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Remembering versus Knowing the Past: Children's Explicit and Implicit Memories for Pictures

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Two studies are reported examining children's explicit and implicit memory for pictures, using measures of recognition memory and perceptual facilitation. In Experiment 1, 3-year-olds showed significant implicit memory, as assessed by perceptual facilitation in identifying blurred pictures after a 3-month delay, even though they showed no explicit memory for the pictures, as assessed by recognition. This was true even though initial exposure to the pictures had been only in clear focus. The finding was replicated in Experiment 2, which also included 5-year-olds and adults. Recognition memory and perceptual facilitation were related for adults, but not for children at either age. The data suggest that age-related improvements in explicit memory could be due, at least in part, to the realization that perceptual fluency can be an indicator of prior experience.

Memory for experienced events and places, and for significant others, is a central part of knowing who we are as individuals. The first few years of life are often considered crucial to development and it might seem natural that memories of this time would play a central role in personality structure. Surprisingly, however, adults can recollect very few memories dating from before the age of 5 or 6 years and virtually none prior to 2 or 3 years of age (Adair Usher & Neisser, 1993; Sheingold & Tenney, 1982). This paucity of memories cannot be accounted for by forgetting simply because of the passage of time (Wetzler & Sweeney, 1986) and has been labeled "infantile amnesia" (Schactel, 1947).

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Infantile amnesia is a term which seems to imply a qualitative shift in the memory system. Several theorists have suggested that we are able to form and preserve coherent memories after a certain age but not before. Such a model was advanced by Freud, in both his blockade and his reconstruction models (Freud, 1916–1917/1963), and by researchers such as Schactel (1947) and Neisser (1962), who used the reconstruction model as a basis for developing somewhat different theories (see Pillemer & White, 1989, for a historical review).

However, more recent research has called this classic picture of infantile amnesia into question. A number of studies have shown that young children do have accessible memories. This has been shown in both controlled experimental paradigms and for natural memories. To take two examples from the first tradition, McKee and Squire (1993) have demonstrated that infants' well-known ability to perform on a visual paired-comparison task reflects a system that can maintain early memories, apparently functioning early in life, but not functioning in amnesics; Bauer, Hertsgaard, and Dow (1994) have found delayed imitation of action sequences modeled by an experimenter, as long as 8 months after the initial demonstration. To take two examples for natural memories, Adair Usher and Neisser (1993) showed that for certain salient life events, such as a birth of a sibling or hospitalization, some corroborated memories can be found in adults dating to events occurring when subjects were as young as 2 years old; Fivush and Hamond (1990) have found memories for routine events in children as young as $2\frac{1}{2}$ years old.

These studies clearly show much better memory performance in infants and young children than seems consistent with infantile amnesia, if infantile amnesia is considered profound and absolute. However, the results do not show that early memory is equivalent to that of adults. Infantile amnesia may most reasonably be thought of as a relative rather than an absolute phenomenon: people recall less than might be expected about their early childhood.

A face recognition study by Newcombe and Fox (1994) showed some of the limits of early memory. While preadolescent children did show above-chance recognition of preschool classmates, their performance was far lower than that seen in a study by Bahrick, Bahrick, and Wittlinger (1975) in which adults were asked to recollect faces of people with whom they attended high school. The study by Bahrick et al. (1975) showed that the subjects were able to recognize classmates' faces with a 90% accuracy rate 15 years after graduation, and with 71% correct even after 48 years. In the Newcombe and Fox (1994) study, recognition of preschool classmates' faces was at 21% after 5 years. This fact cannot be explained by children's difficulty with recognizing faces from photographs: contemporaneous recognition of classmates by preschoolers is at levels above 90% (Campbell, Walker, & Baron-Cohen, 1995; Diamond & Carey, 1977). While the comparison between the Newcombe and Fox and the Bahrick et al. studies is a rough one, because preschool and high-school peer interactions are clearly quite different, some simple confounds can be eliminated as a source of the contrasting results. For instance, recognition was not affected, for either group, by length of time attending the school. Thus, it would seem that there is dramatically better retention for faces learned in adolescence than those learned in early childhood.

If one acknowledges that infantile amnesia is a real phenomenon, although not as profound as is sometimes believed, there are several approaches to explaining it. The overall thrust of several recent treatments is to link various milestones in cognitive development to the waning of infantile amnesia. Such milestones include the acquisition of language, the development of narrative structure and the socialization of memory talk (Nelson, 1993), the development of the child's sense of self (Howe & Courage, 1993), and the development of the child's theory of mind (Perner & Ruffman, 1995, this issue). These views of infantile amnesia almost certainly explain important aspects of the phenomenon. However, they seem not to offer a complete explanation of it: it is hard to see how acquisition of language, narrative structure, sense of self, and theory of mind could explain changes in long-term face recognition, as found by Newcombe and Fox (1994).

A second approach to the problem of early memory (e.g., Nadel & Zola-Morgan, 1984) uses the distinction between explicit and implicit memory (for a review, see Roediger & McDermott, 1993). Adults with brain damage causing amnesia perform, by definition, at profoundly impaired levels on traditional memory tasks, such as recall and recognition, which explicitly asks subjects to indicate memories of which they are consciously aware. Recently, however, it has been found that amnesics show quite well-preserved performance in tasks which draw more implicitly on memory, tasks for which past experience improves performance without subjects consciously remembering the past experience. For example, amnesics complete word-stems with words seen before at above-baseline rates, without being able to report that they saw the words before, and they show better perceptual identification of stimuli seen before than stimuli not seen, again in the absence of awareness of prior exposure. Normal adults can also show facilitation in performance on implicit memory tasks, even when they show low levels of recognition and recall performance.

Developmental studies have seemed to demonstrate that, while there is not much age-related variation in implicit memory performance, there are marked developmental trends in explicit memory (Carroll, Byrne, & Kirsner, 1985; Graf, 1990; Greenbaum & Graf, 1989; Naito, 1990; Parkin & Streete, 1988; for a review, see Ausley & Guttentag, 1993). Developmental improvement in explicit memory occurs in recognition memory tasks as well as in recall. Some experiments find asymptotic levels of recognition in young children (e.g., Brown, 1975) but others showed marked age-related improvement (e.g., Dirks & Neisser, 1977; Mandler & Robinson, 1978; Newcombe, Rogoff, & Kagan, 1977), even with attempts to control encoding conditions (Carroll, Byrne & Kirsner, 1985; Sophian & Stigler, 1981). Age-related differences in recognition are not a product of different retention rates for different ages (e.g., Fajnsztejn-Pollack, 1973; Rogoff, Newcombe, & Kagan, 1974; for a review, see Howe & Brainerd, 1989). Findings of developmental change in explicit but not implicit memory suggest the interest of exploring parallels between infantile amnesia and amnesia due to brain damage.

However, there are two problems with the "explicit/implicit" approach to infantile amnesia. First, the parallel between infantile amnesia and amnesia due to brain damage is not exact, in that the underlying mechanism seems likely to be different. Current evidence indicates that maturation of the brain areas damaged in amnesia is complete early in life (Diamond, 1990). The fact that McKee and Squire (1993) showed that infant performance on visual paired comparison is much superior to that found on the same task in amnesia adults suggests the same conclusion.

Second, the conclusion that implicit memory is robust at an early age has recently been undermined by Parkin's (1993) reanalysis of the Parkin and Streete data. Parkin and Streete (1988) showed perceptual facilitation of equal magnitude in children and adults, along with developmental improvement in explicit memory. However, when Parkin (1993) calculated subjects' facilitation taking into account how well subjects performed on baseline tasks, following an argument and a formula provided by Snodgrass (1993), developmental trends were seen in implicit as well as explicit memory, leading to some doubt about the early robustness of implicit memory.

The present study sought to examine the issue of early implicit and explicit memory, building on past work in several ways. First, past work using perceptual facilitation has presented the perceptual identification task at the initial exposure of the stimuli, as well as at test. This procedure raises the possibility that the implicit memory observed was for *particular* perceptual operations. If so, implicit memory might not be evident with stimuli shown initially in full focus, as is true in natural exposure, and would be a phenomenon not likely to occur often in everyday life. We wanted to examine implicit memories as they might arise during naturalistic, everyday interactions such as looking at pictures in a book.

Second, we wanted to use a time interval between initial exposure and retesting sufficiently long to allow recognition memory to fall to chance. Previous studies of the development of explicit and implicit memory have never studied a situation in which explicit memory, at least for younger subjects, has fallen to chance. If implicit memory remains high when conscious recognition is lacking, as is true in amnesia due to brain damage, parallels between infantile amnesia and amnesia due to brain damage would seem more justified. This is especially true because, for normal adults, if and when explicit memory declines to chance from initially above-chance levels, there is also a dramatic decrease in implicit memory (Moscovitch & Bentin, 1993). Thus, this study sought to examine whether implicit memory was preserved for children in the face of truly chance level performance on an explicit memory task, as has been found for amnesics, or whether implicit memory also declined to chance levels in this case, as has been found with normal adults.

A third issue is whether implicit memory does or does not show developmental trends when the Snodgrass (1993) correction for baseline scores is used. While the robustness of early implicit memory is now widely assumed, the Parkin (1993) reanalysis casts some doubt on this conclusion. In Experiment 2, in which three age groups were used, we addressed this point.

EXPERIMENT 1

Method

Subjects. The subjects in the experimental group were 35 3-year-old children, 17 girls and 18 boys, attending preschool full time. Subjects ranged in age from 2 years, 11 months, to 3 years, 10 months, with a mean of 3 years, 6 months. Subjects in the control group were 10 3-year-old children, 4 girls and 6 boys, also attending preschool full time, ranging in age from 3 years, 1 month, to 3 years, 11 months with a mean of 3 years, 5 months. Children were from predominantly white, middle class backgrounds.

Materials. A children's book entitled *One Yellow Lion* (Van Fleet, 1990) was used as the stimulus. The book contained 10 pictures of colorful animals in the following format: a page displaying a particular number in a particular color (e.g., a large yellow "1"), followed by a page with an animal picture in the numerosity and color referred to on the previous page (e.g., a picture of one yellow lion). Pictures from the book, along with 10 animal pictures, also by Van Fleet, never seen before, were made into transparencies.

In the testing phase, an overhead projector was used to project the 20 animal pictures on a wall. The pictures were shown in progressively diminishing degrees of blurriness, until subjects correctly identified them. Focus was varied using a seven-tiered structure made of clear acrylic, placed directly on the overhead projector to vary the distance of the picture from the projector. The blurriness of the picture was thus a function of the height of the transparency from the projector. When on the highest shelf, labeled one, pictures had the greatest degree of blurriness; when on the lowest shelf, labeled seven, pictures were almost completely focused.

Procedure. Subjects in the experimental group were asked to accompany the experimenter to a separate room to play a "reading" game. The initial phase consisted of five sessions with each child over 5 consecutive days. On Days 1 and 2, children were read a series of books containing animals, in an effort to create interest in the activity. On Days 3 and 4, the experimenter read the book *One Yellow Lion* once each day. On Day 5, children were given a recognition test. The experimenter gave the children a visual cue (the colored number from the book, for example, a yellow "1") and asked the subjects to choose between three possible animal choices for the following page, presented verbally. (Experimenters said "One yellow . . . Do you think it is one yellow canary on the next page, or one yellow lion, or one yellow butterfly?") After responding, children were shown the correct answer. The recognition test concluded Phase 1 of the experiment. A delay of 3 months followed.

After the 3-month delay, the same experimenter returned to complete the experiment with two final tasks. The implicit task involved showing the children 20 pictures of animals (10 of which they had never seen and the others from the book *One Yellow Lion* seen 3 months before). Using an overhead projector, pictures were shown in a range of one to seven on a blurriness scale. The children were asked to identify the animal as soon as possible. If they indicated that the picture was too blurry to identify the animal, the experimenter moved the transparency to a lower shelf making the picture clearer. If children did not respond when the stimulus was at the highest degree of clarity, they were told what the animal was, and an identification score was not recorded for the subject on that picture. Missing data occurred infrequently, with four pictures not identified out of 700 identifications (20 identifications for each of the 35 subjects). The order of the pictures was randomized separately for each subject.

After each picture had been identified, it was brought into full focus and a yes–no recognition test was given. The experimenter asked the children if they remembered seeing the picture before ("Do you remember this picture? . . . Do you remember seeing this animal in a book we read together?"). The experimenter did not use temporal tags such as "three months ago," but merely asked in a general way about memory for the pictures in the book they had read together.

A control group was also studied. These children never saw any of the pictures. They were given only the implicit task outlined above, in order to establish baseline data on children's ability to identify the animals at different degrees of focus.

Results

Initial recognition memory. After reading the book *One Yellow Lion,* the children were given a three-item forced-choice recognition test. Performance was clearly above chance, with a mean d' of 1.84 (*SD* 1.41), $p <$

.001. (The d' analyses were done using procedures and tables in Macmillan & Creelman, 1991, for three-alternative forced-choice analyses.)

Implicit memory after three months. A mean was calculated for each subject to indicate the degree of focus at which experimental and control pictures were identified (higher numbers = higher focus needed for identification). The group means are shown in Table 1.

A 2 (group: control group versus experimental group) × 2 (picture type: experimental pictures versus new pictures) analysis of variance (ANOVA) was conducted on the data. Results yielded a main effect for picture type, $F(1,33) = 5.45$, $p < .02$, no main effect for group type, $F(1,33) = .04$, $p < .85$, and a significant interaction of group type and picture type, $F(1,33) = 45.01$, $p < .0001$.

Analyses of simple effects showed that the experimental group identified the pictures seen before at significantly less focus than the 10 control pictures, $t(34) = 4.85$, $p < .0001$. On the other hand, surprisingly, the opposite was actually true for the control group, $t(9) = 4.06$, $p < .002$. Thus, the *One Yellow Lion* pictures were apparently intrinsically harder to identify than the control pictures. This fact suggests that the significant perceptual facilitation shown by the experimental group was underestimated in size. Between-groups comparisons showed both a significant difference between the experimental and the control groups' performance on the experimental pictures, as would be predicted, $t(43) = 2.84$, $p < .007$, and, surprisingly, a significant difference between the groups on the new pictures, never seen before by either group, $t(43) = 4.32$, $p < .0001$.

The difference between groups on the control pictures could be due to baseline differences between the children. However, its existence could also be due to prior exposure influencing the strategy experimental children used when identifying the pictures. While it would be somewhat surprising to find 3-year-olds using strategies on a task of this kind, given the fairly rudimentary strategies generally used by children of this age on memory tasks (e.g., DeLoache, 1984), we evaluated the issue empirically by examining how performance on the perceptual facilitation task changed over time within the testing session. If children in the experimental group are using a strategy for identification based on memory for some of the pictures, they should become better at identifying experimental pictures and

TABLE 1
Group Means for Picture Type for Control Group and Experimental Group

	Experimental group	Control group
Experimental pictures	3.35 (.609)	4.01 (.758)
New pictures	3.78 (.469)	3.06 (.457)

Note. Higher numbers mean that better focus is required for indentification (range 1–7). Values in parentheses are standard deviations.

worse at identifying new pictures as the task progressed and they formulated and implemented the strategy. However, when the session data were divided into four blocks of five pictures each and a linear trend analysis was performed, there was no trend in the identification of experimental pictures, $F(1,33) = 1.09$, $p < .31$, and a linear trend for the new pictures, $F(1,33) = 5.76$, $p < .02$, reflecting better (rather than worse) performance on the new pictures over time. Analyses of control group data showed no linear trends, Fs < 1.

Recognition memory after 3 months. No statistical analyses were conducted on the 3-month recognition data because no children reported remembering any of the pictures. That is, all children responded "no" when asked if they remembered the pictures from 3 months before. Many of them also denied any general memory for the experimenter or their shared book-reading experience.

Discussion

Results from this experiment revealed a durability of implicit memory in 3-year-olds despite their apparent inability to recognize the pictures. Even though the *One Yellow Lion* pictures seem to be more difficult to identify than the control pictures, subjects in the experimental group were able to identify pictures from the book significantly more easily than the control pictures, as well as significantly more easily than the control group could identify pictures from the book.

The fact that the control pictures were identified more easily by the control group than by the experimental group is somewhat surprising, because none of the children had seen these pictures before. The possibility that prior exposure to some of the pictures affected the strategy that subjects used in identifying pictures, leading experimental subjects to wait for higher levels of certainty before announcing a name than control subjects insisted on, was not supported by trend analyses and seems inconsistent with what is known about strategies used by children of this age and with the lack of recognition memory on which they might base such strategies. Baseline differences between the groups of children may account for the effect. In any case, the significant difference between experimental and control subjects' performance on pictures from the book suggests the existence of perceptual facilitation, in addition to any possible strategy differences. This issue is evaluated in more detail in Experiment 2, in which materials were counterbalanced.

Another question about the data from Experiment 1 concerns the inability of the subjects to recognize any of the pictures. Such a performance might indicate the operation of extreme conservative response bias, rather than true lack of recognition. Children's apparent lack of memory for the experimenter or for the book-reading experience is informal evidence against this possibility. In Experiment 2, the problem was attacked directly by giving children feedback regarding whether their recognition responses were correct in order to reduce or eliminate conservative response biases and encourage children to guess.

The present findings are similar to those of previous research on the performance of amnesic patients, who show preserved implicit memory despite the lack of explicit memory, and contrast with the findings of Moscovitch and Bentin (1993) on normal adults. While normal adults can show significantly above-chance performance on an implicit task in the absence of explicit memory (Eich, 1984), this pattern occurs when exposure to the stimuli has been such that explicit memory was never established. When memory exists at the explicit level, but declines to chance over time, it may be that young children, but not adults, show preserved implicit memory. In other words, the fate of explicit and implicit memory may be linked for adults but not for children below a certain age. This idea was explored in Experiment 2.

EXPERIMENT 2

Experiment 2 had five aims. First, 20 new animal pictures were obtained, allowing counterbalancing of the experimental pictures and the control pictures across subjects, and hence, estimates of the size of the perceptual facilitation effect. Second, at the time of the delayed recognition test, subjects were given feedback as to whether they were correct. Thus, if the subject responded "No, I do not remember that picture," and it was in fact one they had seen before, they were told that they were incorrect. If they responded correctly, they were told that they were correct. This was done in an effort to deter nay saying, which could have been a bias in the delayed recognition data in Experiment 1. Third, older children and adults were observed as well as 3-year-olds. Five-year-old children were chosen because they are just past the critical range to which infantile amnesia is thought to extend. Adults were added for further comparison. Fourth, while perceptual facilitation was above chance in Experiment 1, we could not assess whether it had declined over time. In Experiment 2, one group participated in the implicit task immediately following exposure to the pictures, while the other group participated in the implicit task 3 months later, as in Experiment 1. Fifth, we used the Snodgrass (1993) formula to examine developmental changes in implicit memory relative to the total amount of facilitation subjects *could* show, given their ability to perform the perceptual identification task on new pictures.

Method

Subjects. There were 140 subjects in this experiment. Subjects included 40 3-year-old children, 40 5-year-old children, and 60 adults. The 3-year-old children ranged in age from 3 years to 3 years, 10 months, with a mean age of 3 years, 4 months. The 5-year-old children ranged in age from 5 years, 1 month, to 5 years, 8 months, with a mean age of 5 years, 6 months. Children attended preschool and kindergarten and were from predominantly white middle-class families. The adults were undergraduates and graduate students.

Materials. The materials used in this experiment were similar to those used in the first study, but the pictures were 20 new animal pictures, drawn by Wayne Cherrington. The 20 pictures were divided into two books (book 1 and book 2).

Procedure. As with Experiment 1 the experimenter spent some time with the children so they would be comfortable during the experiment. The children were shown the animal pictures as in the first experiment, with the following modifications. First, one half of the subjects were read book 1 and the other half were read book 2. Second, the reading of the book was confined to 1 day, with 5-year-old children and adults hearing the book once while the 3-year-old children heard the book twice. This difference in exposure was used in an attempt to increase 3-year-olds' recognition performance to the level of 5-year-old children and adults. Finally, the initial recognition test was given immediately following the reading, rather than 1 day later as in Experiment 1.

The testing phase of the experiment was identical to that of Experiment 1 except for the use of the 20 new animal pictures. Testing occurred either after a 3-month period, as in Experiment 1, or in a single session. For the 3- and 5-year-old groups, there were 20 subjects in each delay group; for the adults, 20 were seen in a single session and 40 after 3 months. As in Experiment 1, missing data occurred rarely, with 7 pictures not identified out of 2800 identifications (20 identifications for each of the 140 subjects).

Results

There were no differences as a function of counterbalancing of pictures. Thus, all analyses reported are collapsed across picture sets.

Initial recognition memory. The three-item forced-choice recognition test, given immediately after reading the book, showed all subjects performing significantly above chance, as shown in Table 2. In fact, performance for 5-year-olds and adults was near ceiling levels, with all but a few subjects 100% accurate. (It is for this reason that three of the means and standard deviations in Table 2 are identical.)

Analysis of variance showed no main effect of assignment to time interval group. The main effect of age, $F(2,134) = 24.5, p < .0001$, was due to the fact that 5-year-olds and adults did significantly better than 3-year-olds. This difference occurred despite the fact that the 3-year-olds saw the pictures twice and the other groups saw them only once.

Implicit memory. The means for each time interval and age group can be found in Table 3. An analysis of variance conducted on these values revealed main effects for picture type (experimental vs new), $F(1,134) = 201.27, p$

TABLE 2
Initial Recognition Memory (d') for Each Age and Time Interval Group

	Immediate group	3-month group
3	2.20 (.886)*	2.87 (.902)*
5	3.48 (.428)*	3.24 (.680)*
Adults	3.48 (.428)*	3.48 (.428)*

Note. Values in parentheses are standard deviations.
* $p < .001$ difference from zero.

$< .0001$, age (3, 5, and adults), $F(2,134) = 10.97, p < .0001$, and time interval group (immediate vs 3 months), $F(1,134) = 10.01, p < .002$. Significant or borderline significant interactions were found for picture type $\times$ age group, $F(2,134) = 7.40, p < .001$, and picture type $\times$ time interval group, $F(1,134) = 3.80, p < .06$.

Simple effects analyses utilizing the Bonferroni adjustment showed that performance was worse after delay for the pictures seen before (but there was no difference between delay groups for new pictures) and that adults performed better than children (who did not differ from each other) at naming new pictures.

Developmental differences in the ability to identify new pictures, as were evident in our data, need to be taken into account in assessing perceptual facilitation because they affect the amount of facilitation that subjects could possibly show on the old relative to the new pictures. Therefore, the data were transformed using the equation provided by Snodgrass (1993): savings = $[P(\text{old}) - P(\text{new})]/[1 - P(\text{new})]$. This equation evaluates the difference between performance on the old and performance on the new pictures relative to the maximum effect that could be observed, given performance on the new pictures. Table 4 summarizes the means.

A 2 (time interval: immediate or 3 months) $\times$ 3 (age: 3-year-olds, 5-year-olds and adults) ANOVA was calculated on the data in Table 4. There were

TABLE 3
Group Means for Experimental Pictures and Alternate Pictures for Each Age and Time Interval Group

	Immediate group		3-Month group	
	Exp pics	New pics	Exp pics	New pics
3	2.88 (.680)	3.92 (.579)	3.12 (.510)	4.02 (.532)
5	2.45 (.619)	3.62 (.503)	2.82 (.535)	3.74 (.527)
Adults	2.41 (.676)	3.11 (.694)	3.01 (.680)	3.39 (.688)

Note. Exp pics are the experimental target pictures; New pics are the pictures not seen before. Values in parentheses are standard deviations. Higher numbers mean that better focus is required for identification (range 1–7).

TABLE 4
Implicit Memory Group Means for Time Interval Group and Age Group Using the Snodgrass Formula

	Time Interval	
	Immediate group	3-Month group
3	.315 (.368)**	.275 (.246)**
5	.444 (.227)**	.428 (.603)**
Adults	.365 (.226)**	.128 (.307)*

Note. Values in parentheses are standard deviations.
* $p < .05$ difference from zero.
** $p < .001$ difference from zero.

main effects for time interval, $F(2,134) = 5.13, p < .03$, with less perceptual facilitation after delay, and for age, $F(2,134) = 4.33, p < .02$. There was no time interval × age interaction, $F(2,134) = 1.45, p < .24$.

Post-hoc *t* tests with a Bonferroni adjustment revealed a significant difference between 5-year-old children and adults, with 5-year-old children showing more perceptual facilitation than adults. The 3-year-old children did not differ significantly from either group. However, despite the absence of a significant time interval by age interaction, one might wonder whether the low performance of adults in the 3-month delay group contributed to this pattern. Post-hoc tests on the data from the immediate groups showed no developmental differences.

Delayed recognition memory. Recognition memory was assessed using d' scores to evaluate correct recognition relative to correct rejection of new pictures. Scores were calculated for each subject by converting hit rates and false alarm rates according to the procedures in Macmillan and Creelman (1991). (See Table 5 for values.) All means were significantly above chance with the exception of 3-year-old children in the 3-month delay group.

TABLE 5
Delayed Recognition Memory (d') and Response Bias (c) for Each Age and Time Interval Group

	Time interval			
	Immediate group		3-month group	
	d'	c	d'	c
3	1.95 (.810)**	−.038 (.484)ns	.27 (1.01)ns	−1.804 (860)**
5	2.73 (1.20)**	−.109 (.390)ns	.91 (.785)**	−.024 (.468)ns
Adults	3.31 (1.14)**	.022 (.098)ns	1.25 (.995)**	.423 (.656)**

Note. Values in parentheses are standard deviations.
* $p < .05$ difference from zero.
** $p < .001$ difference from zero.

A 2 (time interval: immediate or 3 months) × 3 (age: 3-year-olds, 5-year-olds and adults) ANOVA was conducted on these data. Main effects were found for time interval, $F(1,134) = 104.16$, $p < .0001$, and age, $F(2,114) = 15.38$, $p < .0001$. Post-hoc t tests with a Bonferroni adjustment revealed that recognition decreased with time for all age groups. In addition, 5-year-old children did better than 3-year-old children and adults did better than both child groups. Thus, unlike the implicit memory data, these data do show clear developmental increases.

Also in accord with procedures in Macmillan and Creelman (1991), response bias was calculated for each subject. This index provides a measure of subjects' general tendency to say either "yes" or "no" on recognition tests. Means (shown in Table 4) reveal that none of the immediate groups showed significant response bias. In the 3-month delay group, 3-year-olds showed significant levels of liberal bias and adults significant levels of conservative bias. A time interval × age ANOVA conducted on the response bias data showed main effects for time interval, $F(1,134) = 18.94$, $p < .0001$, age, $F(2,134) = 49.44$, $p < .0001$, and an interaction of time interval and age, $F(2,114) = 46.94$, $p < .0001$. In the 3-month delay group, 5-year-old children showed significantly less bias than 3-year-old children or adults, $t(38) = 8.13$, $p < .0001$, and $t(58) = 2.75$, $p < .008$, respectively.

Implicit memory as a function of recognition. The last phase of the analyses examined the amount of repetition priming as a function of recognition. Two means were calculated for each subject: an average implicit memory score for pictures correctly recognized and an average implicit memory score for pictures not recognized.

Because 15 of 20 3-year-old children in the 3-month time interval group responded "yes" to every recognition question or "no" to every question, analyses could not be conducted on their data. However, in the immediate group, neither 3- nor 5-year-old children showed significantly different amounts of priming as a function of recognition, $t(16) = .40$, $p < .69$, $t(12) = .521$, $p < .61$, whereas adults did identify pictures they recognized at lesser degrees of focus than those they did not recognize, $t(10) = 5.75$, $p < .001$. In the 3-month delay group, 5-year-old children did not show differing amounts of priming as a function of recognition, $t(18) = .187$, $p < .85$, but adults did, $t(37) = 3.06$, $p < .005$.

Discussion

The data from the two experiments reported here help us to answer the three questions with which we began, while also raising issues needing further evaluation. First, the data from both experiments show that one can obtain perceptual priming effects even when exposure to the stimuli takes place in naturalistic conditions and there is no opportunity to practice the skills involved in perceptual identification or to form memories for the specific perceptual operations involved in naming the blurred pictures. This is an important fact, showing that implicit memories can be formed for everyday events and scenes. They are not merely a laboratory phenomenon. The availability of implicit reactions can thus provide a basis for people responding differently to new and old stimuli, even when explicit memory is lacking.

Second, the data from both studies show that perceptual priming can be demonstrated, in 3-year-old children, even when recognition memory is at chance. In Experiment 1, the children denied having seen any pictures before, and it could be argued that a conservative response bias simply masked their existent recognition memory. In Experiment 2, feedback was used to correct the reluctance of 3-year-old children to say that they had seen any of the pictures before. The procedure eliminated conservative response bias, although, unfortunately, it led to a significantly liberal (but less extreme) response bias instead. The fact that significant perceptual facilitation occurred in the presence of both a ceiling-level conservative bias (in Experiment 1) and a significant liberal bias (in Experiment 2) shows that the effect does not depend on the strategies used in making recognition decisions. It could still be argued, however, that some above-chance recognition ability is being masked by bias. Further work using forced-choice recognition could assess whether recognition memory is truly lacking in these children, rather than simply hidden by response biases.

The fact that 3-year-old children seem to show patterns of results parallel to amnesics (i.e., preserved implicit memory even at apparently chance levels of recognition) invites the question of whether the same phenomenon would be found with 5-year-old children and adults if their recognition levels were to reach chance levels. There was a significant decrease in explicit memory for all age groups across the 3-month period, with the two older groups having begun at a higher level and, arguably, not reaching chance only because the delay interval was not long enough, given the initial encoding. However, the striking independence of priming and recognition for 3- and 5-year-old children, coupled with the fact that adults' performance on the two tasks was related, suggests that priming effects at chance recognition levels might differ for 5-year-olds and adults. Specifically, 5-year-olds might show priming even at chance levels of recognition, whereas adults might not. There may be an important developmental change in the relations of explicit and implicit memory between 5 years and adulthood (see also Ausley & Guttentag, 1993).

Third, the data also show, in accord with most previous studies, developmental increase in explicit memory but no clear age changes in implicit memory. This is contrary to Parkin's (1993) reanalysis of Parkin and Streete (1988), but in line with the conclusions of Carroll et al. (1985), Greenbaum and Graf (1989), and others. However, some caution is required in accepting the conclusion, because the relatively low levels of perceptual facilitation shown by adults in the delay condition of Experiment 2 could be masking developmental trends.

We should consider why the adults in the delay condition of Experiment 2 showed low levels of facilitation (although note that their facilitation was significantly above chance). The apparent dampening of facilitation could be due to the adults using relations between explicit and implicit memory in performing the implicit task.

Jacoby, Kelley, and Dywan (1989) have argued that adult memory performance involves extensive use of strategies in which aspects of one's own cognitive functioning, such as perceptual fluency, are monitored and used to make "memory attributions." Subjective awareness of memory may follow such a process, not precede it, as when the feeling that someone is familiar leads to a process of evaluating where one may know this person from and the eventual retrieval of a specific memory. Evidence for aspects of this model is provided by Jacoby, Toth, and Yonelinas (1993), who showed that adult performance on explicit tasks may be aided by implicit memory and by Kelley and Lindsay (1993) who showed that prior exposure to an answer can be perceived as knowing the answer without necessarily remembering its presentation during the study phase.

The implicit memory test in the present studies was interleaved with the recognition questions. This may have led adults, using strategies of the kind identified by Jacoby and his associates, to want to have a "remembering" experience for the animals as a criterion for giving an identification. Setting such a criterion would impair their chances of showing perceptual facilitation effects, by in effect changing an implicit to an explicit task. This argument can be empirically tested. If the picture identification task is given alone, without asking for recognition judgments, adults should show larger facilitation effects.

Developmental changes in the understanding and use of the relations between explicit and implicit memory may account in part for age-related growth in explicit memory. If the neural substrates for explicit memory are present early, as suggested by the data of McKee and Squire (1993), cognitive influences may be centrally involved in age-related improvement in explicit memory. Such factors likely include the cognitive milestones mentioned before, such as development of language, the forming of narrative structure, the development of the child's sense of self, and the acquisition of a theory of mind. In addition, however, the development of a link between explicit memory and implicit memory may result in a more efficient memory system. Most research has focused on the dissociations between explicit and implicit memory. Another productive line of investigation may be to discern the origins of the link that joins them.

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