nominal performance was compared with the collaborative performance considering both the recall of presented words and the production of false memories for critical lures. We expected to find (1) the collaborative inhibition effect using DRM lists and (2) increased production of false memories in nominal recall compared with collaborative recall. Since nominal recall allows participants to recall more presented words, this would also produce more activation of the critical lure during recall, leading to the production of more false memories.

METHOD

Participants. Eighty-six students from the University of Minho, 40 (46.5%) males and 46 (53.5%) females aged 18 to 45 years old (M = 21.55, SD = 4.46), volunteered for this experiment and received course credits to participate. Participants were divided into 43 pairs.

Stimuli and design. The stimuli were sixteen lists of Portuguese words selected from a normative study from Albuquerque (2005). Each list contained 10 words associated with one non-presented word (critical lure). The words in each list and their respective BAS are presented in Appendix 1. The sixteen lists were divided into two sets – set A (*music*, *blue*, *money, fish, animal*, *meat*, *cold,* and *sweet)* and set B (*music*, *cold, eyes, paper, water, candy, sky,* and *pain)*. The sets did not differ in terms of the total BAS – set A ($M = 2.93$) and B ($M = 3.51$), $Z = -.90$, $p = .33$.

A within-subjects design was applied to the recall test (nominal vs. collaborative). All participants recalled information individually (nominal recall) and collaboratively in a counterbalanced way. This design allowed us to compare the actual performance (collaborative recall) with the potential performance (nominal recall). However, Maki and colleagues (2008) used both a within-subjects design (Experiment 1) and between-subjects design (Experiment 2), and the results were identical. In this sense, and considering that Maki et al. (2008), found no significant differences

between the two subject designs, we chose to use a within-subject design in our study.

Procedure. The pairs of participants sat at separate tables, each facing a 17" monitor connected to a networked computer, such that the word presentations occurred simultaneously. The words were presented at the centre of the screen, and participants were instructed to pay attention because they would be asked to recall them later. The experiment was programmed in Superlab 4.5 (Cedrus Corporation, San Pedro, CA).

The presentation order of the lists (in each set) and recall test (nominal or collaborative) were counterbalanced across participants. When participants arrived at the laboratory, they were informed that they would be completing a memory task and needed to pay attention to the words presented because they would be asked to recall them later. No reference to the production of false memories was made. The participants were instructed on the *turn-taking* method and its rules.

Then, four lists from either set (A or B) were presented to the participants (two lists with high BAS and two lists with low BAS), one word at a time, for 2 s and an interval of 500 ms to separate each list (i.e., at the end of the presentation of 10 words). The lists of words were presented in descending order of BAS; that is, the first word in the list was strongly associated with the critical lure, and the last word had the lowest associative strength. After that, participants were asked to recall the words (nominal or collaborative) in 4 minutes. Then, participants were presented the remaining four lists of the set (A or B), followed by another recall task (nominal or collaborative in a counterbalanced design).

In the nominal recall task, participants had 4 minutes to freely recall all the words that they remembered. The words recalled by the two members of each pair were considered together, and redundant words were removed in order to form the nominal recall. In the collaborative recall task, participants were asked to recall as many words as they remembered with the turn-taking method. Each participant had 10 s to recall each word, and the repetition of words was not allowed. Once the participant recalled a word, the turn passed immediately to the other group member, even if the 10 s had not elapsed. When the participant was unable to recall a word within the 10 s, the turn passed to the other member. Words were written by the participant on a sheet of paper, and the recall procedure had a maximum duration of 4 minutes. The task ended after three consecutive attempts without any recall. This procedure was the same as that used by Basden et al. (1998) and Thorley and Dewhurst (2007).

At the end of the task, the researcher thanked and debriefed the participants. The approximate duration of the experiment was 25 minutes.

RESULTS

Data were analysed with IBM SPSS Statistics v22 (IBM Corporation, 2014). An alpha level of .05 was used for all inferential analyses. All variables were examined to verify the normality of the distribution as required by parametric tests. We analysed the number of words recalled based on the two recall conditions: nominal vs. collaborative. The performance of nominal recall consisted of the sum of the words (for correct recall) and critical lures (for false memories) recalled by the two members of each pair in the nominal recall test, excluding redundancies. For the calculation of the collaborative recall scores, we summed the recall of presented words (correct recall) and critical lures (false memories) by the two group members in the collaborative task, and all scores were transformed into proportions. The proportion of correct recall was calculated based on the total number of presented words (N = 80) and the number of critical lures (N = 8) for each set. Figure 1 shows the proportion of presented words and critical lures by nominal and collaborative recall.

An ANOVA for repeated measures 2 (recall test: nominal vs. collaborative) X 2 (type of word: presented words vs. critical lures) revealed two significant main effects: recall test, F (1, 42) = 277.35, $p < .001$, $\eta_p^2 = .87$; and type of word, F (1, 42) = 111.55, $p < .001$, $\eta_p^2 = .73$. The interaction between the recall test vs. type of word was also significant, F (1, 43) = 10.15, $p = .003$, $\eta_p^2 = .20$. Pairwise comparisons revealed that nominal recall ($M_{Nom} = .54$; $SD = .16$) was higher than collaborative recall ($M_{Col} = .20$; $SD = .09$). Considering the type of word, pairwise comparisons revealed that the presented words ($M_{PW} = .49$; $SD = .20$) were recalled more than the critical lures ($M_{CL} = .24$; $SD = .14$), a result reinforced by the significant effect of the interaction between the two variables under study; this is, in the nominal recall test, more presented words were recalled ($M_{NomPW} = .69$; $SD = .08$) than critical lures ($M_{NomCL} = .38$; $SD = .25$), and the same occurred for collaborative recall ($M_{ColPW} = .29$; $SD = .06$; $M_{ColCL} = .11$; $SD = .10$). Two t-tests for paired samples revealed that, for the presented words, nominal recall significantly outperformed ($M_{NomPW} = .69$; $SD = .08$) collaborative recall ($M_{ColPW} = .29$; $SD = .06$), t (42) = 29.64, $p < .001$, $d' = 4.52$, 95% CI [0.38, 0.43], and the same pattern was obtained for the critical lures, i.e., nominal recall produced significantly more false

memories (M_{NomCL} = .38; *SD* = .25) than collaborative recall (M_{ColCL} = .11; *SD* = .10), *t* (42) = 6.99, *p* < .001, *d* ' = 1.07, 95% CI [0.19, 0.35]. These results replicated the collaborative inhibition effect for the presented words and the production of false memories.

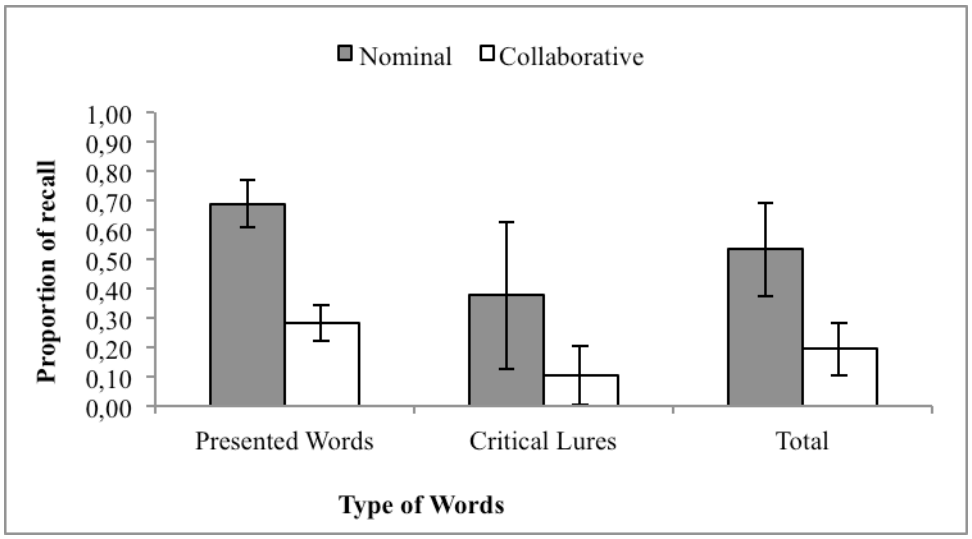

Figure 1: Proportion of nominal and collaborative recall of presented words and critical lures.

Finally, we calculated the adjusted ratio of clustering (ARC – Roenker et al., 1971) applying the algorithm proposed by Senkova and Otani (2012).

A t-test for paired samples revealed that there were significant differences between the values of ARC for nominal and collaborative recall, *t* (42) = 3.83, *p* < .001, *d*' = .58, 95% CI [0.08, 0.25]. Specifically, nominal recall was organized as a list more (M_{NomARC} = .52; *SD* = .16) than collaborative recall (M_{ColARC} = .35; *SD* = .29).

DISCUSSION

The main aims of this experiment were (1) to understand the production of false memories in collaborative memory tasks using the DRM paradigm and (2) to replicate the collaborative inhibition effect.

Regarding correct recall, the results replicated the collaborative inhibition effect. As shown in Figure 1, the performance of collaborative recall was worse than nominal recall. This finding has been reported in several collaborative memory studies (e.g., Barber et al., 2010; Basden et al., 1997).

Concerning the production of false memories for the critical lure, the data revealed that nominal recall produced more false memories than collaborative recall, a result that was contrary to the findings of Basden et al. (1998) and Thorley and Dewhurst (2007). These contradictory findings may be due to different methodological aspects: within-subjects design vs. between-subjects design; size of collaborative groups; number of words per list (15 vs. 10); or BAS, among others. Concerning BAS, we should point out that we do not have enough information from other studies to allow a direct comparison between studies.

Based on our results concerning the production of false memories, we believe that the critical lure was activated differently in the two recall tests (nominal and collaborative). This difference occurred during the retrieval process since the encoding process was similar (i.e., individual) for both recall tests. This argument is addressed in the general discussion.

To explain the pattern of results found for both the recall of presented words and the production of false memories, we focused our attention on the ARC scores. By calculating the ARC, we hypothesized that the collaborative inhibition effect would be due to the disruption of retrieval strategies, as the ARC value was higher for nominal recall than collaborative recall. Considering this result, nominal recall followed a more organized retrieval based on the content of the DRM lists, whereas in collaborative recall, participants switched between lists during recall. Importantly, the present data replicated the results by Basden et al. (1998) on ARC values for presented words. Still, this clustering recall could have produced greater activation of the critical lure at the moment of recall (because more words from the same list were recalled), increasing the production of false memories.

One of the criticisms that can be made about this type of study is that recalling information through the turn-taking method is not the most common form of retrieval in groups. When we are with a group of friends, we do not take turns to remember an event that we have experienced together; that is, we do not have to wait for our turn to recall information. Therefore, it is important to understand if the time that each individual must wait to recall the next word, as in the turn-taking method, affects group performance and induces the collaborative inhibition effect. Considering

this, in Experiment 2, we aimed to understand if the use of two different memory tasks (free recall for nominal recall and turn-taking for collaborative recall, as used in Experiment 1) affected the collaborative inhibition effect. To this end, in this experiment, both types of recall (nominal and collaborative) were performed using the turn-taking method.

EXPERIMENT 2

This experiment aimed to determine whether the time that participants have to wait to recall each word in the turn-taking method has some influence on the collaborative inhibition effect, i.e., whether there are retrieval benefits for the nominal group due to the use of a free recall task, while collaborative recall is diminished by the turn-taking method. In Experiment 2, we wanted to verify whether using the turn-taking method during the performance of nominal retrieval would influence the collaborative inhibition effect similar to the effect of collaborative recall.

Moreover, we intended to replicate the results of the previous experiment concerning the production of false memories, and regarding the collaborative inhibition effect, we expected that the use of the turn-taking method would decrease the number of words recalled in nominal recall. However, this difference would not have been sufficient to eliminate the collaborative inhibition effect. Therefore, we hypothesized that, despite the fact that the amount of recalled information could suffer some losses due to the turn-taking method, it would not be sufficient to eliminate the collaborative inhibition effect since there is an interruption of the retrieval strategies during collaborative recall that accentuates the differences between the two recall tests.

METHOD

Participants. Seventy-two students from the University of Minho, 6 (8.3%) males and 66 (91.7%) females aged between 17 and 35 years old (M = 19.35, SD = 2.75), volunteered to participate in the study and received course credit for their participation. Participants were randomly divided into 36 pairs and tested on individual memory tasks (to create a nominal group) and collaborative memory tasks.

Stimuli and design. The same stimuli and design were used as in Experiment 1.

Procedure. The procedure was similar to Experiment 1 for the collaborative memory task. For the nominal recall task, participants were asked to recall as many words as possible, and each participant had his/her own sheet of paper to write down the words. However, the participants were instructed to write a word solely on his/her turn, similar to what occurred in the collaborative memory task. Thus, each participant had 10 s to write a word before passing the turn to another member of the collaborative group for recall. This procedure was strictly controlled by the experimenter. The rules that were applied to this recall were the same as those applied to collaborative recall, as described in the procedure of Experiment 1. At the end of the task, the researcher thanked and debriefed the participants. The approximate duration of the experiment was 25 minutes.

RESULTS

An ANOVA for repeated measures 2 (recall test: nominal vs. collaborative) X 2 (type of word: presented words vs. critical lures) revealed two significant main effects: recall test, F (1, 35) = 16.76, $p < .001$, $\eta_p^2 = .32$, and type of word, F (1, 35) = 102.03, $p < .001$, $\eta_p^2 = .75$. The interaction effect of the recall test vs. type of word was not significant, F (1, 35) = 2.02, $p = .16$, $\eta_p^2 = .06$.

Pairwise comparisons revealed that nominal recall ($M_{Nom} = .26$; $SD = .06$) was associated with more words retrieved than collaborative recall ($M_{Col} = .21$; $SD = .08$). Considering the type of word, pairwise comparisons revealed that the presented words ($M_{PW} = .31$; $SD = .02$) were more recalled than the critical lures ($M_{CL} = .17$; $SD = .03$). Two t-tests for paired samples revealed that, for the presented words, nominal recall was significantly higher ($M_{NomPW} = .33$; $SD = .04$) than collaborative recall ($M_{ColPW} = .30$; $SD = .05$), t (35) = 3.55, $p = .001$, $d' = .59$, 95% CI [0.01, 0.05]. As in Experiment 1, we found that nominal recall produced more false memories for the critical lures ($M_{NomCL} = .20$; $SD = .11$) than collaborative recall ($M_{ColCL} = .13$; $SD = .09$), t (35) = 2.96, $p = .006$, $d' = .49$, 95% CI [0.02, 0.11]. These results replicate the collaborative inhibition effect for the presented words and the production of false memories for critical lures, similar to the results of Experiment 1. Figure 2 shows the proportion of presented words and critical lures by nominal and collaborative recall.

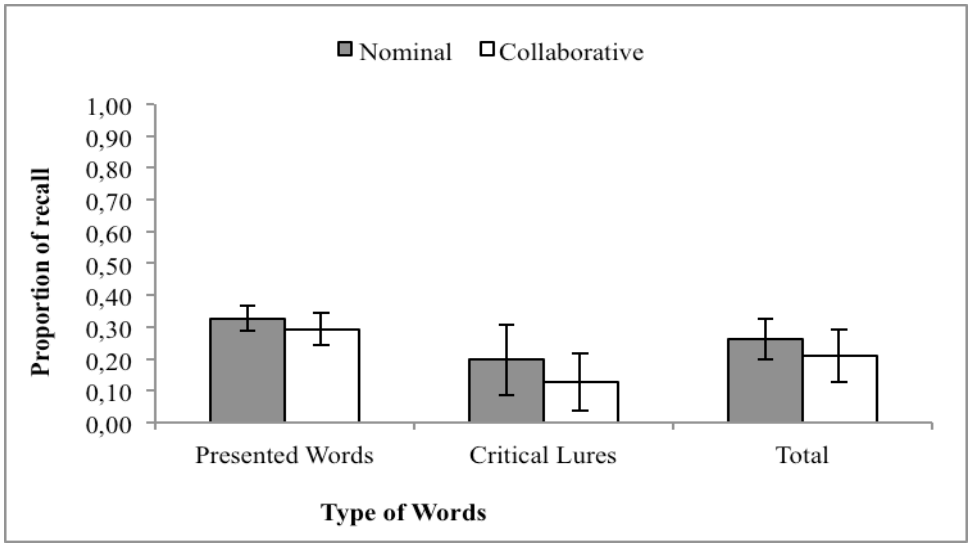

Figure 2: Proportion of nominal and collaborative recall of presented words and critical lures.

To understand how the turn-taking method affected the amount of information recalled, we compared the performance of nominal recall in Experiment 1 (i.e., free recall) with the performance of nominal recall in Experiment 2 (i.e., turn-taking method). An ANOVA for repeated measures 2 (type of word: presented vs. critical lures) X 2 (experiment: 1 vs. 2) revealed a main effect of the type of word, F (1, 35) = 83,89, p < .001, η_p^2 = .71, and a main effect of the experiment, F (1,35) = 120,35, p < .001, η_p^2 = .78. The interaction effect of type of word vs. experiment also proved to be significant, F (1,35) = 11.93, p = .001, η_p^2 = .25. Pairwise comparisons revealed that significantly more presented words were recalled in Experiment 1 (M_{Exp1PW} = .69; SD = .08) than in Experiment 2 (M_{Exp2PW} = .33; SD = .04). The same pattern of results was found for the production of false memories for critical items (M_{Exp1CL} = .38; SD = .25; M_{Exp2CL} = .20; SD = .11).

Finally, similar to Experiment 1, we calculated the ARC scores and applied them to a t-test for paired samples, which revealed a statistically significant difference between nominal recall (M_{NomARC} = .46; SD = .29) and collaborative recall (M_{ColARC} = .27; SD = .19), t (35) = 3.36, p = .002, d' = .56, 95% CI [0.07, 0.30].

DISCUSSION

The main objective of Experiment 2 was to understand if the turn-taking method was responsible for the decreased performance in collaborative recall. To study this, we decided to apply the turn-taking method to nominal recall. In doing so, we attempted to make the two recall tasks as similar as possible.

The results showed that the recall of presented words in nominal recall was higher than in collaborative recall. Even when both groups were using the turn-taking method, the collaborative inhibition effect persisted. Experiment 2 also reveals that, despite the decreased number of presented words recalled in the performance of nominal recall, it was not enough to eliminate the collaborative inhibition effect. That is, the amount of information recalled was affected by the method of recall; however, when the retrieval method was equal for both tasks, the collaborative inhibition effect was not eliminated, so this effect was not explained by the method of recall. As was demonstrated by the ARC score analysis, nominal recall was more organized by list, while collaborative recall was characterized by more switching between lists (i.e., there seemed to be a greater disruption of organized retrieval strategies of information in collaborative recall tasks than in nominal recall). These results replicated the findings of Experiment 1, and the results by Basden et al. (1998) supported the hypothesis that retrieval disruption explained the collaborative inhibition effect. Thus, as concluded by Wright and Klumpp (2004), the collaborative inhibition effect was the product of recall tasks (seeing/hearing information recalled by other group members causes a disruption of retrieval strategies) and was not due to the recall process (e.g., recall method, motivational factors).

Concerning the production of false memories for critical lures, we replicated the results of Experiment 1, namely, that the nominal group produced significantly more false memories than the collaborative group.

GENERAL DISCUSSION

The main goal of this study was to understand the production of false memories in collaborative memory tasks using the DRM paradigm. The studies in this field have produced contradictory results, as previously mentioned. Our results revealed that collaborative recall produces significantly fewer false memories for critical lures than nominal recall. These results are similar to those by Weigold et al. (2014) and Maki et al. (2008). In these studies, the authors explained the lower production of false memories in the collaborative group by the fact that they used the free-for-

all method, which allowed more monitoring of errors (because the group could talk with each other and reach a consensus), decreasing the proportion of false memories. However, in our study, group members could not talk with each other (turn-taking method), so the explanation proposed by these authors did not apply to our results.

However, our results diverged from the results by Basden et al. (1998), who found no differences between the two groups, and were contrary to the findings of Thorley and Dewhurst (2007), which revealed that the collaborative group produced more false memories than the nominal group when the turn-taking method was used. Thorley and Dewhurst (2007) explained their results with the increasing pressure that group members feel to contribute to the recall; that is, as they attempt to generate more presented words, they produce more false memories.

Our results are supported by the theory of activation/monitoring (Roediger, Balota, & Watson, 2001). According to this theory, the production of false memories occurs because of two processes: activation of the critical lure (during encoding and/or retrieval) and failure to monitor the source of the critical lure (during the retrieval) (Gallo & Roediger, 2002). During the presentation of words, a semantic network is activated that spreads the activation also to the critical lure. In our study, this activation occurred both in nominal and collaborative recall because the encoding of words is always individual. During the retrieval phase, the participant should be able to monitor what words are presented and what words are not presented, but sometimes this monitoring process fails, and the individual is not able to reject the critical lures producing false memories.

It was through this process that nominal recall and collaborative recall differed. As shown in the ARC score analysis, in nominal recall, there was a greater tendency to organize the recall list by list. When an individual consecutively recalled a large number of words from the same list, the respective critical lure was more activated, which increased the production of false memories. The opposite occurred in collaborative recall since there was a greater tendency to switch between the lists during the recall phase, which resulted in a lower activation of the critical lure and therefore less recall of the critical lure.

Notwithstanding activation/monitoring framework is the theory that best fits our data, however another theory that is often used to explain the results of studies with DRM paradigm is the fuzzy-trace theory (Reyna & Brainerd, 1995). According to this theory, two types of traces are extracted when participants are involved in a recall or recognition memory task: *verbatim* traces (i.e., perceptual characteristics of the words) and *gist traces*

(i.e., the theme of the lists). The recall of the words presented is generally due to the retrieval of *verbatim* traces, while the production of false memories is mainly due to the retrieval of the *gist*. As stated before, in the collaborative task there is a disruption of individual retrieval strategies. This leads to a decreasing on *verbatim* traces retrieval and consequently to a decrease of presented words recalled. Regarding the false memories, in the collaborative task less critical lures are recalled because the *gist* trace is also weakened by the disruption of individual retrieval strategies. Since during the collaborative task, the participants alternate their recall between lists (ARC) this weakens the *gist* trace and decreases the recall of the critical lures.

Another goal of this study was to replicate the collaborative inhibition effect. In both experiments, we found the same pattern of results considering the presented words: collaborative recall was significantly lower than nominal recall, a result that influenced the collaborative inhibition effect.

The most common explanation for the collaborative inhibition effect is the disruption of the retrieval strategies hypothesis (Basden et al., 1997). Basden et al. (1997) argue that when an individual encodes information, this process follows his/her personal organization. This organization functions as a cue when the individual attempts to retrieve the information. However, when recall involves a collaborative memory task, this individual organization is disturbed, interrupted, and broken by the emergence of the individual strategies of other members of the group (Basden et al., 1997; Barber et al., 2010).

According to Basden et al. (1997), one way to analyse the organization of recall is by calculating the ARC. An ARC value closer to 1 indicates a clustered (by list) recall. In our study, in both experiments, the ARC value was closer to 1 for nominal recall than collaborative recall. This result suggested that nominal recall was organized list by list more than collaborative recall and consequently supported the disruption of retrieval strategies hypothesis as an explanation for the effect of collaborative inhibition.

In Experiment 2, our main goal was to understand the influence of the method of recall (turn-taking) on the amount of information recalled as well as their impact on the collaborative inhibition effect. Therefore, we adopted the turn-taking method both for nominal and for collaborative recall. The results revealed that although nominal recall decreased significantly compared with Experiment 1, the collaborative inhibition effect persisted. Experiment 2 revealed that the turn-taking method significantly influenced

the amount of information recalled by decreasing it without compromising the presence of the collaborative inhibition effect. Although the number of words recalled in the nominal task was significantly lower, the performance did not reach the lower level of recall observed in the collaborative task. That is, it was not the method of recall that explained the collaborative inhibition effect, although it was negatively reflected in the number of words recalled. Thus, the disruption of the retrieval strategies hypothesis seemed to be the best explanation for this effect.

To confirm this hypothesis, we focused again on the ARC values in Experiment 2. The results showed that nominal recall continued to follow an organization by list, contrary to what occurred in collaborative recall.

To conclude, the results of the present study provided a better understanding of the functioning of collaborative memory, especially considering the production of false memories. We therefore conclude that even though nominal recall is greater for presented words, this type of recall is associated with a higher production of false memories.

RESUMEN

La producción de falsos recuerdos en tareas de memoria de colaboración utilizando el paradigma DRM. Los estudios sobre el recuerdo en grupo revelaron un fenómeno interesante llamado inhibición de colaboración, i.e., mayor recuerdo en un grupo nominal que en un grupo de colaboración. Sin embargo, en cuanto a los estudios sobre los recuerdos falsos en tareas de memoria de colaboración se refiere, los resultados han sido objeto de controversia. La finalidad de este estudio era comprender la producción de memorias falsas en tareas de memoria colaborativa, empleándose para ello el método de la alternancia de turnos en el paradigma DRM. En el Experimento 1 estudiamos la influencia de la fuerza asociativa inversa en la producción de falsos recuerdos en contexto de colaboración. El Experimento 2 intentó definir los límites de la inhibición de colaboración cuando la tarea de recuerdo nominal es del tipo alternancia de turnos. Los resultados de ambos experimentos revelaron que, además de la existencia de inhibición de colaboración, el recuerdo en colaboración ha producido significativamente menos falsos recuerdos que el recuerdo nominal. Además, no se observaron efectos del método alternancia de turnos en la eliminación de inhibición de colaboración.

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APPENDICES

Appendix 1– word lists used in Experiment 1, with the total BAS[2] in Portuguese and in English

Música: clássica; guitarra; som; melodia; dança; rádio; ouvir; cantar; caixa.

Music: classical,; guitar; sound; melody; dance; song; radio; listen; sing; box.

Total BAS: 4.58

Doce: açucar; algodão; amargo; chocolate; guloso; mel; rebuçado; saboroso; salgado; sobremesa.

Sweet: sugar; cotton; bitter; chocolate; greedy; honey; candy; tasty; salty; dessert.

Total BAS: 4.52

Frio: agasalho; arrepio; cachecol; casaco; gelado; gelo; inverno; janeiro; quente; tremer.

Cold: sweater; chill; scarf; coat; icy; ice; winter; January; hot; tremble.

Total BAS: 4.50

Peixe: aquário; rio; pescar; espinha; escamas; lago; pesca; salmão; sardinha; signo.

Fish: aquarium; river; fishery; spine; scales; lake; catch; salmon; sardine; sign.

Total BAS: 3.34

Dinheiro: banco; escudo; euro; indispensável; jóias; ladrão; notas; pobreza; roubar; trabalho.

Money: bank; escudo[3]; euro; scarlet; jewelry; thief; bills; poverty; steal; work.

Total BAS: 1.73

Carne: almoço; assado; bife; nervos; encarnado; frango; osso; nojo; fome; talho.

Meat: lunch; roast; steak; nerves; red; chicken; bone; shucks; hunger; gash.

Total BAS: 1.67

Azul: amarelo; caneta; céu; cor; olho; mar; nuvens; oceano; polícia; vermelho.

Blue: yellow; pen; sky; colorcolour; eye; sea; clouds; ocean; police; red.

Total BAS: 1.61

Animal: bicho; cão; feroz; gato; leão; lesma; porco; rugir; tartaruga; vaca.

Animal: bug; dog; fierce; cat; lion; slug; pig; roar; turtle; cow.

Total BAS: 1.49

[2] Total BAS is calculated by adding the BAS for each of the words that make up a list.

[3] Portuguese currency before the euro.

Appendix 2 – word lists used in Experiment 2, with the total BAS, in Portuguese and in English

Música: clássica; guitarra; som; melodia; banda; concerto; rádio; ouvir; cantar; rock.

Music: classical; guitar; sound; melody; band; concert; radio; listen; sing; rock.

Total BAS: 5.44

Água: sede; beber; líquido; balde; copo; cristalina; límpida; bebida; gotas; rio.

Water: thirst; drink; liquid; bucket; glass; crystalline; clear; beverage; drops; river.

Total BAS: 4.89

Céu: estrelas; nuvens; azul; anjo; éden; cinzento; voar; inatingível; claro; andorinha.

Sky: stars; clouds; blue; angel; eden; gray; fly; unachievable; clear; swallow.

Total BAS: 2.16

Olhos: pestanas; visão; lentes; myopia; vista; íris; óculos; cara; fechados.

Eyes: eyelashes; vision; lenses; myopia; look; iris; glasses; face; closed.

Total BAS: 2.13

Dor: vital; sangue; morte; viver; vivo; saudável; meu; coração; sofrimento; oxigénio

Pain: vital; blood; death; live; alive; healthy; my; heart; suffering; oxygen.

Total BAS: 2.23

Doce: açucar; algodão; amargo; chocolate; guloso; mel; salgado; sobremesa; saboroso; bolo.

Sweet: sugar; cotton; bitter; chocolate; greedy; honey; salty; dessert; ;; tasty; cake.

Total BAS: 4.52

Papel: higiénico; reciclado; folha; reciclagem; papelão; lápis; caneta; desenho; saco; rebuçado.

Paper: toilet; recycled; sheet; recycling; paperboard; pencil; pen; drawing; bag; candy.

Total BAS: 2.19

Frio: agasalho; arrepio; cachecol; casaco; gelado; gelo; inverno; janeiro; quente; tremer.

Cold: sweater; chill; scarf; coat; icy; ice; winter; January; hot; tremble.

Total BAS: 4.50

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