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Age differences in the rejection of false memories: The effects of giving warning instructions and slowing the presentation rate

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ABSTRACT

Two experiments were conducted to examine whether children of different ages differ in their ability to reject associative false memories with the Deese–Roediger–McDermott (DRM) paradigm. Two different types of manipulations that are thought to facilitate false memory rejection in adults—slowing the presentation rate and issuing explicit warnings—were analyzed in younger and older children. The results showed that older children were more able than younger children to reject associative false memories through warnings and by slowing the presentation rate. We conclude that although older children are, in general, more prone to produce false memories with the DRM paradigm, they are also more able to reject them when certain conditions facilitate the editing process.

Introduction

Although extensive research has been conducted to analyze the developmental pattern of false memories, both implanted and spontaneous, only a few studies have been concerned with exploring age differences in false memory rejection. The current study examines the extent to which children of different ages are able to use rejection strategies to avoid false memory production.

Research carried out on false memories in children has flourished with studies on implanted suggestion conducted with the misinformation paradigm (e.g., Bruck & Ceci, 1999; Ceci, 1997; Ceci & Bruck, 1993; Ceci, Bruck, & Battin, 2000; Holliday, Reyna, & Hayes, 2002; Roebers & Schneider, 2000) and the imagination inflation paradigm (Ceci, Loftus, Leichtman, & Bruck, 1994; Pezdek &

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Hodge, 1999), and these studies have demonstrated that as children get older they become more immune to suggestions (Bruck & Ceci, 1999; Ceci & Bruck, 1993). One of the explanations for such a decline in suggestibility is given by the fact that there is an increase in source monitoring ability with age, referring to the ability to correctly remember the context in which a particular memory originated. A large amount of literature has shown that young children demonstrate a poor ability to monitor the sources of their memories (for reviews, see Lindsay (2002), and Roberts and Blades (2000)), a difficulty that is particularly apparent in situations involving reality monitoring (e.g., Foley & Johnson, 1985; Foley, Johnson, & Raye, 1983), discrimination between self-performed and other-performed actions (Foley, Ratner, & Passalacqua, 1993), or judgments about similar external sources (Lindsay, Johnson, & Kwon, 1991; Poole & Lindsay, 1995).

For a long time, implanted and misinformation studies led to the conclusion that young children are more prone to any kind of false memories than older children or adults because younger children have more difficulty in monitoring or rejecting false memories. However, research on spontaneous false memory using the Deese–Roediger–McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995) has since provided a different conclusion. This paradigm, first used with adults and then used with children, is based on a procedure in which lists of associates are presented to the participants, always omitting the converging word that is linked to all of the presented words of a list. For example, one list could be composed of several associates, such as *bed*, *rest*, *awake, tired, dream, wake, snooze, blanket,* etc., without the inclusion of its converging word *sleep*. The impressive result of this paradigm is that the converging words (critical items) may be equally or even better recalled and recognized than words presented in the lists (Roediger & McDermott, 1995).

Using this paradigm, recent studies have found an increase in false memory with age, from childhood to adulthood (e.g., Brainerd, Reyna, & Forrest, 2002; Brainerd, Reyna, Forrest, & Karibian, 2006; Carneiro, Albuquerque, Fernandez, & Esteves, 2007; Howe, 2006; Howe, Gagnon, & Thouas, 2008; Odegard, Holliday, Brainerd, & Reyna, 2008), which seems to contradict the developmental pattern usually found with implanted false memories. However, more recent studies have shown that the age increase in false memory is not a finding specific to DRM studies. When connected meaning tasks are used, implanted false memories can also increase with age, as the studies of Connoly and Price (2006), Fazio and Marsh (2008), and Ceci, Papierno, and Kulkofsky (2007) demonstrated. These findings have led some authors (e.g., Brainerd, Reyna, & Ceci, 2008) to argue that there is no dichotomy between implanted and spontaneous false memories in regard to developmental reversals. According to fuzzy trace theory, connected meaning paradigms could lead to increases with age because of two factors: children's limitations in forming semantic (gist) relations and older children's or adults' difficulty in using their superior true (verbatim) memories to suppress meaning-based errors in tasks requiring the processing of many meaning-sharing items (Brainerd & Reyna, 2005; Brainerd, Reyna et al., 2008).

Rooted on different conceptual grounds, an associative activation theory (Howe, 2006, 2008) has proposed that age-dependent increases in the number, strength, and automaticity of interitem associations can explain false memory developmental patterns. The role played by associative relations has been emphasized in some influential accounts of DRM effects (for an extensive presentation, see Gallo, 2006), and the approach continues to inspire the works of numerous researchers. However, it should be noted that the issue of whether there is a real dichotomy between semantic processing (as proposed by fuzzy trace theory) and associative processing (as proposed in the associative account) remains a subject of debate (e.g., Brainerd, Yang, Reyna, Howe, & Mills, 2008).

At the same time, there is some evidence from DRM studies with children indicating that false memory rejection increases with age. Using a mathematical model of recognition to compare the amounts of false memory rejection in children of different age levels, Brainerd, Holliday, and Reyna (2004) and Brainerd and Reyna (2002) found an increase in false memory rejection through development. Furthermore, an event-related functional magnetic resonance imaging study conducted with the DRM paradigm suggests that the right anterior prefrontal cortex, a region activated when conditions make higher monitoring demands, is more likely to be recruited with increasing age (Paz-Alonso, Ghetti, Donohue, Goodman, & Bunge, 2008). Moreover, Rybash and Hrubi-Bopp (2000) found that when a "generate" condition previous to recall was included, where participants were instructed to think of other words that were semantically related to the presented items, young adults were able to decrease false recall, whereas children and old adults increased it. This study seemed to indicate that young adults could reject associative false recall, whereas children and old adults were unable to do so. In keeping with the same line of argument, recent research has shown that older children or adults are more efficient in the use of strategies to reject false memories (Carneiro, Fernandez, & Dias, 2009; Ghetti, 2003, 2008; Ghetti & Alexander, 2004; Ghetti & Castelli, 2006). Only one study suggested the opposite. Howe (2005) showed that children, unlike adults, can suppress DRM false recall after receiving directed forgetting instructions. This result led Howe to conclude that whereas adults' false memories are more automatic and thus escape conscious control, children's false memories are produced with greater effort and therefore are more consciously controlled, facilitating the rejection process.

One way to understand the mechanisms involved in false memory rejection was provided by Gallo (2006). Gallo, assuming that false memory may result from processes that work in opposition and resting on the general source monitoring framework, proposed a distinction between two types of strategies: diagnostic monitoring and disqualifying monitoring. Diagnostic monitoring is based on the absence of an expected recollection, generating the assumption that "if that item had occurred I would have remembered it," whereas disqualifying monitoring is based on a true recollection of another event or item, with the two memories being mutually exclusive (Gallo, 2006). So far as diagnostic monitoring is concerned, the studies by Ghetti and collaborators (Ghetti & Alexander, 2004; Ghetti & Castelli, 2006) showed that only after 9 years of age do children begin to make use of a memorability-based strategy to reject false events of high memorability. Before that age, children were not able to apply the rule that "if that had happened I would have remembered it" to discard false events. In the case of disqualifying monitoring, Carneiro and colleagues (2009) showed that adults, unlike preschoolers and preadolescents, could spontaneously reject false memories by identifying the missing critical word and thus not recalling it later. Manipulating theme identifiability of associative lists, these authors found that false memories decreased for lists in which their critical words could be easily identified compared with lists in which critical words were hard to identify. This specific strategy—the "identify-to-reject" strategy—is used by adults to reject associative false memories (Neuschatz, Benoit, & Payne, 2003), and it seems to be a rather complex strategy not yet used spontaneously by preadolescents.

According to the view that predicts increases in false memory rejection with age, one might expect smaller age differences in false memory production with the DRM paradigm whenever the situations facilitate editing processes. It is known that some factors facilitate the false memory rejection process in adults, but so far as we know none of these effects has yet been studied in children. Slowing the presentation rate and giving warning instructions to avoid false memories are two of the factors that decrease the levels of false memories in adults, and their effects can be explained by either the source monitoring account or fuzzy trace theory. So far as the time of presentation is concerned, some studies have shown that study rate effects on false recall follow a nonmonotonic function; that is, as duration is initially lengthened, false memories increase but only until a certain point (e.g., McDermott & Watson, 2001). When this inflection point is reached, the increases stop and false memories begin to decline, arguably because false memory rejection is operating. For example, some studies have shown that slowing the presentation rate reduces false recall when list words are presented from 250 ms to 5 s (McDermott & Watson, 2001) or from 500 ms to 3 s (Dehon, 2006; Gallo & Roediger, 2002). However, the effect of slowing the presentation rate on false recognition has been less consistent (e.g., McCabe & Smith, 2002; Seamon, Luo, & Gallo, 1998; Seamon, Luo, Schlegel, Greene, & Goldenberg, 2000; Seamon et al., 2002). From a monitoring perspective, a manipulation of the presentation rate can facilitate false memory rejection in two different ways. On the one hand, when the presentation rate increases, participants have more time to engage in item-specific processing of list items, resulting in more distinctive recollections of each item and, thus, facilitating diagnostic monitoring (Gallo, 2006). On the other hand, slowing the presentation rate could give more time to the participants to "figure out" the converging word, to realize that it was not presented, and to hold it in their minds so as not to recall it in the future, thereby facilitating disqualifying monitoring (Gallo, 2006). Also, fuzzy trace theory could explain presentation rate effects by assuming that a longer time exposure to the word lists increases reliance on specific traces of the list items (i.e., verbatim traces), resulting in greater discriminability between verbatim traces and the gist traces and, thus, facilitating the rejection of false memories (Brainerd, Reyna, Wright, & Mojardin, 2003).

So far as warnings are concerned, several studies have shown that specific instructions given before study can reduce false memories, although they are not able to eliminate the DRM effect completely (Gallo, Roberts, & Seamon, 1997; McDermott & Roediger, 1998; Starns, Lane, Alonzo, & Roussel, 2007; Watson, McDermott, & Balota, 2004; Westerberg & Marsolek, 2006). However, if these warning instructions are provided after study, they are not efficient in reducing false memories (Gallo, Roediger, & McDermott, 2001; Neuschatz, Payne, Lampinen, & Toglia, 2001; but see also McCabe & Smith, 2002). It has been thought that warning instructions before study may encourage disqualifying monitoring because participants can strategically identify the related lure at study and thereby avoid false memories at test (Neuschatz et al., 2003). Also, for fuzzy trace theory, warning instructions might reduce false memories by inducing participants into verbatim-based responding. As Reyna and Kiernan (1994) demonstrated, the type of instructions that participants are given—emphasizing either gist-responding or verbatim-responding—can influence the size of the false memory effect.

Two experiments were conducted to analyze the effects of giving warning instructions and slowing the presentation rate on children's false memories. The first experiment analyzed the effect of giving warnings, and the second one analyzed the effect of giving warnings and slowing the presentation rate. The second experiment also allowed us to examine whether the contributions of each factor summate to produce a more pronounced effect on false memory rejection. We predicted that the monitoring limitations of young children, or their less developed verbatim traces, would prevent them from engaging in memory editing, and therefore we also predicted that young children would not be able to decrease false memories following warning instructions or by slowing the presentation rate. If this is the case, it would be possible to argue that although, in general, younger children produce fewer associative false memories than older children and adults, younger children are also less able to reject them.

Experiment 1

The first experiment analyzed children's ability to use disqualifying monitoring via warning instructions. Although, as mentioned previously, fuzzy trace theory could also provide an explanation for age differences in false memory rejection, we focus mainly on the monitoring account because warning and presentation rate manipulations are likely to involve different strategies of monitoring that are important for explaining age differences. With this purpose in mind, younger and older children were warned about the DRM phenomenon before the presentation of lists, and they were instructed to identify the critical word so as not to recall or recognize it later. In the case of younger children, it was expected that the warning instructions would not decrease false memories. Some arguments could justify this prediction. As mentioned previously, younger children have general difficulty in using monitoring or verbatim processing to discard false memories, but they also might be unable to engage in the process of gist extraction necessary to identify the critical words. According to this last alternative, the inability to extract the gist or the difficulty in using gist to avoid recalling or recognizing the critical words would result in a failure to apply this particular rejection strategy. In the case of preadolescents, the forecast is not so clear-cut. Although the study by Carneiro and colleagues (2009) showed that preadolescents are not able to spontaneously use the identify-to-reject strategy, it is not known whether preadolescents are able to apply it if they are instructed to do so. This experiment was concerned with this issue—analyzing the ability of preadolescents to reject false memories through disqualifying monitoring when the strategy is experimenter given.

Because the warning effect had already been observed in adults' recall and recognition tasks, this experiment included both tasks. The recognition task was administered with and without a previous recall task controlling for eventual recall contaminations in the recognition results (Roediger & McDermott, 1995).

Method

Participants

There were 120 Portuguese children (63 boys and 57 girls): 60 4- and 5-year-olds (mean age = 5 years 0 months) and 60 11- and 12-year-olds (mean age = 12 years 5 months). In each age group, there were approximately equal numbers of boys and girls. All of the children were native Portuguese speakers with no reported language or hearing difficulties and were attending schools in middle-class areas of Lisbon, Portugal. Children's parents provided written consent for their participation.

Design

A 2 (Age: 4- and 5-year-olds vs. 11- and 12-year-olds) × 2 (Instruction: standard vs. warning) × 2 (Test Condition: recall plus recognition vs. only recognition) design was used with the three factors manipulated as between-participants variables.

Materials

Each of the lists used in this experiment was composed of a critical word and its 10 strongest associates, following age-specific free association norms for the Portuguese language (Carneiro, Albuquerque, Fernandez, & Esteves, 2004). With the aim of avoiding floor effects, five lists that produced high rates of false memory with children in a previous study (Carneiro et al., 2007) were selected as study lists (see **Appendix A**). The unpresented critical words for these lists were the Portuguese names corresponding to *bed*, *book*, *car*, *dog*, and *rain*, and they were the same for the two age groups. For each study list, the 10 associates were disposed in decreasing order of associative strength and recorded for auditory presentation at a rate of 2 s per word. Note that because the lists were generated on the basis of age-specific associative norms, they differed for each group in terms of some of the specific words included and in the position that the associates occupied in the list. Nonetheless, the total associative strength of the connections between critical words and their corresponding associates was equivalent across age groups, thereby preserving the structural similarity of the lists across age groups while guaranteeing that all of the presented words were already known by the youngest participants.

The recognition test consisted of a total of 30 words: 10 presented words (2 from each studied list, corresponding to positions 1 and 8), the 5 critical words corresponding to these studied lists, 10 new words selected from positions 1 and 8 of similar but unstudied lists, and 5 new words that were critical words for these unstudied lists.

Procedure

Participants in each age group were randomly assigned to one of the four conditions: standard instruction with a previous recall task, standard instruction without a recall task, warning instruction with a previous recall task, and warning instruction without a recall task. In all conditions, they listened to five age-specific lists presented in a counterbalanced order across the participants. Because the members of the younger group were not yet able to write, and to keep the procedure identical for all participants, all of them were tested individually and provided oral responses. Initially, the participants were instructed to pay attention to the presented words for later recollection (immediately after listening to each list if they performed the recall task or after listening to all lists if they performed only the recognition task). Depending on the age group, the task was presented either as a memory test (for older children) or as a memory game (for younger children).

Participants assigned to the standard condition with a recall task followed the usual instructions for children (as in Carneiro et al., 2007). After the audio presentation of each list (2 s/word), children had approximately 90 s to say the words they remembered (recall task) and the experimenter registered them on an appropriate sheet of paper. After all of the lists had been presented and recalled, a single final recognition test was administered. To perform this last task, the experimenter orally presented the test words, and for each word children were instructed to say "yes" or "no" according to whether they did or did not remember hearing the word earlier. In the standard condition without a recall task, participants were told to pay attention to the lists because their memories of the words would be tested later. To equate the retention interval of the recognition test to the one used in the recall plus recognition condition described above, participants in this condition performed a 90-s distractor task immediately following the presentation of each list. The distractor task consisted of solving paper mazes with a difficulty level that corresponded to the children's age and took the same time as the recall task. After the presentation of all lists and their corresponding buffer activities, the same recognition test followed.

Participants assigned to the warning condition with a recall task were informed about the DRM phenomenon and how to avoid false memories:

> We are going to play a memory game/test, and you just need to remember the words you are going to hear spoken on this computer by a young lady. But you should be very careful because the lady wants to cheat you and make you say wrong words. As you are going to notice, all the words in a list are related to another word that is not presented. For example, the lady in the computer may say *flour*, *eggs*, *sugar*, *sweet*, and *birthday*. All of these words will probably make you think of *cake*, but she is not going to say the word *cake*. So, you must be very careful. First you should think about what the central word that was not presented is, and then you should make sure not to say it. Okay? Did you understand? The lady wants to deceive you into saying words that were not presented, so you must be very careful and just say the words that the lady said. Okay?

In the warning condition without a recall test, this instruction was adapted to a recognition task and the procedure was similar to the one used in the standard condition without a recall task. In both warning conditions, a reminder was given immediately before the administration of the recognition test: "Don't forget that the lady wants to cheat you by making you say the central words of her lists. Tell me "yes" only when you think the lady said the word. Okay?"

For all group conditions, the recognition test was administered in a self-paced manner and the test words were presented in a random order, being different for each participant so as to control for order effects.

Results and discussion

Recall

The mean proportions of targets (correct recall) and critical lures (false recall) recalled by instruction and age group were calculated and are presented in Fig. 1. A 2 (Age: 4- and 5-year-olds vs. 11- and 12-year-olds) $\times$ 2 (Instruction: warning vs. standard) mixed analysis of variance (ANOVA) with repeated measures over type of recall was performed separately for correct and false recall. In this and the following experiment, post hoc analyses (by Bonferroni tests, $p < .05$) were performed on all significant interactions, and only significant results are reported.

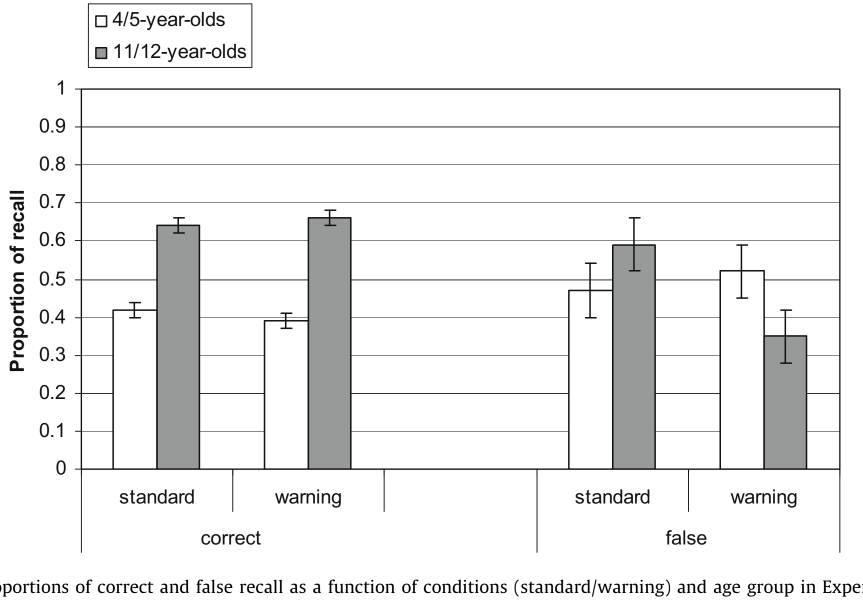

Fig. 1. Proportions of correct and false recall as a function of conditions (standard/warning) and age group in Experiment 1. Error bars represent standard errors of the means.

In the case of correct recall, the results showed only a main effect of age, $F(1, 56) = 141.57$, $MSE = .01$, $p < .001$, $\eta_p^2 = .72$, indicating that older children ($M = .65$, $SD = .08$) recalled more correct items than younger children ($M = .41$, $SD = .07$).

The results of false recall showed a significant Age × Instruction interaction, $F(1, 56) = 4.01$, $MSE = .08$, $p < .05$, $\eta_p^2 = .07$, revealing that the standard instruction produced age increases in false recall (younger children: $M = .47$, $SD = .26$; older children: $M = .59$, $SD = .23$), whereas the warning instruction produced age decreases in false recall (younger children: $M = .52$, $SD = .27$; older children: $M = .35$, $SD = .36$). Warnings decreased the false recall of 11- and 12-year-olds ($p < .05$), whereas it had no significant effect on 4- and 5-year-olds. No main effects were found for false recall.

Recognition

The mean proportions of the targets and critical lures recognized as a function of instruction, age, and type of recognition (with and without a previous recall task) were calculated and are presented in Table 1. Because developmental studies usually show declines in false alarms with age, we also presented the same data corrected for response bias provided by a nonparametric signal detection statistic *A′* (see Fig. 2). However, before the calculation of *A′* values, and as recommended by Snodgrass and Corwin (1988), "yes" responses to targets and critical lures of the presented and nonpresented lists were transformed to avoid responses of 1 or 0 by adding 0.5 to the number of "yes" responses and then dividing by $N + 1$. Estimates of *A′* values were then calculated for targets (correct recognition) and

Table 1
Proportions of recognition (raw data) for target items, critical items, target distractors, and critical distractors of Experiment 1.

		4- and 5-year-olds				11- and 12-year-olds			
		Standard		Warning		Standard		Warning	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Target	With recall	.70	.14	.67	.16	.81	.10	.80	.17
	Without recall	.67	.14	.61	.19	.77	.10	.85	.10
Critical	With recall	.64	.23	.65	.27	.83	.21	.49	.45
	Without recall	.65	.23	.69	.28	.84	.15	.20	.15
Target distractor	With recall	.07	.11	.10	.16	.03	.05	.03	.06
	Without recall	.15	.14	.20	.20	.06	.09	.17	.15
Critical distractor	With recall	.01	.05	.17	.24	.04	.08	.12	.20
	Without recall	.13	.18	.17	.26	.09	.15	.25	.18

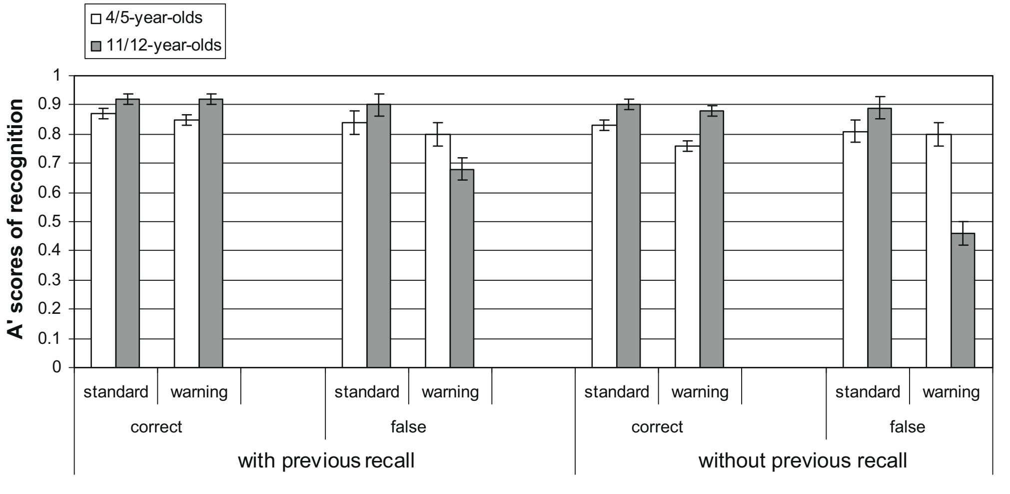

Fig. 2. Proportions of *A′* scores of correct and false recognition as a function of conditions (standard/warning) and age group in Experiment 1. Error bars represent standard errors of the means.

critical lures (false recognition) by applying the formulas for computing recognition sensitivity (presented in Appendix B). To obtain the *A′* values for correct recognition, the transformed mean proportions of the targets of presented lists were treated as hits and the mean proportions of the targets of nonpresented lists were treated as false alarms. To obtain the *A′* values for false recognition, the transformed mean proportions of the critical lures of presented lists were treated as hits and the mean proportions of the critical lures of nonpresented lists were treated as false alarms. *A′* scores for correct and false recognition were analyzed separately by two 2 (Age: 4- and 5-year-olds vs. 11- and 12-year-olds) × 2 (Instruction: warning vs. standard) × 2 (Type of Recognition: with recall vs. without recall) between-participants factorial ANOVAs.

For correct recognition, three main effects emerged: age, $F(1, 112) = 33.76$, $MSE = .005$, $p < .001$, $\eta_p^2 = .23$, showing that older children recognized significantly more correct items than younger children ($M = .90$, $SD = .04$ vs. $M = .83$, $SD = .10$); instruction, $F(1, 112) = 4.18$, $MSE = .005$, $p < .05$, $\eta_p^2 = .04$, indicating that warning instructions significantly decreased the number of correct items recognized (warning $M = .85$, $SD = .10$ vs. standard $M = .88$, $SD = .06$); and type of recognition, $F(1, 112) = 12.37$, $MSE = .005$, $p < .01$, $\eta_p^2 = .10$, revealing that a previous recall task, compared with a distractor task, significantly increased correct recognition ($M = .89$, $SD = .06$ vs. $M = .84$, $SD = .10$). No significant interactions were found.

For false recognition, the results also showed three main effects: age, $F(1, 112) = 9.02$, $MSE = .02$, $p < .01$, $\eta_p^2 = .08$, with younger children revealing higher levels of false recognition than older children ($M = .81$, $SD = .10$ vs. $M = .73$, $SD = .26$); instruction, $F(1, 112) = 41.04$, $MSE = .02$, $p < .001$, $\eta_p^2 = .27$, with standard instructions producing higher levels of false recognition than warning instructions ($M = .86$, $SD = .08$ vs. $M = .68$, $SD = .24$); and type of recognition, $F(1, 112) = 5.60$, $MSE = .02$, $p < .05$, $\eta_p^2 = .05$, with the inclusion of a previous recall task resulting in higher false recognition than the inclusion of a distractor task ($M = .80$, $SD = .18$ vs. $M = .74$, $SD = .21$). The first two main effects were qualified by an Age × Instruction significant interaction, $F(1, 112) = 28.34$, $MSE = .02$, $p < .001$, $\eta_p^2 = .22$. The post hoc analyses showed, first, that warning instructions significantly decreased false recognition for older children (standard $M = .89$, $SD = .06$ vs. warning $M = .57$, $SD = .28$, $p < .001$) but had no effect on younger children. Second, they revealed that with warning instructions younger children showed higher levels of false recognition than older children ($M = .80$, $SD = .11$ vs. $M = .57$, $SD = .28$, $p < .001$), but with a standard instruction no significant difference was observed between the two age groups ($M = .83$, $SD = .09$ vs. $M = .89$, $SD = .06$, $p > .05$). Finally, there was an Age × Instruction × Type of Recognition significant interaction, $F(1, 112) = 4.74$, $MSE = .02$, $p < .05$, $\eta_p^2 = .04$. This interaction reinforces the result that, in both conditions, the difference between warning and standard conditions was nonsignificant for younger children but always significant for older children. With or without a previous recall task, older children can decrease false recognition by warnings, whereas younger children cannot. In this condition, this gave rise to higher levels of false recognition for younger children compared with older children. With standard instructions, no significant age differences in false recognition were observed. Furthermore, this interaction makes clear that the effects of warning are reduced when older children have engaged in previous recall. It is possible that, when performing the recall task, the focus on recalling the items could disrupt the application of the identify-to-reject strategy.

The results of both recall and recognition tasks clearly indicate that by using warning instructions older children, unlike younger children, can reject false memories. In this condition, the decreases observed in the false memories of preadolescents eliminated the usual age differences in false recall and inverted the usual developmental pattern of false recognition, evidencing higher levels of false recognition for younger children. This experiment indicates that preadolescents, when instructed to identify the critical word to avoid its recall or recognition, can reject false memories through strategic and metacognitive processes.

Experiment 2

This second experiment combines two types of manipulation—slowing the presentation rate and giving warning instructions—and was conceived for two main reasons. First, it aims to analyze the effect of slowing the presentation rate on false recall in 4- and 5-year-olds and 11- and 12-year-olds. Only the recall task was selected because manipulation of the rate has not always been effective in recognition tasks (e.g., McCabe & Smith, 2002; Seamon et al., 1998, 2000, 2002).

As mentioned previously, a decrease in the presentation rate of associative lists facilitates adults' false memory rejection through two processes: diagnostic and disqualifying monitoring. It is known from previous research (e.g., Ghetti & Alexander, 2004) that younger children are unable to use rejection strategies of this kind, whereas preadolescents can at least apply diagnostic monitoring strategies. Thus, we expected to observe age differences in the rejection of false memories by slowing the presentation rate of associative lists. It was hypothesized that with more time preadolescents could use at least diagnostic monitoring and decrease false recall by engaging in item-specific processing of list items, that is, increasing their correct recall. On the other hand, it was expected that slowing the presentation rate would be ineffective for younger children because they are limited in their rejection strategies.

The second reason underlying the conception of this second experiment was related to the combination of two types of manipulations that were expected to facilitate the rejection of false memories in preadolescents. It would be interesting to examine whether the effects of both manipulations summate to produce a higher false memory rejection. As demonstrated by the previous experiment, preadolescents could engage in disqualifying monitoring provided that they had been given instructions on how to employ the monitoring strategy. Therefore, it is possible that preadolescents could use both types of monitoring—disqualifying and diagnostic—in a condition where a slower presentation rate is combined with warning instructions, producing an even higher decrease in false memories for this age group.

Method

Participants

There were 72 Portuguese children (34 boys and 38 girls): 36 4- and 5-year-olds (mean age = 5 years 0 months) and 36 11- and 12-year-olds (mean age = 12 years 0 months). The distribution of boys and girls was identical in the two age groups. As in the previous experiment, all of them were native Portuguese speakers with no reported language or hearing difficulties. Participants attended schools in middle-class areas of Lisbon and had parental consent to participate in the experiment. None of these children had participated in Experiment 1.

Materials, procedure, and design

Children listened to nine Portuguese associative lists normed for their age. The lists were selected from children's free associative norms (Carneiro et al., 2004) and included the five presented lists used in Experiment 1 and four additional lists used in previous studies (e.g., Carneiro et al., 2007). By using a computer-controlled audio recorder, the nine lists of each age group were recorded at three different presentation rates: 2, 4, and 8 s per item. The lists were composed of the 10 strongest associates to their corresponding critical words. Participants performed only a recall task. Each participant listened to three lists at each presentation rate, all presented in a random order. Stimulus counterbalancing ensured that each list was presented equally often in each of the three presentation rates across participants.

Besides this, participants of each age group were randomly assigned to a recall task with a standard condition or a warning condition. The instructions for both conditions were the same as those used in Experiment 1. Participants listened to the lists played on the audio system of a portable computer and, after the presentation of each list, needed to say the words they remembered during approximately 90 s. Meanwhile, the experimenter registered them on an appropriate sheet of paper. As in the previous experiment, all of the participants were tested individually and provided oral responses.

This experiment conformed to a 2 (Age: 4- and 5-year-olds vs. 11- and 12-year-olds) $\times$ 2 (Instruction: standard vs. warning) $\times$ 3 (Presentation Rate: 2 s vs. 4 s vs. 8 s) design with age and instruction as between-participants variables and with presentation rate as a within-participants variable.

Results and discussion

Two 2 (Age: 4- and 5-year-olds vs. 11- and 12-year-olds) × 2 (Instruction: warning vs. standard) × 3 (Presentation Rate: 2 s vs. 4 s vs. 8 s) mixed ANOVAs with repeated measures over the presentation rate were performed separately for correct and false recall.

Correct recall

The mean proportions of correct recall by presentation rate, instruction, and age are presented in Fig. 3. For correct recall, two main effects emerged: age, $F(1, 68) = 221.73$, $MSE = .03$, $p < .001$, $\eta_p^2 = .77$, and presentation rate, $F(2, 136) = 8.42$, $MSE = .006$, $p < .001$, $\eta_p^2 = .11$. As expected, older children correctly recalled more items than younger children ($M = .61$, $SD = .12$ vs. $M = .27$, $SD = .11$). So far as the presentation rate is concerned, the post hoc analysis revealed that the fastest presentation rate (2 s) produced significantly lower correct recall when compared with the 4- and 8-s rates ($M = .41$, $SD = .18$ vs. $M = .45$, $SD = .20$ vs. $M = .46$, $SD = .23$). A significant Age × Presentation Rate interaction, $F(2, 136) = 4.73$, $MSE = .006$, $p < .01$, $\eta_p^2 = .07$, showed that the difference between the three presentation rates was nonsignificant for younger children but significant for older children. Older children increased correct recall from 2 to 4 s ($M = .56$, $SD = .12$ vs. $M = .61$, $SD = .12$, $p < .05$) and from 2 to 8 s ($M = .56$, $SD = .12$ vs. $M = .65$, $SD = .13$, $p < .001$). The instruction did not produce main or interaction effects on correct recall.

False recall

The mean proportions of false recall by presentation rate, instruction, and age are presented in Fig. 4. So far as false recall is concerned, main effects of age, $F(1, 68) = 14.78$, $MSE = .10$, $p < .001$, $\eta_p^2 = .18$, and presentation rate, $F(2, 136) = 3.96$, $MSE = .03$, $p < .05$, $\eta_p^2 = .06$, were again found. Older children showed higher false recall than younger children ($M = .28$, $SD = .29$ vs. $M = .11$, $SD = .18$). In general, the slowest presentation rate (8 s) decreased false recall when compared with the fastest presentation rate (2 s) ($M = .15$, $SD = .21$ vs. $M = .24$, $SD = .29$, $p < .05$). The mean false recall of the intermediate presentation rate (4 s) ($M = .20$, $SD = .27$) did not differ from the other two presentation rates. To clarify these results, an Age × Presentation Rate significant interaction, $F(2, 136) = 3.51$, $MSE = .03$, $p < .05$, $\eta_p^2 = .05$, showed that the difference between the three presentation rates was

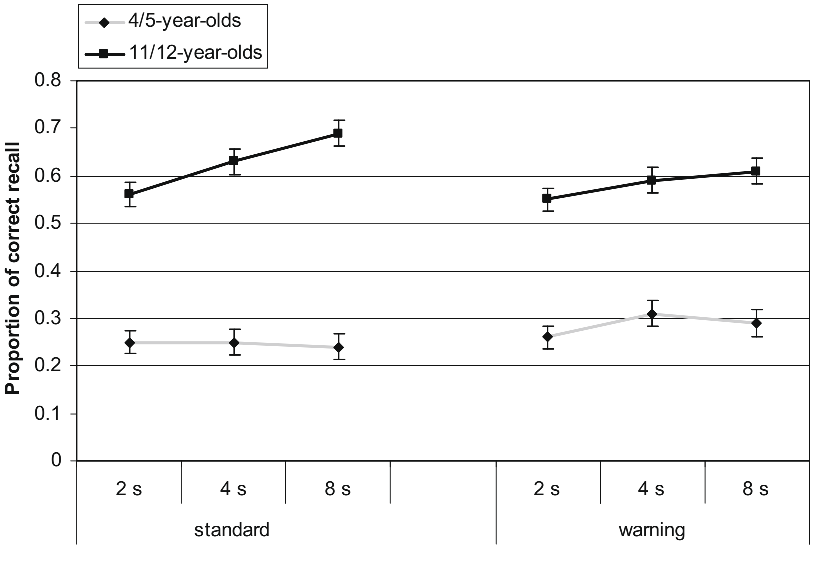

Fig. 3. Proportions of correct recall as a function of conditions (standard/warning), presentation rate, and age group in Experiment 2. Error bars represent standard errors of the means.

nonsignificant for younger children (M_{2s} = .14, M_{4s} = .08, and M_{8s} = .11) but was significant for older children (M_{2s} = .32, M_{4s} = .32, and M_{8s} = .19). Older children decreased false recall from the fastest (2-s) and intermediate (4-s) presentation rates to the slowest presentation rate ($p < .01$). This significant interaction also revealed that age differences were significantly different for the fastest ($p < .01$) and intermediate ($p < .001$) presentation rates but were nonsignificant for the slowest presentation rate ($p > .05$).

A significant Age × Instruction interaction also emerged, $F(1, 68) = 7.32$, $MSE = .10$, $p < .01$, $\eta_p^2 = .10$, revealing that the difference between the two types of instruction was nonsignificant for younger children but significant for older children. Older children significantly decreased false recall when they were given warning instructions ($M_{standard}$ = .37, SD = .32 vs. $M_{warning}$ = .19, SD = .23). This significant interaction also showed that with standard instructions older children showed higher proportions of false recall than younger children (M = .37, SD = .32 vs. M = .09, SD = .15, $p < .001$) but that with warning instructions there is no significant difference between the two age groups (M = .19, SD = .23 vs. M = .14, SD = .21, $p > .05$).

Three conclusions emerged from this experiment. First, this experiment replicated the results of Experiment 1, also demonstrating age dissociations on the effects of warning instructions. When warned and instructed to apply an identify-to-reject strategy, older children decreased false recall. Second, this experiment showed that, unlike younger children, older children could decrease false recall with a slowing of the presentation rate of the items at study. As expected, this decrease of false recall in preadolescents was observed with simultaneous increases in correct recall. This opposite effect for correct and false recall could indicate that at this age children can use item-specific processing of list items to increase distinctive recollections of each item, facilitating diagnostic monitoring. Finally, contrary to what was thought previously, the effects of both giving warning instructions and slowing the presentation rate did not summate to produce a higher rejection level of preadolescents' false memories.

General discussion

The effects of slowing the presentation rate and giving warning instructions were studied for the first time in children's false memories using the DRM paradigm. In general, this study indicates that

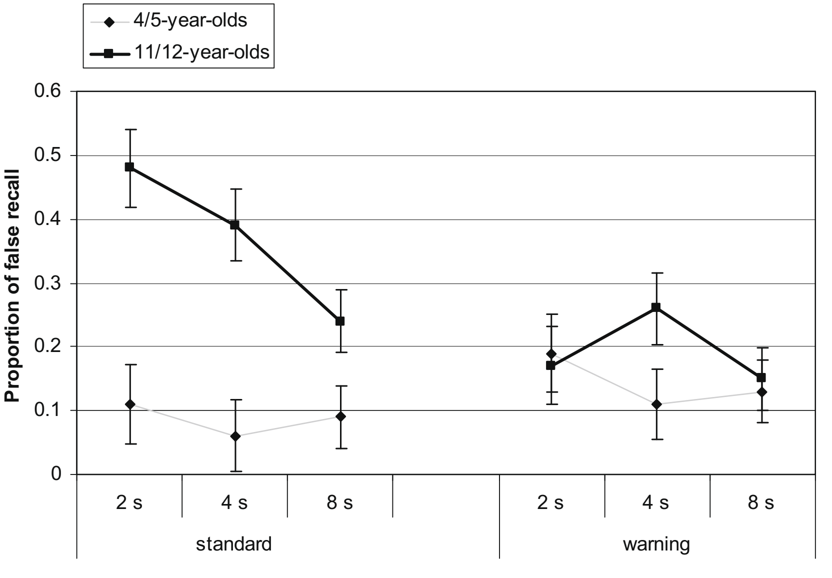

Fig. 4. Proportions of false recall as a function of conditions (standard/warning), presentation rate, and age group in Experiment 2. Error bars represent standard errors of the means.

preadolescents can reject false memories both when the presentation rate is slowed down and when warning instructions are given, whereas younger children are unable to do so.

One explanation for this phenomenon is to relate this finding to the monitoring abilities already present in preadolescents but deficient in younger children. This research allows us to understand what type of monitoring process preadolescents are more skilled at using when rejecting false memories. It has been thought that slowing the presentation rate can facilitate both types of monitoring—diagnostic and disqualifying. However, it is more plausible that, with slower presentation rates, preadolescents can use only diagnostic monitoring because it is known that they do not spontaneously apply the identify-to-reject strategy so as to reject false memories (Carneiro et al., 2009). This argument is reinforced by the fact that slowing the presentation rate in this age group decreased false recall but increased correct recall. The enhancement of correct recall together with a decline in false recall indicates that, when given more time, preadolescents can reject false memories by paying more attention to list items and, therefore, can increase their distinctive recollection of each item. On the contrary, younger children could not use the extra time to increase correct recall and, because of that, were unable to diminish false recall.

On the other hand, it is thought that warning instructions facilitate false memory rejection through disqualifying monitoring. As mentioned previously, this could be achieved by a previous identification of the critical item and its subsequent discarding, which did not imply increases in correct recall. In fact, in the current study, this manipulation did not increase correct recall in any age group. Thus, it seems that preadolescents are able to use disqualifying monitoring when they are instructed to apply the identify-to-reject strategy. Because they are not able to use such a strategy in a spontaneous way (Carneiro et al., 2009), it is possible that preadolescents could behave as if they were production deficient so far as the application of this strategy is concerned (Flavell, 1970). This means that they might not be able to use this specific strategy spontaneously but may profitably apply it if they are given instructions on how to employ it. However, young children might not be able to apply it even when they are shown how to use it, showing what is called a mediation deficiency (Reese, 1962). A similar result was also obtained when young children were warned about a memorability-based strategy (Ghetti & Castelli, 2006). Although they focused on different kinds of strategies, both pieces of research showed that young children were ineffective in applying warning strategies to reject false memories. However, it seems to be premature to conclude that young children cannot learn to reject false memories. These two particular strategies might be very complex for young children to apply because they require a certain level of working memory capacity, probably not yet developed at this age.

Another explanation could be provided by fuzzy trace theory, an account that assumes progression in verbatim processing throughout development, in parallel with and independent of the development of gist abilities (Brainerd & Reyna, 2005). Because older children are more able to use verbatim processing and, as mentioned previously, the current manipulations favor this type of processing, the theory predicted that they would be more prone than younger children to decrease false memory responses when the procedures lead to strengthening verbatim traces relative to gist traces.

In general, the current experiments confirmed the usual pattern of DRM false memory development. Older children produced higher levels of correct recall or correct recognition and, in standard situations (standard instruction or presentation rates of 2 s), generated higher levels of false recall and recognition than younger children. However, in situations where monitoring or verbatim processing is facilitated (through warning instructions or slower presentation rates), preadolescents decreased false recall, abolishing age differences in false recall and reversing the common developmental pattern in false recognition. These are the kind of manipulations that Brainerd and colleagues (2008) termed "necessity manipulations" to test process models of developmental reversals, narrowing the age difference or eliminating it. Within the necessity manipulations, the existing studies have mainly tested variables that interfere with participants' ability to form semantic relations among targets, for instance, presenting items with a phonological interconnection relation rather than a semantic one (e.g., Holliday & Weekes, 2006) or presenting the targets in a random order rather than in a block (Lampinen, Leding, Reed, & Odegard, 2006). However, we argue that studies concerned with variables that test false memory rejection, in this case making it easier for older children or adults to use verbatim traces to suppress false memories, are essential to test opponent process theories. As

Brainerd and colleagues (2008) pointed out, at this point it is crucial to develop experiments to test process mechanisms for developmental reversals.

Only an opponent process theory that incorporates a memory editing process (monitoring or verbatim processing) could account for the observed results. This does not imply that a one-process theory, such as associative activation, could not have a role in explaining children's false memories. We argue that age differences in false memories could be, at least partially, explained by increases in the amount, strength, and automaticity of associative connections, but to account for the results of the current study, an editing process should be incorporated. One way of integrating the current data with this theory might be to assume that both associative activation and monitoring processes increase with age. Other researchers have already shown that age differences in the DRM paradigm may vary under different conditions as a function of the operation of distinct and opposing processes. For example, Ghetti and Angelini (2008) and Lyons, Ghetti, and Cornoldi (in press) showed that familiarity is rather stable during childhood, whereas recollection improves during this period.

Age differences in false memories could also reflect different levels of skill in the use of strategies. If older children and adults are more able to use rejection strategies to edit false memories, then how could developmental reversals be explained? Previous research into the development of strategies indicates that memory strategies, such as rehearsal and organization, are effectively used by young children only if they are prompted (Ornstein, Haden, & Elischberger, 2006; Schlagmüller & Schneider, 2002). Only between 11 and 14 years of age are children able to spontaneously use more complex strategies such as cumulative rehearsal and elaboration (Bjorklund, Dukes, & Brown, 2009). It seems that the increasing ability to use memory strategies is also related to increases in the ability to establish semantic links between words and extract the gist of DRM lists, resulting in a greater amount of associative false memories. This does not, however, mean that older children or adults are less able to reject associative false memories. Instead, as noted previously, older children or adults seem to be more proficient in using strategies to reject false memories. However, in standard conditions they produce more associative false memories because they are also more skilled in using other strategies that promote the extraction of gist and because the automatic activation of concepts and the memory relations they build up are faster and more efficient.

The second experiment showed that the effects of warnings and presentation rate did not summate in preadolescents to produce a higher level of rejection. This could mean that they cannot use different strategies at the same time to reject false memories. According to previous research into strategy development, it is over the course of adolescence that individuals are more likely to use multiple and variable strategies (e.g., Coyle & Bjorklund, 1997; Schwenck, Bjorklund, & Schneider, 2007) and that they become progressively more able to select strategies that are appropriate for a particular task and more flexible in using the multiple strategies that are at their disposal (Ornstein, Haden, & Souci, 2008; Schneider & Bjorklund, 1998).

There is a possible criticism regarding the interpretation of the results obtained in the warning conditions. The null effect of warning instructions for younger children could be interpreted as meaning that they may have difficulty in understanding the instructions and are not motivated to follow them. Although great care was taken in making the explanation clear, including providing simple examples to all of the participants and confirming that they understood them, the possibility nonetheless remains that they did not fully understand the instructions. But even if this is the case, we can rely on the presentation rate manipulation, which did not require an understanding of specific instructions, to argue that young children are less able than older children to reject false memories.

Because in the first experiment we included only the lists that had produced the highest levels of false recall for children in previous studies, the general rate of false recall in Experiment 1 was very high for both age groups. Compared with other DRM studies with children, the false recall percentage for younger children was very high, reaching approximately 50%. We believe that the use of child-normed lists, in addition to the selection of the stronger ones, explains the contrasting results observed in other studies that used adult-normed lists (e.g., Brainerd et al., 2002). This result reinforces the conclusion of the study by Carneiro and colleagues (2007), suggesting that young children are able to process gist if tested with age-appropriate material. On the other hand, the levels of younger children's false memories dropped in Experiment 2 because, to increase the number of tested lists, we included some lists that were less powerful in generating false memories in children (Carneiro et al., 2007). Although the level of false recall for younger children was substantial and similar to what is usually found in other studies (Brainerd et al., 2002; Carneiro et al., 2007), we suggest that in future studies procedural steps should be taken to elevate the baseline level of younger children's false recall with the aim of avoiding potential floor effects and discounting artifactual explanations of the absence of a reduction effect.

In sum, this research emphasizes the idea that although older children are, in general, more prone to produce false memories with the DRM paradigm, they are also more able to reject false memories. Although this seems to be paradoxical, it could be explained by assuming that age increases in false memory formation are due mainly to increases in encoding abilities such as those involved in connecting gist or those deriving from enhanced automatic activation. However, when individuals are tested in situations where false memory rejection is facilitated by monitoring processes or verbatim processing, such as when they have more time to initially process the items or when they have been warned about the possibility of false memories, lower age differences in false memory production emerge. In these cases, older children, just like adults, can substantially reduce false memories by using different types of rejection strategies.

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Appendix A

Lists of Experiment 1

Preschooler. Bed: sleep, pillow, sheets, lay, ni-night, wake up, crib, mother, blanket, mattress.
Book: read, see, stories, paint, drawings, to count, note-book, pages, sheets, front-page.
Car: wheels, drive, steering-wheel, windows, doors, father, glass, lights, seats, go out.
Dog: ruff ruff, bark, bite, feet, lick, puppy, bones, ears, tail, cat.
Rain: water, wet, fall, drops, umbrella, sky, clouds, cold, floor, winter.

Preadolescents. Bed: sleep, sheets, pillow, mattress, blanket, comfortable, room, sleepy, dreams, lay.
Book: read, pages, letters, school, study, reading, stories, sheets, front-page, pen.
Car: wheels, engine, steering-wheel, van, door, ride, accident, drive, street, Ferrari.
Dog: she-dog, cat, animal, bark, leash, collar, friend, bite, kennel, hair.
Rain: water, umbrella, drops, cloud, wet, weather, cold, thunderstorm, winter, sun.

Lists. of Experiment 2

Preschoolers. Airplane: fly, wings, sky, air, fall, travel, people, helicopter, big, clouds.
Bed: sleep, pillow, sheets, lay, ni-night, wake up, crib, mother, blanket, mattress.
Book: read, see, stories, paint, drawings, to count, note-book, pages, sheets, front-page.
Car: wheels, drive, steering-wheel, windows, father, glass, lights, seats, go out, ride.
Dog: ruff ruff, bark, bite, feet, lick, puppy, bones, ears, tail, cat.
Door: open, close, key, enter, house, lock, white, wood, go out, knob.
Rain: water, wet, fall, drops, umbrella, sky, clouds, cold, floor, winter.
Tooth: eat, mouth, white, chew, wash, broken, dirty, fall, bite, rotten.
Tree: leaves, fruits, log, apples, flowers, green, garden, street, play, Christmas.

Preadolescents. Airplane: fly, air, sky, wings, trip, height, small airplane, jet, airport, clouds.
Bed: sleep, sheets, pillow, mattress, blanket, comfortable, room, sleepy, dreams, lay.
Book: read, pages, letters, school, study, reading, stories, sheets, front-page, pen.

Car: wheels, engine, steering-wheel, van, ride, accident, drive, street, Ferrari, tires.
Dog: she-dog, cat, animal, bark, leash, collar, friend, bite, kennel, hair.
Door: knob, lock, house, wood, key, gate, entrance, open, bell, window.
Rain: water, umbrella, drops, cloud, wet, weather, cold, thunderstorm, winter, sun.
Tooth: cavity, dentist, mouth, white, canine, gum, chew, rotten, toothpaste, toothbrush.
Tree: leaves, fruits, nature, log, root, flowers, forest, wood, plant, shade.

Appendix B

When hits (H) > false alarms of hits (FAH), the nonparametric formula (A') applied was as follows: $A' = .5 + [(H - FAH)(1 + H - FAH)]/[4H(1 - FAH)]$; however, if $H < FAH$, an alternative formula was applied: $A' = .5 - [(FAH - H)(1 - H + FAH)]/[4FAH(1 - H)]$.

When criticals (C) > false alarms to criticals (FAC), the formula applied was as follows: $A' = .5 + [(C - FAC)(1 + C - FAC)]/[4C(1 - FAC)]$; however, if $C < FAC$, then $A' = .5 - [(FAC - C)(1 - C + FAC)]/[4FAC(1 - C)]$.

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