Research Article

ARE CHILDREN'S FALSE MEMORIES MORE PERSISTENT THAN THEIR TRUE MEMORIES?

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Abstract—*Fuzzy-trace theory predicts that children's false-memory responses will be well preserved over time, and that under specific conditions, they will be less likely to be forgotten than true-memory responses The reason is that initial true-memory responses are supported by unstable verbatim traces, whereas initial false-memory responses are supported by stable gist Data consistent with these predictions were obtained in three experiments with 5- and 8-year-olds*

False memory, as distinct from normal forgetting, refers to circumstances in which people report having experienced things that they have not experienced Psychologists have studied such phenomena for decades, with false alarms (false recognition of unpresented items) being the usual method of detecting them in experimentation (e g , Anisfeld & Knapp, 1968, Postman, 1951, Underwood, 1965) Recently, awareness of the psycholegal implications of false memories, especially in children, has spawned a rich new literature (Bruck & Ceci, in press, Cassel & Bjorklund, in press, Ceci & Bruck, 1993, Loftus, 1993, Reyna & Titcomb, in press)

There are important differences between classical and psycholegally inspired studies of false memory The former were chiefly concerned with spontaneous false memories, whereas the latter concentrate on deliberate production of false memories via misinformation (see Ceci & Bruck, 1993) Also, classical studies typically involved memory for words or sentences, whereas psycholegal studies deal with memory for everyday events of potential forensic significance (Reyna, 1995) There is commonality, however, when it comes to the issue of formation versus persistence of false memories Both literatures have focused squarely on the question of formation, the conditions that elevate false alarm rates for certain items in the first place The question of whether initial false-memory responses persist across forgetting intervals—and, if so, how their persistence compares with that of initial true-memory responses—has received little attention (Brainerd, in press)

This is a major gap in our understanding of these phenomena From a theoretical point of view, it is essential to determine which of the basic properties of true memories are shared by false ones On the practical side, in forensic interviews and in sworn testimony, decisions as to how to interpret responses that are consistent versus inconsistent over time turn on whether one believes that true-memory responses are more stable than other types of responses (Fisher & Cutler, 1992, Poole, in press)

What do memory theories have to say? The answer depends on one's assumptions about the processes that underlie initial true- and false-memory responses It depends, more particularly, on whether those processes are thought to be similar or different Similar-process theories (cf Loftus & Hoffman, 1989) assume that the types of representations that support true- and false-memory responses are not qualitatively different, whereas different-process theories (cf Reyna, 1995) assume that they are So, in the former case, predictions about relative persistence turn on how much of the unitary memory variable is thought to be available to support true and false responses, respectively (Brainerd, in press) In the latter case, such predictions turn on assumptions about the respective forgetting rates of qualitatively distinct memory processes (Reyna & Brainerd, 1995)

For both misinformation-induced and spontaneous false alarms, similar-process explanations have predominated Most theories of misinformation-induced false alarms assume that subjects first store memories of the target material and that, later on, they store memories of the misinformation When memory tests are administered, false alarms to distractors that contain misinformation may be elevated because (a) true memories were lost before the misinformation was presented, so that only false memories are now accessible, or (b) storage of false memories distorted true memories (e g , via substitution, partial overwriting, blending), or (c) true and false memories are both available but the latter interfere with retrieval of the former, or (d) some combination of these possibilities (for a review, see Loftus & Hoffman, 1989) The standard account for spontaneous false alarms is found in global memory models, such as MINERVA (Hintzman, 1988), SAM (Gillund & Shiffrin, 1984), and TODAM (Murdock, 1982) As targets are studied, their features are stored as values of some unidimensional memory scale When probes are presented on memory tests, the probes' encoded values are compared with stored values of targets Although the encoded values of distractors cannot resemble stored values as much as the encoded values of targets, resemblance may exceed the recognition threshold, producing false alarms

The key assumption of different-process approaches, such as fuzzy-trace theory (Brainerd & Reyna, 1993, Reyna & Brainerd, 1995) and two-memory models of recognition (e g , Gardiner & Java, 1991, Jacoby, 1991), is that target and distractor probes recruit fundamentally different types of memories from storage Experiments on fuzzy-trace theory (e g , Brainerd & Gordon, 1994, Reyna & Kiernan, 1994) have led to a specific model of those memories, one that generates predictions as to the relative persistence of true- and false-memory responses These experiments have suggested that when targets are exposed for study, subjects store dissociated representations of the surface forms of the exposure events (verbatim memories) and of the patterns and meanings that targets instantiate (gist

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memories) On initial memory tests, targets predominantly cue the retrieval of verbatim memories, producing definite recollections of having experienced those specific items, but distractors cue the retrieval of gist memories, producing vague impressions of similarity Thus, hits seem to involve judgments of identity between the surface forms of probes and verbatim memories (often called feelings of remembering), whereas false alarms seem to involve judgments of similarity between the meanings of probes and gist memories (often called feelings of knowing)

What predictions do similar- and different-process theories make about persistence? Both approaches assume that false alarms can be memory based, which means that they should display temporal stability The question is, how stable should false alarms be, relative to hits? According to similar-process theories, false alarms will be less persistent than hits For spontaneous false alarms, the reason is obvious [1] Hits must be based on resemblance values that are farther above threshold (and therefore less likely to fall below threshold after a forgetting interval) because targets necessarily resemble themselves more than they resemble distractors According to different-process theories, however, the answer depends on the respective survival rates of the memories that are recruited by targets versus distractors

Fuzzy-trace theory assumes that on initial tests, targets predominantly cue the retrieval of verbatim memories, but distractors cue the retrieval of gist A familiar principle of memory (e g , Kintsch, Welsch, Schmalhofer, & Zimny, 1990) says that as time passes, verbatim memories become inaccessible more rapidly than gist, so that the memorial basis for initial hits fails more rapidly than that for initial false alarms This principle leads to three predictions that we explored in our experiments First, although, normally, initial hits would be memory based more often than initial false alarms, their respective persistence rates might be comparable because of the superior stability of gist Second, in situations in which the two are memory based about equally often, initial false alarms should be more persistent than hits owing to the superior stability of gist Third, in situations in which the tendency to process gist on distractor probes increases across conditions, so should persistence rates for false alarms Because this tendency increases with age (Brainerd, Reyna, & Kneer, 1995), developmental designs provide one method of evaluating the third prediction Another method is to increase distractors' ability to cue stored gist by increasing the degree of gist overlap between distractors and studied targets

EXPERIMENT 1

The aim of this experiment was to acquire preliminary data on the first and third predictions under conditions that should actually favor similar-process predictions over different-process predictions Using a standard recognition design, we presented children of two age levels with familiar, meaningful targets, followed by a recognition test on which the distractors were also familiar, meaningful items, followed by a repetition of this test 1 week later Distractors were not related to targets in meaning Therefore, initial hits should have been memory based much more often than false alarms, and according to similar-process theories, memory-based hits should involve resemblance values that are much farther above threshold than memory-based false alarms

However, according to fuzzy-trace theory, target presentation leads to the storage of multiple representations at varying levels of gist (Reyna & Brainerd, 1992) Specific targets such as *music* or *meal* may lead to the storage of qualities such as "pleasant," which may then be evoked by a large number of meaningful but nominally unrelated distractors (cf Wittlesea, 1993) Even if initial false alarms were memory based far less often than hits, their overall levels of persistence might be quite high if, when they were memory based, such stable gists were processed Thus, contrary to the similar-process view, false alarms could be as stable as hits

Method

The subjects were 30 kindergarten children (mean age = 5 years, 9 months) and 31 third-grade children (mean age = 8 years, 11 months) They were informed that a vocabulary list would be read to them and that their memory for the words would be tested Each child then listened to an audio recording of 60 familiar, highly meaningful, concrete nouns (level A or AA, $m > 6$, and $C > 6.0$ on the Paivio, Yuille, & Madigan, 1968, norms) Words were read in random order at a 3-s rate The list was constructed by sampling 60 words at random from a larger pool of 120 The presentation order of the sampled words was determined randomly for each individual subject After listening to the recording, the child participated in a 5-min buffer activity, a naturalistic hidden figures test called *Where's Waldo?* (Handford, 1987), in which the task is to find a particular character (Waldo) in familiar crowd scenes

A yes-no recognition test was then administered Instructions were given to say "yes" to any word heard earlier and to say "no" to all other words The child was told to give the best answer he or she could if not completely certain The experimenter then read a test list composed of 30 targets and 30 distractors, and the child responded in a self-paced manner Individual test lists were constructed by randomly eliminating 30 of the presented words and replacing them with 30 new words from the pool One week later, each child returned for a second recognition test The procedure was identical to the test phase of the first session That is, the child was given the same instructions and responded to the same test list in a self-paced manner

Results

Principal interest attaches to whether initial false alarms persisted across the forgetting interval and, if they did, to whether they were more or less persistent than hits and whether persistence increased with age We used standard stochastic depen-

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[1] Similar-process theories do not necessarily make this prediction about misinformation-induced false alarms owing to the fact that misinformation is presented after an interval in which forgetting of the target memory may have occurred For this reason, we concentrated on spontaneous false alarms in our experiments

dency analyses of conditional and unconditional probabilities (likelihood ratios; for details, see Brainerd & Reyna, 1995) to answer these questions. The relevant probabilities appear in Rows 1 through 4 of Table 1.

Persistence of false alarms

Did initial false alarms tend to recur a week later? If so, the delayed false alarm rate for distractors that produced initial false alarms would exceed the base rate of false alarms on the delayed test. Statistically, the conditional probability of a delayed false alarm given an initial false alarm would exceed the unconditional probability of a delayed false alarm. (The conditional probability is the delayed false alarm rate for distractors that produced an initial false alarm, and the unconditional probability is the base rate.)

Each conditional false alarm probability exceeded the corresponding base rate (Table 1, Rows 1 and 2). The difference was reliable for both younger children ($\chi^2 = 35.16, p < .0001$) and older children ($\chi^2 = 101.52, p < .0001$).[2]

Relative persistence of false alarms and hits

Hits, like false alarms, were preserved across the forgetting interval because the conditional probability of a delayed hit given an initial hit was greater than the base rate for delayed hits at both age levels (Table 1, Rows 3 and 4). This difference was reliable for both younger children ($\chi^2 = 60.88, p < .0001$) and older children ($\chi^2 = 72.84, p < .0001$).

Which type of response, false alarm or hit, was more persistent? For each, the persistence rate is the proportion of delayed responses of that type for which the same response occurred on the initial test, which is given by the relevant conditional probability in Table 1. If the persistence rates for the two types of responses were the same, the conditional probabilities in the second row (false alarms) would equal the corresponding conditional probabilities in the fourth row (hits). This null hypothesis was rejected for younger children ($p < .05$ by a likelihood ratio test) but not for older children. As can be seen in Table 1, the persistence rate for hits exceeded the persistence rate for false alarms in younger children, but there was a trend in the opposite direction in older children.

Developmental changes in persistence

There were age increases in persistence rates for both false alarms and hits. Only the increase for false alarms was reliable ($p < .01$ by a likelihood ratio test). Thus, Experiment 1 showed that initial false alarms were preserved across a 1-week forgetting interval, that they were sometimes preserved as well as hits, and that they were preserved better by older children than by younger ones.

EXPERIMENT 2

The purposes of Experiment 2 were to test the predictions that false alarm persistence should increase with increases in gist processing on distractors and that initial false alarms can be more persistent than hits. We measured false alarms in two conditions in which distractors were semantically related to the targets. In one condition, in which gist processing was expected to be high, targets that were typical exemplars of familiar categories (e.g., *cat, red*) were replaced by corresponding category names (e.g., *animal, color*) on immediate and delayed tests.

Table 1 *Conditional and unconditional probabilities of delayed hits and false alarms*

Probability	Age level Younger	 Older
Experiment 1		
$p(FA_d)$	.411	.452
$p(FA_d)\|FA_i)$	.595	.787
$p(H_d)$	.608	.642
$p(H_d\|H_i)$	.695	.715
Experiment 2		
Categories condition		
$p(FA_d)$ categories	.494	.479
$p(FA_d)\|FA_i)$ categories	.905	.930
$p(FA_d)$ unrelated	.389	.488
$p(FA_d\|FA_i)$ unrelated	.620	.840
$p(H_d)$	.588	.675
$p(H_d\|H_i)$	.678	.771
Rhymes condition		
$p(FA_d)$ rhymes	.543	.555
$p(FA_d\|FA_i)$ rhymes	.733	.840
$p(FA_d)$ unrelated	.396	.474
$p(FA_d\|FA_i)$ unrelated	.645	.794
$p(H_d)$	.581	.695
$p(H_d\|H_i)$	.691	.749

Note. FA_d = delayed false alarm, FA_i = initial false alarm, H_d = delayed hit, and H_i = initial hit.

In a second condition, in which gist processing was expected to be lower, targets that had familiar, meaningful rhymes (e.g., *cat, red*) were replaced by those rhymes (e.g., *bat, bed*) on immediate and delayed tests. Semantic-priming studies have shown that the members of familiar rhyme pairs activate each other's meanings (Gernsbacher & Faust, 1995; Siegel, 1993), a key finding being that decision times for targets (e.g., *baseball, sleep*) are affected when prime words (e.g., *cat, red*) rhyme with words (e.g., *bat, bed*) that share meaning with targets. However, such activation ought to be weaker than that for category names.

Thus, there is a clear prediction about the ordering of persistence rates for false alarms. These rates should be higher for categories than for rhymes and higher for both of these kinds of target-related distractors than for nominally unrelated distractors. In addition, because false alarms to target-related distractors are very likely to be based on stable gist memories, persistence rates could be higher for false alarms than for hits in these two conditions.

Method

The subjects were 60 kindergartners (mean age = 5 years, 9 months) and 60 third graders (mean age = 8 years, 10 months).

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[2] Throughout the experiments reported here, differences between conditional and unconditional probabilities were tested for significance using likelihood ratio statistics. These statistics are asymptotically distributed as χ^2 with one degree of freedom.

Half of the children from each age level participated in the categories condition and half participated in the rhymes condition.

The procedure in each condition was the same as in Experiment 1, except for two modifications. First, the study and test lists consisted of 64 (rather than 60) familiar, meaningful, concrete nouns. Second, the test list for each child was constructed by (a) replacing 16 of the presented targets with 16 randomly selected items from the word pool (unrelated distractors) and by (b) replacing another 16 of the presented targets with either the names of familiar categories to which they belonged (categories condition) or familiar rhymes (rhymes condition). Examples of target-related distractor pairs were *cat-animal, steel-metal,* and *red-color* (categories condition) and *cat-bat, steel-meal,* and *red-bed* (rhymes condition).

Results

The conditional and unconditional probabilities for this experiment appear in Rows 5 through 16 of Table 1. We were still interested in persistence of false alarms, in the relative persistence rates of false alarms and hits, and in developmental changes in false alarm persistence. We were also interested in whether false alarm persistence rates followed the theoretically expected ordering. They did. Pooled across age levels, the persistence rates for false alarms (the conditional probability of a delayed false alarm given an initial false alarm) were .918 (categories), .787 (rhymes), and .725 (nominally unrelated distractors).

Persistence of false alarms

Children's initial false alarms were preserved over time. In the categories condition, the conditional probability of a delayed false alarm given an initial false alarm for category names exceeded the base rate for delayed false alarms for category names in younger children ($\chi^2 = 179.73, p < .0001$) and older children ($\chi^2 = 138.56, p < .0001$). The same was true for nominally unrelated distractors in younger ($\chi^2 = 24.82, p < .0001$) and older ($\chi^2 = 66.10, p < .0001$) children. In the rhymes condition, the conditional probability of a delayed false alarm given an initial false alarm for rhymes exceeded the base rate for delayed false alarms for rhymes in younger children ($\chi^2 = 62.94, p < .0001$) and older children ($\chi^2 = 88.27, p < .0001$). The same was true for nominally unrelated distractors in younger ($\chi^2 = 29.73, p < .0001$) and older ($\chi^2 = 54.49, p < .0001$) children.

Relative persistence of false alarms and hits

Children's initial hits, like their initial false alarms, were preserved over time. This was true in the categories condition ($\chi^2 = 74.66, p < .0001$, for younger children and $\chi^2 = 77.56, p < .0001$, for older children) and in the rhymes condition ($\chi^2 = 85.48, p < .0001$, for younger children and $\chi^2 = 61.72, p < .0001$, for older children).

What about the relative persistence of false alarms and hits? The results were different than in Experiment 1 because false alarms to target-related distractors were preserved better than hits. For both false alarms and hits, the statistical indices of persistence are again the conditional probabilities in Table 1. Among younger children, false alarm persistence rates for categories and rhymes were greater than the corresponding rates for hits. The difference for categories was reliable ($p < .005$). Among older children, false alarm persistence rates for categories and rhymes were also greater than the corresponding rates for hits, and both differences were reliable ($ps < .01$). The persistence rates for false alarms to nominally unrelated distractors did not differ from the persistence rates for hits for younger children or for older children in either condition.

Developmental changes in persistence

As in Experiment 1, persistence rates for nominally unrelated distractors increased with age, and so did persistence rates for rhymes ($ps < .01$). Persistence rates for categories did not increase with age, but values were near ceiling. In contrast to the results for Experiment 1, age increases in hit rate persistence were reliable, in both conditions ($ps < .01$).

EXPERIMENT 3

We have found that children repeat spontaneous false alarms with high probability after a forgetting interval, and with even higher probability than hits when distractors share semantic relationships with targets. Our explanation emphasizes the processing of stable gist on distractor probes. Contrary to this explanation, it is possible that target-distractor surface resemblance could also enhance the survival of false alarms. It is well known that, like semantic resemblance, surface resemblance between meaningless targets and distractors (e.g., nonsense words) elevates initial false alarm rates (e.g., Reitman & Bower, 1972). The question is, does surface resemblance confer an analogous increase in the persistence of false alarms? To answer this question, we replicated the rhymes condition of Experiment 2 using nonsense rhymes rather than meaningful ones.

Method

The logic of this manipulation was that it dissociated surface form from meaning. Rhymes could no longer activate each other's meanings because they were meaningless. So, if our explanation were correct, we expected different results than in the rhymes condition of Experiment 2. During the study phase, children (30 kindergartners, 30 third graders) again listened to a recording of 64 words. Half the words were familiar, meaningful nouns drawn from the same pool as before. The other half were one- and two-syllable nonsense words (e.g., *kef, cej, mivig, tyly*). On the immediate and delayed recognition tests, half the meaningful nouns were replaced by meaningful distractors from the pool, and half the nonsense words were replaced by nonsense distractors. Half of these distractors rhymed with the targets that they replaced (e.g., *kef-tef, mivig-tivig*), and half did not.

Results

Two results were of interest: the false alarm rates for related versus unrelated nonsense distractors on the initial test and the persistence rates for these two types of false alarms and for hits involving nonsense targets The first result is just a manipulation check to determine whether surface resemblance elevated children's false alarm rates on the immediate test It did Initial false alarm rates were higher for sound-related than for unrelated nonsense distractors in both kindergartners (45 vs 31) and third graders (43 vs 30)

The second result bears directly on our explanation of why false alarms are so persistent If the explanation is correct, surface resemblance, unlike semantic relatedness, should not enhance initial false alarms' tendency to recur on the delayed test, relative to unrelated distractors That is what we found Persistence rates for false alarms to rhyming nonsense distractors (kindergarten = 42, third grade = 47) were not significantly higher than those for false alarms to unrelated nonsense distractors (kindergarten = 40, third grade = 48) Note, too, that the persistence rates for nonsense rhymes were much smaller than even those for the nominally unrelated distractors in the first two experiments (range = 60–84) Further, the persistence rates for hits to nonsense targets (kindergarten = 53, third grade = 59) were larger than persistence rates for false alarms to either type of nonsense distractor (*ps* < 01) Thus, the picture for nonsense distractors was the opposite of that for meaningful distractors

GENERAL DISCUSSION

We explored three predictions about the tendency for initial false alarms to persist across forgetting intervals Although fuzzy-trace theory was used to generate those predictions, it could be argued that they are also consistent with classical constructivist accounts of memory (e g , Bransford & Franks, 1971, Neisser, 1981) A central assumption of such theories is that storage is a constructive process in which the surface forms of meaningful targets are integrated into an abstract semantic code (Alba & Hasher, 1983) It is this code that is retained and that supplies the basis for subsequent hits and false alarms

On the one hand, our results are in broad agreement with these notions Indeed, the finding that children's false alarms were sometimes more persistent than their hits is reminiscent of Bransford and Franks's (1971) finding that distractors that combined the meanings of several targets were accepted with higher confidence than the individual targets Also, it is reminiscent of Neisser's (1981) observation that witness's false recollections can be more stable than their true recollections if the former preserve the gist of events and the latter do not, and it is reminiscent of Roediger and McDermott's (in press) finding that delayed false alarm rates can be as high as delayed hit rates when distractors (e g , *sleep*) share meaning with several studied targets (e g , *bed, rest, awake, dream*)

On the other hand, constructivist theories have two limitations as explanations of our findings First, several recent experiments have disconfirmed a core prediction of the assumption that the same abstract semantic code underlies hits and false alarms When distractors preserve the meanings of targets (e g , when they are paraphrases of studied sentences or synonyms of studied words), there should be strong positive dependencies between acceptance rates for such distractors and for their related targets However, independence has been observed for sentences, words, pictures, and numbers (for a review, see Reyna & Brainerd, 1995) Moreover, research has identified manipulations that doubly dissociate acceptance rates for targets and meaning-preserving distractors—that is, that drive the two in opposite directions (Ackerman, 1992, 1994, Brainerd & Reyna, 1993, 1995, Reyna, 1995, in press, Reyna & Kiernan, 1994, in press)

The second limitation of constructivist theories is that they do not forecast, for any of the distractors in our experiments, that persistence rates for false alarms should equal or exceed those for hits The reason, as the Bransford and Franks (1971), Neisser (1981), and Roediger and McDermott (in press) examples suggest, is that constructivist theories predict that persistence of false alarms over time depends on how much study-phase meaning is captured by distractors False alarms will be as persistent as hits only when distractors capture as much meaning from the study phase as targets, and false alarms will be preserved better than hits only when distractors capture more study-phase meaning than targets Neither of these conditions obtained in our experiments, meaning overlap was always greater for targets than for distractors

Finally, Poole (in press), in a commentary on our results, explored their generalizability and their application to testimony She reanalyzed the data of a prior eyewitness memory study (Poole & White, 1991) in which children observed staged events, responded to a recall test, and responded to a repetition of that test 1 week later Poole calculated the conditional probabilities for persistence of both initial intrusions (false memory) and initial correct recalls (true memory) The pattern of results, persistence rates of 79 for intrusions and 72 for correct recalls, parallels the pattern for meaning-preserving distractors in Experiment 2 Poole concluded that the pattern reported in this article may also hold for recall tests and for the narrative-style information that figures in eyewitness memory studies

Poole (in press) also pointed out that the fuzzy-trace account of our results may resolve a current dilemma in the literature on forensic interviewing That dilemma concerns lack of empirical support for the hoary practice of using response stability over time as a truth criterion—explicitly, the practice of accepting statements that are consistent over different occasions as reflecting true memories of events and challenging inconsistent statements as being lies or false memories In a series of studies (e g , Fisher & Cutler, 1992), it has been found that the consistency of witness's statements over time is a poor predictor of the accuracy of those statements Poole argued that this result is explicable on the hypothesis that initial false statements are based on recollections of the overall gist of events, whereas initial true statements are based, partly or predominantly, on verbatim memories of actual events

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