Story contexts increase susceptibility to the DRM illusion in 5-year-olds

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False recognition in children aged 5, 8, and 11 years was investigated using the standard version of the Deese-Roediger-McDermott (DRM) procedure and an alternative version in which the DRM stimuli were embedded in stories designed to emphasize their overall theme. Relative to the 8- and 11-year-olds, the 5-year-olds falsely recognized fewer critical lures when the DRM stimuli were presented in lists, but falsely recognized more critical lures when the stimuli were presented in stories. Levels of false recognition in the 8- and 11-year-olds were not affected by study format. We argue that the story context enhanced the ability of the 5-year-olds to make inferences based on the theme of the DRM stimuli. The 5-year-olds then showed higher levels of false recognition than the older children owing to their inability to reject lure words consistent with the stories.

In the Deese-Roediger-McDermott (DRM) procedure (Deese, 1959; Roediger & McDermott, 1995), participants are presented with lists of semantic associates of a word that is not itself presented. For example, participants hear words such as *bed, rest, awake, tired,* and *dream*, which are associates of the nonpresented word *sleep*. In subsequent tests of recall or recognition, *sleep* (the critical lure) is often erroneously identified as having been presented in the study list. Roediger and McDermott developed an activation-monitoring account of the DRM illusion. According to this account, participants spontaneously generate semantic associates of the words presented in the study lists. For example, participants who hear *bed*, *rest*, *awake*, etc, spontaneously generate the associated word *sleep*. When later asked to retrieve the study lists, the participants are unable to distinguish between the words they heard and those they generated in response.

Although the DRM procedure consistently produces false memories in adults, recent research has shown that it is less effective in eliciting false memories in children. For example, Brainerd, Reyna, and Forrest (2002) found that false recall was at near-floor levels in 5- and 7-year-olds, while false recognition was reduced in 5-year-olds relative to 11-year-olds and young adults. The absence of a DRM effect in children is surprising given that they are particularly prone to memory distortion (e.g., Brainerd & Reyna, 1996; Ceci, Crotteau, Smith, & Loftus, 1994) and have relatively poor source monitoring skills (Foley, Johnson, & Raye, 1983).

Brainerd et al. (2002) interpreted their findings in relation to fuzzy trace theory (FTT; Brainerd & Reyna, 1996; Reyna & Brainerd, 1995, 1998). According to FTT, participants in memory experiments create two traces of study items: a gist trace that preserves the meaning of an item, and a verbatim trace that includes surface details of the item and its encoding context. According to Brainerd et al., the critical lures are falsely remembered because of their overlap with the gist traces of the studied items. They argued that the DRM procedure is ineffective with children because they fail to notice that the words in a list are semantically related and do not create the gist traces that are responsible for the DRM effect.

In contrast to the findings of Brainerd et al. (2002), Dewhurst and Robinson (2004) found that the DRM procedure can elicit false memories in children. However, the false memories they observed were qualitatively different from those typically produced by adults. Dewhurst and Robinson's results suggested a developmental shift from phonological to semantic false memories. Whereas 11-year-olds falsely recalled words that were semantically related to the study items, 5-year-olds falsely recalled words that rhymed with the study items. It is therefore not the case that the DRM procedure is ineffective with children, but rather that the nature of the false memories produced by the DRM procedure changes with age. Nevertheless, the 5-year-olds tested by Dewhurst and Robinson still produced relatively few semantic intrusions, thereby supporting the proposal by Brainerd et al. (2002) that young children fail to create gist memories representing the semantic themes of the lists.

Despite their relative immunity to the standard DRM illusion, young children have been found to be susceptible to semantically-driven false memories when asked to remember more complex linguistic materials, such as sentences and stories (see Oakhill & Cain, 2004, for a review). For example, Paris and Carter (1973) found that 7- and 10-year olds falsely recognized sentences that were consistent with the meaning of other sentences previously read out to them, and Brown, Smiley, Day, Townsend, and Lawton (1977) found that children aged 8 years and older falsely recognized lure sentences that were congruent with a previously heard story. Findings such as these show that children make inferences and associations that are consistent with the overall meaning of a passage of text. If this is the case, it should be possible to increase young children's susceptibility to the DRM illusion by presenting the DRM stimuli in the context of a story that highlights their overall theme.

In order to investigate this, we created a series of short stories based on 8 DRM lists and presented them to 5-, 8-, and 11-year-olds. Our sample therefore included children younger than those tested by Paris and Carter (1973) and Brown et al. (1977), allowing us to investigate developmental changes in susceptibility to story-based memory illusions. The broader age range also allowed comparison with previous DRM studies, which included 5-year-olds. Half the children in each age group heard the stories and were given tests of recognition memory for the DRM stimuli (including the critical lures) after each story. The remaining participants heard the DRM stimuli in the standard list format and were similarly tested for recognition memory after each list.

Brainerd et al. (2002) found that the false recognition of critical lures was lower in 5-year-olds than in 11-year-olds and young adults. In contrast, Ghetti, Qin, and Goodman (2002) found that false recognition was not influenced by age. However, they also found that false recall decreased with age, with 5- and 7-year-olds falsely recalling more critical lures than adults when overall levels of recall were controlled. As noted by Ghetti et al., their use of relatively short study lists (7 items rather than the usual 12 or 15) may have reduced the levels of false recall and false recognition in adult participants, which were much lower than in Brainerd et al.'s study. The longer lists used in the present study enabled us to investigate whether the developmental increase in susceptibility to the DRM illusion is found in recognition as well as in recall.

According to FTT, the absence of a DRM effect in 5-year-olds is due to their inability to identify the themes of the DRM stimuli when presented in lists. Embedding the DRM stimuli in a story that emphasizes their overall theme should therefore increase 5-year-olds's susceptibility to the illusion. Predictions regarding the effects of stories on the 8- and 11-year-olds are less clear. However, given that the ability to form gist representations increases developmentally, it is possible that the story context will have less of an effect on the 8- and 11-year-olds, who are already able to connect the gist of the DRM stimuli when they are presented in lists. The greater ability of the 8- and 11-year-olds to use verbatim traces to reject critical lures may also restrict any increase in false recognition beyond the levels produced by lists. Our prediction therefore was that the story context would lead to a significant increase in false recognition for the 5-year-olds, but a smaller increase (or no increase) in false recognition for the 8- and 11-year-olds.

Method

Participants. Sixty children (31 girls and 29 boys) were recruited from two schools in Caernarfon, Wales. There were twenty 5-year-olds, twenty 8-year-olds, and twenty 11-year-olds. All were fluent English speakers with no reported language difficulties. Ten children in each age group were presented with the standard DRM lists and ten were presented with the DRM stimuli in stories.

Stimuli and Design. Eight DRM lists were selected from Roediger and McDermott (1995) and consisted of semantic associates of the following critical lures: sleep, smell, doctor, lion, fruit, thief, music, and cold. Each study list contained 14 associates of the critical lure, presented in descending order of associative strength. A fifteenth word that was highly associated to the critical lure was omitted from each study list to serve as a second critical lure in the recognition test. Eight stories were written, each based on a single DRM list (see Appendix for a sample story). The stories ranged in length from 65 to 104 words and included the 14 DRM words presented, as far as possible, in the same order as they appeared in the list condition (in the few cases where this was not possible the order of the words in the List condition was altered to match the Story condition). Each recognition test consisted of the 14 studied DRM words, the two critical lures, and 5 unrelated words taken from other DRM lists not used in the study. A between-groups design was employed, with the two factors of Age (5, 8, or 11 years) and Study Format (lists or stories).

Procedure. The children were tested individually by a female experimenter (the second author). They were told that the experimenter would read aloud a series of words (or stories) and that after each one they would be given a memory test for some of the words they heard. In the list condition, the words were read aloud in descending order of associative strength at a rate of one every two seconds. After each list, the experimenter read aloud a second series of words and asked the participants to indicate whether they thought the word had appeared in the list they just heard by saying “yes” or “no”. They were told to say yes only if they were certain the word had definitely appeared. This procedure was repeated until all eight DRM lists had been presented and tested. The procedure for the story condition followed a similar schedule. The stories were read aloud by the experimenter and took between 30 and 40 seconds per story to deliver. Each story was followed by the same recognition test as was used in the corresponding list condition.

Results

Three scores were calculated for each child: The number of words correctly recognized, the number of critical lures falsely recognized, and the number of unrelated lures falsely recognized. These scores were analyzed in a series of 3x2 (Age x Study Format) between-groups Analysis of Variance (ANOVA). Effect sizes measured by partial eta-squared (η_p^2) are also given. Table 1 shows the mean proportions of hits and false alarms as a function of Age and Study Format.

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As expected, correct recognition showed a significant main effect of Age, F (2, 54) = 8.37, MSE = 147.95, $p < .001$, $\eta_p^2 = .24$. Table 1 shows that correct recognition increased steadily across the three age groups. The main effect of Study Format was marginally significant, F (1, 54) = 3.18, MSE = 147.95, $p = .08$, $\eta_p^2 = .06$, and showed higher levels of correct recognition for the Story format than for the List format. These effects were qualified by a significant interaction between Age and Study Format, F (2, 54) = 4.35, MSE = 147.95, $p < .05$, $\eta_p^2 = .14$. This was explored in a series of post-hoc comparisons (Tukey tests). Comparisons across Study Format showed that correct recognition in the 5-year-olds was higher in the Story condition than in the List condition, $p < .01$, but was not reliably affected by Study Format in the 8- and 11-year-olds. Comparisons across Age showed that correct recognition was greater in the 11-year-olds than the 5-year-olds in the List condition, $p < .001$, and greater in the 11-year-olds than the 8-year-olds in the Story condition, $p < .05$. No other differences were significant.

Our main focus was on the effects of Age and Study Format on the false recognition of critical lures. The main effect of Age was not significant, $F < 1$. However, a significant main effect of Study Format was observed, F (1, 54) = 4.54,

$MSE = 5.31$, $p < .05$, $\eta_p^2 = .08$, with children in the Story condition falsely recognizing more critical lures than children in the List condition. This was qualified by a significant interaction between Age and Study Format, $F(1, 54) = 10.00$, $MSE = 5.31$, $p < .001$, $\eta_p^2 = .27$. Post-hoc comparisons across Study Format showed that the 5-year-olds falsely recognized more critical lures in the Story condition than in the List condition, $p < .001$, while Study Format did not reliably affect the 8- or the 11-year-olds. Post-hoc comparisons across Age showed that, in the List condition, the false recognition of critical lures was greater in the 8- and 11-year-olds than in the 5-year-olds, $p < .05$. The 8- and 11-year-olds did not differ reliably. In contrast, the false recognition of critical lures in the Story condition was greater in the 5-year-olds than in the 8- and 11-year-olds, $p < .05$. Again, the 8- and 11-year-olds were not reliably different.

The false recognition of unrelated lures showed a significant main effect of Age, $F(2, 54) = 6.01$, $MSE = 17.14$, $p < .01$, $\eta_p^2 = .18$, and decreased as the age of the children increased. The main effect of Study Format was not significant, $F(1, 54) = 1.12$, $MSE = 17.14$, $p = .29$, $\eta_p^2 = .02$. The interaction between Age and Study Format bordered on significance, $F(2, 54) = 3.13$, $MSE = 17.14$, $p = .05$, $\eta_p^2 = .10$. Post-hoc comparisons across Study Format showed that the 5-year-olds falsely recognized more unrelated lures in the List than in the Story format, $p < .05$, whereas the 8- and 11-year-olds were not reliably affected by Study Format. Comparisons across Age showed that the 5-year-olds falsely recognized more unrelated lures than the 11-year-olds in the List condition, $p < .001$. No other differences were significant.

Discussion

The main finding from the present study is that the susceptibility of 5-year-olds to the DRM illusion was increased when the DRM stimuli were presented in the context of a story. When the DRM stimuli were presented in the standard list format, 5-year-olds falsely recognized significantly fewer critical lures than either the 8- or the 11-year-olds. When the stimuli were presented in stories, the 5-year-olds falsely recognized significantly more critical lures than the older age groups. The present findings are therefore consistent with the conclusion by Brainerd et al. (2002) that young children are not susceptible to the standard DRM illusion because they fail to form a gist representation of the list theme. Presenting the DRM stimuli in a context that highlights their overall theme increases 5-year-olds' susceptibility to the illusion.

This conclusion is reinforced by the finding that the false recognition of unrelated lures by the 5-year-olds was greater in the list condition than in the story condition. According to Brainerd et al. (2002), the inability of young children to connect the gist of the DRM stimuli leads then to produce high numbers of intrusions that are unrelated to the list theme (see Dewhurst & Robinson, 2004, for similar findings). The finding that the 5-year-olds made fewer false alarms to unrelated items in the story condition confirms that the story context made it easier for them to identify the theme. As a result, they made associations consistent with the overall theme of the story rather than the ad hoc associations to individual items that 5-year-olds typically make when the DRM stimuli are presented in lists. The finding that the 5-year-olds in the story condition made fewer false alarms to unrelated lures also rules out the possibility that the increase in false recognition of critical lures in the story condition was due to a response bias.

If the story contexts led the 5-year-olds to make inferences based on an overall representation of a story, it is somewhat suprising that the stories did not increase false recognition in the 8- and 11-year-olds, as the ability to construct a representation of a story has been shown to improve with age (e.g., Ackerman, 1986, 1988; Barnes, Dennis, & Haefele-Kalvatis, 1996). One explanation that can be ruled out is that the null effect of story contexts in the older children is due to the relatively small sample sizes. As can be seen in Table 1, both the 8- and the 11-year-olds falsely recognized more critical lures in the List condition than in the Story condition. The finding that stories did not increase false recognition in the older children may reflect a combination of two factors: the greater ability of older children to form gist representations of the DRM stimuli in list format, and developmental improvements in the ability to use verbatim traces to monitor memory processes at retrieval (Brainerd & Reyna, 1996; Reyna & Brainerd, 1995, 1998).

The present findings therefore highlight the complex interaction between encoding and retrieval processes that determines susceptibility to the DRM illusion. Young children are not susceptible to the standard DRM illusion because they fail to connect the gist of the words at encoding. Presenting the stimuli in a story context allows children as young as 5 years of age to use higher-level inferences to connect the gist. In contrast, 8-and 11-year-olds are able to connect the gist when the DRM stimuli are presented in lists (though not necessarily as successfully as adults) and are therefore more susceptible to the illusion than 5-year-olds. However, once the gist of the DRM stimuli has been identified, 5-year-olds show greater susceptibility to the illusion than older children because they are less able to use verbatim traces to reject the critical lures at retrieval.

This explanation can also be couched in terms of the activation-monitoring account of the DRM illusion proposed by Roediger and McDermott (1995). In these terms, young children lack the semantic knowledge to identify the themes of the DRM lists and therefore fail to generate the critical lures. When the themes are made salient by the story contexts, 5-year-olds can make the associations that give rise to the illusion. They are then more likely than older children to falsely recognize the critical lures because of their relatively poor source monitoring skills. Thus, although the associative processes that lead to the DRM illusion develop with age, their effect is offset by developmental increases in the accuracy of the monitoring processes that inhibit false memories.

To summarize, the present study showed that 5-year-olds are less likely than 8- and 11-year olds to falsely recognize critical lures in the DRM procedure when the stimuli are presented in lists, but more likely than 8- and 11-year olds to falsely recognize critical lures when the stimuli are presented in stories. The format in which the DRM words were studied did not reliably influence levels of false recognition in the 8- and 11-year-olds. These findings indicate that the DRM procedure can be effective with young children when the stimuli are presented in a context that emphasizes their overall theme, and suggest that age-related differences in susceptibility to the DRM illusion are the result of developmental changes in both the representations formed at encoding and the strategies available at retrieval.

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Table 1. Mean Proportions of Correct Recognition and False Recognition of Critical and Unrelated Lures as a Function of Age and Study Format.

	5-year-olds	8-year-olds	11-year-olds
Correct recognition			
Lists	.61	.71	.80
Stories	.76	.69	.81
Critical lures			
Lists	.50	.69	.66
Stories	.81	.63	.65
Unrelated lures			
Lists	.20	.11	.01
Stories	.08	.10	.05

Appendix

An example of the stories used in this study (based on the "doctor" list taken from Roediger and McDermott, 1995). Words presented in the list format are underlined. The word "patient" was omitted from the study presentation in order to serve as a second critical lure.

The nurse had written a prescription for Sally because she was sick. Her mum, who was a lawyer, told Sally she had to take the medicine because it would improve her health. She said if Sally did not take it she would have to go to the hospital. Sally hated them more than the dentist. Sally saw a physician the last time she was ill. She went into his office and he listened to her heart with a stethoscope. She then went to a different clinic where she saw a surgeon who gave her the treatment she needed to cure her.