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ARTICLE

Effects of Presentation Format and List Length on Children's False Memories

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The effect of list length on children's false memories was investigated using list and story versions of the Deese/Roediger-McDermott procedure. Short (7 items) and long (14 items) sequences of semantic associates were presented to children aged 6, 8, and 10 years old either in lists or embedded within a story that emphasized the list theme. Subsequent tests of recognition memory revealed different effects of length for lists and stories across development. Longer lists produced more false alarms to critical lures for 8- and 10-year-olds only, and longer stories produced more false alarms to critical lures for 6-year-olds only. These results demonstrate that increasing the number of items presented at study increases false recognition for younger as well as older children when the theme of the items is made salient.

The Deese/Roediger-McDermott (DRM) procedure (Deese, 1959; Roediger & McDermott, 1995) has been used extensively to investigate memory errors in adults and children. Briefly, participants study lists of semantic associates of a nonstudied ''critical lure'' (e.g., participants study *hot, ice, snow*, etc., which are associates of the critical lure *cold*). When memory for the lists is tested, participants often falsely recall or recognize the critical lures at rates equaling or even exceeding those of correct recall and recognition. Although the DRM procedure reliably produces high levels of false recall and recognition in adults, a surprising finding from investigations of the DRM illusion in children is a developmental reversal, whereby levels of false memory increase with age (Brainerd, Reyna, & Forrest, 2002; Howe, 2005, 2006; Metzger et al., 2008; Wimmer & Howe, 2009, 2010; see Brainerd, Reyna, & Ceci, 2008, for a review). The aim of the current study

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was to investigate factors that influence the developmental trajectory of false recognition using variants of the DRM procedure. Specifically, we investigated the effects of varying the number of associates on false recognition using both the standard list version of the DRM procedure and an alternative version developed by Dewhurst, Pursglove, and Lewis (2007) in which the DRM stimuli are embedded within a story.

Two theoretical explanations for the developmental reversal in false memory have been proposed. According to fuzzy trace theory (FTT; Brainerd et al., 2008), participants encode two traces of study items—a verbatim trace that encodes specific details of an item and its encoding context and a gist trace that preserves relational information about the meaning of an item or list of items. It is the gist trace that is believed to be responsible for false memories. The age-related increase in false memories is attributed to developments in the ability to extract the gist traces of DRM lists. An alternative explanation is provided by associative activation theory (AAT; Howe, 2005; Howe, Wimmer, Gagnon, & Plumpton, 2009), which attributes false memories to the activation of associates of the list items. Developed from the activation–monitoring account proposed by Roediger, Watson, McDermott, and Gallo (2001), AAT attributes the developmental increase in false memories to the increasing automaticity with which associates are activated (see also Wimmer & Howe, 2009, 2010). Although FTT and AAT differ in terms of the processes assumed to underlie the DRM illusion, a core feature of both theories is that the developmental trajectory of false memories is driven by age-related changes in the representations formed at encoding.

The importance of encoding processes in determining the developmental trajectory of false memories is illustrated by the findings of Dewhurst et al. (2007). They found that the developmental reversal previously observed with lists was eliminated when DRM stimuli were embedded in a story. They presented 5-, 8-, and 11-year-olds with 14 associates either in a list (as in the standard DRM paradigm) or in a story that emphasized the list theme. In a subsequent recognition test, more false alarms to critical lures were made in the story format. There was also an interaction between age and presentation format, whereby 5-year-olds falsely recognized more critical lures in the story condition than in the list condition, but there were no such differences for 8- and 11-year-olds. In line with predictions from both AAT and FTT, 5-year-olds falsely recognized more unrelated lures in the list condition (where they failed to grasp the theme), and there was no difference between list and story formats in the endorsement of unrelated lures in 8- and 11-year-olds (where list and story themes were grasped equally well).

Story formats provide a useful vehicle for investigating false memories in young children because they increase relational processing relative to item-specific processing (Hunt & Einstein, 1981). Enhanced access to knowledge-based schemata also reduces the cognitive effort required to process the relations between associates (Bjorklund & Muir, 1988). Stories also allow other processes to come into play that may increase false memory, such as engagement with the material and higher-level knowledge in the form of schemas (see Dewhurst, Holmes, Swannell, & Barry, 2008). Presenting the DRM items in a story context may, therefore, reveal effects of experimental manipulations in younger children that are not readily observed with the standard list version of the DRM procedure. In the present study, we investigate the effects of list length on the developmental trajectory of false memories by manipulating the number of DRM items presented in lists versus stories.

Research with adults has shown that levels of false recall increase significantly with list length (e.g., Robinson & Roediger, 1997). A comparison of the first two published studies of the DRM illusion in children suggests that list length may also influence children's false memory. Brainerd et al. (2002) found near-floor levels of false recall among 5- and 7-year-olds, together with significantly lower levels of false recognition for 5-year-olds compared with 11-year-olds and adults, when participants studied lists of 12 (Experiment 1) or 15 (Experiments 2 and 3) associates. In contrast, Ghetti, Qin, and Goodman (2002) found a developmental *decrease* in false recall (but not in false recognition) between 5- and 7-year-olds and adults when lists of 7 associates were presented. Ghetti et al. suggested that the critical difference between their study and that of Brainerd et al. (2002) was the length of the study lists. However, Reyna, Mills, Estrada, and Brainerd (2007) suggested that the developmental decline in false recall observed by Ghetti et al. was an artifact of an inappropriate data scoring method. Ghetti et al. calculated levels of false recall by dividing the number of critical lures falsely recalled by the total number of words recalled (studied or unstudied). As Reyna et al. pointed out, this method led to higher levels of false recall in children relative to adults because levels of correct recall increased with age, while levels of false recall did not vary across age groups. Nevertheless, the null effects of age in raw false recall and in recognition memory observed by Ghetti et al. stand in contrast to the effects observed in subsequent studies and suggest that list length is an important factor in determining the developmental trajectory of false memory.

In a direct investigation of the effect of list length on false memory, Sugrue and Hayne (2006) presented eight lists composed of 7 or 14 associates to 9- and 10-year-olds and adults for immediate free recall followed by tests of recognition memory. They found age-related increases in false recall and false recognition for long lists but not for short lists (but see Carneiro, Alberquerque, Fernandez, & Esteves, 2007). Sugrue and Hayne argued that adults receive greater activation of the critical lure from studying long lists because they have a more extensive associative network than children do. Children, on the other hand, experience similar levels of activation from short and long lists but find long lists harder to source monitor. Sugrue and Hayne suggested that this pattern led to higher levels of false memory for 10-year-olds in the long-list condition. In a follow-up study, Sugrue, Strange, and Hayne (2009) also found higher levels of false recall with longer lists. In addition, they conducted a postrecall analysis of source monitoring by asking participants to report other items they had thought about, but not reported, during the study phase. They found no significant main effects or interactions involving age and list length in the postrecall phase and concluded that the effect of list length is due entirely to associative processes at study.

Although Sugrue and Hayne (2006) found that list length had a greater effect on adults than on children, they did not report whether list length had a significant effect on children's false memory, although levels of false recall and false recognition in the 9- and 10-year-olds were numerically higher for long lists than for short lists. However, Sugrue et al. (2009) concluded that adults were no more likely than 10-year-olds to activate the critical lures. To determine the developmental trajectory of list-length effects, the current study recruited children younger than those tested by Sugrue and colleagues. We also investigated whether effects of list length would be enhanced in children when the list items were embedded within a story. If the effect of list length is driven by the activation of associates at encoding, as Sugrue et al. concluded, then embedding the DRM lists into story contexts that emphasize their semantic theme should increase children's false recognition by facilitating activation processes. Our primary interest was in how the effects of list length and presentation format would interact with age.

METHOD

Participants

One hundred and seventy-three children were recruited from local primary schools. There were fifty-seven 6-year-olds ($M_{age} = 6;0$), fifty-seven 8-year-olds ($M_{age} = 8;0$), and fifty-nine 10-year-olds ($M_{age} = 10;11$). All children were native English speakers and had no reported history of learning or hearing difficulties. Children were awarded a sticker in return for their participation.

Design

A 3 (age: 6, 8, and 10 years) × 2 (format: lists vs. stories) × 2 (length: short vs. long) mixed-factorial design was used, with repeated measures on the third factor. The dependent variables were the number of hits to targets and the numbers of false alarms to critical lures, semantic lures, and unrelated lures.

Materials

The materials were based on those used by Dewhurst et al. (2007) and consisted of the critical lures *cold, doctor, fruit, lion, music, sleep, smell,* and *thief*, taken from Stadler, Roediger, and McDermott (1999). For each critical lure, Dewhurst et al. (2007) selected 14 of the associates and presented them in a list or embedded into a story in descending order of backward associative strength. The remaining associate from the Stadler et al. norms was not presented but was used as a second critical lure in the recognition test. In the present study, all second semantic lures were taken from positions 9 or 10 of the original lists developed by Stadler et al.

To manipulate length, 2 lists were generated per critical lure. Long lists were simply those used by Dewhurst et al. (2007), and short lists were composed of 7 items from these lists. The position of the items chosen for the short lists varied depending on the theme to ensure that the short lists could be made into a coherent story. The 16 lists (8 short and 8 long per critical lure) were embedded into stories that emphasized the theme of the critical lure. Most of the stories were adapted from Dewhurst et al. (2007). For stories with 14 associates, the mean word length was 99.38 words (range = 93–106), and for stories with 7 associates, the mean word length was 50.63 words (range = 48–53). See the Appendix for an example of the 7- and 14-item stories.

The lists/stories were separated into two sets for counterbalancing purposes. The sets were devised according to the norms generated by Stadler et al. (1999) and were matched for backward associative strength. Set 1 was composed of *doctor, smell, thief,* and *fruit*, and Set 2 was composed of *cold, sleep, music,* and *lion*. In each condition, half the participants heard Set 1 materials in short format and Set 2 materials in long format, and half the participants heard Set 2 materials in short format and Set 1 materials in long format. There was a 10-item recognition test for each list/story, which was composed of three targets (taken from Positions 2, 4, and 6 of the short study lists), the critical lure, the second semantic lure, and five unrelated lures. The second semantic lure was included to be consistent with Dewhurst et al. (2007). However, preliminary analyses indicated that the critical lure and the second semantic lure together were a less sensitive measure than the critical lure alone. The second semantic lure will not, therefore, be discussed further.

Procedure

Participants were tested in a quiet area of their school. The experimenter explained what the participant would be required to do and then sought verbal assent from the child to continue. All children were told that this was not a test they could pass or fail. Lists were read out by the experimenter at a rate of approximately one item every 1.5 seconds. Stories were read at a normal reading pace. After the presentation of the first list/story, the following instructions were given to participants:

> *I'm going to read out some words now. Some of them were in the list/story you just heard and some of them are tricks that were not in the list/story. For each word, I'd like you to say to me either 'yes' if it was definitely in the list/story or 'no' if it definitely wasn't in the list/story or 'don't know' if you aren't sure whether it was or it wasn't in the list/story.*

The experimenter then tested the participants' understanding of the instructions by saying, "*For example, if I said the word 'school,' what would you say?*" All participants correctly confirmed that the word *school* had not been presented. The experimenter then proceeded to read out the remaining materials until all eight trials had been completed. Before subsequent recognition tests, the experimenter abbreviated the above instructions to remind participants of the response options.

RESULTS

Prior to statistical analyses, *yes, no*, and *don't know* responses for targets, critical lures, and unrelated lures were calculated for each participant. Mean numbers of *yes* responses are presented in Table 1. To control for age-related differences in response bias, *A*' scores were computed for hits and critical lures using the false alarm rates for unrelated lures. *A*' scores are also shown in Table 1. We used *A*' rather than *d*' because *A*' has been shown to be the more accurate measure when criterion changes occur (see Donaldson, 1993), as is typically the case when comparing across different age groups. The *A*' scores for hits and critical lures were entered into separate 3 (age: 6-, 8-, and 10-year-olds) × 2 (format: list, story) × 2 (length: short, long) mixed analyses of variance (ANOVAs) with repeated measures on length. Post-hoc tests were conducted using a Tukey correction, and simple main effects were explored via a series of univariate and repeated-measures ANOVAs. The alpha level was set at .05, and effect sizes are given by partial eta squared (η_p^2).

Correct Recognition of Targets

There was a significant main effect of age, $F(2,167) = 20.42$, $MSE = 0.01$, $\eta_p^2 = .24$, with significant differences between 6- and 8-year-olds and between 6- and 10-year-olds. There was also a significant main effect of length, $F(1,167) = 6.95$, $MSE = 0.01$, $\eta_p^2 = .04$, with greater recognition

TABLE 1
Mean Number of 'Yes' Responses to Targets, Critical Lures (CL), and Unrelated Lures in Short- and Long-Story and -List Conditions for 6-, 8-, and 10-Year-Olds, Plus A' Scores for Targets and Critical Lures

	6 years		*8 years*		*10 years*	
	Short	*Long*	*Short*	*Long*	*Short*	*Long*
Lists						
Target	8.00 (0.47)	7.76 (0.51)	9.54 (0.38)	9.25 (0.41)	10.38 (0.26)	9.31 (0.34)
CL	1.93 (0.19)	1.90 (0.23)	2.39 (0.21)	3.07 (0.15)	2.24 (0.20)	2.93 (0.22)
Unrelated	0.62 (0.26)	0.83 (0.28)	0.07 (0.05)	0.14 (0.07)	0.03 (0.03)	0.10 (0.08)
A' Hits	0.88 (0.02)	0.87 (0.02)	0.93 (0.01)	0.92 (0.01)	0.95 (0.01)	0.92 (0.01)
A' CL	0.83 (0.01)	0.80 (0.02)	0.88 (0.01)	0.91 (0.01)	0.86 (0.02)	0.91 (0.01)
Stories						
Target	8.07 (0.45)	7.43 (0.37)	9.24 (0.30)	8.72 (0.47)	10.17 (0.26)	9.87 (0.26)
CL	2.43 (0.21)	3.00 (0.15)	3.14 (0.18)	3.17 (0.17)	3.20 (0.10)	3.20 (0.16)
Unrelated	0.75 (0.20)	0.79 (0.22)	0.72 (0.31)	0.93 (0.30)	0.57 (0.16)	0.60 (0.16)
A' Hits	0.88 (0.01)	0.87 (0.01)	0.91 (0.01)	0.90 (0.01)	0.93 (0.01)	0.93 (0.01)
A' CL	0.86 (0.02)	0.89 (0.01)	0.91 (0.01)	0.90 (0.01)	0.91 (0.01)	0.91 (0.01)

Note. Standard errors are given in parentheses.

accuracy in the short condition than in the long condition. No other effects reached statistical significance.

False Recognition of Critical Lures

There was a significant main effect of age, $F(2{,}167) = 14.11$, $MSE = 0.01$, $\eta_p^2 = .15$. Pairwise comparisons showed reliable differences between 6- and 8-year-olds and between 6- and 10-year-olds, but not between 8- and 10-year-olds. Second, there was an effect of format, $F(1{,}167) = 11.87$, $MSE = 0.01$, $\eta_p^2 = .07$, with higher levels of false recognition in the story condition than in the list condition. Finally, there was an effect of length, $F(1{,}167) = 5.06$, $MSE = 0.01$, $\eta_p^2 = .03$, with higher levels of false recognition in the long condition than in the short condition.

Although none of the first-order interactions were significant, there was a significant age $\times$ length $\times$ format interaction, $F(2{,}167) = 8.31$, $MSE = 0.01$, $\eta_p^2 = .09$. To explore this interaction further, separate age $\times$ length ANOVAs with repeated measures on length were performed for the list and story conditions. For the list condition, there was a significant main effect of age, $F(2{,}83) = 10.36$, $MSE = 0.01$, $\eta_p^2 = .20$, with significant differences between 6- and 8-year-olds and between 6- and 10-year-olds. The main effect of length was not significant, $F(1{,}83) = 2.51$, $MSE = 0.01$, $\eta_p^2 = .03$, $p = .12$. There was, however, a significant age $\times$ length interaction, $F(2{,}83) = 5.03$, $MSE = 0.01$, $\eta_p^2 = .11$. Planned comparisons indicated that both 8- and 10-year-olds falsely recalled significantly more critical lures in the long condition than in the short condition. This pattern was reversed in 6-year-olds but did not reach statistical significance, $p = .10$. A reliable effect of age was observed for long lists, with 6-year-olds showing significantly lower levels of false recognition than both 8- and 10-year-olds, who did not differ reliably from each other. No significant effects of age were observed with short lists. The age $\times$ length interaction can be seen in Figure 1.

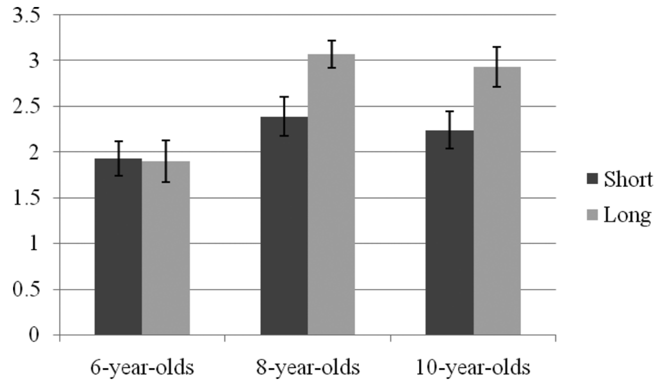

FIGURE 1 Mean numbers (with standard errors) of false alarms to critical lures in the short- and long-list conditions as a function of age.

For the story condition, there was a main effect of age, $F(2,84) = 4.14$, $MSE = 0.01$, $\eta_p^2 = .09$. Pairwise comparisons showed a significant difference between 6- and 10-year-olds only. The main effect of length was not significant, $F(1,84) = 2.97$, $MSE = 0.01$, $\eta_p^2 = .03$, $p = .09$. This was qualified by a significant age × length interaction, $F(2,84) = 3.51$, $MSE = 0.02, \eta_p^2 = .08$. Planned comparisons showed that 6-year-olds falsely recalled significantly more critical lures in the long condition than in the short condition. No effects of length were observed for 8-year-olds, $p = .81$, or 10-year-olds, $p = .95$. A reliable effect of age was observed for short stories, with 6-year-olds showing significantly lower levels of false recognition than both 8- and 10-year-olds, who did not differ reliably from each other. No significant effects of age were observed with long stories. The interaction is illustrated in Figure 2.

It is clear that the cause of the second-order interaction is the different pattern of results for list and story conditions. For stories, there is a length effect for 6-year-olds only, and for lists, the reverse is true with a length effect for 8- and 10-year-olds only. Additionally, in the story

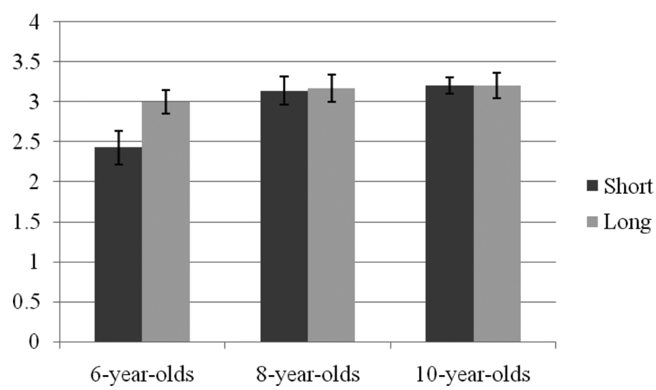

FIGURE 2 Mean numbers (with standard errors) of false alarms to critical lures in the short- and long-story conditions as a function of age.

condition, false alarm rates only increased with age in the short condition, and for lists, the reverse was true with false alarm rates increasing in the long condition only.

DISCUSSION

The aim of the current study was to investigate the effects of list length and presentation format on children's susceptibility to the DRM illusion. As predicted, different age $\times$ length interactions for story and list formats were observed. For lists, there were reliable effects of length at 8 and 10 years of age but not for 6-year-olds, whereas for stories, the opposite pattern was observed, with an effect of length at 6 years and not at 8 and 10 years old. In addition, false recognition increased for long lists only and for short stories only, as a function of age. Contrary to predictions, an age $\times$ format interaction was not found. Overall, the dominance of the story format in eliciting false memories held at all ages and not just for 6-year-olds. Although the effect of age for lists was expected, the effect of age for stories is somewhat surprising and contrary to what was found by Dewhurst et al. (2007). This effect is, however, consistent with the findings of Howe and Wilkinson (2011) of a reliable, although attenuated, effect of age in false recognition using story contexts.

The pattern of results suggests that the effects of list length and presentation format are additive for younger children. Increasing the number of items in a list did not raise levels of false recognition for the 6-year-olds, but increasing the number of items in a story did. For 6-year-olds then, when study conditions encourage the spontaneous processing of the theme of associates (i.e., in the story condition), extra associates increase activation processes. This is probably because at 6 years old, the story format increases the automaticity of the processes that underpin false memories in older children and adults. Automatic processes by definition require fewer cognitive resources, thereby enabling young children to process the additional items. Older children in the story format can process relatively few associates with ease and so do not benefit from the extra associates. However, in the list condition, where study format does not encourage automaticity in the processing of thematic content, extra associates create an overload such that 6-year-olds cannot utilize them effectively. It is only with increased age and the development of automaticity in processing semantic relatedness that extra associates increase false memory.

These findings provide further evidence that young children can process semantic relatedness in a way that generates theme-consistent false memories. As discussed above, story formats allow young children to spontaneously access relevant knowledge bases and schemata that can lead to false memories. According to Bjorklund (1987), age-related differences in knowledge bases are correlated with age-related differences in the speed and efficiency with which individual items are activated in semantic memory systems. As a result, less cognitive effort is required to process the relatedness of items as a function of the complexity and size of relevant knowledge bases. According to activation accounts of the DRM illusion, false-memory formation is reliant on such processes. Due to the presence of automatic spreading activation in the story format, young children can use extra associates to increase levels of activation. Older children do not gain extra activation from the presentation of additional associates because their level of activation is likely to be at ceiling in the short condition. Conversely, in the list format, older children can use extra associates to boost their levels of activation (due to the relative maturity of their semantic networks), but young children fail to do this because they simply do not possess the means, either cognitively or neurologically, with which to increase activation.

The above account is in agreement with the explanation of list-length effects proposed by Sugrue et al. (2009). They considered two potential explanations for the list-length effects found by Sugrue and Hayne (2006). Specifically, do long lists activate the critical lure more often, or do short lists promote source monitoring? They found that participants who studied short lists were no more likely than those studying long lists to report a nonrecalled critical lure at the postrecall phase. This, they argued, is indicative of short lists *not* facilitating source monitoring. In addition, they found a higher proportion of critical lure recall and postrecall in the long condition. This suggests that activation of the critical lure is the crucial factor in accounting for the differences between short and long lists. As discussed above, a central element of AAT (Howe, 2005; Howe et al., 2009) is that age-related improvements in source monitoring are not essential in accounting for developmental trends in false memory in the DRM paradigm and that developmental increases in activation predominantly drive the increases in false memory. Howe and colleagues proposed that activation of unpresented critical lures in the DRM paradigm increases so rapidly between early and late childhood that developmental increases in the ability to monitor the source of a memory (see Cycowicz, Friedman, Snodgrass, & Duff, 2001; Lindsay, Johnson, & Kwon, 1991) provide little restraint. The current findings are easily accommodated by AAT in that longer lists and story contexts increase the automaticity with which critical lures are activated at study. Whereas either factor alone is sufficient to increase the activation of the critical lures in 8- and 10-year-olds, both are required to produce equivalent levels of activation in 6-year-olds.

The current findings can also be explained by FTT (Brainerd et al., 2008). Both younger and older children spontaneously extract gist in the story format, whereas only older children can do so in the list format. According to Brainerd and Reyna (2002), false memory will decrease or will not alter with age if young children are able to store and retrieve relevant gist traces (as they can do in the story format). The spontaneous extraction of gist in the story format allows young children to use additional associates to strengthen this gist trace. For older children, improved recollection rejection strategies are suppressed for short stories due to the strength of the gist trace, and so both short and long stories elicit high levels of false memory. For lists, individuals become more adept at extracting gist across development (Brainerd et al., 2008). Therefore, false memory should be expected to increase with age. Where gist extraction is spontaneous (in older children and adults), additional associates serve to increase gist and thus create more false memories. This creates a developmental increase in false memory for long lists. However, false memory does not increase as a function of age for short lists because increases in gist processing are opposed by strengthened verbatim strategies.

To summarize, the current study examined the development of semantic false memories in story and list formats. The results confirm previous findings by Dewhurst et al. (2007) that story formats increase false memory in children, relative to lists. This qualifies the common finding that semantic false memory in the DRM paradigm increases significantly with age. The findings from the current study suggest that when young children are able to process automatically the relatedness of associates, manipulations that affect false memory in adults and older children also affect false memory in young children (i.e., length in the story format). However, when young children cannot process the relatedness of associates, such manipulations have little or no effect on false-memory production.

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APPENDIX

The 7- and 14-item Versions of the Story Format for the Critical Lure *Cold*

Items in italics are associates of the critical lure and were presented in the corresponding list versions.

Seven-item version. It was lovely and *hot* inside Jack's house, but when he looked out of the window, it was the middle of *winter* and thick *ice* covered the ground. Jack stepped out into his garden and realized that he didn't like the *weather*. Jack was sure that he would *freeze* as the atmosphere made him *shiver* and his teeth chatter. Jack imagined he was in the *arctic* because of all the white that surrounded him.

Fourteen-item version. It was *hot* inside Jack's house, but outside, he could see lots of *snow*. He didn't want to leave his *warm* house. It was *winter* and *ice* covered the *wet* ground. Jack went into his garden, and the *cool* wind made him feel *chilly*. He didn't like this *weather*. Jack thought he would *freeze* as the *air* made him *shiver*. Jack thought he was in the *arctic* because of all the *frost* around him.