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Creating false memories in children using French word lists

Pierre MARTIN^{1,2*}, Mario SPERANZA³, Fabienne COLOMBEL¹.

1: Nantes Université, Laboratoire de Psychologie des Pays de la Loire (LPPL - EA 4638), F-44000 Nantes, France

2 : Centre de rééducation fonctionnelle ESEAN-APF

3: Centre de Recherche en Épidémiologie et en Santé des Populations, INSERM U1018, Université de Paris-Saclay, Université de Versailles St Quentin, Paris, France. Service Universitaire de Psychiatrie de l'Enfant et de l'Adolescent, Versailles Hospital Center

*Correspondance:

Pierre MARTIN

Bureau 125, UFR de Psychologie

Université de Nantes, Campus du Tertre

C, Nouveau Tertre, Bâtiment Central,

Chemin de la Censive du Tertre

44300 Nantes.

Pierre.martin@univ-nantes.fr

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Abstract

The sensitivity of children to the production of false memories from a DRM paradigm appears to be low. Activation Association Theory suggests that the associative network plays a central role in the production of DRM false memories. However, relatively few studies have created child-specific lists.

One hundred and thirteen children with an average age of 9 years and 7 months were solicited to create DRM lists via a lexical association task. These lists were then tested on a sample of 42 children with an average age of 9 years and 6 months.

Depending on the lists used, the children produced a proportion of false memories ranging from .04 to .46. The use of lists specifically created by and for children seems to favor the emergence of false memories. The results are consistent with activation explanatory theories of DRM false memories. However, confidence in their response is higher for correct answers than for errors.

Keywords: *Memory, False Memories, Children, Association, Activation.*

Public Significance Statements: We can create false memories, i.e. the memory of an event that never happened, in participants using word lists constructed in such a way that all the words in the list converge towards the same associated concept. To do so, these lists need to be designed specifically for the population in which we want to create these false memories. This study presents the creation of lists for children aged 8 to 10.

A false memory (FM) is defined by Roediger and McDermott (1995) as mnemonic distortion, a memory error or even the creation of a memory of a non-existent event with the conviction that it really existed. Sensitivity to FM can be evaluated experimentally using the DRM paradigm (i.e., Deese-Roediger-McDermott paradigm) (Deese, 1959; Roediger & McDermott, 1995). In this task, participants are asked to learn a list of words all belonging to the lexical field of a concept not included in the list. The lists are generally created following a lexical association task which allows, from a target word, to identify the most frequent associations within a given population. Recall or recognition of the target word (i.e., the critical lure) then evokes the emergence of a FM. According to Roediger and McDermott (1995), critical lure recall rate is near to .40 and good answer recall rate is near to .65. The critical lure is also recognized with a high rate of confidence. This paradigm is simple to implement and the conclusions it allows are robust (Gallo, 2010; Otgaar et al., 2013).

Association Activation Theory (Howe et al., 2009) is one of the theories that explains the appearance of false memories. According to this theory, our knowledge is organized in a network. Each concept is linked to the others by semantic, temporal, experiential and personal links. For example, if a person tends to eat a sandwich on a bench each Sunday, it is possible that the concepts of *sandwich*, *Sunday* and *bench* are linked in their associative network. When a list of words is learned, the activation of concepts in semantic memory is propagated to adjacent concepts. In this way, certain words not present in the list could be activated. Secondly, a source control error during the retrieval of information could lead to the production of words that do not belong to the initial list but towards which the activations would have converged. These words could include the critical lure, which refers to the general theme of the list in DRM paradigms.

Children seem to be less sensitive to DRM effects than adults. Several studies have shown that children do not activate the critical lure as well as adults (Brainerd et al., 2011; Calado et al., 2019). For example, in their study, Brainerd et al. (2002) showed that the critical lure appearance rate varied between .04 and .09 for children aged from five to seven. According to Dewhurst et al. (2007) and Roediger et al. (2001), children's weaker lexical networks do not allow high activation of the critical lure. Furthermore, Brainerd and Reyna (1996) and Otgaar et al. (2013) postulate that children are not always able to access the general theme of the list, thus hindering the appearance of the critical lure. According to Howe et al. (2009), children are, on the contrary, perfectly able to access the global meaning of a list of words. However, this activation is less automatic than in adults (Howe, 2000). Moreover, the associative network seems to be specific to each individual and each age group. The material usually used in adults may not activate the same concepts in children.

Few studies conducted in children used child-specific DRM materials, opting rather for DRM lists composed by and for adults (Brainerd et al., 2011). We can legitimately question the similarity of child and adult lexical and associative networks (Howe et al., 2009). Several developmental elements suggest that the lexicon is not organized in the same way in children as in adults (Bjorklund, 1987). Consequently, children do not categorize in the same way as adults (Frutos & Berger, 2001). There is no evidence that a DRM list created for adults activates the critical lure in the same way in children. Some studies (Carneiro et al., 2007; Ghetti et al., 2002; Metzger et al., 2008; Rousselle et al., 2023) show that children can produce FMs in this task if the conditions are adapted to this population. Metzger et al. (2008) showed that ten-year-old children had a critical lure appearance rate of .04 with long word lists, but of .16 with short children-specific word lists, during a recall task. The lists were

created using a lexical association task. However, no study has conducted a prior lexical association task, critical lure based, with French children to construct lists that are most representative of these children's associative network. Rousselle et al. (2023) asked French children to list four concepts associated with a given theme to form short lists. However, they did not use the critical lure of the lists to build them. Moreover, the lists constructed are short and are intended to be used in working memory tasks.

The main objective of the present study was to create a specific series of DRM word lists in French, adapted to children. This study presents both the creation phase of the lists and their application, in order to select those most likely to produce the critical lure in children aged eight to ten years. This age range was selected because according to Dewhurst and Robinson (2004), it is from this period onwards that the child begins to be sensitive to the DRM effect. Each part of this study was validated by an ethics committee (study reference number 05012022-1). The study was not preregistered but all study data and materials are available from the authors.

Experiment 1: creation of the DRM word lists

Method

Participants

One hundred and thirteen children were recruited for this part of the study, aged from 8 years to 10 years and 11 months. The mean age was 9 years and 7 months, or 114.93 months (± 10.34). There were 65 boys and 48 girls, with no significant difference between the number of boys and girls, $\chi^2 = 2.558$, $df = 1$, $p = .110$, $\phi^2 = .014$. The participants were recruited in leisure centers and in French state schools with the agreement of the regional educational

authorities. Each participant had a sufficient mastery of French language, as confirmed by teachers.

Materials

To create age-appropriate word lists, we proposed a lexical association task to the children. First, we selected the critical lures from Corson and Verrier's study (2007), which indexes 36 DRM lists in French. We began by checking each critical lure to ascertain if it could be considered part of a child's lexicon. We selected the 15 critical lures which occurred the most frequently in school textbooks for eight to ten-year-olds, using *Manulex*, a tool created by Lété et al. (2004), which lists the appearance rate of each word in school textbooks for each school grade. The most frequently selected critical lure is "Water" (*Eau* in French), which presents a frequency index of 69.73, and the least frequently selected critical lure is "Coffee" (*Café* in French), which presents a frequency index of 60.37. The mean frequency index of the 15 selected critical lures is 64.40 (± 2.83). Then, we created the lexical association task. Each critical lure was presented on a sheet of paper with the following instruction: *what does the word "... " make you think of?* The participant could list as many words as they wanted. The only instruction was not to formulate a sentence but to give only words.

Procedure

Participants were welcomed in groups of six to ten in a room provided by the school or the leisure center. No time limit was imposed. Children took an average of 30 minutes to complete the task. Before children wrote their answers on the page, the instructions were read out loud for the whole group. They were authorized to raise their hand if they encountered difficulties in understanding the instructions or writing down their own answers correctly. The experimenter ensured that none of the participants tried to copy their classmates.

Results

Four thousand four hundred and fourteen words were produced by the participants, with an average of 294.27 words (± 48.65) per critical lure. We decided to keep as close as possible to the associations produced by the participants. All the words suggested by the children, whether the associations were semantic or phonological or other, were accepted, with the objective of guaranteeing a non-unique lexical association strength. The only modification we made was to transpose the conjugated verbs into the infinitive form. For each critical lure, we listed the suggestions and their occurrences, i.e. the number of participants who had written that word on their answer page. To form the lists, we chose to keep only the nine most frequent proposals for each critical lure, considering the conclusions of Metzger et al. (2008) on the size of lists. The lists are available as supplemental material (URL). For each critical lure, the nine most frequent proposals, with, in parentheses, the forward associative strength (FAS) of each word, i.e. the number of children who produced the word over the total number of participants, are presented. We also calculated the ratio of the number of proposals to the number of occurrences for each list as a measure of internal consistency (Metzger et al., 2008). The higher the ratio, the less homogeneous the list. For example, for the critical lure “Sea”, the number of answers for the total group was 415, but there were 111 different words, so the internal consistency is .27.

As for adults, the lists are constructed in order of decreasing frequency. The first word on the list is the most frequently mentioned by children during the lexical association task. A qualitative comparison between these lists and those used in the Corson and Verrier (2007) study shows that there are few similarities. The common words between the lists vary from one (for the lists “Sea” and “Car”) to seven (for the lists “Door” and “Silver”). There are an

average of 4.27 words (± 1.75) in common between the adult and children lists. Qualitatively, we also note that the words are very rarely positioned in the same order in the list.

Experiment 2: Selection of the DRM word lists most likely to produce the critical lure.

Once the lists were created, we tested them with a sample of children to see if they were able to produce FM. Due to the activation strength, which is supposed to be higher in respect of children's associative networks, and the children's source monitoring capabilities, which are still low given their age (Yim et al., 2022), we hypothesized that the risk of the critical lure occurring should be high. To check that children have access to the overall meaning of the list, we compared the proportion of critical lure appearances with other types of errors. In addition, Metzger et al. (2008) raised the possibility that the more homogeneous the list, the higher the risk of producing false memories. Moreover, according to Brainerd and Wright (2005), we hypothesized that the higher the mean FAS, the higher the critical lure appearance would be. Our aim was to identify the lists that allowed the most critical lures to appear. Finally, we also compared confidence in their responses to check if there was a difference between their correct responses and the critical lures.

Method

Participants

Recruitment for this part of the study was carried out in French state schools with the agreement of the regional educational authorities. Participants were between 8 and 10 years and 11 months old. They had no sensory disorders or neurological history. They had sufficient mastery of French. Forty-two children were recruited for this study. There were 27 boys and 15 girls, with no significant difference between the number of each, $\chi^2 = 3.429$, $df = 1$, $p =$

.064, $\phi^2 = .044$. The mean age of the participants was 9 years and 6 months, or 113.76 months (± 10.17).

Materials

Each list was previously recorded to guarantee the standardization of the procedure. The words were presented aurally one by one, beginning with the most frequent and ending with the least frequent, with a time interval of two seconds between each of them and with a neutral tone of voice. We also created a five-point confidence scale as suggested by Ghetti et al. (2002). This scale is available as a supplemental material (URL).

Procedure

Each of the 42 children was interviewed individually in a neutral room provided by the participating schools. They were told that they would hear lists of words that they would have to memorize. After listening to each list, they were asked to say as many words as they could remember. Then each child's response was repeated one by one so that they could assess their confidence in their response and confirm it. Once the self-assessment was completed, the next list was presented. Three groups of five DRM lists were created (Group 1, Group 2 and Group 3). The groups were constituted in such way that they did not enable to be confronted with word repetitions within the critical lures or the words of other lists. Indeed, some of the lists included words which were the critical lures of other lists. Each child was given two groups of five DRM lists. The order in which the lists were presented was the same for all participants. However, the groups and the order of presentation of the groups of lists were counterbalanced. In total, six experimental conditions were created: (1) Group 1 then Group 2, (2) Group 1 then Group 3, (3) Group 2 then Group 1, (4) Group 3 then Group 1, (5) Group 2 then Group 3, (6) Group 3 then Group 2. Thus, each group of lists was equally learned in

the first and second condition. In total, each word list was tested with 28 children. Between the two groups of lists, a break of five to ten minutes was systematically proposed.

Results

For each list we calculated the proportion of correct responses by dividing the number of correct responses by the number of words in the list. We then calculated the proportion of production of the critical lures for each list (i.e. every time a child recalls the word *cat* for the list *cat*, for example), by dividing the number of appearances of each critical lure by the number of children who heard the associated word list. Finally, we calculated the proportion of errors, while distinguishing between intrusions that were semantically related to the list which had been heard and those that were not. We then added up each type of error and divided it by the number of participants. The data are shown as supplemental material and a graph showing the proportions of correct answers and critical lures per list (URL). We added to this table the internal consistency indices, relative to the homogeneity of the lists, and the mean FAS of each list.

The proportion of production of critical lures is variable according to the lists used, between 0.04 for the list “Kitchen” and 0.46 for the list “Tree”. There was no effect of gender on the production of correct responses, $t(40) = 0.799$, $p = .429$, $d = 0.257$, nor on the production of critical lures, $t(40) = 0.210$, $p = .834$, $d = 0.068$. Furthermore, we performed an ANOVA analysis to see if the experimental condition assigned to the child influenced the production of responses. This was not the case for either the production of correct responses, $F(5-36) = 1.713$, $p = .157$, $\eta^2 = 0.192$, or for critical lures, $F(5-36) = 1.075$, $p = .391$, $\eta^2 = 0.130$.

Correlation tests were performed and no significant correlations were found between critical lures and internal consistency, $r = -0.389$, $p = .152$, and mean FAS, $r = 0.137$, $p = .627$, nor

than between correct answers and internal consistency, $r = -0.133$, $p = .635$, and mean FAS, $r = 0.315$, $p = .253$.

To complete our statistical analyses, we also tested whether there were significant differences between the proportions of critical lure occurrences and intrusions. We assumed that the proportion of critical lures would be higher than the proportion of other errors. We used the non-parametric Wilcoxon test for paired measures, due to the abnormal distribution of errors. It shows that children produce equal proportion of critical lure and intrusion semantically related, $z = 1.278$, $p = .106$, $r_{pb} = .375$, but they produce more critical lure, $z = 2.667$, $p = .004$, $r_{pb} = .872$ and more intrusion semantically related, $z = 1.817$, $p = .037$, $r_{pb} = .533$ than intrusion not semantically related.

Finally, we treated participants' confidence rates in their responses (from one to five) for both correct responses and critical lures. This data is not normally distributed. Children seem to have more confidence in their correct answers ($4,56 \pm 0,147$) than in the critical lures ($3,93 \pm 0,676$). A Wilcoxon test shows that the children are significantly more confident in their correct answers than in the critical lures, $z = 2.783$, $p = .002$, $r_{pb} = .817$.

General Discussion

In this study, we were first able to create child-adapted DRM lists based on an association task proposed to a population of children aged between eight and ten years. Interestingly, from the same inducing word, the lists created differ to a certain extent from those created from a lexical association task in adults. These findings support the hypothesis that children's associative networks differ from those of adults. Furthermore, this result reinforces the idea that the use of material adapted to children's associative networks is a necessary condition for

studying FM in children (Carneiro et al., 2007; Howe et al., 2009; Metzger et al., 2008). The creation of DRM lists must therefore also take language and culture into account. It is possible that a simple translation of the lists created in these studies will not work with children from another culture, due to associative networks that may differ from one culture to another.

In the second experiment, we tested the created lists with a group of 42 children. Results showed high variability in critical lure productions. Brainerd et al. (2006) showed that this difference in sensitivity according to the list used was not observable in children, unlike in adults, because of their difficulty to access the general theme of the list. Our results seem to contradict the idea that children may not access the general theme of the list, or *gist* in the fuzzy trace theory, another theory which explains false memory production (Brainerd & Reyna, 1996). According to the lists, we found a critical lure appearance rate of between .04 and .46 for an average of .22 for all the lists. Without reaching the critical lure appearance rate found by Roediger and McDermott (1995), we identify an appearance rate that is still higher than in most studies conducted in children using non-adapted DRM word lists (Brainerd, 2013). Moreover, the eight most effective lists show an average appearance rate of .31. These results also appear higher than the critical lure appearance rate found by Metzger et al. (2008) with their adapted lists. The recall condition (i.e. children had to write down the words he remembered) could perhaps explain this variation in performance, as could the list presentation condition. In Metzger et al (2008), the lists were presented to groups of 15 to 25 children, whereas we chose an individual presentation, which may have strengthened their involvement and attention to the words in the list, thus allowing the activation to spread within their network.

These results can be commented on with respect to the Association-Activation Theory (Howe et al., 2009). In our study, due to the adapted material, activation seems to propagate to the critical lure, for some lists and for some children. Furthermore, although the size of our sample calls for caution when interpreting the results, the fact that semantically related errors are more frequent than non-semantically related errors reinforces the validity of the theory. However, the fact that children are more confident in their correct answers than in their errors (unlike adults, especially in Roediger & McDermott, 1995) suggests that the memory trace of the words in the list is more vivid than that of the general theme of the list, as evoked in the fuzzy trace theory (Brainerd & Reyna, 1996). Considering the definition of FMs (i.e. the memory of a non-experienced event with a high level of confidence), we still think that the critical lures produced by children do indeed represent FMs (the average confidence index for critical lures being high). However, given children's poor metacognitive abilities (Krasny-Pacini et al., 2015), we must be cautious regarding our interpretations and the validity of the confidence scale.

We did not find any correlation between the internal consistency of the lists, the mean FAS, the critical lure production rate and the correct answers production rate. In a recent study, Beato and Arndt (2021) showed that there is no correlation between FAS and critical lure production. However, our sample sizes may have limited the statistical power of our tests. With a larger sample, it is possible that correlations between the proportion of critical lures and internal consistency, as inferred by Metzger et al. (2008) or between correct responses and mean FAS would have been found, as in Beato and Arndt (2021). In our study, we did not calculate the backward associative strength (BAS), i.e. the associative force of the words in the list towards the critical lure, which seems more predictive of the critical lure production rate (Howe et al., 2009). It is one of the limit of our study.

Conclusion

Our study allowed the creation of DRM material in French adapted to children. With this material, we were able to find that children produced a high rate of critical lures compared to most other studies in this area. It seems particularly important to use this type of list to study DRM false memories in children. In future studies, it may be useful to use these lists by controlling internal and external variables that may influence the production of false memories (BAS, lexical and attentional level of the children...). Replications of this study in populations with a low lexical level (such as children with learning disabilities) or a low attentional level (such as children with ADHD) could be relevant to explore mechanisms which could explain production of FM in children.

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