Test-induced priming increases false recognition in older but not younger children

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Abstract

The effect of test-induced priming on false recognition was investigated in children aged 5, 7, 9, and 11 years using lists of semantic associates, category exemplars, and phonological associates. Consistent with effects previously observed in adults, nine- and eleven-year-olds showed increased levels of false recognition when critical lures were preceded by four studied items. This pattern was present with all three list types. In contrast, no effects of test-induced priming were observed in five- or seven-year-olds with any list type. The findings also support those of previous studies in showing a developmental shift from phonological to semantic false memories. The findings are discussed in terms of current theories of children's false memories.

Keywords: False memory; test-induced priming; memory development.

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In the Deese/Roediger-McDermott (DRM) procedure, named after studies by Deese (1959) and Roediger and McDermott (1995), participants study lists of words that are semantic associates of a nonstudied critical lure. For example, participants study words such as *bed, dream, awake,* and *tired*, which are associates of the critical lure *sleep*. When memory for the lists is tested, participants often falsely remember the critical lures, with levels of false recall and recognition often equalling or even exceeding levels of correct recall and recognition (for a review see Gallo, 2006). The DRM illusion has been explained in terms of an activation-monitoring account (Roediger, Watson, McDermott, & Gallo, 2001), in which it is suggested that participants spontaneously generate the critical lures at study and are then unable to remember the source of the lures (externally presented or internally generated) at test. An alternative account is provided by fuzzy-trace theory (FTT; Brainerd, Reyna, & Ceci, 2008), according to which 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.

Although the DRM procedure produces high levels of false recall and recognition in adults, children have been shown to be less susceptible to the effect. For example, Brainerd, Reyna, and Forrest (2002) found that false recall was at near-floor levels in 5- and seven-year-olds, and false recognition was reduced in five-year-olds relative to eleven-year-olds and young adults. Reduced susceptibility to the DRM illusion in children has been confirmed in a number of subsequent studies (e.g., Howe, 2006; Howe, Wimmer, Gagnon, & Plumpton, 2009; Metzger, Warren, Shelton, Price, Reed, & Williams, 2008; Odegard, Holliday, Brainerd, & Reyna, 2008; see Brainerd et al., 2008, for a review). Although levels of false memory in children can be increased under some conditions, for example when the DRM items are embedded in a story that emphasizes their overall theme (Dewhurst, Pursglove, & Lewis, 2007), there is little doubt that the standard list version of the DRM procedure is less effective with children than with adults.

Two theoretical accounts of young children's reduced susceptibility to the DRM illusion have been proposed. According to associative activation theory (AAT: Howe et al., 2009), false memories are caused by the activation of associates of the list items. Developed from the activation-monitoring account proposed by Roediger et al. (2001), AAT attributes the developmental increase in false memories to the increasing automaticity with which associates are activated (Wimmer & Howe, 2009, 2010). According to FTT (Brainerd et al., (2008), false memories increase with age because children are less able than adults to extract the gist traces of DRM lists. The two theories differ in terms of the underlying representations that are assumed to support the DRM illusion. Whereas AAT is based on associative relations between studied items and critical lures, FTT stresses the importance of across-list thematic relations. Nevertheless, a core feature of both theories is that false memories in the DRM procedure are driven largely by representations formed at study (associates of studied items or gist traces). The aim of the current study was to investigate whether false memories in children can be created by similar processes operating at retrieval.

Roediger and McDermott (1995) suggested that the DRM effect in adults could be due in part to associations activated at test. This possibility has been tested in a number of studies using the test-induced priming (TIP) procedure. In the TIP procedure, the number of studied items (or unstudied but related items) that precede the critical lure in the recognition test is manipulated. Although some studies have found no effects of TIP on false recognition (e.g., Dodd, Sheard, & McLeod, 2006), others have shown significant increases in false recognition when critical lures are preceded by several studied items. For example, Marsh and Dolan (2007) found that test primes increased false recognition when participants had to make old/new decisions before a 750 msec deadline. In addition, Coane and McBride (2006) found higher levels of false recognition in self-paced response conditions when critical lures were preceded by six or twelve studied items than by zero studied items (see also Dewhurst, Knott, & Howe, in press). Although the effects of activation at test are weaker than the effects of activation at study, the observed effects of TIP suggest that levels of false recognition can be increased by the activation of critical lures at test.

The aim of the current research was to investigate whether false recognition in children, as in adults, can be increased by TIP. From the perspective of the theories of false memory development discussed above, it is important to demonstrate that the processes believed to be responsible for the creation of false memories at study i) exert the same effect at test, and ii) show the same developmental pattern at test as at study. If TIP is caused by the same processes that lead to false recognition at encoding, then it can be predicted that the effects of TIP will show the same developmental trajectory as the standard DRM effect, whereby susceptibility will increase with age.

A second aim of the current study was to compare the effects of TIP on semantic (DRM) lists and lists organized in terms of other features. Previous research has shown that children are susceptible to false memories produced by lists of phonological associates (e.g., Holliday & Weekes, 2006) and by lists of category exemplars (e.g., Howe et al., 2009). For both list types, children have been shown to falsely recognize words that are consistent with the core theme of a list. By using all three lists types, we aimed to determine whether TIP produces a similar effect regardless of list type or whether susceptibility to TIP emerges earlier with some list types than with others.

In order to address these issues, we presented children aged 5, 7, 9, and 11 years with DRM lists, categorized lists, and lists of phonological associates. Within each list, the crucial manipulation was the position of the critical lure relative to the studied items, whereby half the critical lures were preceded by four studied items and half were not preceded by studied items.

The overall aim was to investigate developmental changes in the effects of TIP on the false recognition of associative, categorical, and phonological associates.

Method

Participants

Eight-six children were recruited from local schools, and consisted of 20 five-year-olds (*M*=5.38, *SD*= 0.26), 22 seven-year-olds (*M*=7.51, *SD*= 0.29), 23 nine-year-olds (*M*=9.69, *SD*= 0.34), and 21 eleven-year-olds (*M*=11.53, *SD*= 0.27). Children were predominantly white and middle class and were tested following parental consent and their own agreement on the day of testing.

Design, materials, and procedure

A 4 (Age: 5 vs. 7 vs. 9 vs. 11 years) x 2 (Priming: Primed vs. unprimed) x 3 (List type: Phonological vs. Category vs. DRM) design was used with repeated measures on the latter two factors. Participants were presented aurally with 12 lists of 10 items each. The DRM lists were adapted from Stadler, Roediger, and McDermott (1997) and consisted of semantic associates of the critical lures *sleep*, *foot, cold* and *sweet*. The category lists (vehicles, fruit, vegetables, and furniture) were taken from Van Overschelde, Rawson, and Dunlosky (2004). The highest frequency exemplar was used as the critical lure for each category (*car, apple*, *carrot*, and *chair*). The phonological lists were taken from Sommers and Lewis (1999) and consisted of phonological associates of the critical lures *back*, *cat*, *right*, and *pot.* The four lists of each type were presented in a single block followed by a recognition test. After the presentation of the last item of the fourth list within a block, participants carried out a 10 second distractor task before being presented with the recognition test. This procedure was then repeated for the two remaining blocks. The order of presentation for each block of lists and each list within the block was determined randomly for each participant.

Each recognition test contained 26 items in total, comprising 10 studied items (the first studied item from each list plus three additional studied items from the two lists in the primed condition), the 4 critical lures, and 12 unrelated items (randomly chosen from unstudied DRM, category, or phonological lists). For the two primed lists, the critical lures were presented after the four corresponding studied items. For the unprimed lists, the critical lures were presented before the corresponding studied item (only one studied item was presented for the unprimed lists in order to keep the recognition test to a length suitable for children). Recognition tests were presented aurally. The children were asked to respond "yes" if they remembered hearing the item and "no" if they did not. They were instructed to respond "yes" only if they were sure that a word had been presented in the study list. After the final recognition test, the children were thanked and told that they had done well.

Results

Table 1 shows the mean proportions of correctly recognized targets as a function of Age and List Type. In order to control for age-related differences in response bias, *A' scores were computed using the false alarm rate for* *unrelated lures (shown in the lower half of Table 1).* The *A'* scores were entered into a 4 (Age: 5 vs. 7 vs. 9 vs. 11 years) x 3 (List Type: DRM vs. category vs. phonological) mixed analysis of variance (ANOVA) with repeated measures on the second factor. Alpha was set at .05 for this and all subsequent analyses. A significant main effect of Age was observed, $F(3,82) = 5.37$, $MSE = .02$, $\eta_p^2 = .17$. Bonferroni-adjusted pairwise comparisons showed higher levels of correct recognition in both the nine- and eleven-year-olds relative to the five-year-olds, with no other significant differences. The main effect of List Type was also significant, $F(2,164) = 6.66$, $MSE = .01$, $\eta_p^2 = .08$. Pairwise comparisons showed higher levels of correct recall for DRM and category lists relative to the phonological lists, with no reliable difference between DRM and category lists. The interaction between Age and List Type was not significant ($F < 1$).

Our main focus was on the false recognition of critical lures, and in particular how levels of false recognition were influenced by test primes and list type. Table 2 shows the mean proportions of critical lures falsely recognized as a function of Age, List Type, and Priming. *A' scores were again computed using the false alarm rate for unrelated lures and* entered into a 4 (Age: 5 vs. 7 vs. 9 vs. 11 years) x 2 (Priming: primed vs. unprimed) x 3 (List Type: phonological vs. DRM vs. category) mixed ANOVA with repeated measures on the latter two factors. There was a significant main effect of Age, $F(3,82) = 17.92$, $MSE = .08$, $\eta_p^2 = .40$, with the five-year-olds showing significantly lower levels of false recognition than the other three age groups, who did not differ reliably from one another. There was also a significant main effect of Priming, $F(1,82) = 9.12$, $MSE = .03$, $\eta_p^2 = .10$, whereby false recognition were higher when critical lures were primed. The main effect of List Type was not significant ($F<1$).

The main effect of Priming was qualified by a significant interaction with Age, $F(3,82) = 4.53$, $MSE = .03$, $\eta_p^2 = .14$. Pairwise comparisons showed that priming significantly enhanced false recognition in nine- and eleven-year-olds, but not in five- or seven-year-olds. Separate 2 (Priming: primed vs. unprimed) x 3 (List Type: phonological vs. DRM vs. category) repeated measures ANOVAs were then conducted on the data from the nine- and eleven-year-olds. Nine-year-olds showed a significant priming effect, $F(1,20) = 4.33$, $MSE = .05$, $\eta_p^2 = .16$, but no significant main effect of List Type, $F=1.32$, and a nonsignificant interaction, $F<1$. Eleven-year-olds showed significant main effects of Priming, $F(1,20) = 24.50$, $MSE = .02$, $\eta_p^2 = .55$, and List Type, $F(2,40) = 7.87$, $MSE = .04$, $\eta_p^2 = .28$, with a nonsignificant interaction, $F<1.6$.

The main effect of List Type was qualified by a significant interaction with Age, $F(6,164) = 5.35$, $MSE = .14$, $\eta_p^2 = .16$. Separate 2 (Priming: primed vs. unprimed) x 3 (List: phonological vs. DRM vs. category) repeated measures ANOVAs for each age group showed that, for five-year-olds, false recognition was significantly higher for phonological critical lures relative to both DRM and category lists, which did not differ reliably from each other. There were no significant differences across list types for either seven- or nine-year-olds. For eleven-year-olds, false recognition was significantly lower for phonological critical lures relative to both DRM and category lists, which did not differ reliably from each other.

The interaction between Age and List Type was further explored in separate 4 (Age) x 2 (Priming) mixed ANOVAs for each list type. The analysis of critical lures of DRM lists showed a significant main effect of Age, $F(3,82) = 15.99$, $MSE = .06$, $\eta_p^2 = .37$. Pairwise comparisons showed significantly lower levels of false recognition by the five-year-olds relative to all other age groups, who did not differ reliably from one another. Neither the main effect of priming, $F<1.5$, nor the interaction, $F<1$, were significant. The analysis of phonological lures showed a nonsignificant main effect of Age, $F<1.2$, but a significant priming effect, $F(1,82) = 9.25$, $MSE = .03$, $\eta_p^2 = .10$. The interaction between Age and Priming was not significant, $F(3,82) = 2.29$, $MSE = .03$, $\eta_p^2 = .08$.

The analysis of category lists showed a significant main effect of Age, $F(3,82) = 15.28$, $MSE = .06$, $\eta_p^2 = .36$. Pairwise comparisons showed significantly lower levels of false recognition by the five-year-olds relative to all other age groups, who did not differ reliably from each other. The main effect of Priming was not significant, $F< 1$, but there was a significant Age x Priming interaction, $F(3,82) = 3.15$, $MSE = .03$, $\eta_p^2 = .10$. Pairwise comparisons showed that the priming effect with category lists was significant in the nine-year-olds but not in the other age groups.

Discussion

The main finding from the current study is that false recognition in nine- and eleven-year-olds was reliably increased by TIP. This pattern was present for DRM, category, and phonological lists in both age groups. In contrast, no effects of TIP were observed in five- or seven-year-olds with any list type. These findings support those of previous investigations of TIP in showing that the associative processes that give rise to the DRM illusion at study also occur at test. However, the current findings indicate that this effect does not occur before the age of nine. The effect of TIP on false recognition thus follows the same developmental trajectory as the standard DRM illusion, whereby susceptibility increases with age. Developmental improvements in the ability to generate associates (or to extract gist representations) not only increase susceptibility to associative memory illusions per se, they also increase susceptibility to the enhanced levels of false recognition caused by TIP.

The developmental patterns of false recognition for the different list types (DRM, category, and phonological) match those reported in previous studies. Consistent with the findings of Dewhurst and Robinson (2004), there was a developmental shift from phonological to semantic false memories, whereby five-year-olds were more likely to falsely remember critical lures from phonological lists than from DRM lists, while eleven-year-olds were more likely to falsely remember critical lures from DRM lists. This pattern is also consistent with earlier studies showing that younger children learn lists on an instance-by-instance basis rather than on the basis of semantic relatedness (Bjorklund, 1978, 1980) or make associations based on phonetic rather than semantic properties (Cramer, 1972). Neither seven nor nine-year-olds showed different levels of false memory as a function of list type. However, while phonological (and to a lesser extent categorical) false memories emerged in children as young as 5 years, no effects of TIP were observed in five- or seven-olds with phonological or categorized lists. This pattern indicates that, as well as developing relatively late in childhood, the processes that give rise to TIP are independent of list type.

As discussed above, the effect of TIP was reliably observed in both nine- and eleven-year-olds, and the pattern was present with all list types. The one difference to emerge between nine- and eleven-year-olds was a significant effect of List Type in the eleven-year-olds but not the nine-year-olds. Whereas levels of false recognition did not vary significantly across the different list types for nine-year-olds, eleven-year-olds showed significantly lower levels of false recognition for phonological lists relative to both DRM and category lists. This pattern indicates that, while effects of TIP emerge by nine years of age, developmental changes in susceptibility to different types of false memories continue beyond this age, with an increasing reliance on semantic associations relative to phonological associations.

We would argue that the current results show important developments in the trajectory of children’s ability to activate associates in response to test items. Analogous to the activation of associates at study, the ability to generate associates in response to test items develops with age. These findings can easily be accommodated by associative activation theory (Howe et al., 2009) by assuming that, like the activation of associates at study (e.g., see Wimmer & Howe, 2009, 2010), the activation of associates in response to test primes becomes increasingly automatic with age. In terms of fuzzy trace theory (Brainerd et al., 2008), it could be argued that gist extraction processes also occur at the retrieval phase in response to test primes. The current findings do not, therefore, arbitrate between AAT and FTT. However, the findings indicate that the encoding processes believed to be responsible for children’s false memories in these paradigms (increased automaticity of activation or the formation of gist traces) also operate online when memory is being tested.

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Table 1. Mean proportions (with standard errors) of correct recognition of targets and false recognition of unrelated lures as a function of Age and List Type.

Correct recognition of targets			
Age	DRM	Category	Phonological
5-year-olds	.64 (.06)	.62 (.06)	.75 (.05)
7-year-olds	.81 (.04)	.74 (.05)	.74 (.05)
9-year-olds	.83 (.03)	.80 (.04)	.76 (.03)
11-year-olds	.89 (.03)	.88 (.03)	.76 (.04)
False recognition of unrelated lures			
Age	DRM	Category	Phonological
5-year-olds	.20 (.06)	.15 (.06)	.34 (.07)
7-year-olds	.16 (.03)	.11 (.02)	.15 (.03)
9-year-olds	.13 (.02)	.11 (.02)	.18 (.03)
11-year-olds	.11 (.03)	.10 (.02)	.17 (.03)

Table 2. Mean proportions (with standard errors) of false recognition for critical lures as a function of Age, List Type, and Priming.

Age	DRM		Category		Phonological	
	Prime	No Prime	Prime	No Prime	Prime	No Prime
5-year-olds	.33 (.09)	.30 (.08)	.20 (.07)	.30 (.07)	.78 (.08)	.78 (.08)
7-year-olds	.68 (.07)	.68 (.07)	.68 (.08)	.73 (.08)	.77 (.06)	.73 (.08)
9-year-olds	.83 (.06)	.78 (.08)	.74 (.06)	.61 (.08)	.76 (.08)	.54 (.05)
11-year-olds	.95 (.03)	.81 (.07)	.81 (.05)	.67 (.07)	.76 (.07)	.45 (.07)